CIVIL DEPARTMENT	CONTENTS TECHNICAL PROCUREMENTSPECIFICATION FOR CIVIL & STRUCTURAL WORKS – CONSTRUCTION OF 10000 MT AMMONIA STORAGE AT FACT CD	32686-12-PS-002 Page 1 of 1

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CIVIL AND STRUCTURAL WORK REQUIREMENT FOR THE PROPOSED 10000MT CAPACITY AMMONIA TANK AT FACT COCHIN DIVISION, AMBALAMEDU

1.0 Civil ,Structural and Architectural Bidder's Scope of Work

- Civil, Structural and Architectural work for :
  - Ammonia Tank foundation. The proposed location for tank foundation is rocky terrain. Rock anchoring shall be considered for tank foundation as per Structural design requirement if any.
  - Pipe/cable rack as per piping requirement with in the battery limit.
  - Control room building including sanitary and plumbing.

    Control room building shall house the console area, panel room, UPS room and battery room as a minimum. Amenities shall be considered as per standard. False flooring and air conditioning shall be provided for the Console room, panel room and UPS room.
  - Substation building as per electrical design philosophy.
  - Compressor house building with structural roofing and compressor equipment foundations.
  - Providing approach staircase/ladders and operating platform for the equipments / valve operation as per requirement.
  - Providing dog legged Staircase for access to the top of Ammonia Tank
  - Cooling tower
  - Flare Stack structure and foundation
  - Pump House as per requirement and Pump Foundations
  - Instrument air compressor house
  - Foundation/skid for refrigeration unit
  - DG shed structure and DG foundation
  - All access road work. Access Roads shall be connecting up to the nearest existing road
  - RCC Paving shall be provided in Ammonia Pump area, Cooling Tower & DG Area

- 1m PCC flooring shall be provided around Ammonia Tank, buildings and miscellaneous equipment and Platforms .
- Storm Water drains shall be provided and it should be connecting up to the nearest existing drain.
- Fencing and gates
- Construction of boundary wall/dyke wall.

- The preliminary proposed layout for the Ammonia Tank and Associated facilities with the levels are indicated in drawing no 32686-03-AP-00002.
- The proposed location for tank foundation is at rocky terrain. Detailed topography survey report is indicated in Survey drawing attached in Annexure-1.
- Soil investigation reports as a guideline will be shared with the Bidder during pre-bid or earlier.
- The complete area will be levelled and graded to FGL by the Owner as per plot plan before handing over the site to the Bidder.
- Micro grading as per the final Layout shall be in the scope of the Bidder. For the purpose of Micro-grading the Bidder's scope is not limited only up to the Unit Battery Limit, but to be extended up to the adjacent roads around the unit as per requirement.
- If required existing buildings in the proposed area can be utilized by the Bidder. Any dismantling requirement of existing buildings, as per layout done by the bidder will be in the scope of the Owner.
- Removal of foundation structures of the dismantled building shall be in the scope of Bidder.
- Diversion/rerouting (if required) of existing underground utilities (if any) will be in the scope of owner.
- Bidder shall Issue stability certificate for civil structures after commissioning of the project.

The above referred work is not conclusive. Any other items of work as required for the satisfactory completion of the Project shall be under the scope of the Bidder.

1.0.0 **GENERAL**

1.0.1 This specification covers the design criteria and materials to be used and the standards to be followed for the construction and commissioning of all civil and structural works. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

1.0.2 All Civil, Structural and Allied works as specified in the scope of work, shall be in bidder scope.

1.0.3 Order of precedence

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows –

Statutory regulations

Job specifications

Engineering design basis

Standard specification

1.1.0 **DESIGN CRITERIA**

1.1.1 The structural design of all civil and structural work such as Tank foundation, equipment foundations, buildings, dyke wall, sleepers, pipe supports, miscellaneous structures etc. shall be carried out as per the design specifications and relevant latest Indian Standard Codes of Practice. Items not covered in the IS codes shall be designed based on accepted engineering practices.

1.1.2 As far as possible, RCC structures shall be used and wherever structural steel is used, it is to be shot blasted and painted with anticorrosive paint as per the detailed specification given in clause 8.5.0.

1.2.0 DESIGN CODES AND STANDARDS

1.2.1 The design of structures, foundations, water retaining structures etc. shall be as per latest relevant Indian Standard codes. The design & construction shall conform to the following codes:

a) Structural safety of buildings- Loading standards, IS 875 (Part I to V)

b) Earthquake resistant design of buildings, IS 1893

c) Plain and reinforced concrete, IS 456

d) Handbook on Concrete Reinforcement and Detailing, SP 34

e) National Building Code of India

f) Code of Practice for Design and Construction of Pile Foundations, IS 2911 (Part 1 / Sec 2)6403

g) Load Test on Piles, IS 2911 (Part 1V)

h) Code of Practice for General Construction in Steel, IS 800

i) Concrete structures for storage of liquids, IS 3370 (Part I to IV)

j) Design and construction of machine foundations, IS 2974 (Part 1 to 4)

k) Code of Practice for Structural safety of Masonry walls, IS 1905

l) Code of Practice For design & construction of foundations in Soils, IS1904

m) Design and construction of shallow foundation, IS 1080

n) Design and construction of Raft foundations, IS 2950(Part 1)

o) Design and Construction of shallow foundations on Rock- IS 12070

p) Design and Construction of Bored cast-insitu piles founded on Rock- IS 14593

q) Structural safety of building on shallow foundations on Rock- IS 13063

r) Glossary of terms and symbols related to Rock Mechanics-IS 11358

s) Ductile Detailing of RCC Structures Subjected to Seismic Forces IS 13920

t) Earthquake resistant construction of building, IS 4326

1.2.2 The materials used, construction practices etc., shall conform to relevant IS codes. Only tested quality Material shall be used. Some of the relevant codes for commonly used materials and construction practices are listed below.

a) High Strength Deformed Bars, IS 1786

b) Specification for Fusion Bonded Epoxy Coated Reinforcing Bars IS 13620

c) Mild steel and medium steel bars for reinforcement, IS 432 (Part I)

d) Specification for 43 grade Ordinary Portland Cement, IS 8112

e) Specification for Sulphate Resistant Portland Cement, IS 12330

f) Specification for Coarse and Fine Aggregates from Natural Resources for Concrete, IS 383

g) Handbook on Concrete Mixes, SP 23

h) Method for the Quantitative descriptions of Discontinuities in Rock masses - IS 11315 (Part 1-Part 12)

i) Methods of Sampling and Analysis of Concrete, IS 1199

j) Methods of Test for Strength of Concrete, IS 516

k) Structural steel, IS 2062

l) Burnt clay building bricks , IS 1077

m) Construction of stone masonry, IS 1597 (Part I & II)

n) Brick work, IS 2212

o) Preparation and use of masonry mortars, IS 2250

p) Unplasticised PVC pipe for potable water supply, IS 4985

q) Cement and cement lime plaster finishes, IS 1661

r) Painting concrete, masonry and plaster surfaces, IS 2395 (Part I & II)

s) Painting of ferrous metals in buildings, IS 1477 (PartI& II)

t) White washing & colour washing, IS 6278

u) Laying in situ concrete flooring, IS 2571

v) Specification for Integral Cement Water proofing Compounds, IS 2645

w) Aluminum doors, windows and ventilators, IS 1948/ IS1949

x) Specification for Cast Iron Manhole Covers and Frames, IS 1726

y) Specification for Precast Concrete Manhole Covers and Frames, IS 12592

z) Measurement of Works , IS 1200

1.2.3 The list of codes given is not conclusive and the design, materials & Construction shall conform to relevant codes published by the Bureau of Indian Standards or other statutory bodies.

2.0.0 DESIGN LOADS

2.1.0 DEAD LOAD (DL)

Dead load is the vertical load due to actual weight of all permanent structural and non-structural components of building such as floors, roofs, walls, staircases, fixtures etc.

Dead loads shall be estimated for purposes of design using the actual weights of material of construction and finishes on the basis of unit weights given in IS 875-Part 1

The following densities shall be considered for computation of dead loads:

Density of reinforced cement concrete	2500 kg/cum
Density of plain concrete	2400kg/cum
Density of structural steel	7850kg/cum
Density of soil	1800 kg/cum

2.1.1 Buildings

The following dead loads shall be included in the design of buildings:-

- Self-weight of structural elements.
- Framing, walls, floors, roofs, suspended ceilings, finishes, permanent partitions, and stairs.
- Equipment, fixed services, machinery, lifts, runway beams, electrical feeders, heating/ventilating/air conditioning, etc. wherever their loads are transmitted to structural elements. Equipment loads shall be taken from Manufacturer's Data.
- Fireproofing on structural steelwork.
- Self weight of piping (if any).
- Any other permanent load, if applicable.

2.1.2 Process Structures

The following dead loads shall be included in the design of process structures:-

- Self-weight of structural elements.
- Equipment, machinery, lifts and runway beams.
- The following dead loads from piping shall be included in the design of all structures except piperacks:

  Piping equal to or less than 300 mm diameter shall be considered as a maximum distributed load of 0.5 kN/m2 over the gross area of the supporting floor. This value is to be assumed where extensive piping is anticipated. This load is based on ANSI standard pipe and fittings. Where non-standard pipe and fittings are to be specified, the load shall be adjusted to suit.

  Pipes larger than 300 mm diameter shall be considered as concentrated loads in their actual locations.
- Fireproofing on structural steel, vessel skirts and equipment.
- Vessels, including all internals, refractory linings and hydrotest.

- Insulation installed on piping and equipment.
- Steel platform framing and floor plate.
- Weight of platforms, piping and ladders on towers shall be as specified on the vessel drawings.
- Any other permanent load if applicable.

2.1.3 Piperacks

- Self weight of structural elements.
- The following dead loads from piping shall be included for the design of piperacks:-

  Pipes equal to or less than 300 mm diameter shall be considered as a distributed load of 0.5 kN/m2.

  Pipes larger than 300 mm diameter shall be considered as concentrated loads in their actual locations.

  When individual pipe loads are not available for racks with pipes exceeding 300 mm diameter, but not exceeding 400 mm diameter (e.g.heater – reactor piping) the piping dead load shall be considered as a distributed load of not less than 0.8 kN/m2.

  These loads are based on ANSI standard pipe and fittings. Where nonstandard pipe and fittings are to be specified, the loads shall be adjusted to suit.
- Runway Beams, equipment, airfins (with associated platforming).
- Fireproofing on structural steel.
- Insulation installed on piping and equipment.
- Steel platform framing and floor plate.
- A uniformly distributed dead load of 1.0 KN/m2 for a single level of cable trays and 1.9 KN/m2 for a double layer of cable trays.
- Any other permanent load if applicable.

2.1.4 Equipment Foundations

- Self weight of Equipment.
- Self weight of other structural elements.
- Equipment valves and piping.
- Fireproofing on vessel skirts and equipment.
- Vessels including all internals, refractory linings, platforming and ladders.
- Insulation installed on piping and equipment.
- Any other permanent load if applicable.

2.2.0 IMPOSED LOADS (IL)

2.2.1 Buildings

Live Loads

For the design of each structural element the imposed loads shall be applied in the least favorable pattern.

Imposed loads on floors shall be the actual loads when these are known, but shall not be less than the distributed loads given below:-

Control rooms, filter houses and other light shelters	5.00 kN/m^2
Substations	10.00 kN/m^2
Pump and compressor houses	7.5 kN/m^2
Battery rooms	10.00 kN/m^2
Laboratories	4.00 kN/m^2
Warehouses and open storage areas	7.50 kN/m^2
Offices, residential and domestic buildings	Refer to IS 875
Pedestrian areas, balconies, fire escape, etc. and areas accessible to normal vehicular traffic	Refer to IS 875
Sheeted roofs with access for maintenance only	0.75 kN/m^2
Concrete roofs with access for maintenance only	1.50 kN/m^2
Roofs used for access to equipment	2.50 kN/m^2

Roofs carrying equipment shall, in addition to the above, be designed for the load imposed by the equipment supported.

All roof members shall be checked for a single concentrated load of 2 kN in the least favorable location and in addition to the distributed loads specified above.

The loads due to rain on roof should be considered as per Clause 4.3 and Table 2 of IS 875: Part 2.

Piping Loads

Generally, not applicable to buildings such as offices, control rooms, substations, Laboratories etc.

Equipment Loads (Contents)

The Contents of equipment shall be considered as live load and shall be applied in the least favorable pattern. Ensure the correct specific gravity is applied when calculating the load.

Handling Loads

Consideration should be given to loadings occurring during installation, operation and possible removal and replacement of any equipment contained within the buildings. The actual loads shall be checked against the above loading, with due account being taken of material handling methods such as for forklift trucks, which impose high concentrated loads.

2.2.2 Process Structures

Live Loads

Loads on floors, platforms and framing in structures shall not be less than the distributed loads given below:

Main Access Platforms and Floors (Plate, Grating,Slabs)	5.0 kN/m^2
Main Access Platforms and Floors (Framing,Columns,Brackets)	5.0 kN/m^2 NOTE (2)
Platforms subject to storage of heavy equipment (All elements – Plate, Grating, Slabs, Framing,Columns	7.0 kN/m^2 NOTE (1)

and Brackets)

Walkways and Minor Platforms used for access to equipment only 2.5 kN/m^2

NOTES:

(1) The structural elements shall be checked when the actual equipment storage loads become known.

(2) Live Load Reduction on Columns

For process floor areas not used for storage (including during shutdown), the reductions given in the following Table 1 (based on the number of floors qualifying for load reduction carried by the member under consideration) may be applied to the uniformly distributed

imposed floor load in the design of columns, their supports and foundations.

Number of floors with loads qualifying for reduction carried by member under consideration	Reduction in total distributed Imposed Load on all Floors to be carried by the member under consideration. (Percent)
1	0
2	10
3	20
4	30
5 to 10	40
Over 10	50 Max

Table 1: Live Load Reduction on Columns.

Reduction of live load on beams shall be taken as per Clause 3.2.2 of IS 875: Part 2. The moments on a column should be determined from the load used to design the beams at the appropriate level and not reduced on the same basis as the axial load.

- Roofs used as platforms around equipment 2.5 kN/m^2

- Roofs with access for maintenance only 1.0 kN/m^2

Roofs carrying equipment shall, in addition to the above, be designed for the actual load imposed by the equipment supported.

Stairs and landings	5.0 kN/m^2 or
	4.5 kN single point load
Platforms attached to vessels	2.5 kN/m^2
Hand railing systems	0.36 kN/m run

100% or the weight of process or test fluid, in vessels and piping as appropriate for the load combinations given in Table 2 of this Specification.

Piping Loads

The following live loads from piping shall be included in the design of all structures except piperacks:-

- Pipes larger than 300 mm diameter shall be considered as concentrated loads in their actual locations under empty, normal operation and test conditions, whichever gives the most severe effect.
- Piping equal to or less than 300 mm diameter shall be considered as a maximum distributed load of 0.75 kN/m2 for operating condition and 1.5 kN/m2 for test condition over the gross area of the supporting floor.This maximum value shall be assumed where extensive piping is anticipated.
- The load given above is based on ANSI standard pipe and fittings.Where non standard pipe and fittings are to be specified, the load shall be adjusted to suit.
- When individual pipe loads are not available for racks with pipes exceeding 300 mm diameter, but not exceeding 400 mm diameter (e.g. heater reactor piping) the piping shall be considered as a distributed load of not less than 1.2 kN/m2 for the operating condition and 2.5 kN/m2 for the test conditions. This maximum value shall be assumed where extensive piping is anticipated.

- Consideration shall be given to loads on the structure from pipework where the configuration, operating loads and operating temperatures may give rise to significant horizontal forces due to friction at supports. A notional horizontal thermal force of 5 KN per floor level per frame shall be applied to the structure in the orthogonal directions. The structure shall be checked when the actual pipe stress forces are known.
- The following coefficients of static friction shall be used to determine forces at sliding surfaces:-
  - Teflon on Teflon 0.10
  - Steel on steel 0.30
  - Steel on concrete 0.45
- Pipe anchor forces and thermal forces on equipment and vessels shall be included under normal operation and test conditions, whichever gives the most severe effects.
- Point loads from pipe supports on structures shall be the actual loads when they are known. In the absence of known point loads from pipe supports each structural member (excluding bracing) shall be checked for a single point load of 4.5 kN in the least favourable position.

Equipment Loads (Contents)

The Contents of equipment shall be considered as live load and shall be applied in the least favourable pattern. Ensure the correct specific gravity is applied when calculating the load.

Handling Facilities

Permanent handling facilities shall be designed for the following loads:-

- Trolley beams and their supports shall be designed to IS 800/ IS 807/ IS 3177 with an allowance of 25 % of the total load for vertical impact.Where the hoist is to be operated with a grade mounted winch, a line pull of not less than 25 % of the lifted

load shall be included.i.e. Design Load = 1.25 (W + 0.25 W + weight of trolley).This line pull allowance assumes the pulley system has a mechanical advantage of 4.

- Crane beams and supports for travelling cranes shall be designed in accordance with IS 800/ IS 807/ IS 3177.
- Elevator imposed loads shall be increased by 100% to allow for dynamic forces.
- Davits shall be designed for the heaviest item to be lifted plus 25 % for impact but not less than a total of 450 kg. Lateral forces shall be assumed as 20 % of the lifted load. A line pull of 100 % of the lifted load shall be included to provide for the possibility of the load being handled by a line over a single pulley.

Process Vibration

Structures supporting process equipment subject to vibration due to normal process surging, e.g. fluid crackers, fluid hydroformers and fluid cokers, shall be designed for the following dynamic loads which will be periodic in the range of 60 to 100 cycles per minute (1 to 1.67 Hz):-

Fluid coker	0.150 C
Fluid cracker and Hydroformer	0.075 C

where C = weight of fluid in vessel and adjacent piping.

Miscellaneous Loads

Consideration shall be given to loads of a special nature such as piping counterweights, spring hangers, thrusts from expansion joints, expansion loads from horizontal vessels and exchangers, purpose made handling equipment such as counterbalanced crane hooks, and thermal expansion of the structure.

2.2.3 Piperacks

Live Loads

To be applied if permanent access (walkways) is provided.

Access for maintenance only	1.0 kN/m2
Access to Equipment	2.5 kN/m2

Piping Loads

The following imposed piping loads shall be included for the design of piperacks:-

Piping equal to or less than 300 mm diameter shall be considered as a distributed load of 0.75 kN/m2 for operating condition and 1.5 kN/m2 for test condition.

Pipes larger than 300 mm diameter shall be considered as concentrated loads in their actual locations.

When individual pipe loads are not available for racks with pipes exceeding 300 mm diameter, but not exceeding 400 mm diameter (e.g. heater reactor piping) the piping shall be considered as a distributed load of not less than 1.2 kN/m2 for the operating condition and 2.5 kN/m2 for the test conditions.

Note that piping loads for the operating condition are considered as live loads since they do not represent the “pipe full” condition.

Test loads (“pipe full”) may be applied with a reduced load factor equivalent to a dead load.

Test loads should not be applied to more than one tier simultaneously.

The location and magnitude of anchor forces for all pipes over 400mm diameter shall be established before the design is started.

Point loads from pipe supports on piperacks shall be the actual loads when they are known. In the absence of known point loads from pipe supports each piperack member (excluding bracing) shall be checked for a single point load of 4.5 kN in the least favorable position in addition to the distributed loads specified above.

A longitudinal thermal force of 10 per cent of the operating load per tier shall be assumed to act uniformly distributed at each bent. The piperack shall be checked when the actual pipe stress anchor forces are known.

Transverse anchor or guide forces equivalent to 0.75 kN per metre of rack width per tier shall be assumed to act on each bent, applied as a single force at each tier level. The piperack shall be checked when the actual pipe stress anchor forces are known. Transverse forces due to wind acting on piping shall be calculated in accordance with specification given under "Wind loads".

When considering the erection load combination, piping shall be considered as a distributed load not greater than 0.5 kN/m2 irrespective of pipe diameter.The piperack structure self weight shall be considered as a distributed load of 0.5 kN/m2 per tier unless the pipe rack is fireproofed prior to erection, when the actual weight of fireproofing shall be included.

2.2.4 Equipment Foundations

Live Loads

The contents of equipment shall be considered as live load and shall be applied in the least favorable pattern. Ensure the correct specific gravity is applied when calculating the load.

Exchanger and horizontal vessel foundations shall be designed for thermal forces due to vessel expansion.

The following coefficients of static friction shall be used to determine forces at sliding surfaces:-

a) Teflon on Teflon	0.10
b) Steel on steel	0.30
c) Steel on concrete	0.45

Piping Loads

Consideration shall be given to loads on the foundation from pipework where the configuration, operating loads and operating temperatures may give rise to significant horizontal forces due to friction at supports.Pipe anchor forces and

thermal forces on equipment and vessels shall be included under normal operation and test conditions, whichever gives the most severe effects.

Handling Loads

The fixed shell support of removable-bundle heat exchangers shall be designed to withstand a longitudinal force equal to 150% of the bundle mass applied at the heat exchanger bundle centreline. The shear stress for supports shall not exceed 40 % of the yield strength of the material.

In the absence of any suitable provision for live loads in this specification or relevant IS codes for any particular type of floor or structure, the assumed loading shall be got approved. Apart from the specified live loads, any other equipment load or possible overloading during maintenance/ erection shall also be considered in the design.

2.3.0 **WIND LOADS (WL)**

Where the references listed above do not cater for the wind loading on a structure due to dynamic effects such as gusting, vortex shedding, flutter and galloping then the load shall be determined in accordance with the latest technical literature and practice. If a specialist supplier or consultant is employed for the design of such a wind sensitive structure, then the wind loading design criteria shall be reviewed by FEDO and approved prior to the commencement of design.

Design Wind loadings for buildings

Design wind loading shall be in accordance with IS 875:Part 3-"Code of practice for design loads for buildings and structures-Wind loads" and as per clause given below.

Design Wind loadings for Process Structures, Piperacks and Equipments

Design wind loading for process structures, piperacks and equipment shall be established from IS 875: Part 3 with the following minimum requirements:

Basic wind speed shall be 39 *m/sec* for a 50 year return period for structural and equipment design.

Design wind pressure,

$P_d = K_d \times K_a \times K_c \times p_z$ N/m2 Ref Clause 7.2 of IS: 875 Part-3

Where wind pressure $p_z = 0.6Vz^2$

Design wind speed, $V_z = V_b \times k_1 \times k_2 \times k_3 \times k_4$ Ref IS: 875 Clause 6.3

Basic wind speed, V_b = 39 m/s

Probability factor, k_1 = 1.0 Risk coefficient

Terrain height and k_2 Ref. Table 2 of IS: 875 Part-3, based structure size factor on terrain category 3

Topography factor k_3 = 1.0

Cyclonic factor k_4 = 1.0

The values of P_d, however shall not be taken as less than 0.70 P_z

Wind pressure and forces shall be calculated as per latest IS 1875(Part 3)

The effective exposed area of open framed structures which support piping and equipment shall be estimated as a percentage of the gross projected area.

Vessels or other large equipment supported on a structure shall be calculated separately and be additive in computing the total wind load .

The design wind loading shall be assumed to act in any direction. Reduction shall not be made for the shielding effect of adjacent structures or equipment except: -

a) In case of open structures with two or more parallel frames where the windward frame has a shielding effect on the frames to leeward , a shielding factor shall be applied in accordance with Clause 7.4.3.4 and Table 32 of IS 875: Part 3.

b) The shielding effect shall also be considered when assessing wind load on series of pipes in one plane.

c) In case of vessels and stacks where leeward items are shielded for some wind directions.

Transverse forces due to wind acting on pipes in racks shall be calculated in accordance with IS 875. The effect of wind on all pipes shall be considered, but the shielding effect shall be taken into account as described above. Wind forces on longitudinal beams shall also be included, but shielding effect shall be neglected.

Alternatively for racks up to 6 metres wide and with pipes not greater than 450 mm diameter the wind load may be deemed equivalent to the load on a 1.5 m high band. For racks with pipes larger than 450 mm diameter the actual wind load shall be calculated.

Dynamic Effects

Structures such as, but not limited to, heater stacks, chimneys and tall towers, may be sensitive to wind gust effects and/or vibrations due to vortex shedding. In general, the following guidelines may be used for examining the problems of wind induced oscillations:

a) Building and closed structures with a height to minimum lateral dimension ratio of more than about 5.0, or

b) Buildings and structures whose natural frequency in the first mode is less than 1.0 Hz.

Any building or structure which satisfies either of the above two criteria shall be examined for dynamic effects of wind.

If vortex shedding analysis results indicate that unacceptable levels of vibrations can occur, then helical strakes, dynamic vibration absorbers or other means shall be adopted provided prior approval is obtained from FEDO.

All calculations for gust or vibration analysis on purchased equipment shall be submitted to FEDO for review prior to release for fabrication.

2.4.0 EARTH QUAKE LOADS (EL)

The plant structures must be designed for design basis earthquake (DBE) as per clause no. 7.0 and the design spectra given in IS: 1893 (Part-IV), Annex B

The design value of horizontal seismic coefficient Ah shall be computed by the following expression:

$$Ah = \frac{ZI\,Sa}{2\,R\,g}$$

Following data are to be considered:

Seismic load on the structures shall be calculated as per IS 1893 by taking Zone factor Z corresponding to Zone III.

Response reduction factor “R” shall be taken as per Table 4

Damping (for DBE) 5% (for concrete)

2% (for steel)

Importance factor I:

Should be considered as per Table-3, IS-1893, Part-4 based on the category of structure defined in Table-6 of IS-1893: pt-4).

For Cryogenic Bulk storage tank with refrigerated liquefied gases (e.g ethylene, LNG.NH3 etc)- Category-1, so Importance factor I = 2.0

Sa/g is the average Response acceleration coefficient to be taken from Annex B corresponding to the natural period of the structure.

Ductile detailing of reinforcement is mandatory for moment resisting RCC frames and hence response reduction factors corresponding to special moment-resisting frame shall be considered.

2.5.0 LOAD COMBINATIONS

All buildings, structures, equipment, and foundations shall be investigated for each of the loading combinations given in Table 2 and the most severe shall determine the final design.

LOADING	LOADING COMBINATIONS				
DEAD	**Erection**	**Test**	**Normal Operation**	**Abnormal Operation**	**Empty or Shutdown**
Structures	Include (7)	Include	Include	Include	Include
Equipment	Include (7)	Include	Include	Include	Include
Internals	Include (6)	Include (3)	Include	Include	Include
Internals linings	Include (6)	Include	Include	Include	Include
Piping	Include	Include	Include	Include	Include
Floors/Platforms	Include	Include	Include	Include	Include
Insulation	Include	Include	Include	Include	Include
Fireproofing	Include (6)	Include	Include	Include	Include
Vessel Platforming	Include	Include	Include	Include	Include
IMPOSED					
Floors/platforms	-	Modified (4)	Include (9)	Include	Include
Normal Fluids	-	-	Include	Maximum(1)	-
Test Fluids	-	Include (5)	-	-	-
Vessel Platforming	-	Modified (4)	Include	Include	Include
Surge (normal contents)	-	-	Include	Include	-
Thermal (piping)	-	-	Include	Include	-

Wind or Earthquake	Greater of two	Modified wind (2)	Greater of two	Modified wind (2)	Greater of two
Construction Equipment	Include (8)	Include (8)	-	-	Include (8)

Notes below refer to numbers in brackets shown in Table above:-

(1) Load shall be computed due to faulty unit operation from items such as catalyst or liquid backup.

(2) Wind loading shall be based on a wind speed of 0.77 times the design wind speed, but not greater than 39 m/sec.

(3) Loads shall be included only if in place during the future test condition.

(4) Include only 50% of the platform live load for the test condition.

(5) Load for vertical vessels includes only the test fluid as permitted by the vessel design for the hydrostatic field test.

(6) Include only if installed in shop or before lift.

(7) The erection load shall be calculated in conjunction with the clause of this Specification.

(8) The construction equipment load shall only be included if it is greater than the operating load or increases the overturning moment.

(9) Live load reduction may be considered as defined in this Specification.

3.0.0 ANALYSIS OF RCC STRUCTURES

3.1.0 All buildings shall be of RCC framed construction except buildings with sheet roofing. Compressor House roof structure may be of steel. Frame analysis shall be carried out for all structures for all load combinations using structural analysis and design software STAAD Pro. Rigidity at Column Beam joints shall be considered in the analysis.

3.2.0 Ductile detailing of RCC frames shall be done as stipulated in IS 13920 for RCC structures in Zone 3.

3.3.0 Minimum Grade of concrete for structural RCC elements of Piles and Pile Cap shall be M35. Minimum Grade of concrete for all other structural RCC elements shall be M30 and the minimum grade for general RCC works like cable trenches & drains shall be M20.

3.4.0 Ready Mixed Concrete (RMC) shall be used with prior approval of the Engineer-in-charge. Ready mixed concrete shall conform to the provisions in IS 4926.

4.0.0 STRUCTURAL DESIGN OF RCC ELEMENTS

4.1.0 Limit state design shall be adopted for design of all structural elements.

4.2.0 The following values of partial safety factors shall be considered as specified by IS 456 for different load combinations

DL + IL	1.5 DL	1.5 IL		
DL + WL	1.5DL	1.5WL		
DL + WL	0.9DL	1.5WL		
DL + IL + WL	1.2DL	1.2IL		1.2WL

While considering earthquake effects, EL shall be substituted in place of WL and appropriate portion of IL shall be considered as stipulated by IS 1893.

4.3.0 MINIMUM SIZE REQUIREMENTS OF RCC ELEMENTS

Minimum thickness of various RCC components of the structure shall be as given below.

a. Floor slabs 120mm

b. Column footing 200mm

c. Pile cap 500mm

d.	Raft	300mm
e.	Underground pit slab /walls	180mm
f.	Minimum dimension of beam / column	250mm
g.	Cable/Pipe Trench/Launder walls & base slab	100mm
h.	Parapet/Chajja	75mm
i.	Louver/fin	50mm
j.	Precast Trench cover slab	80mm
k.	Precast louver/slab in contact with liquid	100mm
l.	Liquid retaining/ leak proof structure walls & base slab	150mm
m.	Ground floor slab	150mm

4.4.0 Minimum cover for reinforcement shall be as per the provisions of IS456 & IS 3370 for liquid retaining structures. The following values of nominal cover to steel reinforcements including link shall be provided for general structures.

i.	Foundations	75mm
ii.	Columns	50mm
iii.	Beams	30mm
iv.	Slab/Walls	20mm

4.5.0 REINFORCEMENT RODS

The reinforcement rods for concrete shall be as follows.

Main bars in piles	High strength deformed TMT bars conforming to IS 1786 and of grade Fe 500 having elongation more than 14.5%. of make SAIL,RINL,TISCON,JSW.
Main bars in foundations, columns, footings, slabs, etc	-DO-
Lateral ties, stirrups, etc	-DO-
Reinforcement for floors	-DO-

4.6.0 **SLABS**

Two way slabs shall be designed based on the Bending moment coefficients given in annexure D of IS 456. For continuous one way slabs moment coefficients given in Table 12 of IS 456 shall be used. Deflection check of the slabs as envisaged in IS 456 shall also be done .

4.7.0 **BEAMS**

Reinforcement steel shall be provided for the required moment of resistance obtained from the analysis of frames. Shear stirrups shall be provided to withstand balance shear after deducting the shear capacity of concrete section based on the percentage steel provided to resist Bending Moment. Spacing of stirrups shall be detailed in accordance with IS 13920.

4.8.0 **COLUMNS**

Columns shall be designed for the combined effect of axial loads and biaxial moments due to frame action obtained from the analysis for the worst load combination and the detailed design output specifying the percentage steel to be provided and the interaction ratios shall be furnished.

4.9.0 **FOUNDATIONS**

4.9.1 The soil investigation report to be furnished by Owner during pre-bid or earlier is just a guide line. The Bidder may perform a Soil Investigation from his end if required. All foundations shall be designed to suit the existing soil conditions and all major foundations shall be on isolated/raft foundation or bored cast-in-situ piles as per the soil investigation report. The sizing of foundations & design shall be done as per recommendations given in the soil investigation report. The bearing capacity / safe pile capacity shall satisfy strength as well as settlement criteria. The permissible increase in bearing capacity/ pile capacity in wind and seismic load combinations shall be as per IS 875 - part5 and IS 1893 respectively. If the Soil investigation recommends ground improvement bidder may consider any standard Ground improvement technique.

4.9.2 Foundation design for major structures shall be verified by a Geo Technical expert.

4.9.3 While designing foundations at various levels, effect of uplift/ subsoil water table shall also be considered.

4.9.4 Grouting of foundation bolts below base plates for steel structures/ equipment foundations shall be as follows:

a. column bases	CONBEXTRA GP2 or Eqvt.
b. Static Equipment	CONBEXTRA GP3 or Eqvt.
c. Pumps	CONBEXTRA GP3 or Eqvt.
d. Compressors	CONBEXTRA GP3 or Eqvt.

4.9.5 All underground pits, sumps, etc. shall be designed to take care of the uplift forces due to buoyancy, if required.

4.9.6 If the sub soil is of aggressive nature, suitable precautions are to be taken as recommended in the soil investigation report in respect of type of cement, concrete cover etc. for foundations / underground structures.

4.9.7 PCC 1:4:8 is proposed for levelling course, except for liquid retaining structures. The thickness of levelling course shall be 80mm and when used as a structural

element, the minimum thickness shall be 150mm. Levelling course below liquid retaining structures shall be of CC 1:3:6 mix

4.9.8 Concrete surfaces below GL shall be provided with 2 coats of anticorrosive bituminous coating

4.9.9 Existing Works

Where available, drawings showing existing buildings, foundations, underground services and any other information pertinent to the design and construction of foundations shall be used to assist in establishing the foundation design criteria. Information obtained from such drawings shall be verified on site preferably before finalising the new designs.

4.9.10 MINIMUM HEIGHT OF PLINTH /PEDESTAL

The minimum height of plinth/pedestal above finished grade or floor level shall be as follows.

1. Building plinth	300mm above nearest road/pavement level.
2. Pedestal / encasements of structural columns	
Open area	300mm
Covered area	150mm
3. Pedestal for all equipments	
Open area	as required but not less than 300mm
Covered area	as required but not less than 150mm
4. Stair pedestal	150mm
5. Ladder pedestal	150mm

5.0.0 **LIQUID RETAINING STRUCTURES**

5.1.0 Design shall conform to IS 3370 Part I to IV. All elements of water retaining structures or similar structures in contact with water shall be designed as uncracked section.

5.2.0 M30 grade concrete shall be used.

5.3.0 For tanks resting on grounds cement concrete 1:3:6 mix levelling course shall be provided.

5.4.0 The provisions regarding expansion joints, contraction joints, construction joints, bitumen sliding layer above levelling course, etc. shall be provided as recommended in the standards.

5.5.0 Hydro swelling gasket kept in place by a single component hydro swelling polyurethane sealant for sealing or other approved treatment shall be provided at construction joints in concrete both at vertical and horizontal construction joints of water retaining structures to make it leak proof.

5.6.0 For underground storage tanks, pits, trenches etc. where protection against uplift due to buoyancy from subsoil water is to be considered, a min. factor of safety of 1.2 shall be ensured. For purpose of calculating downward load due to overburden, only the mass located vertically over the projected area of the base shall be considered.

5.7.0 All liquid retaining/ storage structures shall be designed assuming liquid up to the full height of wall irrespective of provision of any overflow arrangement.

5.8.0 The walls and base slab of liquid retaining/ storage structure shall be provided with reinforcement on both faces irrespective of any thickness.

5.9.0 All embedded parts such as nozzles, pipes, bolts, etc. shall be provided at the time of concreting.

5.10.0 Plastering with cement mortar 1:4, 10 mm thick, mixed with integral waterproofing compound like Conplast X4211C of M/s. FOSROC or equivalent shall be provided for inside surface after hydro test.

5.11.0 All leaks or wetting noticed during hydro tests shall be rectified as per approved methods, using approved materials.

6.0.0 **REINFORCEMENT DETAILING**

6.1.0 All requirements governing quantum of reinforcement and detailing of reinforcement as per clause 26 of IS 456 and as detailed in SP 34 for detailing of reinforcement shall be adhered to while preparing the construction drawings.

6.2.0 The recommendations for detailing for earthquake resistant construction given in IS 13920 shall also be followed.

7.0.0 **EXPANSION JOINTS**

7.0.1 Expansion joints in concrete structures shall be provided as per IS 456/ IS 3414 Code provisions.

7.0.2 Bitumen impregnated fibre boards of approved manufacture as per IS 1838 Part 1 shall be used as fillers for expansion joints.

7.0.3 The gap between the expansion joints shall be thoroughly cleaned and the bitumen fibre boards placed in position as per manufacturer's specification and the surface shall be sealed with elastomeric silicone rubber sealants.

7.0.4 All expansion/ separation joints in ground floor slabs shall be filled with sand for the full depth of the slab except top 25 mm, which shall be filled with approved mastic sealing compound.

8.0.0 STEEL STRUCTURES

8.1.0 Basic consideration of structural framework shall primarily have strength to withstand the various loads mentioned in clause 2.0.0. Ease of fabrication, erection and overall economy satisfying IS stipulations shall also be a criteria for design. Design shall be done in accordance with IS 800.The deflection limits specified in IS 800 shall also be complied with.

8.2.0 MINIMUM THICKNESS OF STEEL

Trusses, Purlins, side girts & bracings	6mm
Columns & beams	7mm
For gussets, stiffeners, plate guides, etc.	8mm
For base plates	10mm
Chequered plates	6mm (on Plain)
Grating flat	5mm

However the minimum thickness of structural components (except gratings & chequered plates) which are directly exposed to weather and inaccessible for repainting shall be 8mm.

The minimum thickness of tubes shall be as specified in IS 1161 for medium class tubes.

The min. thickness for rolled beams and channels shall be mean flange thickness regardless of web thickness.

8.3.0 SLENDERNESS

Maximum Values of Effective Slenderness Ratios

Sl.no.	Member	MaximumEffective Slenderness Ratio (KL/r)
i	A member carrying compressive loads resulting from dead loads and imposed loads	180
ii	A tension member in which a reversal of direct stress occurs due to loads other than wind or seismic forces	180
iii	A member subjected to compression forces resulting only from combination with wind/earthquake actions, provided the deformation of such member does not adversely affect tbe stress in any part of the structure	250
iv	Compression flange of a beam against lateral torsional buckling	300
v	A member normally acting m a tie in a roof truss or a bracing system not considered effective when subject to possible reversal of stress into compression resulting from the action of wind or earthquake forces]]	350
vi	Members always under tension[1)] (other than pre-tensioned members)	400

[1)]Tension members, such as bracing's, pre-tensioned to avoid sag, need not satisfy tbe maximum slenderness ratio limits.

Where 'KL' is the effective length of the member and 'r' is appropriate radius of gyration based on the effective section

8.4.0 **PERMISSIBLE DEFLECTION**

The permissible vertical deflection for structural steel members shall be as specified in IS 800:2007.

8.5.0 **CONNECTIONS**

As far as possible, the connections shall be welded. Field connections shall be made with black bolts for ladders, hand rails posts, stair stringers, removable members and floor plates, platform forming members 200mm and under in size, purlins, girts and minor pipe support members that require not more than three bolts per connection. The minimum size of bolts shall be 16mm unless limited by the size of the connected parts. Any connection shall have at least two bolts.

8.3.0 **MATERIAL**

8.3.1. Unless otherwise specified, steel for hot rolled structural shapes and plates shall conform to IS 2062.

FOR ISMB, ISMC, ISA (ANGLES) : IS: 2062 GRADE E250A
FOR FLATS : IS: 2062 GRADE E250A
FOR PLATES : IS: 2062 GRADE E250BR
FOR UNIVERSAL COLUMNS/BEAMS : BSEN 10025 S275JR / S275J0
CHEQUERED PLATE : IS: 3502 (GRADE A)
STEEL GRATING : IS: 2062 (GRADE A)

8.3.2. Steel tubes for structural purpose shall conform to IS 1161.

8.3.3. Bolts shall conform to IS1367.

ORDINARY BLACK BOLT : CLASS 4.6 (IS: 1367- PART 3)
HIGH STRENGTH BOLT : CLASS 8.8 (IS: 1367- PART 3, IS: 3757, IS: 4000)

8.4.0 **ERECTION LOADS**

All loads to be carried by the structure or any part of it due to storage or positioning

of construction material and erection of equipment including all loads due to operation of such equipment shall be considered as erection load. Proper provision shall be made including temporary bracings to take care of stresses due to erection loads. The structure as a whole and all part of the structure in conjunction with temporary bracings shall be capable of sustaining this erection load without exceeding the permissible stresses subject to the allowable increase of stresses. Dead loads, wind loads and all such parts of live load as would be imposed on the structure during the period of erection shall be taken as acting together with the erection load.

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8.5.0 Fabrication drawings of all major steel structures shall be prepared and got approved before starting up the work.

8.6.0 All structural steel work shall be shot blasted and painted with epoxy paint as per the following specifications

Preparation of Surface	Shot blasting to near white metal grade SA 2.5 as per IS 9954
Primer	Two coats of Epoxy red oxide zinc chromate primer (one shop coat and one coat after fixing /erection)
Intermediate Coats and Finish coat	One intermediate coat of Micaceous Iron Oxide epoxy paint of 70-micron DFT One coat of two pack polyamide cured epoxy finish paint of 40-microns DFT One coat of aliphatic acrylic polyurethane finish paint of 40-microns DFT

8.7.0 Grouting of foundation bolts below base plates for structural columns shall be provided using CONBEXTRA- GP2 or equivalent. Minimum thickness for grouting shall be 25mm.

8.8.0 Expansion joints in steel structures shall be provided as per the guidelines in IS 800.

8.9.0 Roofing over steel trusses shall be with non-Asbestos fibre reinforced cement corrugated sheet (as per IS: 14871) roofing 6 mm thick up to any pitch and fixing with polymer coated J, or L hooks, bolts and nuts 8 mm dia. G.I. plain and bitumen washers or with self-drilling fastener and EPDM. All accessories like flashing, capping, shall be made of the above specified material. The gutter shall be of 180mm dia half round moulded PVC

8.10.0 Roofs shall generally have a slope of 1:3. Rain water gutters and pipes shall be provided for proper roof drainage and collection of rainwater in accordance with SP 35.

ARCHITECTURAL PLANNING & DESIGN PHILOSOPHY OF AMMONIA PLANT AND BUILDINGS

The layout of the Ammonia plant shall be made considering all other factors and local site conditions with minimum foot print on the land. Architectural design shall take into account of:

a) User requirements

b) Functional requirements

c) Statutory requirements

d) Environmental conditions

e) Local building practices and materials available

f) Aesthetics

g) Economy in construction and maintenance

h) Hazards associated with the location, such as Noise, High temperatures and Fire

i) Incorporation and coordination of designs and calculations by other disciplines of engineering, involved in this work such as process, electrical, machinery, piping, instrumentation etc.

Following user requirements shall be considered while carrying out architectural design of buildings.

a) Buildings shall generally be of RCC framed structure and RCC roof.

b) Interior wall partitions can be of brick masonry, frameless glass partitions or 12mm thick gypsum partitions.

c) Water proofing shall be done over RCC roofs.

d) Furniture and soft furnishing are in the scope of contractor

e) Plinth protection around buildings shall have a minimum width of 1000mm .

f) Flooring in process areas shall be with densified matt finish concrete.

g) Sanitary fittings in Control building shall be contact less (sensor fitted) to the extent possible. Normal sanitary fittings can be provided in Workers toilets. At least one number Indian water closet shall be provided in workers toilet.

h) At least one Water dispenser (Hot / Cold / Normal) shall be provided in all buildings

All the facilities shall conform to all Local Rules and Regulations, Factory Inspector Rules, TAC rules, etc. whichever is more stringent.

It shall be the responsibility of the vendor to accommodate all the functional requirements such as access, cut outs, clearances, interference etc. while designing / detailing of various structures / facilities.

1. Buildings & Structures

Each building shall be planned and designed for optimisation of spaces while obtaining maximum utility for the purpose intended. The buildings shall have simple aesthetics, with higher utility and safety with economy. The maintenance cost of the buildings shall be kept in account while selecting the materials and components for the design.

For all buildings, plinth protection with 1000 minimum width shall be run all around. The minimum height of plinth level shall be 300mm for all buildings.

Minimum overhead clearances shall be as follows:

Above platforms and walkways	2100 mm
Above finished floor to ceiling (RCC buildings)	3600 mm
Eaves of steel roofs	4500 mm

Vertical head room for stairs	2400 mm
Safety gauge for ladders	2400 mm
Access for forklift trucks	2800 mm
Above main roads and crane access	7000 mm
Above other plant roads and truck access	4200 mm
Equipment access doors	2500 mm
Other doors	2100 mm
Above railroads / roadways	7000 mm

The guidelines of NBC 2005 shall be followed for all buildings.

a) Building Services

Following services shall be provided for all building / sheds as essential services.

Water supply, Distribution and Drainage, Sanitary Services.

The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per following references.

a) National Building Code of India, Part-IX, Section 1 & 2

b) State Factories Rules.

Drinking water provisions, including one number water cooler per floor/building shall be provided within an enclosure separated from the toilets. Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.

Each building shall be equipped with approved overhead water tank of capacity not less than 100 litres per person.

Electrical Services

This service shall be provided as essential service for all building / sheds. Electrical services for buildings shall consist of electrical supply and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc. including all accessories, cabling etc. including emergency power supply, all as per requirement. All electrical switches / sockets shall be of as per the Electrical Design basis.

Air Conditioning & heating

Areas of control room, spaces housing equipment / machinery / panels etc. which required conditioned environment and certain specified areas like offices, specific office accommodation shall be suitably air-conditioned by window / split / package / centrally airconditioned type units, as per requirement with respect to other relevant Design Basis.

Accordingly, AC Plant / AHU etc. of the required capacity, whenever required, shall be provided and housed, suitably.

b) Building Components

Following are the minimum requirements for the building components / elements. For components not mentioned here within, the requirement shall be as per CPWD specifications / best engineering practices for the durability of the structure.

Sl.	Building Component	Requirement
1	Building / Equipment / Tank foundations	M30 grade RCC with cement content not less than 330kg/cum
2	RCC piles / pile cap	M35 grade RCC with cement content not less than 400kg/cum
3	Underground sump tanks / Reactors	M30 grade RCC with cement content not less than 350kg/cum with waterproofing compound mixed with concrete. Additional water proofing on concrete

		surface – surface coating / membrane application shall be done to make underground structures watertight.
4	Masonry work below ground	Minimum 230 thick solid cement block (200 thick brick) or First-class bricks plastered on both sides
5	Masonry work in super structure	Minimum 100 thick half brick partition walls. 230 thick walls for exterior. 100/150/200thick walls are permitted for interior walls as required. Use of AAC blocks / Solid Cement Concrete blocks / Clay bricks are permitted
6	Plastering	15mm thick plaster in CM 1:4 over rough / exterior face of masonry. 12mm thick plaster in CM 1:4 over fair / interior face of masonry. 6mm thick plaster in CM 1:3 over / under RCC elements
7	Concrete Columns / beams / slabs/ Lintels / Sunshades	M30 grade RCC with cement content not less than 330kg/cum
8	Lean concrete	Cement concrete mix 1:4:8 with an average thickness of 80mm under foundations / grade beams etc. Cement concrete mix 1:3:6 for levelling course below for liquid retaining structure.
9	Doors	External Doors: Partially or Fully Glazed Aluminium Doors (polyester powder coated) with MDF infills and 8mm thick toughened glass. Internal Doors: Partially Glazed Aluminium Doors (polyester powder coated) with MDF infills and 8mm thick float glass. Toilet Doors: Moulded uPVC doors with uPVC frames

		(Sintex or equivalent) for workers toilets
10	Windows	Aluminium windows, side hung in Aluminium frame work with 4mm thick float glass. All external openings shall be protected with openable type Flynets in metal or PVC frame to prevent entry of flies and mosquitoes
11	Ventilators	Aluminium ventilators, top hung in Aluminium frame work with 4mm thick pin head glass. All external openings shall be protected with openable type Flynets in metal or PVC frame to prevent entry of flies and mosquitoes
12	Roofing / Cladding	Flat roof: Minimum 120 thick RCC slabs supported on RCC beams or 230 thick masonry walls Sloped Roof: Non-Asbestos cement sheets / High impact resistant Polypropylene roofing sheets Cladding: Non-Asbestos cement sheets / High impact resistant Polypropylene sheets
13	Flooring	Yards / Parking area: Cement Concrete with nominal reinforcement Plant buildings: Densified Concrete with matte finish Control Room: False flooring tiles and Vitrified tiles / Ceramic tiles for other areas not requiring false floor MCC Room: Densified matt finish concrete or Kota stone finish Battery rooms: Heavy duty (Industrial grade) acid resistant tiles Toilets: Ceramic floor tiles
14	Handrails	In plant buildings / External: MS or FRP

		Inside building: MS handrails with enamel paint finish
14	Anti-termite treatment	Pre-construction anti-termite treatment of soil with chemical agents
15	False flooring	Noncombustible false flooring / cavity floor of modular 600 x 600 size and min thickness of 35mm with pre-moulded (USF 1000 grade) infilled access floor tile made from steel and cementitious infill material, with edge beading and faced with 3mm thick anti-static high-pressure laminates. The Panels shall confirm to Class 0 & Class 1 Fire Ratings tested as per BS 476 and ASTM E84
16	False ceiling	Aluminium Metal Grid ceiling supported on Aluminium sections hung from roofing. Gypsum ceiling at locations with architectural features
17	Window grills	Made from MS flats or square bars with weight not less than 15kg/sqm, painted with two coat primer and two coats synthetic enamel
18	Painting	Corrosion resistant Epoxy Coating shall be provided for Ammonia tank Foundation as per CPWD Spec-13.24. Available brands are Armerlock 400 marketed by AsianpaintsPPG or equivalent. Other Structures shall be painted as per the spec below. Exterior:-Weather proof Exterior paint, of approved brand (Asian paints Apex Ultima Protek or equivalent) on new surfaces over a coat of cement primer Interior:- 2 Coats of Premium Acyrilic Emulsion of Interior grade on new surfaces over a coat of cement

		primer. Steel structures shall be painted as follows: Surface shall be prepared by shot blasting to near white metal grade SA 2.5 as per IS 9954. Two coats of Epoxy red oxide zinc chromate primer (one shop coat and one coat after fixing /erection) shall be applied. One intermediate coat of Micaceous Iron Oxide epoxy paint of 70-micron DFT. One coat of two pack polyamide cured epoxy finish paint of 40-microns DFT and one coat of aliphatic acrylic polyurethane finish paint of 40-microns DFT. Wood work shall be painted with two coats of enamel paint over two coats of wood primer.
19	Plumbing	Concealed plumbing in buildings with CPVC pipes. Fittings shall be CP brass in interiors and PTMT in exteriors. PVC ball valves shall be used. External plumbing lines shall be run through utility trenches. SWR lines shall be used for disposal of Sanitary waste / Sewage / Sullage. PVC shall be used for fixtures or fittings as necessary.
20	Sanitary ware	Vitreous China ceramic ware sanitary appliances (white colour) for Urinals (Flat back), Wash basins (Counter sunk), Water closets (Indian / European) Fittings shall be touchless / sensor based in Control building.
21	Urinal Partitions	Engineered marbles 12mm thick embedded in wall or screwed to wall with SS fixtures
22	Pre-cast Cover slabs	RCC M25 / RCC M30

23	Grouting	Non-Shrink cement Grout with minimum strength of 40 N/mm² at 28 days, 25mm thick or as specified by equipment manufacturer for Structural bases of Columns and static equipment Grouting of foundation bolts below base plates for steel structures/ equipment foundations shall be as follows: a. column bases — CONBEXTRA GP2 or Eqvt. b. Static Equipment — CONBEXTRA GP3 or Eqvt. c. Pumps — CONBEXTRA GP3 or Eqvt. d. Compressors — CONBEXTRA GP3 or Eqvt.
24	Water Proofing	Water proofing over roofs shall be with fibre reinforced elastomeric water proofing membrane as per CPWD specifications. Water proofing of sumps and water retaining structures shall be done by adding hydrophilic crystalline admixtures to concrete and applying cement slurry over the RCC with water proofing admixtures as per CPWD specifications.

c) The philosophy for the design of individual structures are as follows:

1) Roads

Roads shall be properly planned for access to all buildings and plant units from the existing plant road network. All elements associated with roads and related services like culverts and road crossings as required for the proposed site shall be included in the plan.

The road section shall be as follows:

Surface : 25mm thick Bituminous concrete over 75mm thick bituminous Macadam

Shoulder	: 75mm thick in PCC 1:2:4
Base Course	: WBM in One layer of 100mm spread thickness compacted to 75mm for each layer using 36mm broken stones
Sub Base	: WBM in two layer of 100mm spread thickness compacted to 75mm for each layer using broken stones graded in the ratio 7:3 of 60mm & 36mm sizes
Sub grade	: Compacted sub grade

All road surface shall be prepared in accordance with Section-16 of CPWD Specifications & designed in accordance with IRC 37 (Latest) for crossing of drains, pipes, cable trenches, culverts etc. The culverts shall be designed for class `AA' loading and also checked for class `A' loading in accordance with IRC.

Camber of 1:50 shall be given for all roads. The roads may be raised at culverts to facilitate the maintenance of levels of pipes running through culverts. Kerbs shall be provided for roads as per IRC standards.

2) Drains

The proper surface drainage of rain water from all parts of the plant shall be envisaged. Proper drainage system for all roads also shall be provided. All drain work shall be in RCC. The drainage system shall be by gravity. Storm water drains shall be sized for the peak discharge arising out of either rain water or firefighting water.

Rain water falling on portion of paved areas of process unit where it is not likely to get contaminated, shall be collected in open rectangular drains provided in floor paving. These drains shall be covered by FRP gratings and shall be generally connected to peripheral storm water drains. Drains shall be designed for the maximum of rainwater / firewater on same principles as storm water drains.

3) Utility Trenches

Trenches shall be of RCC to lay utility cables and pipes. Sizing shall be done as per requirement, with a minimum width of 450mm. Pre-cast concrete covers with lifting arrangement shall be provided on top. In paved areas, the top will be flush with finished floor level. Covers shall overlap walls and joints with paving shall be sealed to prevent water entry. In unpaved areas, walls shall be raised above ground level by 150 mm.

Trench floors shall be provided with a nominal slope to drain pits, where any water entering trenches can collect and be detained to the nearest contaminated rain water sewer / storm water sewer. Trench covers shall be designed for the vehicle load relevant to the area where the trench is located.

4) Sewage Disposal

Sanitary sewerage shall not be combined with storm water. Building drainage shall be designed as a dual pipe system with separate soil & waste pipe.

Soil pipe shall be taken to Septic tank nearby and the waste pipe shall be taken to a sand trap to separate solid wastes.

Wherever the SWR pipes are crossing road, sufficient cushion shall be given to the pipes either by encasing them in concrete bed or running them through culverts / hume pipes / sand cushions of 1200mm.

Solid wastes from non-plant areas shall be segregated at source into bio and non-biodegradable. Non-biodegradable shall be separated into Hazardous and non-Hazardous. Each type of waste shall be collected, treated and disposed as per prevailing Disposal guidelines of the state.

5) Concrete Yards

Paving and trenches including covers in process units shall be suitable for Hydra crane movement. Where movement of bigger cranes for maintenance is envisaged paving and trenches including covers shall be designed for the loads arising from the same.

Yard paving thickness and concrete grade shall be as follows:

Paving within Process & Utility areas for maintenance compatible to crane movements / dropout / Loading / Unloading areas / Vehicular movement areas	200mm thick, M30 grade RCC
Non-vehicular movement areas	150mm thick 1:2:4 nominal mix concrete with nominal single layer reinforcement
Under Pipe rack & foot paths	100mm thick PCC 1:3:6 with 20mm aggregate

Finish of 50 thick concrete screed, with non-metallic (Quartz based) hardener topping shall be provided on paving after erection and commissioning of equipment is over. Expansion joints & isolation joints shall be as per relevant IS codes and standards.

Acid / alkali / chemical resistant coating as required shall be applied in areas where such corrosive materials are likely to come in contact with concrete. Suitable drainage arrangements will be provided within curbed areas around pumps, for drainage leaks.

d) Approved brands of materials

All materials used for construction shall be bought by the contractor with the approval of engineer in-charge. The contractor shall furnish the product manual with full specification and application methods of materials to the engineer in-charge and obtain his/her approval in writing before commencement of work

a) ULTRATECH / SANKAR / COROMANDAL / MALABAR / ACC / AMBUJA / BIRLA are approved brands of cement.

b) SAIL / RINL / TISCON / JINDAL / JSW are the approved brands for HYSD reinforcement bars of Fe500D grade steel

c) SAIL / RINL / TISCON / JINDAL / JSW are the only approved brands for structural steel

d) ASIAN / BERGER / JOTUN / NEROLAC / ICI DULUX / SHALIMAR are the approved brands of Paint products. Thinner used for the painting work shall conform to the brand specified by the manufacturer in the product literature.

e) HINDALCO / JINDAL / BHAGAWATI SAI are approved brands for Aluminium extrusions.

f) SAINT GOBAIN / ASAHI / GUJARAT GUARDIAN / GOLD PLUS / HNG / SEJAL FLOAT are approved manufacturers of Float glass

g) NAMRA TECH SOLUTIONS is an approved applicator for densified concrete. Other applicators with equivalent method to obtain the intended result can be used for the work with the concurrence of Engineer in-charge.

h) ISI marked pipes are acceptable for Galvanised Iron and PVC rain water pipes

i) Godrej / Wipro / Featherlite are approved brands of furniture (Chairs / Desks / Tables / Cabinets)

j) For those materials, for which brands are not specified, separate approval may be taken by the bidder from the Consultant, during the submission of design documents.

e) Furniture requirements

The minimum furniture to be supplied and maintained by the Bidder for the plant operations are as follows:

Sl.	Furniture	Minimum Qty
1	Vertical Filling Cabinets. Sample model: Godrej Vertical Cabinet 4 drawer	2
2	Credenza Side Unit for manager. Sample model Godrej Orion	1
3	Storage Cabinet-Drawer type. Sample model: Godrej Vertical Cabinet 4 drawer	2
4	Executive Chairs with high back for Manager Sample model: Godrej Leoma	1
5	Executive Chairs with medium back for conference room. Sample model: Godrej Ace Mild Back	6
6	Executive Chairs with medium back for Other technicians. Sample model: Godrej Smile	4
7	Visitor Chair for labors, Security Staff and normal visitors. Sample model: Godrej PCH-7112R	4
9	Executive Desk with side unit for manager of 1800mm x 1200mm, Size of side credenza unit: 1200mmx600mm. Sample model: Godrej Oreon	1
10	Executive desk with side unit for other technicians of 1650 x 900 mm Sample model: Godrej Oreon	4
12	6-seater conference table. Sample model: Godrej Ideate	1
13	Personal lockers- 6 door. Sample models: Endura plus locker unit (WIPRO)/ Personal Locker (Godrej)	1
14	Shoe Rack-3 Door Sample model: Godrej MFS 203	1

This is a tentative list. This shall be finalised after detailed design of Plant Buildings.

CIVIL AND STRUCTURAL WORK – DELIVERABLE LIST FOR THE PROPOSED 10000MT CAPACITY AMMONIA TANK AT FACT COCHIN DIVISION, AMBALAMEDU

1. GENERAL

1.1 SCOPE

The LSTK scope of work with related to Civil and Structural works shall include, but not limited to, the following main activities:

i) All Civil & Structural Works (as mentioned in the scope of work) related to the Project, transportation, Insurance, loading / unloading, storing & material control, Construction of temporary facilities, temporary work, painting, insulation, construction, inspection, testing, total project management, including covering Ammonia Tank battery limit area, so as to complete the execution of Ammonia Storage Tank in all respects and later on hand over the Tank and Associated facilities to Owner and assistance in closing of contract in all respect. The works shall be carried out as per the specifications, standards, codes, data sheets, drawings of the Vendor, and as per the instructions of the Engineer -in-Charge.

ii) CONTRACTOR shall provide and be responsible for the task summarised below but not limited to the following for Civil & Structural Works:

- Detailed Design Engineering.
- Compliance with applicable Codes and Standards.
- Submission of Drawings and Documents.
- Soil survey & geo-technical studies

- Procurement of equipment &materials.
- Laisioning for Govt. Clearances / statutory approvals / Environment Related Approvals during Construction, if any.
- Project Planning, Management & Scheduling.
- Spares
- Construction Tools including cranes and other special lifting equipment's.
- Port / Custom Clearance, Transportation, Loading/Unloading and storing of equipment at site & Material Control.
- Temporary Work (Construction of Temporary Facilities if required).
- Civil & Structural Works of items specified in scope of work.
- Preparation of Architectural drawings.
- Design, preparation of drawings and construction of all structures.
- Preparation of as built drawings of all structures and facilities to reflect as built status of construction.
- Submission of as built drawings in Autocad in CDs.
- Plumbing & sanitary works.
- Painting.
- Anti-termite and anti-weed treatment in all areas / buildings as per IS:6313.
- All temporary roads and approach roads necessary for construction purpose shall be of WBM for a minimum width of 4m.
- All permanent roads as stipulated in the specification.

It is not the intent to specify herein all the works in the scope of this contract.

All other buildings, structures and works necessary which are not specifically mentioned here but required for construction, operation and maintenance of the Ammonia tank are deemed to be included in the scope of the Contractor.

In the event of conflict between requirement of any two clauses of this specification, or different codes / standards, the more stringent requirement as per the interpretation of Owner is to be followed by LSTK contractor.

All works shall conform to the specification. The works shall conform to high standards of design, engineering and workmanship. Design and construction shall conform in every respect to all local and state regulations governing such works and to stipulations of Indian Standards unless stipulated otherwise in detail specification.

1.2 Protection of existing utilities and services

During construction, the contractor shall provide all protection for existing utilities and services as may be required by his construction operations.

Permanent protection of certain items shall be as included under other sections or as instructed by the Owner.

In addition to the requirements as specified, herein the contractor shall comply with the following requirements:-

a) Use all necessary precautionary and protective measures required to maintain existing utilities, services and appurtenances that must be kept in operation. In particular, the contractor shall take adequate measures to prevent undermining of utilities and services presently in services.

b) Protect existing or new utilities and services where required by the contractor's operations and/or as directed by the Owner. The contractor shall be responsible for bracing and supporting utilities and services to prevent settlement, displacement or damage.

2 INSTRUCTION TO BIDDERS

2.1 DATA TO BE FURNISHED BY BIDDER AT THE TIME OF BID

- A Layout drawing indicating the various building / structure facilities for the Ammonia Storage Tank and Associated facilities.
- Detail general arrangements / architectural drawings of all buildings and structures showing dimensions, levels, plans, sections, elevations.
- Detail design criteria proposed to be adopted for each building, structures, foundations, facilities etc.
- The list of documents which will be submitted by the contractor to the Owner for his approval and manner in which the same will be submitted. No construction shall commence at site without obtaining approval from the Owner on these documents. Therefore, it is necessary that bar charts for buildings / structures / area wise shall be submitted for design / drawing activity indicating.

  a) A Level-1 pert chart showing the starting and completion date of all civil construction activities.

  b) A Level-2 pert chart showing the time required for preparation of design criteria, for approval of design criteria by Owner, time required for detailed design and drawing preparation and time required for approval of design and drawing by Owner. This part shall taken into account the construction schedule (Level – 1 part).

2.2 INSPECTION OF SITE BY BIDDER

Bidder shall inspect the site, examine and obtain all information required and satisfy himself regarding matters and things such as access to site, communications, transport, right of way, the type and number of equipment and facilities required for the work, availability of local labour, materials and their rates, local working conditions, weather,

sub-soil conditions, natural drainage etc. Ignorance of the site conditions shall not be accepted by the Owner as basis for any claim for compensation or extension of time.

The submission of a bid by the Bidder will be considered as an evidence that such an examination was made and any later claims / disputes in regards to rates quoted shall not be entertained or considered by the Owner. The contractor shall organize his own arrangement to transport his equipment, men and materials so as to match the construction schedule.

2.3 DELIVERABLES AFTER AWARD OF CONTRACT

The following documents are to be submitted for the approval of the OWNER, prior to commencement of fabrication & erection / construction. All drawings shall be of standard sizes (metric system) as indicated in Design Philosophy/Basis document of the tender and shall be made on AUTOCAD. Software used for design shall be STAAD Pro. Hard and soft copies of the drawings / document to be furnished to the OWNER. The list is not exhaustive but indicative only.

Design Report (Including Calculations) for Foundations and Structures

- Detailed Foundation & Structural Construction Drawings
- Specification, MTO for Civil/Structural Materials
- Layout & Detailed Design Drawings for Foundations, Structures, Anchors, Supports,
- Platforms, Ladders, Stairways, Walkways & Buildings etc.
- Pipe Rack & Pipe Support Detailed Drawings
- Cable Trench Detailed Drawings
- Site Drainage Plan Drawings
- Drawing for Foundations, Reinforcement & Reinforcing Bar Schedules
- Building Drawings
- Detailed Drawings for Roads and Pavings
- Detailed Drawings for Underground Services

- Bill of Quantities for Civil / Structurals
- Soil Investigation Report if conducted by Bidder
- Final Calculation for Piles, Foundations, Buildings, Structures
- Work order copies of all erection activities
- As Built Drawings

Preparation of design drawings with maximum detailing possible and developing all possible connection / joint details for all the buildings are within the scope of civil / structural works.

General plant layout drawing with coordinates of roads, boundary wall and facilities, piping / cable corridors, pipe and cable trestles, diversion roads and drains, equipment lay down areas etc.

BIDDER shall furnish complete list of drawings/documents to be submitted after award of contract indicating different categories For Owner's approval, for reference/information etc for Ammonia Tank area. All documents need not be approved by the owner. The documents to be approved by owner shall be mutually agreed between owner and the successful bidder.

BIDDER shall submit to owner/PMC the required number of hardcopies of the design documents and drawings for approval as indicated below.

Detailing / drafting shall be done on latest version of AUTOCAD only. Drawing size used shall be preferably of A1 size only. For foundation layout, drainage plans and paving plans, A0 size drawings can be used if necessary

All Drawings shall be in metric units showing dimensions in millimeters and elevations/ levels in metres. Drawings shall indicate quantities of concrete grade wise and or nominal mix wise, reinforcement bars diameter wise and structural steel section wise and or thickness wise as detailed therein.

The contractor shall submit requisite number of prints (as mentioned below) of the

supporting design calculations along with explanatory notes/ sketches, computer inputs & outputs and Drawings (complete in all respects) to Owner/ Consultant for review and checking purposes. All the above design calculations and Drawings submitted by the Contractor shall be completed in all respects and thoroughly checked, Approved, stamped as "Approved for Construction" and signed by the Contractor's authorised representative (irrespective of the fact that whether the same are prepared in the Contractor's own Design Office or by an Approved Agency to ensure accuracy and correctness) before submission to the Owner/ Consultant. Incomplete, unchecked and unsigned Drawings and design calculations shall not be accepted for review/ checking and will be returned forthwith.

The design calculations and Drawings prepared for this works shall have to be got checked and Approved by the Owner/ Consultant as per mutually agreed time schedule and the Contractor should strictly adhere to these Approved Drawings and specifications. Construction work shall be carried out only with the Approved Drawings and specifications. Correctness / soundness of the designs/ Drawings and their execution at site shall be the sole responsibility of the Contractor irrespective of the fact whether the same has been Approved by Owner/ Consultant or not. Any defect, observed during construction or during the defect liability period of works, shall be rectified and removed by the Contractor. The contractor shall carry out whatever modification or re-construction is needed for the purpose, to the entire satisfaction of the Engineer-in-Charge / Owner without any extra cost to the Owner. But this will not in any way absolve Contractor of the final responsibility for fulfillment of all Guarantee Clauses specified elsewhere.

The Contractor shall forward to Owner / Consultant four prints of design calculations and Drawings preferably for the whole work at a time along with all the concerned civil scope Drawings and load data sheets. After reviewing the above design calculations and Drawings, Consultant will send comments to the Contractor within four weeks time from the date of receiving the above. The Contractor will send their designer, if

required, to Owner / Consultant's office for clarifications /modifications/ incorporations and to finalize designs/Drawings across the table. The design calculations and Drawings for each independent building/structure along with scope/load data shall be submitted by the Contractor in one lot so as to facilitate systematic review/ checking and approval. The contractor shall start submitting such first set of design calculations and Drawings within thirty days from the date of issue of Letter of Intent and complete the submission of the same for all the items/ units to Owner / Consultant's Office within the period mutually agreed upon depending on the volume of job. Any delay in submission of design calculations and/ or Drawings with complete data and getting the same Approved from Owner /Consultant shall not absolve the contractor of their responsibility to complete the work within the completion time.

If at a later stage, the contractor feels the necessity for any addition or alteration, prior approval of Owner / Consultant must be taken for effecting the changes. The contractor shall also be bound to incorporate any addition and alteration which Owner/ Consultant may suggest at a later stage.

At any stage of work Owner/ Consultant may review and offer comments / suggestions on the layout, structural schemes, designs and/or Drawings prepared by the Contractor and the latter shall adhere to such comments/ suggestions and revise his designs/ Drawings accordingly and incorporate the same in the construction without any extra cost to the Owner. The contractor shall carry out whatever modification or re-construction is needed for the purpose, to the entire satisfaction of the Engineer-in-Charge / Owner without any extra cost to the Owner.

The Contractor shall furnish to Owner/ Consultant eight prints each of the finally Approved Drawings which must be included but not limited to the same to carry out construction work at site by the Contractor .

ANNEXURE 1

SCALE : 1:1

DATE	26/04/2021
DRAWN	SONU
CHECKED	DIXON

LEGENDS

- SPOT LEVEL
- PIPE SPOT LEVEL
- ELECTRIC POST
- LIGHT POST
- ACACIA TREE
- OTHER TREE
- MANGO TREE
- PALM TREE
- JACKFRUIT TREE
- ARROW TREE
- BANYAN TREE
- RUBBLE
- WALL
- FIRE HYDRANT PIPE
- PIPE LINE
- BOUNDARY
- TAR ROAD

AREA

ALL DIMENSIONS ARE IN METRE

GRID INTERVAL - 5X5 M

SURVEYED BY

ANANTHU

SREEKUTTAN

TITLE

CONTOUR & TOPO SURVEY

DRAWING CODE

2790

SITE AT

FACT

SURVEYED BY,

PRECISION SURVEY

DOOR No.49/297 C
2nd FLOOR
SH LANE,VYTTILA
Pin - 682019
Mob: 8593052147
8943318707

precisionsurvey121@gmail.com

S.No.	Doc. No.	Description	No. of Pages	Rev. No. with Issue			
				1	2	3	4
1.0	**TECHNICAL DOCUMENTS**						
1	32686-13-PS-002 SW	Scope of Work-Electrical	1	0			
2	32686-13-PS-002 DP	Design Philosophy- Electrical	10	0			
3	32686-13-PS-002-INS	Scope of Inspection and Tests	15	0			
4	00ES001/01	Vendor Data Submission Procedure	3	-			
5	32686-13-PS-002-VDI	Vendor Data Index	1				
6	32686-13-PS-002-VDR ELEC	Vendor Data Requirements	13	0			
7	13ES900/14	Engg Specification – General Requirements for Electrics	4	-			
8	32686-13-DA-90001	Data sheet – General Requirements for Electrics	1	0			
9.	13ES924/14	Engg Specification-Electric for Turnkey Installation	10	-			
10	32686-13-DA-924-02	Data Sheet- Turnkey installation	11	0			
11.	32686-13-TP-924-02	Technical particulars- Electric for Turnkey installation	6	0			
12.	13ES903/14	Engg Specification – High Voltage Switchboards	**16**	**-**			
13.	32686-13-TP-90302	Technical Particulars- High Voltage Switchboard	**5**	**0**			
14.	13ES906/14	Engg Specification – Medium Voltage Switchboards	**16**	**-**			
15.	32686-13-TP-90602	Technical Particulars- Medium Voltage Switchboards	**4**	**0**			
16	13ES919/14	Engg. Specification- High Voltage induction Motors	**7**	**0**			
17	32686-13-TP-919-02	Technical Particulars- High Voltage Induction Motors	**4**	**0**			
18	13ES909/14	Engg. Specification- Uninterruptible Power Supply system	**8**	**-**			
19	32686-13-TP-909-02	Technical Particulars- Uninterruptible Power Supply system	**8**	**0**			
20	32686-13-PS-921 SW(MECH)	Scope of Work – Mechanical(Diesel Engine)	2	1			
21	32686-13-PS-921-SPL(MECH)	Diesel Engine - Spl. Requirements	5	1			
22	32686-01-DA-001	Data Sheet - Diesel Engine	2	1			
23	32686-13-PS-921 LD(MECH)	Lubrication Data	1	1			

TPS NO :

ITEM : ELECTRICS FOR TURNKEY INSTALLATION OF AMMONIA STORAGE SYSTEM

EQPT. NO.

The Scope of work include the following

Sl.No.	Description	Required	Remarks
	ELECTRICS		
1.0	Design, detailed engineering, manufacturing, testing at works supply ,erection, testing and commissioning of all electrics required for the package, fully conforming to the attached specification and data sheets and special requirements, including drive motors,HV Switch board, Motor Control Centre,Local Control Stations, Parallel reduntanat UPS for DCS,EOT Crane ,Emergency DG set, Battery charger, cables,Cabling,Earthing,Lightning protection,Lighting, system etc	**YES**	
2.0	Arranging for Inspection & Tests as per "Scope of Inspection & Tests" attached	**YES**	
3.0	Furnishing all documents as per " Vendor Data Requirements" attached	**YES**	
4.0	Assistance in obtaining necessary statutory approval for electrical installation from Electrical Inspectorate/CEA.	**YES**	
5.0	Post warrantee Comprehensive annual maintenance contract (CAMC) of 5 years for UPS, including all spares, consumables etc.	**YES**	
6.0	**Battery Limit for Power Supply**		
	2 numbers 3.3KV 50 Hz ,3 phase, 150MVA AC Power Supply shall be made available by the purchaser at incoming side of HV switch board . Termination of incoming cables at vendor's switch board shall be done by the vendor. .		
	Two numbers,415V+/-10%, 50 Hz+/-5%,35MVA,3 phase and neutral AC supply shall be made available by the purchaser at the incoming terminals of MV Switch board/Motor Control Centre provided by the vendor. Termination of incoming cables at vendor's switch board shall be done by the vendor. .		
	240 V,50HZ,single phase AC supply for anti condensation heaters, control panels etc shall be derived from vendor's MV Switch Board		

1.0 SCOPE

The Scope of work include the Design, detailed engineering, manufacturing, testing at works , supply ,erection, testing and commissioning of all electrics required for the package, fully conforming to the attached specifications , data sheets and special requirements, including drive motors, HV Switch board, Motor Control Centre, VFD, Local Control Stations, Parallel redundant UPS for PLC, Emergency DG set , battery and charger ,EOT Crane ,Cabling, Earthing, Lightning protection, Lighting, etc required for setting up Ammonia storage tank and associated facilities at FACT, Cochin Division. This design philosophy contains specifications of the major equipment's to indicate the basic requirement and serve as a guideline. However, it shall be the responsibility of the bidder to offer any other equipment, not specified, but required for safe, proper, trouble free and efficient operation of the system

Power at 3.3kV and 415V will be provided at the incoming terminals of 3.3kV switch board and MV switch board of LSTK contractor. Downstream power distribution as required shall be under the scope of LSTK contractor

The 3.3kV switchboard for the New Ammonia storage system shall have two number of incoming feeders and one bus coupler and adequate number of outgoing feeders and spares.
The bidder shall offer the best and most suitable type of energy efficient equipment's manufactured by well-known reputed manufacturers as per the vendor list attached with this tender document. However for the sake of standardization of the electrical equipment and material used for the electrical installation, the bidder shall be ready to supply the equipment of a particular type and / or make.

Construction Power at 415V,50Hz,3 phase and neutral will be provided by client at one point.. LSTK contractor shall distribute construction power with adequately rated distribution board , sub distribution boards/feeder pillars, power supply cables and other associated materials for feeding loads to carry out construction and fabrication activities at his own cost. Bidder shall indicate details of construction power in the bid with month-wise breakup for the entire duration of project. LSTK contractor shall have to arrange emergency power, if required, through DG set at their own cost.
Bidder shall provide adequate area lighting at site of construction, fabrication yards and office etc. by means of suitable lighting fixture, lighting masts, flood lighting poles etc. which are to be supplied and maintained by the bidder as per safety aspect.
Mandatory spares of the electrical system are listed in this tender document cost of which has to be included in the LSTK price and will be considered for evaluation. Commissioning spares for each item shall be supplied by the vendor without extra cost. Vendor shall also furnish additional recommended list of spares if any required for two years trouble free operation which will not be considered for evaluation.
It shall be the responsibility of the LSTK contractor to ensure that the complete installation supplied and / or erected by him fully meets with relevant standards / Acts / rules / Regulations applicable and duly got approved by statutory authorities like Electrical Inspectorate.
Any modifications / rectification required by the owner / Electrical Inspectorate resulting from improper installation by the vendor or to make the same in full conformity with the relevant standards / Rules / Acts / Regulations applicable for the installation shall be carried out by the vendor without any extra cost to the purchaser.
Supply of all erection materials required for the erection of electrical equipments supplied shall be the responsibility of the LSTK contractor These items shall include all accessories for cable-jointing, cable terminations/ cable tray/ racks, supporting steel structures, pipes, clamps, bricks, sand, cement, rubble, compression type cable glands, insulating materials etc. Necessary grouting, fixing etc. also shall be arranged by the LSTK contractor.
It shall be the responsibility of the LSTK contractor to supply and install all items that are incidental and necessary for the completion of the installation, whether specifically mentioned or not, so that the installation complies with relevant standards and regulations, at no extra cost to the purchaser.
Commissioning works includes all pre-commissioning tests, checking of all power, control & earthing connections, testing and commissioning of all equipment / system supplied, erected and / connected by the vendor, as per relevant standards and as directed by purchaser.

The electrical installation work shall be carried out only through a contractor possessing valid and competent electrical contractor's License(A grade for HV installations) issued by the State Electricity Licensing Board for carrying out electrical installation works in Kerala.
All equipment which do not come under a roof shall be provided with weather proof features, and be suitably protected using hoods /canopies .
For documents/ drawings to be submitted by the LSTK contractor refer doc. 32686-13-PS-002 VDR ELEC.

2.0 CODE AND STANDARDS.

The general design shall follow relevant Indian/International standards and codes for practices for various electrical items. In their absence the standards of country of manufacture shall be followed.
Other codes, Regulations and Standards applicable for design and detailed engineering of electrical system are as follows.
Indian Electricity Act 1910
Indian Electricity Rules 1956
Indian Electricity Supply Act 1948
Indian Factories Act.
Fire Insurance Regulations.
Guidelines, instructions, directions issued by Pollution control Boards of state as well as central government. Guidelines, instructions, directions issued by Chief Controller of Explosives (CCoE), CPCB, CMRI, DGMS, CEA etc.

3.0 DESIGN CRITERIA

3.1 Supply voltage levels.

3.3 kV $_{\pm}$10%, 50 Hz ± 5%, 3 phase resistance earthed neutral.

0.415 kV ± 10%, 50 Hz ±5%, 3 phase, 4 wire with solidly earthed neutral.

240V ± 10%, 50 Hz ±5%, single phase with solidly earthed neutral.

Instrument power/control voltage is 110V AC through UPS.

3.2 Voltage Rating of consumers.

a)	Motors of rating above 150 kW and upto 1000kW	:	3.3kV, 50 Hz, 3 phase, AC
b)	MV motors of rating upto and including 150 kW	:	415V, 50 Hz, 3 phase, AC
c)	Lighting-Normal & Emergency	:	240V, single phase & neutral, 50 Hz, AC.
d)	Power socket outlets for welding sockets.	:	415V, 50 Hz, 3 phase
e)	3.3kV closing and trip circuit, indication lamps	:	110V DC
f)	3.3 kV switchboard other circuits	:	240V, single phase & neutral, AC
g)	0.415 kV switchgear (ACB) Closing and trip circuit, Indication lamps	:	110V DC

h)	0.415 kV switchgear other feeders, motor controls, indications etc.	:	110V AC single phase derived through common control transformer with secondary centre tap earthed
i)	Anticondensation heaters for Switchgear panels, motors (37 kW and above) DG Sets etc.	:	240V, 50 Hz, single phase AC.

3.3 Short Circuit Levels.

a)	3.3 kV system	:	150 MVA
b)	415V system	:	35MVA

3.4 SWITCH BOARD RATINGS

All switch boards shall be adequately rated for all operation conditions of the plant. The switchboard current ratings shall be selected with due consideration to the actual load and the max. design ambient temperature and future requirement also . 20% of each feeder ratings, minimum one feeder in each rating/size shall be provided as spare.

3.5 Cables and Cabling System.

3.5.1 Type of Cables.

All HV power cables shall be made of aluminium conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type, conductor screen, insulation screen and construction as per IS: 7098 (Part 2). HV cables shall be of unearthed type.

All LV power cables shall be with aluminium/copper conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Power cables with conductor size upto and including 4 sq. mm shall be with copper conductor, conductor size 6 sq. mm and above shall be aluminium conductor.

All control cables shall be with 2.5 sq. mm, stranded copper conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Control cables shall be twisted pair or shielded wherever electro-magnetic/electrostatic interference is anticipated.
All cables for Instrumentation interface shall be stranded 1.5Sq.mm copper cable.

All control cables shall have spare cores as per data sheet attached. All cores shall be identified with numerical core numbers printed on core instead of colours.

Cables connected in parallel shall be of the same type, cross section and terminations.
All power and control cables shall be in continuous lengths (except for very long feeders) without any joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals. Cable joints in hazardous areas shall not be permitted.

3.5.2 Minimum cross section of cables.

MV power cable	:	Upto and including 4 sq mm- copper, above 4Sq.mm Aluminium
Control cables	:	2.5 sq mm (copper)
Lighting	:	4 sq mm (copper) for circuit main and

2.5 sq mm (copper) for individual circuits

No. of cores for control : 5core/ 7 core /10core / 16core , 2.5 sq mm for control cable from HV/MV Switchboards to local push button stations/DCS of Motors.

The cables shall be sized based on the maximum continuous load current, the voltage drop, system voltage, system earthing and short circuit current with stand criteria. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil etc. shall have to be taken into account.

Cables shall be selected to meet the following maximum permitted voltage drop at normal load:

Sub feeders	:	2%
Motor feeders	:	3%
Lighting circuits	:	5%
Control circuits	:	5%

3.6 Type of cabling

a) Switchgear room/MCC room pump house/Compressor house	: Built in cable trenches
b) Paved area	: Built in cable trench /Directly buried underground with removable concrete slabs on top layer for identification of cable route.
OR	Through G.I pipe/conduits.
c)Unpaved area	: Directly buried where overhead cabling is not possible.
d)Road crossing	: Through RCC cable trench
e)Fire alarm cabling	: Directly buried along road side.
f)Telephone cabling	: Directly buried where overhead cabling is not possible.
g)Overhead cabling	: In GRP trays

4.0 AREA CLASSIFICATION.

All electrics shall be suitable for the hazardous / non-hazardous area involved and /or specified. Electrics suitable for the hazardous area involved shall be selected as per the relevant Indian Standards and shall be of proven design approved by CIMFR / relevant statutory bodies. In such cases copies of relevant certificates shall be furnished for Purchaser's approval.

5.0 POWER SUPPLY DISTRIBUTION SCHEME

Battery Limit for Power Supply

Two numbers 3.3KV 50 Hz ,3 phase, 150MVA AC Power Supply shall be made available by the purchaser at incoming side of HV switch board .Two numbers, 415V+/-10%, 50 Hz+/-5%,35MVA,3 phase and neutral AC supply shall be made available by the purchaser at the incoming terminals of MV Switch board/Motor Control Centre provided by the vendor. Termination of incoming cables at vendor's switch board shall be done by the vendor. .240 V,50HZ,single phase AC supply for anti-condensation heaters, control panels etc shall be derived from vendor's MV Switch Board

During normal operation both Incoming power sources shall remain in line to provide 100% normal operating load. In case of failure of one power source, the other power source shall fulfil total power requirement of Ammonia Tank through Bus-coupler. Necessary switch board shall be in LSTK Bidder's scope.

The electrical system shall be designed for a high degree of reliability and availability.

In the event of failure of normal power in the plant, the plant shall be brought to safe operating condition through Emergency power.
The Emergency power shall be arranged by the LSTK bidder through one number suitably rated DG Set at 415 V. The capacity of DG Set shall be suitable to meet the emergency power requirement of Ammonia Storage system and, lighting loads plus keeping a margin of 25% over the actual requirement.
DG Sets & Diesel tanks shall be located at centralized place at a minimum safe distance from substations as per relevant IS/IEC of hazardous area classification. Emergency power shall also cater to the load of emergency lighting, UPS system, battery charger etc.
Further distribution to all emergency equipment's at 415V/240V AC through proper type and size of cables, their supply, erection, testing & commissioning etc. shall also be in bidder's scope.
Each incoming feeder shall be sized for 125% load of the switch board. The outgoing feeders shall be sized for the nominal load.
Lighting of the tank area and associated facilities shall conform to specifications for the lighting installation attached.

6.0 Layout of Substation Building

MCC/Switch gear room shall be provided by LSTK contractor. The switch gear room shall be situated outside the hazardous area limits.
The buildings shall have adequate space for installation of the following main equipment:
3.3kV Switchboard
0.415kV PMCC/MCC
110V DC Battery & Battery Charger

The design of the switchgear room shall allow space for the equipment to be installed, including space for future extension of switchboards, and it shall also include a free area for maintenance of heavy equipment, like HV circuit breakers.
The placement of the panels shall be conforming to CEA safety regulations/ IE rules etc.

7.0 Control, Monitoring and Protection Systems

Control, monitoring and protection of the 3.3kV and 0.415KV power distribution systems shall follow relevant standards/regulations of electrical inspectorate requirements and will be specified in the data sheets.

7.1 Controls and Monitoring

Electric motors shall be controlled from the local control stations (LCS) located near the motor and from control panels (DCS)in the control room.
In addition motors shall be tripped directly through the process trip system whenever required
The local control station for HV motors shall as per standard comprise the following devices:-
ON and OFF Pushbuttons
Ammeter with compressed scale
"Ready-to-start" indication lamp
"Breaker tripped" indication lamp
"Space heater ON" indication lamp
Local Remote or Auto-Manual selector switches if required by process requirements
The local control station for LV motors shall comprise the following devices:-
ON and OFF Push Button with padlocking in OFF position
Ammeter with compressed scale and 1/1 load indicator (only for motors from 7.5kW and above)
"Space heater ON" indication lamp (on for motors from 37 KW and above)
Local/Remote or Auto/manual selector switch if required by process requirements
Current transformers with 1A secondary winding will be installed in the motor starters for the above ammeters.
For critical motors the ON-OFF and "Ready-to-start" status shall be monitored from the control system in the Control Room.
Motor operated valves shall have local operation and shall be operable from control room through control system.

Interconnections between the electrical systems and control systems shall be made through terminal boxes and/or relay panels.
Furthermore, all 3.3kV feeders and critical 0.415KV feeders shall have facilities for remote control.

7.2 Colors of Push Buttons and Indication Lamps

The following standard colors shall be used in control panels and switchboards:-

Indicator lights

- Equipment in operation : Red
- Equipment in Standby position (ready to start) : Clear White
- Alarm & trip (e.g. breaker tripped) : Amber
- By-pass of trip : Orange
- OFF Position : Green

Push Button

- ON : Green
- OFF and EMERGENCY : Red

7.3 Protection, Metering and Recording Systems

All circuits shall be properly protected by suitable relays in order to ensure maximum safety of the systems/equipments.
All relays and meters in the 3.3kV switchboard and MV switch boards shall be numerical type with communication ports compatible with international protocols to communicate with the remote Power Management System/ SCADA.

8.0 SWITCHGEARS

8.1 HV Switchboards

The HV switchboards (3.3 kV) shall comply with the enquiry specification for High Voltage Switchgear and relevant standards.Two numbers incoming feeders , one bus coupler and adequate number of outgoing feeders shall be provided for the HV switch board.
The HV Switchboards shall be of the metal clad, free standing type with the switchgear arranged on withdraw able trucks, single tier.
The circuit breakers shall be of Vacuum type with required ratings for the connected loads and short circuit currents.
The switchboards shall be of a rigid construction with separation walls between the various sections and with no access to live parts.
The breakers shall be suitable for manual local operation as well as remote operation. Control and monitoring circuits shall be supplied from a 110V DC Battery & Charger unit in order to render reliable service under all conditions.
Cable entry to HV switch boards shall be from the bottom. Refer engineering specification for HV Switch boards 13ES903/14 and data sheet 32686-13-DA-92402

8.2 MV Switchboards/MCC

The MV Switch boards shall comply with the enquiry specification for Medium Voltage switchboards and relevant standards for Switchgear.MV switch board shall have three numbers incomer feeders(two from grid supply and other from emergency DG set), bus couplers as required and adequate number of outgoing feeders. Critical loads as per process requirements ,power supply to UPS,battery charger and lighting loads etc shall have emergency DG back up power. Emergency loads shall be segregated on one side of bus coupler so that during power failure ,DG back up power shall be made available by opening the bus coupler
The switchboards shall be of the metal clad single/double fronted, free-standing type with withdrawable switch units in multi tier modular cubicles with side cable entry compartments having entry from the bottom.

The vertical height of a feeder module shall not be less than 200mm.
Air Circuit Breakers shall be provided for feeders above 400A.Feeders rated upto and including 400A shall be MCCB type.The incoming and bus coupler circuit breakers shall be of the motor spring charged type.
All outgoing feeders shall be SFU type.
Motor feeder modules 22KW above and up to 150KW rating shall be provided with motor protection relays having characteristics in accordance with the actual motor size/duty.
The equipment within each module size shall be standardized so that the modules can be interchanged when required.
Motor feeder modules with rating 15KW and above shall be equipped with current transformers (1A secondary) for remote ammeters.
The draw out facility shall include a “test” position in which all control circuits can be tested without energizing the main circuits.
The motor feeder modules shall have “ON” indication, “FAULT” indication and the reset of the thermal overload relay/release shall be brought to the front of the module.
In addition to the “ON” indication all circuit breakers shall have mechanically operated indication visible from the front.
Maximum allowable current density shall be 0.80A/sq mm for Aluminium bus bar sizing. Minimum switch rating shall be 63/32 Amps AC22. Motor feeder switches shall have AC23 rating to match with full load current of motor. Refer engineering specification 13ES906/14 and data sheet 32686-13-DA-92402

9.0 Lighting System

Lighting system shall cover lighting of the control room,switch gear rooms, other plant and non plant building, Pump/compressor house, Tank area, shall be provided with industrial LED light fittings/recess mounted fittings. Flame proof well glass type LED type light fittings shall be provided for hazardous area.
Lighting distribution boards/panels shall preferably be located in non-hazardous area.
For out door areas/road where sufficient lighting is not available area lighting shall be provided with steel street light poles .
Sampling/ gauging platforms, manifold and frequent operating platforms, stair case platforms shall be provided with localized area lighting.
All outdoor lighting including tank area shall be automatically controlled through 24 hour Timer circuits/ photo cells. Outdoor area lighting feeders shall be contactor controlled and ON/OFF push buttons shall be provided for switching control of entire lighting.
Lighting feeders shall be grouped together and fed from Emergency DG Set. Total lighting system shall be connected to emergency system

The following average lighting intensity for various area shall be maintained

Area		**Illuminance (lux).**
Control rooms	:	300
Battery rooms	:	150
switch gear rooms	:	200
Exterior walkways, platforms, stairs/ Ladders	:	50
Exterior pump and valve areas	:	100
Pump/compressor houses	:	150
Outdoor yard/area	:	20
General Process /tank farm area	:	50
Escape route	:	25

Refer engineering specification 13ES927/14 and data sheet 32686-13-DA-92402 attached.

10.0 Earthing system

10.1 System Earthing

Earthing system in general shall cover the following:

Equipment earthing.
emergency DG and UPS neutral earthing
Static earthing and lightning protection.

The earthing system envisages an earthing network with designed number of earth electrodes. Earthing system shall be designed as per IS: 3043 and as per standardsThe following shall be earthed.
Metallic non current carrying parts of all electrical apparatus.
Steel structures,cable trays
Storage tanks.
.
All utility process pipe lines and flanges shall be earthed . In addition steel pipe racks in the process units shall be earthed as per standard.

Type of earth electrode	:	Cast iron plate earth electrode
Earth pit interconnection & other equipments	:	PVC covered Aluminium Conductor cables.

Refer engineering specification for earthing 13ES916/14 and data sheet 32686-13-DA-92402 attached

10.2 Lightning Protection

Lightning protection system shall be provided tanks, buildings and structures as per guidance in IS/IEC:62305 P1-4. Necessary earth pits, air terminations, down conductors, earthing conductors etc. shall be provided.
Earth electrode for lightning protection - GI pipe electrode
Material of air termination Conductors, down conductors, Earth conductors - GI strip(25x6mm min.)
Earth electrode of lightning protection shall be interconnected to earth electrodes of main plant earthing system using PVC sheathed conductors.

11.0 Uninterruptible AC Power Supply Units

One set parallel redundant type 110V AC Uninterruptible Power Supply unit (UPS unit) in accordance with Engineering Specification for Uninterruptible power Supply shall be provided. The units shall be in sheet steel enclosures and shall comprise batteries, duplicated battery chargers and inverters, static switches, etc.
The batteries for units shall be of the SMF type type and shall be arranged on separate battery stand, located in a separate, well ventilated room in control room building with a backup for 30 minutes. 25% Spare capacity shall be considered for future requirements. Refer specification for UPS 13ES909/14 and data sheet 32686-13-DA-92402.UPS shall be located in control room building.

12.0 Battery, Battery Charger and DC switchboard

One set of 110V DC Battery system with float cum boost charger and standby float cum boost charger shall be provided to meet the control supply requirement for 3.3KV switch board, 415V Air Circuit Breakers, critical lighting in switch gear /MCC room etc. The battery rating for 110V DC shall be suitable for minimum 1 hour rating. Back up time for continuous load shall be 2hours. SMF type battery shall be provided
DC distribution board provided shall have adequate number of feeders to meet above DC loads.
Refer datasheet 32686-13-DA-92402 and engineering specification 13ES907/14.

13.0 Electric Motors

The electric motors shall comply with enquiry Specifications for High Voltage Induction Motors and Medium Voltage induction Motors, and shall be suitable for asynchronous, direct-on-line/soft starting. Energy efficient motors shall be supplied.
All motors rated 75kW and above shall be suitable for soft starting.
The insulation class of motors shall be F with maximum temperature rise corresponding to Class-B.
All motors shall have a degree of protection suitable for operation in the area where it is installed, however, for reasons of standardization, minimum IP55 enclosure is specified.
Motors that are exposed to direct sun radiation/rain shall be provided with sun shields/canopy.

All motors rated 37 KW and above shall be provided with space heaters automatically energized when the motor is not operating.

Drive motors shall be suitable for VFD operation as per process requirement. Motors in the hazardous areas shall be with suitable enclosure for the classified area. Refer Engineering specification13ES.919/14 and 13ES 924/14.

14.0 Emergency Power Supply DG set

One number 415V 3 phase and neutral DG set of sufficient rating shall be provided for emergency power supply. This DG set shall feed supply to emergency bus of the MV Switch board.
The auto starting time (time between actuation of loss of power contact to availability of emergency power) in case of failure of main power shall be in accordance with the requirement of process parameters.
In case under voltage is detected on both normal supply sections in the 415V PCC/MCC, a starting signal to the emergency diesel generating unit shall be given and when emergency power is available, the emergency incomer shall close automatically after isolating the emergency bus section from normal section, thus transferring emergency supply to the emergency supply switchboard section only.
If the normal supply returns before the emergency supply is available – say within 10 Sec. – the system shall continue on the normal supply.
The emergency section shall have indication for “Emergency Supply Available”. The signal for the indication shall be taken before the incoming circuit breaker.
Motors on emergency supply shall be automatically or manually started (re-started) according to the process requirements.
The emergency plant lighting and other critical emergency loads shall be on emergency supply.
DG set shall be installed outside substation building. CPCB approved Acoustic enclosure shall be provided for all generators. Portal frame with roofing sheet and accessories shall be provided for the DG set.
Refer engineering specification 13ES921/14 and data sheet 32686-13-DA-92402.

15.0 Telephone System

The telephone system in the Ammonia tank area shall comprise required number of telephones connected to the Junction box available in the existing Ammonia storage area. Telephones shall be provided in switch gear room and control room

16.0 Local Push button stations

All push button stations for motors shall be of cast aluminium alloy (LM-6) make. PB stations for motors of rating 15kW and above shall have ammeters. Local control stations shall be installed within 3 meter distance from the corresponding equipment and shall have start, stop and other facilities as specified in the specification.
Flame proof IP55 weather proof in cast AL (LM-6); PB station shall be provided for equipments in hazardous area locations. Refer engineering specification 13ES924/14 and data sheet 32686-13-DA-92402

17.0 E.O.T. Crane

EOT crane shall be provided for the compressor house as detailed in the mechanical specification. All the electrical equipments involved in the EOT crane system shall be suitable for the hazardous area involved.
Operation of the crane shall be possible from the floor level using pendent control push buttons. This pendent control station shall also be provided with flameproof enclosure. All operation shall be possible through the pendent controller. Control panel shall be located at an accessible position for maintenance. Refer engineering specification 13ES922/14.

18.0 Air conditioning and Ventilation /Pressurization system.

Control room, Marshalling room and Aux. Room housing UPS,VFD etc shall be air conditioned

19.0 Safety items

Supply erection commissioning of all required safety items like resuscitation chart, fist aid box, safety gloves, rubber mats in front of the switch boards, danger notice boards etc included in the turnkey contractors scope.

20.0 Comprehensive Annual Maintenance Contract (for UPS)

The vendor has to quote separately in the bill of quantities, for 5 years comprehensive annual maintenance contract (CAMC) charges including all spares, consumables etc. in after the warrantee period. UPS supplied shall be covered under post warranty Comprehensive Annual Maintenance Contract (CAMC) for 5 years.
For this, OWNER may enter into separate contract with respective OEMs before expiry of Defect liability period at the rates agreed by LSTK and OEMs. The price, terms and conditions shall be as agreed by the LSTK contractor in his offer. Scope of comprehensive AMC will include deputing of technical personnel for servicing/ maintenance with supply of required spares.
The CAMC Charges quoted shall be inclusive of all the charges for Transportation, Lodging, Boarding, all insurances including third party insurance, all Taxes /Duties / Cess / Levies / Fees and all other incidental charges etc. but excluding GST which shall be payable extra at actual on Submission of Invoice as per GST Invoicing rules. Owner will not have any liability, whatsoever, over and above the quoted prices. The payment towards the CAMC shall be half yearly and shall be based on OWNER's prevailing commercial terms and conditions at the time of placing the CAMC order on OEM.
In the event of breakdown of the UPS, the OEM's engineer shall report to site at the earliest but not later than 24 hours from the time of first intimation to attend the problem.
. Any parts/ components that may be found defective by the customer due to manufacturing defects, faulty parts/ components and workmanship within the warrantee/ CAMC period should be replaced or repaired immediately in good working condition free of cost by the vendor. The vendor shall carry out regular (monthly) preventive maintenance also during the warrantee / CAMC period. Documents such as guarantee card for the above mentioned years, equipment catalogue etc., shall be handed over to client during the time of installation.
During CAMC period, all the emergency spares recommended by respective OEM shall be supplied and kept under client custody. Additional spares if any required at site shall be supplied as and when required during CAMC period within reasonable time after intimation/ identification.

21.0 GUARANTEE/ WARRANTY

All the equipment and instruments supplied shall be offered with guarantee/ warrantee for minimum period of 12 months from the date of commissioning/ hand over or 18 months from the date of supply whichever is later. During this period, the vendor is responsible to replace / rectify the damage immediately without any time/ cost implication to owner. Should the LSTK contractor fail to rectify/ replace such damage within reasonable time, the same will be attended by the client with recovery of assessed amount from the LSTK contractor.

TPS NO: 32686-13-PS-002

ITEM : ELECTRICS FOR TURNKEY INSTALLATION – AMMONIA STORAGE SYSTEM

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	**Routine tests** at Manufacturer's works on all electrics (Motors, cables,MV Switchboard/ Control panel,LCS etc) as per relevant standards.	Reqd	Reqd	
2.0	Physical verification at Manufacturer's works for compliance with purchase order specifications and approved drawings/ documents	Reqd	Reqd	
3.0	Verification of CMRI certificates for electrics of Hazardous area	Reqd		
4.0	Tests at site			
4.1	Pre-commissioning tests and commissioning tests as per relevant standards	Reqd	Reqd	
4.2	Insulation Resistance test	Reqd	Reqd	
4.3	Primary and secondary injection tests on CTs and Relays	Reqd	Reqd	
4.4	Checking power, control and earthing system and connections.	Reqd	Reqd	
5.0	Other specific tests			
5.1	Checking The Lightning Protection System	Reqd	Reqd	

TPS NO. 32686-13-PS-002

ITEM : HIGH VOLTAGE SWITCH BOARDS

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	**Physical verification** for compliance with P.O. specs., scope, approved drawings & BOM	Reqd	Reqd	
2.0	**Routine tests**			
2.1	Power frequency voltage withstand dry tests on main circuits.	Reqd	Reqd	
2.2	Voltage withstand tests on control and auxiliary circuits.	Reqd	Reqd	
2.3	Measurement of resistance of the main circuits.	Reqd	Reqd	
2.4	Mechanical operation tests	Reqd	Reqd	
2.5	Tests of the auxiliary electrical and pneumatic devices .	Reqd	Reqd	
2.6	Verification of wiring	Reqd	Reqd	
2.7	Electrical operation test	Reqd	Reqd	
2.8	Megger test	Reqd	Reqd	
2.9	Safety interlocks and protection against electric shock and short circuits.	Reqd	Reqd	
2.10	Verification of CT ratio and polarity of CTs.	Reqd	Reqd	
2.11	Verification of nameplate information & marking	Reqd	Reqd	
2.12	Separate testing of operating mechanism and other accessories	Reqd	Reqd	
2.13	Primary and secondary injection tests on panels and protective gears	Reqd	Reqd	

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
2.14	High voltage tests on panels and protective gear			
3.0	**Type tests**	**Type test certificates to be furnished**		
3.1	Impulse voltage dry test			
3.2	Power frequency voltage dry tests			
3.3	Temperature rise tests			
3.4	Verification of dielectric properties			
3.5	Verification of making and breaking capacity			
3.6	Verification of temp. limits and characteristics of relays			
3.7	Short time current tests on main circuits			
3.8	Short time current test on earthing circuits			
3.9	Mechanical operation test			
3.10	Verification of degree of protection			
3.11	Capacitor switching test			

TPS NO. : 32686-13-PS-002

ITEM : ALTERNATOR AND ACCESSORIES

EQPT. NO. :

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	**Physical verification** for compliance with P.O. specifications & approved drawings	Reqd	Reqd	
2.0	**Routine Tests:**			
2.1	Measurement of dc resistances of stator and rotor windings	Reqd	Reqd	
2.2	Insulation resistance of stator winding (before and after high voltage test), rotor winding, bearings and embedded temperature detectors.	Reqd	Reqd	
2.3	High voltage test	Reqd	Reqd	
2.4	Phase sequence test	Reqd	Reqd	
2.5	Determination of open-circuit characteristics	Reqd	Reqd	
2.6	Determination of short circuit characteristics	Reqd	Reqd	
2.7	Over speed test	Reqd	Reqd	
2.8	Pressure test on coolers for close circuit cooling	Reqd	Reqd	
2.9	Determination of efficiency by separation of losses method	Reqd	-	
2.10	Vibration test	Reqd	Reqd	
2.11	Impedance test of the rotor winding	Reqd	Reqd	
2.12	Routine test on exciters for dc machines, as per IS/IEC 60034	Reqd	Reqd	
2.13	Routine tests on control panels / desks, protection & metering panels, synchronising panels,excitation panels / AVRs, etc	Reqd	Reqd	
3.0	**Site tests** - All commissioning tests on turbo - alternators / DG set including the following:			
3.1	Guaranteed performance test at specified design rating	Reqd	Reqd	
3.2	Demonstrate voltage regulation over load range	Reqd	Reqd	
3.3	Demonstrate speed response to load change	Reqd	Reqd	
3.4	Demonstrate transient behavior of alternator	Reqd	Reqd	
4.0	**Type Tests:**	Reqd.		
4.1	Measurement of dc resistance of stator and rotor windings.			
4.2	Insulation resistance of stator winding(before and after high voltage test), rotor winding, bearings and embedded temperature detectors			

4.3	High voltage test			
4.4	Phase sequence test			
4.5	Determination of open circuit characteristics			
4.6	Determination of short circuit characteristics			
4.7	Over speed test			
4.8	Pressure test on coolers			
4.9	Determination of efficiency by separation of losses method			
4.10	Over pressure hydraulic test on stator frame for hydrogen cooled machines			
4.11	Vibration test			
4.12	Gas leakage test			
4.13	Impedance test of the rotor winding			
4.14	Temperature rise test			
4.15	Instantaneous short circuit test			
4.16	Voltage wave-form test			
4.17	Determination of reactances and time constants			
4.18	Type test on exciters, as per IS/IEC 60034, applicable for DC machines			

TPS NO. 32686-13-PS-002

ITEM : MEDIUM VOLTAGE INDUCTION MOTORS

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	Physical verification for conformity with P.O. specifications and approved drawings	Reqd	Reqd	
2.0	**Routine test** (as per IS), including the following:			
2.1	Insulation resistance test	Reqd	Reqd	
2.2	High voltage test	Reqd	Reqd	
2.3	No load running test	Reqd	Reqd	
2.4	Locked rotor test	Reqd	Reqd	
2.5	Reduced voltage running test at no load	Reqd	Reqd	
2.6	Open circuit voltage ratio test	-	-	
2.7	Testing of accessories / auxiliaries for correct functioning	Reqd	Reqd	

TPS NO.: 32686-13-PS-002

ITEM : BATTERY AND BATTERY CHARGER

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	Physical verification of battery, panels and components for conformity with P.O. specifications and approved drawings	Reqd	Reqd	
2.0	Megger and high voltage tests	Reqd	Reqd	
3.0	Testing of control circuits, annunciators and alarms	Reqd	Reqd	
4.0	Simulation tests for AC failure	Reqd	Reqd	
5.0	Temperature rise test	Reqd	Reqd	
6.0	Voltage variation tests	Reqd	Reqd	
7.0	Load test for panels			
8.0	Rectifier efficiency test	Reqd	Reqd	
9.0	Tests to prove load limit feature	Reqd	Reqd	
10.0	Tests to prove auto /manual operation	Reqd	Reqd	
11.0	Overload capability tests	Reqd	Reqd	
12.0	Transient response test	Reqd	Reqd	
13.0	Short circuit and earth fault capability tests			
14.0	D.C. ripple content tests	Reqd	Reqd	
15.0	Harmonic distortion tests			
16.0	Radio frequency interference tests			
17.0	Noise tests			
18.0	Vibration and shock tests			
19.0	Battery routine tests	Reqd	Reqd	
20.0	Battery capacity test at site			
21.0	Battery type tests			

0	**25-03-2021**	**Issued for Enquiry**	**SM**	**IK**	**IK**
REV.	**DATE**	**DESCRIPTION**	**PRPD.**	**CHKD.**	**APPRD.**

TPS NO. 32686-13-PS-002

ITEM : MEDIUM VOLTAGE SWITCHBOARDS

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	**Physical verification** for compliance with P.O. specification, scope, approved drawings & BOM	Reqd.	Reqd.	
2.0	**Routine tests**	Reqd.	Reqd.	
2.1	Power frequency Voltage dry tests on main circuits.	Reqd.	Reqd.	
2.2	Voltage tests on control and auxiliary circuits	Reqd.	Reqd.	
2.3	Measurement of resistance of main circuit	Reqd.	Reqd.	
2.4	Mechanical operation test	Reqd.	Reqd.	
2.5	Tests of auxiliary electrical and pneumatic devices	Reqd.	Reqd.	
2.6	Verification of wiring	Reqd.	Reqd.	
2.7	Electrical operation test	Reqd.	Reqd.	
2.8	Megger test	Reqd.	Reqd.	
2.9	Safety interlocks and protection against electric shock and short circuits	Reqd.	Reqd.	
2.10	Verification of CT ratio and polarity of CTs	Reqd.	Reqd.	
2.11	Verification of nameplate information & marking	Reqd.	Reqd.	
2.12	Relay operation tests	Reqd.	Reqd.	
2.13	Primary and secondary injection tests on panels and protective gears	Reqd.	Reqd.	
2.14	Separate testing of breaker operating mechanism and other accessories	Reqd.	Reqd.	
3.0	**Type tests**			Type test certificates to be furnished
3.1	Impulse voltage dry test			
3.2	Power frequency voltage dry test			
3.3	a) Temperature rise tests of Switchboard			
	b) Temperature rise tests of Circuit breaker			
3.4	Verification of dielectric properties			
3.5	Verification of making and breaking capacity of breaker			
3.6	Verification of temp. limits and characteristics of relays			
3.7	Short time current tests on main circuits			

3.8	Short time current test on earthing circuits			
3.9	Mechanical operation test			
3.10	Verification of degree of protection			

TPS NO. 32686-13-PS-002

ITEM : CABLES

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	**Physical verification for conformity with P.O. specifications**	Reqd	Reqd	
2.0	**Routine tests**			
2.1	Conductor resistance test	Reqd	Reqd	
2.2	High voltage test	Reqd	Reqd	
2.3	Partial discharge test on full drum length	Reqd	Reqd	For HV cables
3.0	**Type tests**			
3.1	Annealing test (for copper)			
3.2	Tensile test (for Aluminium)			
3.3	Wrapping test (for Aluminium)			
3.4	Conductor resistance test			
3.5	Test for armour wires or strips			
3.6	Test for thickness of insulation and sheath			
3.7	Physical test for insulation			
3.8	Physical test for outer sheath			
3.9	Bleeding and glooming test			
3.10	Partial discharge test			
3.11	Bending test			
3.12	Dielectric power factor test			
3.13	Flammability test			
3.14	Insulation resistance (volume resistivity) test			

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	25-03-21	Issued for Enquiry	SM	IK	IK

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
3.15	Heating cycle test			
3.16	Impulse with stand test			
3.17	High voltage test (water immersion test)			
4.0	**Acceptance Tests**			
4.1	Annealing test (for copper)	Reqd.	-	
4.2	Tensile test (for Aluminium)	Reqd.	-	
4.3	Wrapping test (for Aluminium)	Reqd.	-	
4.4	Conductor resistance test	Reqd.	-	
4.5	Test for thickness of insulation and sheath	Reqd.	-	
4.6	High voltage test	Reqd.	-	
4.7	Insulation resistance (volume resistivity) test	Reqd.	-	
4.8	Hot set test for insulation	Reqd.	-	
4.9	Partial discharge test	Reqd.	-	
4.10	Tensile strength & elongation at break test for insulation and sheath	Reqd.	-	
5.0	**Any other tests** (specify below)	-	-	
5.1	Test to prove FR properties	Reqd	-	

TPS NO. 32686-13-PS-002

ITEM : BUS TRUNKING

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	Routine tests			
2.0	Short circuit test	Reqd	Reqd	
3.0	Temperature rise test	Reqd	Reqd	
4.0	Impulse voltage withstand test	Reqd	Reqd	
5.0	Power frequency voltage withstand test	Reqd	Reqd	
6.0	Milli volt drop test	Reqd	Reqd	
7.0	Physical verification for compliance with P.O. specifications and approved drawings	Reqd	Reqd	

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TPS NO: **32686-13-PS-002**

ITEM : UNINTERRUPTIBLE POWER SUPPLY SYSTEM

EQPT NOS: **Ins./test Reqd** ■ **Witness Reqd** ■

The following inspection and test shall be conducted and records submitted

■ **Required** ☐ **Not Required**

Sl. No.	Description	Tests to be performed	Tests covered by authorized certificates	Tests covered by Manufacturer's type test report	Tests to be witnessed by Client's representative	Rectifier Units	Inverter Units	Bypass Units	AC/DC Distribution Boards
1.0	Physical Verification of panels, components and interconnecting cables for conformity with PO specs. & approved drawings.	**Reqd**			**Reqd**				
2.0	Dielectric test	**Reqd**			**Reqd**				
3.0	No-Load test	**Reqd**			**Reqd**				
4.0	Load test	**Reqd**			**Reqd**				
5.0	Overload test	**Reqd**			**Reqd**				
6.0	Temperature rise test	**Reqd**							
7.0	Fault Current Limiting test			**Reqd**					
8.0	Electrical Operation test general	**Reqd**			**Reqd**				
9.0	Alarm Circuit Function test	**Reqd**			**Reqd**				
10.0	AC input distortion measurement	**Reqd**			**Reqd**				
11.0	AC output waveform measurement	**Reqd**			**Reqd**				
12.0	DC ripple measurement	**Reqd**			**Reqd**				
13.0	Synchronising test	**Reqd**			**Reqd**				
14.0	Voltage regulation test	**Reqd**			**Reqd**				
15.0	Frequency regulation test	**Reqd**			**Reqd**				
16.0	Automatic / manual transfer test	**Reqd**			**Reqd**				
17.0	Soft start (walk-in) test	**Reqd**			**Reqd**				
18.0	Charging method test	**Reqd**			**Reqd**				
19.0	Efficiency measurement	**Reqd**			**Reqd**				
20.0	Verification of Degree of Protection		**Reqd**						
21.0	Overall system efficiency measurement to be performed	■ Yes			☐ No.				

REMARKS:
Oscillographic records shall be furnished for the following tests.
(a) Output voltage wave form giving details of the percentage of each of the harmonic present.
(b) Time and Variation of inverter output voltage when load is changed from inverter to bypass or vice versa.
(c) Time and variation of Inverter output voltage for 0-100% load and 100%-0 load.

REV.NO.	DATE	DESCRIPTION	PRPD	CHKD	APPRD
0	25.03.21	Issued for Enquiry	SM	IK	IK

TPS NO : 32686-13-PS-002

ITEM : ELECTRICS OF EOT CRANE

EQPT. NOS.:

The following inspection and test shall be conducted and records submitted

Sl. No.	Description	Ins./test Reqd.	Witness Reqd.	Remarks
1.0	Routine tests on motors as per IS 325	Reqd.	Reqd.	
2.0	Insulation resistance test for control panel	Reqd.	Reqd.	
3.0	Schematic operation test for controls and interlocks	Reqd.	Reqd.	
4.0	Physical verification for compliance with P.O. specifications	Reqd.	Reqd.	
5.0	Tests at site (Refer cl no. 16.2 & 16.3 of 13ES922)	Reqd.	Reqd.	

REV.	DATE	DESCRIPTION	PRPD.	CHKD.	APPRD.
0	25.03.21	ISSUED FOR ENQUIRY	SM	IK	IK

TPS NO.	32686-13 -PS-002
ITEM :	**DIESEL ENGINE**
EQPT. Nos.	-

The following inspection and test shall be conducted and records submitted.

Sl No.	Description	Inspn. Reqd.	Witness Reqd.	Remarks
1.0	**Shop Tests**			
	1.1 No Load running	✓		Duration 30 min
	1.2 Appearance and dimensional	✓		
	Visual	✓		
	Dimensinal	✓		
	1.3 Performance (Power)	✓		
	1.4 Emission level (Shall comply with statutory norms)	✓		
	1.4 Fuel tank hydro test	✓		
	*** Test certificates of the shop tests shall be submitted after Tests and before supply (During vendor data review).**			
2.0	**Site Tests**			
	2.1 No Load running	✓	✓	
	2.2 Appearance and dimensional	✓	✓	
	Visual	✓	✓	
	Dimensinal	✓	✓	
	2.3 Noise Level	✓	✓	
	2.4 Performance Guarantee Test Run (PGTR)	✓	✓	

Witnessing of tests where specified will be done by FACT/ FEDO or their authorized representative.

REV.NO.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	30.03.21	Re-issued	LA	SK	AAN
0	05.10.20	For Enquiry	LA	SK	AAN

SCOPE

This document together with "VENDOR DATA REQUIREMENTS (VDR)" defines FEDO's requirements for vendor drawing and data for any enquiry, work order or purchase order.

Bidders unable to comply with these requirements must detail all exceptions in their proposal. The timely delivery of quality drawings and data is as crucial as delivery of the equipment itself and hence the same shall be strictly adhered to after commitment.

Failure to provide adequate preliminary data / drawing may render a proposal non-responsive and hence may be rejected. After commitment failure to provide documents as per purchase order may delay progressive payments and adversely affect future invitation to bids.

VENDOR DATA REQUIREMENTS (VDR)

FEDO will provide a partially completed VDR form along with each enquiry. This form explains group code of the document, quantity of each document required and lead time for submission. Columns are available for the vendor to fill in his deviations, if any, from FEDO's requirements.

The vendor shall forward a filled-in VDR form along with his offer, if he has got any deviation from FEDO's requirements. In the absence of a filled-in VDR form along with the offer, it will be presumed that the vendor is accepting FEDO's requirements specified in the VDR.

CLASSIFICATION OF DOUCMENTS
Documents are classified based on their status and nature of content.
Status of documents:
Preliminary documents required along with the offer.
Documents to be submitted after commitment.
Final documents.

3.2.0. The documents are further classified into Groups A,B and C, depending on the nature of the documents as explained below.

Group A requirements

These documents are urgent in nature and contains information that are required for proceeding with the detailed engineering of surrounding/down stream equipments in the plant and hence are to be submitted on priority basis.

Group B requirements

These documents are to be reviewed by FEDO for compliance with the purchase order / work order specifications but are not essential for other engineering activities of FEDO.

Group C requirements

Documents in this group contains data / information / records which are final in nature and that are required for the equipment user and need not be reviewed by FEDO.

VENDOR DATA INDEX (VDI)

Vendor shall forward a filled up and updated VDI along with each vendor data transmittal. VDI shall list out all documents that are being prepared for the particular order, their current revision status and indicate the documents included in the present transmittal. A blank VDI is attached along with this document which shall be used for this purpose.

QUALITY OF VENDOR DRAWINGS

vendor drawing and data shall be supplied in full size drawings, reproducibles and CDs as specified in the VDR.

All drawings / documents shall be clear, legible, right reading and made out of originals prepared in black ink. English language and metric units shall be used for the preparation of all documents.

The documents shall be prepared n any of the following standard sizes.

A1: 594 mm x 840 mm
A2: 420 mm x 594 mm
A3: 297 mm x 420 mm
A4; 210 mm x 297 mm

All documents submitted to FEDO shall be folded into A4 size (210 x 297 mm) except originals/ reproducibles which may be rolled. All reproducibles shall be in high quality polyester films. Soft copies shall be furnished in CD for final drawings/documents.
Each drawing / document shall have a title block at the right hand bottom corner with the following information.
Name of Vendor.
Name of Project, Owner and location.
Name of Consultant: FEDO
FEDO Purchase Order Number.
Equipment name and number.
Drawing title.
Drawing number, revision and page number.

All drawings shall be drawn to some standard scales only and the same shall be indicated in the drawing.
The status of the document like “PRELIMINARY, FINAL, FOR REVIEW” etc. shall be stamped on all copies forwarded to FEDO.
All documents shall have a block of 100 mm x 100 mm space left vacant for FEDO to put their stamp after review.
All drawing/document shall have a revision block explaining revision number, revision description, data of revision, revision authorization etc. When the revised drawings are submitted all currently revised area shall be clearly demarcated by clouding. Any revisions made on other parts of the documenting will not be reviewed by FEDO.
When drawings are received back from FEDO with comments, vendor shall incorporate all the comments and resubmit the same. If the vendor is not in a position to incorporate certain comment made by FEDO, then the reason for such deviation shall be highlighted in the forwarding letter to FEDO.

The respective engineering specification and other purchase order spec. will explain the minimum data / details required in various drawings. In the absence of any such information in the purchase order documents, vendor shall follow the standard good engineering practices in detailing the drawing.

CONDITIONS OF FEDO REVIEW

FEDO and / or its client reserve the right to review the vendor documents. FEDO's REVIEW WITH OR WITHOUT COMMENTS OF THE VENDOR DOCUMENTS SHALL NOT RELIEVE THE VENDOR OF RESPONSIBILITY TO COMPLY WITH ALL PURCHASE ORDER TERMS AND CONDITIONS, including all implied requirements relating to fitness for service and good engineering practices. Approval or acceptance does not imply or infer any determination relating to compliance by the vendor with its full responsibilities under the purchase order.
FEDO's comments are limited to identifying requirements within the scope of the purchase order or failure by the vendor to comply with the requirements of purchase order, as revealed by the limited review. Oversights in the above limited review cannot be taken as approval for the vendor to deviate from the purchase order conditions. FEDO reserve the right to point out any such deviations at any stage of the order execution. The vendor shall comply with all such requirements without any price / delivery implications.
FEDO review will be authorized by an official stamp as given below, properly filled and signed by the concerned. Comments if any will be indicated in red ink or clouded in the case of copies of commented drawings.

Appropriate comment in the 'comments' column and 'status of review' column will be marked.

Comment	Status of Review
As noted	Revise and resubmit for review
No comments	Proceed as noted and submit revised docs. For records
Not reviewed	No further review required
	Forward final docs. as per P.O.

All documents received in FEDO shall be dispatched after review within 15 days from the date of receipt. Vendor shall notify FEDO of non receipt of reviewed documents in time immediately, to take corrective actions.
The delivery of the equipment shall in no case be linked with the review of the vendor drawings and data by FEDO. It is the sole responsibility of the vendor to execute the job as per the purchase order conditions. If required the vendor shall depute his technical personnel to FEDO after submission of documents for timely finalisation of documents.

PROJECT :AMMONIA STORAGE SYSTEM

ITEM: ELECTRICS FOR TURNKEY INSTALLATION

CLIENT :M/s. FACT-CD

TPS. NO: 32686-13-PS-002

PO NO:

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT**

VENDOR:

Sl. No.	Group code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd	@ Proposed	Agreed	
1.0		Item wise deviations, if any, from specification.	1S+1P					
2.0		Technical particulars as per prescribed proforma		1S+1P	4			1S+4P
3.0		Single Line diagram of Power Distribution	1S+1P	1S+1P	4			1S+4P
4.0		List of Electrical loads with rating (kW/Amps) and quantity	1S+1P	1S+1P	4			1S+4P
5.0		General layout of the system indicating location of all electrics and MCC room if any	1S+1P	1S+1P	4			1S+4P
6.0		Harmonics calculations for VFD		1S+1P				
7.0		Dimensioned foundation plan showing floor cut outs for cable for VFD.		1S+1P				
8.0		Technical literature, installation ,operation and maintenance manual of VFD .		1S+1P				
9.0		Power Layout		1S+1P	4			1S+4P
10.0		Cable Schedule		1S+1P	4			1S+4P
11.0		Earthing Layout		1S+1P	4			1S+4P
12.0		Dimensioned GA drawing of individual electrics		1S+1P	4			1S+4P
13.0		Schematic wiring diagram of controls of the MCC		1S+1P	4			1S+4P
14.0		Schematic wiring diagram of controls and interlocks for HV motors if any		1S+1P	4			1S+4P
15.0		Bill of Materials for all electrics indicating make, type, quantity, rating, catalogue ref details etc.		1S+1P	4			1S+4P
16.0		Manufacturer's Routine test certificates		1S+1P	4			1S+4P
17.0		Manufacturer's Type test certificates		1S+1P	4			1S+4P
18.0		CIMFR certificates for electrics in hazardous areas.		1S+1P	4			1S+4P
19.0		List of spares for two years trouble free operation for all electrics	1S+1P	1S+1P	4			1S+4P

Legend: Group code: A-For review and detailed Engineering, B-For review, C- For information and record
Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media.

Notes:
1. @ Vendor shall fill in proposed lead time if different from the required lead time.
2. @@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and dispatched with the equipment.

REV.	DATE	DESCRIPTION	PRPD.	CHKD.	APPRD.
0	25.3.21	ISSUED FOR ENQUIRY	SM	IK	IK

PROJECT: AMMONIA STORAGE SYSTEM **ITEM: HIGH VOLTAGE SWITCHBOARDS**

CLIENT : M/sFACT-CD **TPS. NO: 32686-13-PS-002**

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **P.O. NO.:**

Sl. No.	Grp. code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd.	@ Propd	Agrd.	
1.0	B	Duly filled in **Technical particulars of High volt-age switchboards** as per proforma enclosed	1S+1P	1S+1P	4			4P+1S
2.0	A	Dimensioned general arrangement drawings – internal & external, including busbar disposition		1S+1P	4			4P+1S
3.0	A	Foundation plan showing cutouts / floor openings and foundation pockets		1S+1P	4			4P+1S
4.0	A	Single line diagram, control schematic, wiring diagrams, terminal and bus wiring diagrams		1S+1P	4			4P+1S
5.0	B	Schedule of material / components	1S+1P	1S+1P	4			4P+1S
6.0	B	Characteristic curves of relays and their range of adjustments		1S+1P	4			4P+1S
7.0	B	Type test certificates of breakers		1S+1P	4			4P+1S
8.0	B	Routine test certificates		1S+1P	4			4P+1S
9.0	C	Certificate of short circuit rating of breakers		1S+1P	4			4P+1S
10.0	C	Test certificates of bought out items like protective relays, CTs, energy meters etc.						4P+1S
11.0	C	Technical literature, Pamphlets and brochures relating to the various equipment used.	1S+1P					4P+1S
12.0	C	Operation and maintenance manuals						4P+1S
13.0	B	Spare parts list	1S+1P	1S+1P	4			4P+1S
14.0	B	Duly filled and signed **Compliance statement** as per proforma enclosed	1S+1P					
15.0	B	Unpriced copy of price data sheet	1S+1P					4P+1S
16.0	A	Relay co ordination details, with recommended settings, calculations, etc.						
17.0	A	Dimensioned drg. of bus trunking flange showing busbar arrangement, bolt hole, etc.						

Legend:	Group code: A - For review and detailed Engineering, B - For review, C - For information and record Document type: R - Reproducible, P - Print, S-Softcopy
Notes: @	Vendor shall fill in proposed lead time if different from the required lead time.
@@	Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Final documents shall be submitted in soft copy also.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	25.3.21	ISSUED FOR ENQUIRY	SM	IK	IK

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

13FT903C/14

PROJECT: AMMONIA STORAGE SYSTEM **ITEM: ALTERNATORS AND ACCESSORIES**

CLIENT : M/s.FACT-CD **TPS. NO: 32686-13-PS-002**

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **P.O. NO.:**

Sl. No.	Grp. code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd.	@ Propd	Agrd.	
1.0	B	Duly filled in Technical particulars of Alternators and accessories , as per format attached	1S+1P	1S+1P	4			4P+1S
2.0	A	Dimensioned general arrangement drawing separately for alternators and terminal boxes		1S+1P	4			4P+1S
3.0	A	Dimensioned general arrangement drawing of control panels / desks, metering & protection panels , synchronising panels ,AVR/ excitation panels, Line & neutral cubicles, etc		1S+1P	4			4P+1S
4.0	A	Foundation plan of alternators & panels		1S+1P	4			4P+1S
5.0	B	Protection , control & alarm scheme		1S+1P	4			4P+1S
6.0	B	Single line diagram		1S+1P	4			4P+1S
7.0	B	Write up on AVR/ excitation system ,protection/ control system	1S+1P	1S+1P				
8.0	B	Schematic wiring diagram of control diagram of control panels / desks, metering & protection panels , synchronising panels AVR/ excitation panels ,etc		1S+1P	4			4P+1S
9.0	C	Type & routine test certificates of alternator , AVR, control panels, etc.						4P+1S
10.0	C	Technical literature / catalogue on alternator , AVR and other accessories	1S+1P	1S+1P	4			4P+1S
11.0	C	Installation, operation and maintenance manuals						4P+1S
12.0	B	List of spares for two years trouble free operation	1S+1P	1S+1P	4			4P+1S

Legend:	Group code: A-For review and detailed Engineering, B-For review, C- For information and record Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media.
Notes: @	Vendor shall fill in proposed lead time if different from the required lead time.
@@	Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Final documents shall be submitted in soft copy also.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	25.3.21	ISSUED FOR ENQUIRY	SM	IK	IK

ITEM: ALTERNATORS AND ACCESSORIES

Sl. No.	Grp. code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd.	@ Propd	Agrd.	
13.0	C	Test certificates / reports of bought out components						4P+1S
14.0	B	Compliance statements, with item wise deviation from spec. If any	1S+1P					
15.0	B	Unpriced copy of price bid	1S+1P					
16.0	A	DG set room layout with dimensioned details & layout arrangement of DG set and accessories	1S+1P	1S+1P	4			4P+1S
17.0	A	Fountain drawing / Details of DG set	1S+1P	1S+1P	4			4P+1S
18.0	A	Foundation drawing / Details of DG set	1S+1P	1S+1P	4			4P+1S
19.0	A	Capability curves of generator	1S+1P	1S+1P	4			4P+1S
18.0	A	Cable schedule indicating power and control cable interconnection between Purchaser's Emergency Switchboard and DG set control panel and between ESB and Alternator.		1S+1P	4			4P+1S

PROJECT: AMMONIA STORAGE SYSTEM

ITEM: MEDIUM VOLTAGE INDUCTION MOTORS

CLIENT : FACT

TPS. NO: 32686-03-PS-002

STATUS : ■ ENQUIRY **COMMITMENT** **P.O. NO.:**

Sl. No.	Grp. code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd.	@ Propd	Agrd.	
1.0	**A**	Duly filled in **Technical particulars of Medium Voltage induction motor** as per proforma enclosed	1S+1P	1S+1P	4			4P+1S
2.0	**A**	Dimensional GA. Drawings, separately for motors and terminal boxes		1S+1P	4			**4P+1S**
3.0	**A**	Foundation drawings / Mounting details		1S+1P	4			**4P+1S**
4.0		Performance characteristic curves		1S+1P				**4P+1S**
4.1	**B**	Speed v/s torque		1S+1P	4			**4P+1S**
4.2	**B**	Speed v/s current		1S+1P	4			**4P+1S**
4.3	**B**	Speed v/s time		1S+1P	4			**4P+1S**
4.4	**B**	Thermal withstand curves under hot & cold conditions (at 100% & 80% rated voltage)		1S+1P	4			**4P+1S**
5.0	**C**	Type test certificates for similar Motors		1S+1P				**4P+1S**
6.0	**C**	Routine test certificates		1S+1P	4			**4P+1S**
7.0	**C**	CMRI certificate / certification from statutory authority of the country of origin, For hazardous area applications		1S+1P	4			**4P+1S**
8.0	**C**	Installation, operation and maintenance Manuel						**4P+1S**
9.0	**B**	Spare parts list						
10.0	**B**	Duly filled and signed **Compliance statement** stating item wise deviation from specs, if any						

Legend:	Group code: A - For review and detailed Engineering, B - For review, C - For information and record Document type: R - Reproducible, P - Print, S – Soft-pendrive/CD
Notes: @	Vendor shall fill in proposed lead time if different from the required lead time.
@@	Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Final documents shall be submitted in soft copy also.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	**25.3.21**	**ISSUED FOR ENQUIRY**	**SM**	**IK**	**IK**

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

PROJECT: AMMONIA STORAGE SYSTEM **ITEM: UNINTERRUPTIBLE POWER SUPPLY SYSTEM**

CLIENT : M/s. FACT **TPS. NO: 32686-13-PS-002**

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **P.O. NO.:**

Sl. No.	Grp. code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd.	@ Propd	Agrd.	
1.0	B	Duly filled in **Technical particulars of Uninterruptible power supply system**, as per proforma	1S+1P	1S+1P	4			4P+1S
2.0	A	Dimensioned general arrangement drawings		1S+1P	4			4P+1S
3.0	A	Schematic diagram of UPS system indicating breakers, isolators, fuses of the power circuit	1S+1P	1S+1P	4			4P+1S
4.0	A	Battery sizing calculation		1S+1P	4			4P+1S
5.0	B	Principle of operation	1S+1P	1S+1P	4			4P+1S
6.0	C	Catalogs and technical literature of UPS & battery	1S+1P	1S+1P	4			4P+1S
7.0	B	Wave forms during transfer / retransfer		1S+1P	4			4P+1S
8.0	B	Wiring diagrams		1S+1P	4			4P+1S
9.0	C	Installation, operation, and maintenance manual						4P+1S
10.0	C	Test certificates (Routine and Type tests)						4P+1S
11.0	B	Compliance statement, with item wise deviation if any from specifications if any	1S+1P					
12.0	C	List of executed orders						
13.0	B	Bill of materials	1S+1P	1S+1P	4			
14.0	B	Recommended list of spares	1S+1P	1S+1P	4			4P+1S

Legend: Group code: A-For review and detailed Engineering, B-For review, C- For information and record
Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media.

Notes:
1. @ Vendor shall fill in proposed lead time if different from the required lead time.
2. @@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and dispatched with the equipment.

0	**25.3.21**	**ISSUED FOR ENQUIRY**	**SM**	**IK**	**IK**
REV.	**DATE**	**DESCRIPTION**	**PREPARED**	**CHECKED**	**APPROVED**

PROJECT:AMMONIA STORAGE SYSTEM **ITEM: BATTERY AND BATTERY CHARGER**

CLIENT :M/s FACT-CD **TPS. NO: 32686-13-PS-002**

PO NO:

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **VENDOR:**

Sl. No.	Group code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd	@ Proposed	Agreed	
1.0	A	Duly filled in Technical Particulars of Battery and battery charger	1S+1P	1S+1P	4			4P+1S
2.0	A	General Arrangement Drawing of battery with stand		1S+1P	4			4P+1S
3.0	B	Schematic Diagram of charger (indicating breakers, isolators, fuses of the power circuit and the control scheme)		1S+1P	4			4P+1S
4.0	B	Wiring diagrams		1S+1P	4			4P+1S
5.0	A	Battery sizing calculation		1S+1P	4			4P+1S
6.0	B	Principle of operation of charger		1S+1P	4			4P+1S
7.0	B	Write up on voltage, current control schemes		1S+1P	4			4P+1S
8.0	B	Write up on earth leakage and protections		1S+1P	4			4P+1S
9.0	C	Catalogs and technical literature						
10.0	C	Installation, Operation and maintenance manual						
11.0	B	Test Certificates						
12.0	B	Bill Of Materials		1S+1P	4			4P+1S
13.0	B	List of spares with recommended quantity & price	1S+1P	1S+1P	4			4P+1S
14.0	B	Unpriced copy of price bid including spares						
15.0	B	Compliance Statement, with item wise deviation if any from specifications.						

Legend: Group code: A-For review and detailed Engineering, B-For review, C- For information and record
Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media.

Notes:
1. @ Vendor shall fill in proposed lead time if different from the required lead time.
2. @@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and dispatched with the equipment.

0	**25.3.21**	**ISSUED FOR ENQUIRY**	**SM**	**IK**	**IK**
REV.	**DATE**	**DESCRIPTION**	**PRPD.**	**CHKD.**	**APPRD.**

PROJECT: AMMONIA STORAGE SYSTEM **ITEM: MEDIUM VOLTAGESWITCHBOARDS**

CLIENT :M/s FACT-CD **TPS. NO: 32686-13-PS-002**

PO NO:

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **VENDOR:**

Sl. No.	Group code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd	@ Proposed	Agreed	
1.0	B	Duly filled in **Technical particulars of Medium voltage switch boards** , as per format attached	1S+1P	1S+1P	4			4P+1S
2.0	A	Foundation plan, showing cutouts/ floor openings, foundation pockets, etc. along with out line dimensions and static & dynamic loading		1S+1P	4			4P+1S
3.0	A	Dimensioned general arrangement drawing - internal & external, including busbar disposition		1S+1P	4			4P+1S
4.0	A	Sectional view showing fixing details		1S+1P	4			4P+1S
5.0	A	Drawing of Bus trunking flange, with complete dimensions including bolt hole locations & sizes and bus bar arrangement		1S+1P				
6.0	A	Single line diagram of switch boards	1S+1P	1S+1P	4			4P+1S
7.0	B	Schematic diagram and wiring diagrams (including inter panel wiring diagrams), with ferrule nos, terminal nos, arrangement of terminals, etc.		1S+1P	4			4P+1S
8.0	B	Schedule of materials / components, with quantity, rating, type, make, etc.		1S+1P	4			4P+1S
9.0	B	Relay co- ordination details, with recommended settings, calculation etc		1S+1P	4			4P+1S
10.0	B	Calculation sheet proving busbar capacity		1S+1P	4			4P+1S
11.0	B	Calculation sheet proving capacity of control transformers		1S+1P	4			4P+1S
12.0	B	Certificates / records of routine & type tests conducted as per scope of Inspection and tests		1S+1P	4			4P1S

.

Legend:	Group code: A-For review and detailed Engineering, B-For review, C- For information and record
Notes: @	Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media
	Vendor shall fill in proposed lead time if different from the required lead time.
@@	Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

0	**25.3.21**	**ISSUED FOR ENQUIRY**	**SM**	**IK**	**IK**
REV.	**DATE**	**DESCRIPTION**	**PREPARED**	**CHECKED**	**APPROVED**

13.0	B	Type test certificates of breakers, switches, MCCB etc.		1S+1P	4			4P+1S
14.0	B	Certificate of short circuit rating of breakers		1S+1P	4			4P+1S
15.0	B	CPRI test certificate for similar switchboard assembly						4P+1S
16.0	B	Test Certificates of brought out items like protective relays, CTs, energy meters, etc.						4P+1S
17.0	B	Characteristic curves of fuses and thermal overload relays, with range of adjustment relays.		1S+1P	4			4P+1S
18.0	C	Technical literature / catalogues of relays, MCCB KWH / KW / PF meters, etc. With its wiring diagrams.		1S+1P	4			4P+1S
19.0	C	Technical catalogue & internal wiring diagrams of circuit breakers		1S+1P	4			4P+1S
20.0	C	Technical literature, pamphlets and brochures relating to the various equipment used.		1S+1P	4			4P+1S
21.0	C	Erection , Operation & Maintenance manuals of breakers and complete switchboard						4P+1S
22.0	B	Spare parts list	1S+1P	1S+1P	4			4P+1S
23.0	B	Duly filled and signed **Compliance statement** as per format attached						
24.0	B	Unpriced copy of price bid						
25.0	B	Testing procedure for temperature rise test		1S+1P				
26.0	C	Quality Assuarance Plan (QAP)		1S+1P				

PROJECT: AMMONIA STORAGE SYSTEM **ITEM: CABLES**

CLIENT : M/s.FACT-CD **TPS. NO: 32686-13-PS-002**

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **P.O. NO.:**

Sl. No.	Grp. code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd.	@ Propd	Agrd.	
1.0	B	**Technical Particulars of Cables**, duly filled in, as per proforma attached.	1S+1P	1S+1P	4			4P+1S
2.0	B	Calculations to prove short circuit rating of conductor and armour		1S+1P	4			4P+1S
3.0	C	Test Certificates and Test Reports						4P+1S
4.0	C	Detailed Technical Literature and pamphlets		1S+1P	4			4P+1S
5.0	C	Instruction manual / technical literature of cable termination / jointing kits.						4P+1S
6.0	B	Compliance statement with item wise deviations from specs. If any.						

Legend: Group code: A - For review and detailed Engineering, B - For review, C - For information and record
Document type: R - Reproducible, P - Print, S-Soft copy

Notes: @ Vendor shall fill in proposed lead time if different from the required lead time.
@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Final documents shall be submitted in soft copy also.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	25.3.21	ISSUED FOR ENQUIRY	SM	IK	IK

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

13FT930C/94

PROJECT: AMMONIA STORAGE SYSTEM **ITEM: BUS TRUNKING**

CLIENT : M/s. FACT-CD **TPS. NO: 32686-13-PS-002**

PO NO:

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **VENDOR:**

Sl. No.	Group code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd	@ Proposed	Agreed	
1.0	A	Duly filled in Technical particulars of Bus Trunking	1S+1P					4P+1S
2.0	B	G.A. drawing of Bus Trunking	1S+1P	1S+1P	4			4P+1S
3.0	B	Arrangement of busbar supports and details		1S+1P	4			4P+1S
4.0	B	General Arrangement Drawing showing flanges, end terminations, bends, phase crossover box with spacing and supports, wall/floor opening and cut out requirements.		1S+1P	4			4P+1S
5.0	B	Detailed Dimensioned view of bus duct.		1S+1P	4			4P+1S
6.0	B	Terminal marking and location of all devices or circuits which requires connection to remote devices		1S+1P	4			4P+1S
7.0	B	Complete dimensions of terminals and flanges including face to face dimensions of terminals, bolt hole locations and sizes.		1S+1P	4			4P+1S
8.0	C	Bill of materials		1S+1P	4			4P+1S
9.0	C	Test report(Routine and type Tests)		1S+1P	4			4P+1S
10.0	C	Busduct Design calculations		1S+1P	4			4P+1S
11.0	C	Catalogs and technical literature		1S+1P	4			4P+1S
12.0	A	Compliance statement with item wise deviation, if any	1S+1P					

Legend: Group code: A-For review and detailed Engineering, B-For review, C- For information and record
Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media.

Notes:
1. @ Vendor shall fill in proposed lead time if different from the required lead time.
2. @@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and dispatched with the equipment.

0	**25.03.21**	**Issued for Enquiry**	**SM**	**IK**	**IK**
REV.	**DATE**	**DESCRIPTION**	**PRPD.**	**CHKD.**	**APPRD.**

PROJECT : AMMONIA STORAGE SYSTEM **ITEM: ELECTRICS OF EOT CRANE**

CLIENT : M/s. FACT-CD **TPS. NO: 32686-13-PS-002**

PO NO:

STATUS : ■ **ENQUIRY** ☐ **COMMITMENT** **VENDOR:**

Sl. No.	Group code	Description	Offer	After commitment				@@ Final
			Qty.	Qty.	Lead time in weeks			Qty.
					Reqd	@ Proposed	Agreed	
1.0	A	Duly filled in Technical particulars of Electrics of EOT Crane	1S+1P					4P+1S
2.0	A	General arrangement drawings of current collection system and supporting calculations for sizes selected		1S+1P	4			4P+1S
3.0	B	General arrangement drawing giving layout of all electrical components and earthing scheme		1S+1P	4			4P+1S
4.0	B	Schematic wiring diagram of control s and protections		1S+1P	4			4P+1S
5.0	B	Details of resistance unit for slip ring motors		1S+1P	4			4P+1S
6.0	B	Detailed writeup on speed control and scheme		1S+1P	4			4P+1S
7.0	B	Bill of materials with type, rating and make of components		1S+1P	4			4P+1S
8.0	C	Catalogues and technical literature		1S+1P	4			4P+1S
9.0	C	Operation and maintenance manual		1S+1P	4			4P+1S
10.0	C	Manufacturers' test certificates for all electrics		1S+1P	4			4P+1S
11.0	C	CIMFR certificates for flameproof motors /other equipments		1S+1P	4			4P+1S
12.0	C	Recommended list of spares		1S+1P	4			4P+1S

Legend: Group code: A-For review and detailed Engineering, B-For review, C- For information and record
Document type: R-Reproducible, P-Print, S-Soft copy in properly secured media.

Notes:
1. @ Vendor shall fill in proposed lead time if different from the required lead time.
2. @@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and dispatched with the equipment.

0	**25.03.21**	**Issued for Enquiry**	**SM**	**IK**	**IK**
REV.	**DATE**	**DESCRIPTION**	**PRPD.**	**CHKD.**	**APPRD.**

PROJECT :	10,000 MT Ammonia Storage Facility at CD	**ITEM :**	Diesel engine drives for DG set
CLIENT :	**FACT-CD**	**TPS No :**	**32686-13 -PS-002**
STATUS :	☑ ENQUIRY ☐ COMMITMENT	**PO No :**	

Sl. No	Grp Code	Description	Offer	After Commitment				Final@@ Qty
			Qty	Qty	Lead time in weeks			
					Reqd	Prop@	Agrd	
1.0	A	General Layout	1S	1P+1S	4			1P+1S
2.0	A	General Arrangement drawing of diesel Engine	1S	1P+1S	4			1P+1S
3.0	A	Foundation plan and load details		1P+1S	4			1P+1S
4.0	A	General Arrangement drawing of fuel oil tank		1P+1S	4			1P+1S
5.0	A	Fuel piping layout	1S	1P+1S	4			1P+1S
6.0	A	Cooling water piping layout		1P+1S	4			1P+1S
7.0		General Arrangement drawing of compressed air system if provided						
8.0	A	Layout of of compressed air system if provided						
9.0	A	**Engine data sheet (Shall be duly furnished)**	1S	1P+1S	4			1P+1S
10.0	C	**Test cerificates***		*** After Tests and before supply.(During vendor data review)**				
11.0	C	Instruction manual for operation and maintenance manual						1P+1S
12.0	C	Technical literature and catalogues	1S					
13.0	C	Reference list of previous supplies	1S					
14.0	B&C	Lube data sheet		1P+1S	4			1P+1S
15.0	B	Spares list for two years normal operation	1S	1P+1S	4			
15.0	B	**Spares list for Mandatory spares.**	1S	1P+1S	4			

Legend :

Group code : A - For review and detailed Engineering , B - For review , C - For information and record

Document type : R - Reproducible , P - Print , M - Microfilm, S - Soft copy

Notes :

'@' Vendor shall fill in proposed lead time if different from the required lead time

'@@' Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	30.03.21	Re-issued	LA	SK	AAN
0	05.10.20	For Enquiry	LA	SK	AAN

	# VENDOR DATA INDEX	32686- 13 - PS - 002 VDI	
		PAGE 1 OF 1	R0

PROJECT: Ammonia Storage system at FACT-CD	**PROJECT NO. : 32686**	**VENDOR:**
ITEM:	**P.O NO.:**	**DATE:**

Sl. No.	Doc. / Drawing No.	Description	Rev. 0 / Date	Rev. 1 / Date	Rev. 2 / Date	Rev. 3 / Date	Rev. 4 / Date	Rev. 5 / Date	Relevant to This issue

ISSUE NO.														
DATE														
SIGNATURE														

FACT ENGINEERING AND DESIGN ORGANISATION

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00FT020/14

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for supply and installation of all electrical items as applicable.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification:

2.1.1 Data sheet of General Requirements for Electrics.

2.1.2 Engineering specifications, Data sheets and Technical Particulars of individual equipment / items.

2.1.3 Scope of work, Scope of Inspection and Tests, Special requirements of the project, Vendor Data Requirements, etc attached with the Technical Procurement Specifications.

3.0.0 COMPLETENESS OF CONTRACT

3.1.0 The electrics supplied / installed shall be complete with all accessories for the safe, smooth and efficient operation of the system. Such parts shall be deemed to be within the scope of this specification whether specifically mentioned or not.

4.0.0 COMPONENTS AND CONSTRUCTION

4.1.0 Each and every component shall be of reputed make and be of proven design for best performance, reliability and durability. They shall be brand new. Workman ship shall be of the highest grade and the entire construction shall be in accordance with the best modern engineering practice.

5.0.0 STANDARDS & REGULATIONS

5.1.0 All electrical equipment / installations shall fully comply with the requirements laid down in the following rules / regulations / acts / standards / codes as amended up to date.

5.1.1 Indian Electricity Rules.

5.1.2 Indian Electricity Act.

5.1.3 Indian Electricity Supply Act.

5.1.4 Indian Factories Act.

5.1.5 Fire Insurance Act.

5.1.6 Petroleum Rules.

5.1.7 OISD Standards.

5.1.8 Pollution control norms as per Environmental Regulations.

5.1.9 Standards / regulations of statutory bodies applicable for the place of installation.

5.1.10 Relevant Indian / International standards and in their absence, the standards of the country of manufacture.

5.2.0 Vendor shall furnish all necessary assistance & documents for obtaining approval from statutory bodies. Making whatever additions/ modifications considered necessary by the Electrical Inspectorate and other authorities to bring the equipment / installation in conformity with the above rules, Regulations, acts and standards shall be in the scope of the vendor.

5.3.0 All equipment shall be of tropical design according to relevant Indian / International Standards.

5.4.0 All electrics shall be suitable for the hazardous / non-hazardous area involved and /or specified. Electrics suitable for the hazardous area involved shall be selected as per the relevant Indian Standards and shall be of proven design approved by CIMFR / relevant statutory bodies. In such cases copies of relevant certificates shall be furnished for Purchaser's approval.

6.0.0 SERVICE CONDITIONS

6.1.0 All equipment shall be suitable for the service conditions specified in the **Data sheet of General Requirements for Electrics** attached.

7.0.0 EARTHING

7.1.0 Duplicate earthing terminals, suitable for terminating earthing conductors of sizes indicated in the data sheets of individual equipment, shall be provided on the body of the equipment apart from those, if any, provided inside the terminal boxes.

8.0.0 POWER SUPPLY DETAILS

8.1.0 The equipment shall be suitable for the power system details furnished in the **Data sheet** of **General Requirements for Electrics** unless otherwise specified in the data sheets of individual equipment.

8.2.0 The equipment shall perform satisfactorily even with variation in supply voltage and frequency as detailed in the data sheets. The equipment shall operate at the specified rating without exceeding the permissible temperature rise as per the relevant I.S. in spite of the variation in supply voltage and frequency.

9.0.0 NAME PLATES

9.1.0 Necessary nameplates, conforming to standards, giving relevant details of the equipment, shall be provided on individual equipment. Any additional details shall also be indicated in the nameplate, if so specified in the specifications / data sheets of individual equipment.

10.0.0 PAINTING

10.1.0 Unless otherwise specified in the specifications / data sheets of individual equipment / items, painting procedure described in this clause shall be adopted.

10.2.0 All exposed metal parts shall be subjected to at least the following pretreatment before painting to suit the material and environment involved.

10.2.1 De-greasing.

10.2.2 Rust removing.

10.2.3 Phosphating/ equivalent chemical treatment.

10.2.4 Giving two coats of corrosion resistant primer suitable for final coating.

10.3.0 Two coats of anticorrosive painting shall be given after the above process so as to render the materials suitable for the highly corrosive environment specified.

10.4.0 Final Colour and finish of the equipment shall be Dark Admiralty Grey (shade no: 632) as per IS: 5 unless otherwise specified in the data sheet for individual equipment/item.

10.5.0 Vendor shall furnish detailed painting procedure proposed, along with the bid.

11.0.0 INTER-CHANGEABILITY

11.1.0 All similar parts shall be inter-changeable with each other.

12.0.0 DANGER NOTICE PLATES

12.1.0 Danger Notice plates conforming to IS: 2551 and other statutory requirements shall be affixed on equipment wherever required.

13.0.0 TOOLS AND APPLIANCES

13.1.0 The vendor shall supply one set of special tools and appliances that may be required for carrying out the maintenance, special inspection etc. of the equipment offered, without any extra cost.

13.2.0 Vendor shall also furnish list of tools and appliances required for the maintenance of different equipments.

14.0.0 SERVICES OF MANUFACTURERS' TECHNICAL EXPERTS

14.1.0 Services of the manufacturer's technical experts shall be made available to the Purchaser, if found necessary, during erection, testing, and commissioning and during the guarantee period.

15.0.0 TRAINING

15.1.0 The vendor shall render all facilities free of cost for imparting training to purchaser's technical personnel at manufacturer's works, if required, for the proper assembly, installation, testing, commissioning, operation and maintenance of the equipment supplied. The travel and living expenses of the personnel deputed for training will be borne by the Purchaser.

16.0.0 PERFORMANCE OF EQUIPMENT

16.1.0 Duly filled in **Technical Particulars** of individual equipment / item shall be furnished as per formats attached. Performance figures of the equipment as per **Technical Particulars** furnished along with the offer shall be guaranteed.

17.0.0 TESTS

17.1.0 All the tests specified in **Scope of Inspection & Tests** attached along with the **Technical Procurement Specification** shall be performed.

18.0.0 DOCUMENTS

18.1.0 Drawings and documents shall be furnished as per **Vendor Data Requirements (VDR)** attached with **Technical Procurement Specification.**

19.0.0 INSTRUCTIONS TO THE BIDDER

19.1.0 All the drawings and documents as per Vendor Data Requirements shall be furnished along with the offer. Offers without these details will be treated as incomplete and are liable for rejection.

19.2.0 In the absence of clearly spelt-out item wise deviations from purchaser's specification, it will be presumed that the equipment offered are in conformity with the specification.

19.3.0 The Vendor shall supply all equipments and items of make specified in the vendor list attached with the specification. The Vendor shall obtain Purchaser's approval before placement of purchase order for electrical items / components wherever makes are not specified in the respective data sheets.

DATA SHEET	GENERAL REQUIREMENT OF ELECTRICS	32686-13-DA-90002
		Page 1 of 1

1.0	**Project**	AMMONIA STORAGE SYSTEM	
2.0	**Owner**	M/s. FACT CD	
3.0	**Location**	FACT COCHIN DIVISION	
4.0	**Service conditions**		
4.1	Altitude	8m above MSL	
4.2	Humidity Min	69%	
4.3	Humidity max.	85%	
4.4	Humidity design	100% at 20° C	
4.5	Ambient temperature ^{0} C-Min.	24	
4.6	Ambient temperature ^{0} C-Max.	36	
4.7	Ambient temperature ^{0} C-Design	40	
4.8	Rain fall – Max . Record in an hour	40MM	
4.9	Rain –fall Max record in 24 Hours	169.5MM	
5.0	**Environment**	Tropical atmosphere+ corrosive CHEMICAL PLANT atmosphere	
6.0	**Wind velocity for structural design**	124 KM/h; Design as per IS:875	
7.0	Seismic factor for design	Within seismic zone 3 as per IS:1893-1975	
8.0	Soil data	*	
8.1	Soil resistivity	*	
8.2	Type of soil (hard / loose)	*	
9.0	**Power system**		
9.1	Voltage (V) & Variation (± %)	415V±10%	3300V±10%
9.2	Frequency (Hz) & Variation (± %)	50 Hz±5%	50 Hz±5%
9.3	No of phases	3	3
9.4	No. of wires	4	3
9.5	Fault level (MVA)	35 MVA	150 MVA
9.6	Method of neutral earthing	Solidly earthed	Resistance earthed

* If required these data to be collected separately from the purchaser

					PROJECT	AMMONIA STORAGE SYSTEM
					CLIENT	M/s.FACT- CD
					P.O.NO.	
0	**25.3.2021**	**SM**	**IK**	**IK**	**VENDOR**	
REV.	**DATE**	**PRPD.**	**CHKD.**	**APPRD.**		

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

13FT900A/14

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the requirements for design, engineering, supply, receiving materials at site, inspection at site, storage, transportation at site, erection, testing and commissioning of all electrics required for the safe, efficient and smooth running of the turnkey installation / package.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification

2.1.1 **Engineering specification** and **Data Sheet** of **General Requirements** for **Electrics**
2.1.2 **Data Sheet** of **Electrics** for **Turnkey Installation**.
2.1.3 **Technical Particulars** of **Electrics** for **Turnkey Installation**.

3.0.0 STANDARDS.

3.1.0 Requirements laid down in the latest revisions of the following Indian Standards and other relevant standards shall be strictly adhered to.

IS: 325	Three phase Induction Motors.
IS/IEC:60034	Rotating Electrical Machines.
IS/IEC:60947	Low voltage switchgear and control gear.
IS: 8623	Low voltage switchgear and control gear assemblies
IS: 1248	Direct acting indicating analogue Electrical measuring instruments and accessories
IS: 2705	Current transformers.
IS: 13703	Fuses for voltages not exceeding 100V AC or 1500V DC
IS: 10118	Code of practice for selection, installation and maintenance of switchgear and control gear.
IS: 732	Code of practice for electrical wiring installation.
IS: 694	PVC insulated cables for working voltage upto and including 1100 volts.
IS: 1554	PVC insulated (Heavy duty) Electric cables.
IS: 3043	Code of practice for earthing.
IEC:62305-P-1 to 4	Protection against lightning.
IS: 7689	Guide for control of undesirable static electricity.

IS: 5571	Guide for selection of electrical equipment for hazardous areas.
IS: 5572	Classification for hazardous areas (other than mines) for electrical installations.- Part 1 - Areas having flammable gases and vapors.
IS:12615	Energy Efficient Induction Motors- Three Phase Squirrel cage

4.0.0 GENERAL REQUIREMENTS

4.1.0 The scope of work for electrics shall be complete in all respects and shall include necessary Medium Voltage switchboards / Motor Control Centres, Motors, Local Control Stations, Cables, Earthing Materials, Safety items and interlocks, Cabling, Earthing, Lighting, etc. required for the installation, as specified in the data sheets.

4.2.0 The Purchaser will be providing adequate power supply at 415 Volts, 50 Hz, 3 phase and neutral A.C. to the MV switch boards / Motor control centres provided by the vendor. The incoming cables shall be connected to the MV Switchboard / MCC by the purchaser. Voltage and frequency variation shall be $\pm$10%and $\pm$5%, unless otherwise specified in the Data Sheet.

4.3.0 For Motors/Equipments suitable for voltage rating above 415Volts, purchaser will arrange power supply through purchaser's circuit breakers. Necessary power cabling upto the motors /equipments and control cabling upto the local control stations of motors as well as termination of the above cables at both ends shall also be arranged by the purchaser in such cases. The interconnecting cabling for protection/ alarm required, between HV motors and purchaser's HV switch board is included in the scope of purchaser.

4.4.0 The purchaser will be terminating the main earth bus at single point within battery limit (size and material of main earth bus shall be as per Data Sheet). Further earthing within battery limit shall be included in the scope of the vendor.

5.0.0 MOTORS.

5.1.0 All drive motors required for the system shall be included in the scope of the vendor unless otherwise specified in the Data Sheet.

5.2.0 Motors shall be suitable for the voltage ratings indicated in the Data Sheet and shall conform to the following specifications.

5.2.1 Motors provided shall have adequate performance characteristics such as starting torque pull out torque, etc. and rating for meeting the driving and starting duty of the driven equipment.

5.2.2 All motors shall be squirrel cage induction type with insulation Class B / F with temperature rise limited to Class B and totally enclosed fan cooled enclosure with IP 55 / IPW55 degree of protection; except in cases of special types of motors such as slip- ring motors, variable speed motors, etc. required to meet special drive requirements, and environmental conditions. In all such cases, motors with necessary special features shall be provided and approval for the same shall be obtained from the purchaser. Degree of protection for the enclosure shall be as specified in the Data Sheet.

5.2.3 Motors shall be provided with 240V,50Hz, single phase anti- condensation heaters, if so specified in data sheet and shall be wired up to separate terminal box with cable glands suitable for the cable sizes specified in Data Sheet.

5.2.4 Motors shall be provided with terminal boxes (where in all six winding ends are brought out), cable glands, etc. suitable for the type and sizes of cables selected by vendor. In addition, the motor shall have the largest terminal box possible in the frame size.

5.2.5 All motors are envisaged to be started on Direct-On-Line unless otherwise specified in the Data Sheet.

5.2.6 All motors shall be suitable for number of starts specified in the Data Sheet.

5.2.7 Motor frame sizes shall be in accordance with IEC recommendations / relevant Indian Standards.

5.2.8 For unidirectional motors, the direction of rotation shall be clearly marked on the body of the motor.

5.2.9 Motors shall have a starting time, which is less than hot locked rotor withstand time of motor by at least two seconds at the rated conditions of voltage and frequency specified with driven machine coupled.

5.2.10 Motors shall be suitable for starting at 80% of the rated voltage against torque speed characteristics of the driven equipment.

5.2.11 The terminal box of Medium Voltage motors shall be capable of withstanding the calculated fault level in terms of the let through energy of combination starter unit at the place of installation.

5.2.12 An indelible warning inscription shall be provided on the motor to indicate that switching of anticondensation heater supply shall also be ensured before carrying out any work on the motor.

5.3.0 In addition to the above requirements high voltage motors shall conform to the following:

5.3.1 Ensure that starting current is not more than 600% of full load current at rated voltage and frequency.

5.3.2 All the six winding ends shall be brought out and marked, three to one terminal box for power supply connections and three to another terminal box on the opposite side for star connection. Further main terminal box shall be phase segregated type and terminal boxes shall be suitable for system fault level for 0.25 seconds or as indicated in the Data Sheet.

5.3.3 If temperature detectors / oil level indicators etc. are provided as per Data Sheet, the same shall be wired upto a terminal box with cable gland suitable for the cable sizes indicated in the Data Sheet.

5.3.4 Additional protection features such as zero speed switches for loads with high starting time, embedded resistance temperature detectors for windings and bearings, oil temperature detectors and level indicators (with alarm and trip contacts) for oil lubricated bearings etc. shall be provided, if specified, in the Data Sheet. For resistance type winding / bearing temperature detectors suitable temperature scanner / monitoring relays with alarm and trip contacts shall be provided, in a weather proof enclosure, if specified in the data sheet.

6.0.0 VARIABLE SPEED DRIVES

6.1.0 The Variable Speed Drive System shall be suitable for the load characteristics and operation duty of the driven equipment, the equipment shall be suitable for continuous operation.

6.2.0 The converter design shall impose minimum harmonics on the electrical power system in accordance with the relevant standards and shall be acceptable to the Owners electrical network.

6.3.0 The Converter Vendor shall advise the percentage of current harmonics over the full range of frequencies. Filters shall be fitted within the converter to minimise harmonic currents.

6.4.0 The converter shall incorporate a programmable microprocessor based control system allowing updating / modifying of the logic functions of the converter by a simple programme procedure using a control panel keypad/ and panel display.

6.5.0 The converter shall be provided with self-check facilities including failure reporting and signalling. The programme shall be protected against loss of supply voltage with back-up for the programme memory and the fault diagnostic and indication shall be equipped with a memory function to retain information with regard to tripping of the Converter.

6.6.0 If requested in the requisition, the converter shall be able to communicate with a remote control/diagnostic system by means of a serial communication interface

6.7.0 The converter shall accurately control the driven equipment speed and torque of any standard induction motor and shall be suitable for pump, fans, mixers, agitator applications etc., as specified in the requisition.

6.8.0 A reference signal of 4mA shall correspond with the minimum operational speed and the reference signal of 20mA shall correspond with the maximum speed.

6.9.0 The Variable Speed Drive System shall be capable of running through voltage dips of up to 20% and equipped with an automatic restart facility which will restart the system with voltage dips greater than 20% less than 4 seconds. Restart shall only take place with voltage recovery greater than 90%. Upon restart the converter shall be capable of synchronising onto rotating motor “flying restart” and develop full acceleration torque.

6.10.0 If the speed exceeds 105% of the maximum operational speed the VSDS shall trip, if the speed reduces to 95% of minimum speed for more than 10 seconds the VSDS shall trip. The converter shall have available critical speed function where it is necessary to avoid certain speeds due to mechanical resonance problems.

6.11.0 Speed control will be carried out either manually for maintenance, or automatically via 4-20mA signal from the process control.

6.12.0 Depending on operational requirements the motor start/stop will be either carried out manually by push buttons or automatically via the process control system.

6.13.0 Emergency stop located at each motor shall trip the supply contactor, removal of power by an emergency shall not cause damage. All stop buttons shall operate at all times.

6.14.0 When the converter is switched on, the drive shall breakaway at a minimum frequency consistent with the slip of the motor. Once motor rotation is established the drive shall ramp up to the set point speed at a controlled rate. Set point speed having been established, change of set point speed shall also be at a controlled rate superimposed on the rate of change demanded by the operator or controller.

6.15.0 During all starting operations, the rate of increase of torque, up to the maximum limited by the protection, shall also be at a controlled rate. The drive shall be suitable for a "windmilling" start with the motor being rotated by the driven equipment in either direction.

6.16.0 Programmable converter relay outputs shall be included with volt free contacts for control and alarm functions.

6.17.0 VFD’s shall comply with IEEE 519 for total harmonic distortion calculation and measurement. If harmonic filters are required to meet this specification, the VFD manufacturer must provide the filter and is fully responsible for the design, manufacturing and installation of the filter as an integral part of the VFD package.

6.18.0 The variable frequency drive shall provide near sinusoidal voltage and current waveforms to the motor at all speeds and loads. Output current THD shall be less than 5%. Standard induction or synchronous motors shall not require derating or upgraded turn-to-turn insulation and shall not require additional service factor.

6.19.0 Variable frequency drive induced torque pulsations to the output shaft of the mechanical system shall be less than 1% to minimize the possibility of exciting a resonance.

7.0.0 M.V. SWITCHBOARDS / MOTOR CONTROL CENTRES (M.C.C.)

7.1.0 The control gear for all Medium Voltage loads shall be housed in centralized MCC's installed in a suitably located electrical room.

7.2.0 MCC's shall be rated for minimum 25 MVA symmetrical fault level with switch fuse/ MCCB incomers and shall conform to the following stipulations:

7.2.1 Number of MCCs shall be selected in such a way to limit the incomer rating to 630 Amps, unless otherwise specified in the Data Sheet.

7.2.2 MCC shall be of self-standing, dust, damp and vermin proof construction in fully compartmentalized cubicle type execution. The MCC shall be single / double front, draw out / non draw-out type as specified in Data Sheet. The enclosure shall be of folded sheet steel construction. Thickness of sheet steel shall not be less than 2 mm except for certain non load bearing members like instrument mounting plates, partitions, doors, etc. for which a minimum thickness of 1.6 mm shall be ensured.

7.2.3 The construction of MCC shall be in such a way that each vertical row of modules shall have separate vertical bus bars, vertical bus bar chamber and cable alleys. The width of the cable alley shall be sufficient to accommodate all the cables and shall have free access for cable terminations and in any case shall not be less than 150 mm.

7.2.4 For draw out type MCC the following stipulations shall also be adhered to:

(i) Power and control contacts shall be of fully draw out, self aligning type which get automatically disconnected when the module is withdrawn.

(ii) A distinct and stable “TEST” position for each module shall be provided. Test push button for checking the control circuitry shall be provided, if specified in Data Sheet.

(iii) Identical feeder types shall be interchangeable with each other. Also all modules shall carry labels identifying KW rating & type of control wiring.

(iv) Necessary earthing arrangements shall be provided for the draw out module in TEST and SERVICE positions.

7.2.5 The bus bar supports shall be of non-hygroscopic glass reinforced plastic material with anti-tracking features.

7.2.6 Bus bars shall be provided with insulating sleeves and bus bar joints shall be shrouded.

7.2.7 MCC including dropper bus bars to each module shall be rated for the minimum symmetrical short circuit level of 25 MVA at 415V.

7.2.8 MCC shall be provided with incoming feeders comprising of suitably rated AC 22 duty switch fuse units/ Moulded Case Circuit Breakers, voltmeter with 3 way and off selector switch & fuses (connected on the incoming cable side) , CT fed ammeter with necessary CTs & 3 way and off selector switch and CT operated KWh meter. CTs & meters shall be of accuracy class 1.5 and meters shall be of size 96mm x 96mm.

7.2.9 Outgoing motor starter feeders shall comprise of suitably rated AC 23 duty load break switches/MCCBs, HRC fuses, 100% capacity AC 3 category Air break contactors and bimetal overload relays. Feeder switches shall have AC 23 rating corresponding to the full load current of the motors connected. Rating of load break switch shall not be less than the rating of the HRC fuses.

7.2.10 The bi-metal overload relays shall be manual / auto reset type as specified in the data sheet. For manual reset type, reset push button shall be provided on the door. These relays shall have single phasing protection feature. If built-in feature is not available, separate current operated type single phasing preventor shall be provided.

7.2.11 Overload relays for motor of blowers, fans, agitators, compressors, crushers & mills shall be of heavy-duty - delayed action type to allow more starting time.

7.2.12 Ammeters shall be provided for outgoing feeders, if so specified in the Data Sheet.

7.2.13 CTs of ratio and VA capacity suitable to connect remote ammeters (in one phase) shall be provided for all motor feeders of 15 kW and above unless otherwise specified in the Data Sheet. Secondaries of these CTs shall be of 1A rating. Minimum VA capacity shall be 7.5 and class of accuracy 1.5 unless otherwise specified in Data Sheet.

7.2.14 Control supply for the motor starters shall be 110V AC, 50 Hz, single phase AC unless otherwise specified in Data Sheet. In case of 240 V control supply, each circuit shall be provided with individual control fuses and links.

7.2.15 For control voltages less than 240 volts separate control transformers (cast resin insulated type) for each modules or common for each bus section shall be provided as specified in the Data Sheet. In case common control transformer for each bus section is envisaged, it shall have adequate capacity and provisions to feed entire control loads of both bus sections of switchboard, when required. The control transformer shall have $\pm$5% taps on primary side and with center tap of secondary winding earthed & having fuse protection on primary side and double pole MCB on secondary side. Common control transformers shall also have suitable switch fuse unit on primary side and additional tapping of $\pm$2.5% on secondary side. It shall be ensured that control supply of each feeder gets isolated automatically when power supply to that particular feeder is switched off.

7.2.16 If anti-condensation heaters are provided for motors, provision shall be made to feed the same through isolator with HRC fuse protection/ MCB and NC contact of Main contactor of respective motor starter.

7.2.17 All power and control fuses shall be of the HRC link type, with operation indicators.

7.2.18 In each motor feeder module, at least one Normally Open and one Normally Closed auxiliary contact shall be wired up to the terminal block as spare. The terminal block shall have at least 10% spare terminals, subject to a minimum of two.

7.2.19 All feeders controlled by contactors shall be provided with OFF buttons. Indicating lamps and Reset button shall be provided, if specified, in the Data Sheet.

7.2.20 Providing pressure switches, limit switches, safety switches etc. wherever required for the safety of the equipment and facilitating interlocking shall be the responsibility of the supplier. Interlock defeat switches, as required shall be provided on the control panel (where such panels are provided) or on local control station near the motor and not on the MCC.

7.2.21 All outgoing switch fuse feeders shall be provided with AC 22 load break switch, HRC fuses and neutral link.

7.2.22 The incomer switch fuse unit shall have single phasing annunciators wired up to a terminal block, if so specified in the Data Sheet.

7.2.23 In MCCs having two incomers each shall be of 100% capacity. Interlocks shall be provided between incomers / bus coupler to prevent paralleling.

7.2.24 Facility shall be provided for padlocking feeder switches in the OFF position.

7.2.25 Necessary switch-to-door interlock shall be provided in all compartments so that the door of a compartment can be opened only when the switch is in OFF position.

7.2.26 Space heater/ anti condensation heaters (suitable for 240 V, single phase AC) shall be provided for each vertical panel if so specified in the Data Sheet. For double front MCC's space heaters shall be provided on both fronts. Space heaters shall be controlled through isolator with HRC fuse protection / MCB, thermostat etc.

7.2.27 Continuous earth bus of 70 sq. mm. bare Copper Conductor, or 120 sq. mm. bare Aluminium conductor or 240 sq. mm. GI strip or as specified in the Data Sheet shall be provided for the entire length of the MCC. Duplicate earth terminals shall be provided for external connection.

7.2.28 Maximum allowable current density for bus bar sizing shall be 1.25 Amps/ sq. mm for copper or 0.78 Amps /sq. mm for Aluminium.

7.2.29 Horizontal busbars shall be of uniform cross section throughout the length of the switchboard. Vertical busbars of all vertical panels of the switchboard shall also be of uniform cross section.

7.2.30 Power wiring shall be carried out with PVC insulated, stranded copper / aluminium conductors of 650 Volts grade having adequate current carrying capacity. Minimum size of conductor for power wiring shall be 4Sq.mm copper. Control wiring shall be carried out with 650 V grade, PVC insulated, copper conductor of size not less than 2.5 Sq.mm.

7.2.31 For draw out MCC, provision of control supply in the test position of draw out modules shall be available. In draw out switchboards with module control supply, required test control supply feeder (complete with switch fuse/ and test control supply transformer with double pole MCB on secondary, centre tap of secondary winding earthed, etc. as in clause 6.2.15 above), associated test supply bus / wiring, etc. shall be provided.

7.2.32 The feeder arrangement shall be such that the operating height (ie. operating handle, switches, push buttons, etc.) lies **within 1828 mm, but above 300mm**, from the floor level.

7.3.0 MOULDED CASE CIRCUIT BREAKERS

7.3.1 Where moulded case circuit breakers are used for feeder circuit protection, rating and characteristics shall be chosen in such a way as to ensure proper discrimination with other upstream and downstream protective devices within the assembly.

7.3.2 The MCCB should be current limiting type with trip time of less than 10 milli second under short circuit conditions. The MCCB should be either 3 or 4 poles as specified in data sheet.

7.3.3 MCCB shall comply with the requirements of the relevant standards IS13947 – Part 2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

7.3.4 MCCB shall comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses

7.3.5 The breaking capacity of MCCB shall be as specified in the schedule of quantities. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCB's for motor application should be selected in line with Type-2 Co-ordination as per IS 13947-2. The breaker as supplied with ROM should meet IP54 degree of protection.

8.0.0 LOCAL CONTROL STATIONS

8.1.0 Each motor shall be provided with a local control station near motor. The enclosure shall be of Cast Iron or Cast Aluminium construction with IP-55 / IPW 55 degree of protection, as specified in the Data Sheet.

8.2.0 Local control stations for M.V motors shall be provided with 'ON' push button (Green) and 'OFF' push button (Red).

8.3.0 Local control station for H.V Motors shall be provided with 'ON' push button (Green), 'OFF' push button (Red), Ammeter and five numbers Indication lamps. (viz 'ON'-Red , 'OFF'-Green, 'Tripped on fault' - Amber, 'Ready for start' -Clear, 'Space heater ON' - Yellow.).

8.4.0 For all motors of 15 kW and above or as specified in Data Sheet, suitable ammeters shall be provided in the local control stations. Ammeters shall have an accuracy class of 1.5 unless otherwise specified in Data Sheet and shall have a suppressed end scale to suit the starting current.

8.5.0 The OFF push button shall be lockable with a pad-lock in pressed 'OFF' position.

8.6.0 If starting of motors / equipment are envisaged from more than one location or Auto / manual operation is envisaged, necessary Local - Remote or Auto-Manual switches shall be provided either in the Local Control Station or in the Instrument Control panel, if any. Stop facility shall be available from any location irrespective of the position of selector switches.

8.7.0 All spare contacts shall be wired up to the terminal block. The terminal block shall have 10% spare terminals subject to a minimum of two.

8.8.0 Nameplates in white perspex acrylic sheet with letters engraved in black shall be provided for each control station indicating the service.

8.9.0 Circuit breaker contactors controlling motor feeders shall have rating at least 125% of the maximum continuous rating of connected motors.

9.0.0 **CABLES AND CABLING**.

9.1.0 All power cables shall be PVC insulated, armoured and PVC sheathed with Aluminium conductor unless otherwise specified in Data Sheet.

9.2.0 All control cables shall be PVC insulated, armoured and PVC sheathed with Copper conductor .The control cable shall be laid segregated from the power cables.

9.3.0 The sizes of cables shall be so chosen that they are rated to carry the full load current continuously after allowing for necessary derating factors for the service conditions of installation, and also that the voltage drop in cables does not exceed 3% for full load running. For motor starting, voltage drop up to 15% shall be permitted.

9.4.0 M.V power cables of 400 sq mm and above shall be laid with a clearance of 70 mm in between and shall be clamped individually. Other cables can be laid touching and clamped in groups.

9.5.0 Cables shall be clamped at every 1500 mm interval on the horizontal trays / racks and at 750 mm interval on the vertical trays / risers, at 400 mm interval for cables laid on walls, columns and other structural works, and at bends and take off points.

9.6.0 A clearance equal to one diameter of the bigger cable shall be maintained between two adjacent power cables buried underground and no such clearance need be provided for control and lighting cables.

9.7.0 All fixing materials shall be given coatings of anticorrosive paint. Cable tags made of Aluminium sheet shall be provided at every 10M interval. The purchaser will furnish the identity numbers of cables after submission of the cable schedule by the supplier. All the cable racks in trenches and overhead structure shall be bonded for continuity.

9.8.0 Selection of the size of cables for motors shall be done from the table indicated in the Data Sheet. However, higher sizes may be used if warranted by voltage drop consideration in individual cases.

9.9.0 Wherever cables pass through masonry or concrete work, they shall be taken through suitable PVC / GI pipes. For road crossing suitable GI or concrete pipe shall be provided.

9.10.0 After drawing the cables in GI / PVC pipes, the ends shall be sealed with cable compounds.

9.11.0 The size and minimum number of cores in control cables shall be as specified in the Data Sheet.

9.12.0 Type of cabling shall be overhead / buried in ground / through pipes / through permanently constructed trenches with RCC / CI chequered plate covers as specified in Data Sheet.

10.0.0 EARTHING.

10.1.0 All electrical equipment shall be provided with duplicate earthing in conformity with relevant standards / regulations applicable. The main earth bus shall be of bare / insulated aluminium or copper or galvanized iron strip as specified in the Data Sheet and earthing of individual equipment shall be done with conductors of type, sizes & material specified in the Data Sheet.

10.2.0 Earthing cables / strips shall be taken along with the power cables on the cable trays / racks / risers / GI pipes / non-metallic pipes or buried. Earthing cables shall be clamped at intervals same as that of power cables. Bare earthing strips shall be clamped at 3000 mm interval on horizontal trays / racks, 1500 mm interval on vertical trays / risers, 800 mm interval on walls, columns, and at bends / take off points.

10.3.0 Metallic cable trays / risers shall be earthed at both ends. Electrical continuity of earthing throughout the tray shall be ensured.

10.4.0 Earthing of equipment, vessels, pipe lines etc. if required towards protection against static electricity, shall be done in conformity with relevant standards / regulations applicable.

10.5.0 Earthing system for protection of building and structures against lightning shall be provided if so specified in Data Sheet in conformity with relevant standards / regulations applicable.

11.0.0 SAFETY ITEMS

11.1.0 Safety items required as per statutory regulations such as danger notice plates, rubber mat in front of switch boards, fire extinguishers, resuscitation charts and fire buckets shall be supplied by the vendor, if specified in Data Sheet.

12.0.0 HAZARDOUS AREA CLASSIFICATION FOR SELECTION OF ELECTRICS.

12.1.0 All electrics and their installation shall be suitable for the hazardous/ Non-hazardous area involved and / or specified in the Data Sheet. Electrics suitable for the hazardous area involved shall be selected as per the relevant Indian Standards and shall be of proven design approved by CIMFR / relevant statutory bodies. In such cases copies of relevant certificates shall be furnished for Purchaser's approval.

13.0.0 ERECTION, TESTING AND COMMISSIONING.

13.1.0 Supply of all erection materials required for the erection of electrical equipments supplied by vendor shall be the responsibility of the vendor. These items shall include all accessories for cable-jointing, cable terminations/ cable tray/ racks, supporting steel structures, pipes, clamps, bricks, sand, cement, rubble, compression type cable glands, insulating materials etc. Necessary grouting, fixing etc. also shall be arranged by the vendor.

13.2.0 It shall be the responsibility of the vendor to supply and install all items that are incidental and necessary for the completion of the installation, whether specifically mentioned or not, so that the installation complies with relevant standards and regulations, at no extra cost to the purchaser.

13.3.0 Commissioning works includes all precommissioning tests, checking of all power, control & earthing connections, testing and commissioning of all equipment / system supplied, erected and / connected by the vendor, as per relevant standards and as directed by purchaser.

13.4.0 The electrical installation work shall be carried out only through a contractor possessing valid and competent electrical contractors license issued by the State Electricity Licensing Board for carrying out electrical installation work in the place of installation.

13.5.0 All equipments which do not come under a roof shall be provided with weather proof features, and be suitably protected using hoods /canopies

14.0.0 APPROVAL FROM ELECTRICAL INSPECTORATE.

14.1.0 It shall be the responsibility of the vendor to ensure that the complete installation supplied and / or erected by him fully meets with relevant standards / Acts / rules / Regulations applicable and duly got approved by statutory authorities like Electrical Inspectorate.

14.2.0 Any modifications / rectification required by the owner / Electrical Inspectorate resulting from improper installation by the vendor or to make the same in full conformity with the relevant standards / Rules / Acts / Regulations applicable for the installation shall be carried out by the vendor without any extra cost to the purchaser.

15.0.0 LIGHTING.

15.1.0 If lighting is included in the scope of the vendor, the same shall conform to specifications for the lighting installation attached.

16.0.0 MAKE OF ELECTRICAL EQUIPMENT / ITEMS

16.1.0 Make of Electrical equipment / items shall be as specified in Data Sheet / Sub vendor list attached.

16.2.0 Approval shall be got from the Purchaser for the individual makes of the different electrical items, wherever makes are not specified in the Data Sheet, before placement of purchase order.

1.0	Power supply voltage (clause 4.2.0/ 4.3.0)	1. 3.3KV± 10%, 50 Hz ±5%, 3 Phase power supply at the incoming terminals of 3.3KV switch board provided by the LSTK contractor 2. 415V± 10%, 50 Hz ±5%, 3 Phase & neutral AC at the incoming terminals of 415V switch board provided by the LSTK contractor
1.1	**All Electrics shall be suitable for Hazardous area Zone-1 class IIA/IIB,**	
2.0	**MOTORS**	
2.1	Scope of supply of vendor (clause 5.1.0)	Squirrel cage induction motors –energy efficient –class IE3
2.2	kW range and voltage ratings of motors (clause 5.2.0)	
	a) Type of motor	Squirrel cage induction motor –energy efficient
	b) Motors of rating upto and including 150kW	415V ± 10%, 50 Hz ±5%, 3 Phase AC
	c) Motors of rating above 150kW upto and including 1000 kW	3.3kV ± 10%, 50 Hz ±5%, 3 Phase AC
2.3	Class of Insulation (Clause 5.2.2)	Class F with temperature rise limited to Class B
2.4	Degree of Protection (Clause 5.2.2)	a) IP55 for Indoor b) IPW55 weatherproof for Outdoor
2.5	Enclosure for (Clause 5.2.2	
	a) Non Hazardous area	-
	b) Hazardous area	Flame proof suitable for Zone-1 class IIA/IIB,
2.6	Anti condensation heaters (Cl. 5.2.3)	Required for motors of rating 37 KW & above
2.7	Method of Starting (Clause 5.2.5)	Direct On Line or VFD as per the process requirement. Soft starter for Motors rated 75kW and above.
2.8	Number of Starts (Cl. 5.2.6)	
	a) Number of consecutive cold starts	3
	b) Number of consecutive hot starts	2
	c) Number of equally spaced starts/hr.	4 for 415V motors and 3 for 3.3KV motors
2.9	Additional requirements of H.V. Motors (Cl.5.3)	
	a) Starting Current (Cl. 5.3.1)	As per IS
	b) Main terminal box (Phase segregated) (Cl. 5.3.2)	Required
	c) Star terminal box (Cl. 5.3.2)	Required for HV motor

	d) Zero speed switches for motors of high starting time required. (Cl. 5.3.2)	
	e) Winding temperature detectors (Cl. 5.3.3)-RTD	Required
	f) Bearing Temperature detectors (Cl. 5.3.3) - RTD	Required
	g) Oil temperature detectors (Cl. 5.3.3)	As required shall be provided
	h) Oil level indicator (Cl, 5.3.3)	As required shall be provided
	i) Temperature scanner / Monitoring relays with alarm and trip contacts for winding/bearing RTD	Required
	j) Foundation bolts for motors	
3.0	**3.3KV SWITCHBOARD**	
3.1	Rating	3.3kV ± 10%,50 Hz ± 5%,3 phase 3 wire
3.2	Fault level (sym)	150 MVA
3.3	Short time current, kA / sec.	Power bus 26.2kA / 1sec. CT 26.2kA/1 sec. Ground bus 26.2 kA for 3sec.
3.4	Location	Indoor
3.5	Enclosure	IP4X as per IS3427/IEC
3.6	Type of breaker	Vacuum Circuit Breaker
3.7	DC auxiliary supply voltage	110V DC, for spring charging motor, shunt trip coil, closing coil, indication lamps, etc
3.8	AC auxiliary supply voltage	240V AC for panel/ motor anti-condensation heater
3.9	VT secondary voltage	110V
3.10	Bus bars-material	* Insulated aluminium (Bus bars shall be insulated with heat shrinkable sleeves rated for phase voltage and joints shall be shrouded. (Raychem/ eqvt.)
3.11	Earth bus – material	Copper
3.12	Current transformers	a) Metering CT- Accuracy-1, Instrument security factor-5 b)ALF for protection CT- 5 P 20 for numerical relay(over current & earth fault protection) c)Insulation class-E
3.13	Cable entry	Bottom
3.14	Earthing truck	One number Required
3.15	Interlocks	Required between incomers and bus coupler
3.16	Voltage transformers	As required for metering and protection shall be provided
3.17	LED indication lamps	Required for a)Breaker ON(Red), OFF (Green) ,Trip(Amber), Ready for ON(clear), Trip circuit healthy

3.18	Numerical meter measuring current, voltage, kW, KWh, kVA, kVAr, frequency, pf etc and having communication port compatible with the standard international protocols to communicate with remote Power Management System/ SCADA	Required for all incoming and outgoing feeders
3.19	Protection relays(Numerical)	a) O / C + E / F -51/51N (feeder management relay) required for incomer and bus coupler. b) Breaker controlled motor feeders- composite motor protection relay with thermal overload, over current(50/51), earth fault, load unbalance/ negative phase sequence, locked rotor, under voltage, starts per hour, vibration monitoring,.(with RTD monitoring for motor winding RTD(6Nos). & bearing RTD(2Nos) c) Line lock out – master trip - 86 (Alstom) or eqvt. And trip circuit supervision relay required for all feeders
3.20	Auxiliary relays, wiring and terminals	As required for process interlock trips, starting interlocks, remote operation from DCS,LCS ,remote indications to LCS,DCS etc shall be provided
3.21	AC supply to remote heater equipment	Required for motor feeder
3.22	Spare breaker NO & NC contacts (3Nos, each)	Required for all feeders
3.23	Component details-common to switch board	Control switch fuse / MCB for AC &DC aux. supply, DC ON lamp (red) & DC failure lamp, DC fail sensing relay, PB for accept – Trip & non trip alarm, PB for reset – Trip & non trip alarm, PB for DC fail alarm accept, PB for DC fail lamp & alarm reset, Hooter for trip alarm, Buzzer for DC failure alarm
3.24	Note:3.3KV Switch board shall have 2Nos. incomer feeders, one bus coupler ,and outgoing motor feeders(breaker controlled) as required. One number spare motor feeder of each rating shall also be provided	
4.0	**MV SWITCHBOARDS / MOTOR CONTROL CENTRES (MCC)**	
4.1	Incomer rating	To suit the load requirement (vendor to furnish) .Air Circuit Breakers shall be provided for feeders above 400A.Feeders rated upto and including 400A shall be MCCB current limiting type
4.2	Number of Incomers in each MCC	Three(Two from Client's power distribution system and one from Emergency DG being provided by LSTK contractor) Multi-Function meters shall be provided for incomers.
4.3	Enclosure	IP 52
4.4	Number of Bus coupler in each MCC	Minimum two. Additional bus coupler as required for segregating emergency loads shall also be provided.
4.5	Type of MCC (Clause 7.2.2)	a) Single front /Double front

		b)	Draw out for breaker panels and motor feeders below 30kW.
4.6	Cable entry	Bottom	
4.7	Material of Bus bars	PVC sleeved Aluminium/ Copper	
4.8	Test Push Button (Cl. 7.2.4)	Not Required (but test facility for control circuit required)	
4.9	Type of overload relay reset (Clause 7.2.10 & 7.2.19)	Thermal overload(bimetal) relay -manual with reset button. CT operated motor protection relay shall be provided for motor feeders 22kW and above	
4.10	Ammeters for outgoing feeders (Clause 7.2.12)		
	a) For Switch fuse/ MCCB feeders	Not Required	
	b) For motor feeders	Required	
4.11	Current transformer for remote ammeter (Cl.7.2.13)		
	a) For motor feeders	Required for motors of rating 15kW and above	
	b) Class of Accuracy	1.5	
4.12	Control supply (Cl. 7.2.14)	110V	
4.13	Control voltage Transformer (Cl. 7.2.15)	Required, for each module	
4.14	Indication lamps on Motor feeders (Clause 7.2.19)		
	a) Motor ON (red)	Required	
	b) Motor OFF (Green)	Required	
	c) Overload Tripped (Amber)	Required	
	d) Voltage rating for indication lamps	110V AC, with LED lamps.	
4.15	Short circuit rating of MCCB	50KA for 1 sec	
4.16	Single phasing annunciator for incomer (Cl. 7.2.22)	Thermal bimetallic overload relays provided for motor feeders shall have integral / built in **single phasing preventing feature**	
4.17	Panel anti-condensation heaters (Clause 7.2.26)	Required	
4.18	Earth bus for MCC(Clause 7.2.27)	Suitable for 50kA/1sec	
4.19	Other requirements	1) Outgoing feeders as required for the Ammonia storage system including lighting and two numbers welding socket outlets. Spare feeders minimum one number for each rating shall be provided. All out going feeders shall be SFU type.	
4.20	Type of motor starter	DOL /VFD as per process requirement. Soft starter for Motors rated 75kW and above. SFU shall be provided for all motor feeders as overload protective device. Type of co-ordination between contactor, overload protective device and short circuit protective device shall conform to Type II as per relevant standards .	

4.21	Note:1) DG set incomer and grid incomer in MCC shall be suitable for automatic operation in conjunction with AMF type control panel provided by DG set vendor .DG set control panel shall be provided with required meters and control which are to be powered from the DG incomer & grid incomer in MCC.. Potential leads for metering and control ,potential free contacts of DG incomer and grid incomer shall be provided for wiring to DG set control panel. In case of under voltage on MCC bus, emergency supply from DG set should be available by starting DG set using voltage monitor relay provided in AMF panel(by DG set vendor),after tripping the grid incomer breaker, the closing of DG set breaker from AMF panel. Interlock between grid incomer breaker and DG incomer shall be provided to avoid paralleling 2)**Single front or double front panel is acceptable meeting the clearance requirements of CEA/ Inspectorate**	
	Interlock in connection with Automatic change over in case of under voltage on one MCC bus section(IL) a) If an under voltage is detected on a bus section of MCC the automatic change over shall take place, provided the following conditions are met. i) The bus coupler auto-Independent-Manual control switch in Auto mode. ii) The voltage on the other bus section is healthy(U>80%) iii) The under voltage is not caused by bus short circuit or bus earth fault. iv) The residual voltage on the bus to be transferred is below 30%. v) The corresponding incomer has been tripped. b) Upstream under voltage trip of an incomer shall only take place if supply is healthy on the other incomer and if the bus coupler is ready for service and in auto mode c) The interlock can be defeated by the synchro check relay(in series with key switch) in order to allow short time parallel operation. During the manual bus transfer momentary paralleling of two incomers and one bus coupler shall take place and then only the selected incomer shall trip out.	
5.0	**UNINTERRUPTIBLE POWER SUPPLY SYSTEM**	
5.1	Output Voltage with regulation	110V AC +/- 2%
5.2	Output free running frequency with regulation	50 Hz ± 1%
5.3	No. of phase / wires at output	Single Phase, 2 wire
5.4	Continuous output rating (KVA)	KVA rating to meet the requirement of DCS of proposed Ammonia storage system. 25% Spare capacity shall be considered for future requirements
5.5	Duty (Back up time)	30 minutes
5.6	No. of sets required	1set
5.7	No. of inverters required per set	Two (Parallel redundancy is required for UPS, inverter and charger. Battery shall be common
5.8	Location	Indoor
5.9	INPUT POWER SUPPLY DETAILS	
5.9.1	Main and Reserve input power supply	415V AC ± 10%,50 Hz ± 5 %,3 Phase / 4 wire
5.9.2	Method of neutral earthing	Solidly earthed
5.9.3	Symmetrical fault level	25 MVA
5.10	RECTIFIER SECTION	
5.10.1	Type	Parallel redundant type rectifier unit with IGBT

5.10.2	Float and Boost Chargers	Combined Float and Boost Chargers
5.11	INVERTER SECTION	
5.11.1	**Semiconductor power control device**	Power Transistor (IGBT)
5.11.2	Type	Parallel redundant type inverter units.Total harmonic distortion for linear load shall be < 3% and non linear load shall be < 5%
5.11.3	**Overload capacity**	125% for 10 minutes, 150% for 10 seconds and 200% for 10 cycles
5.11.4	Static switch for transfer and retransfer facility	Required with manual and automatic selector switch
5.11.5	Reserve supply arrangement	Required with static stabilizer . Voltage regulation ±2%
5.11.6	Distribution board	Required with adequate number of outlets(Double pole MCB with HRC fuse
5.11.7	Meters	Vendor shall provide digital / microprocessor based indication and metering as per manufacturers' standard with computer compatibility software and RS 232 /485 communication port
5.11.8	Annunciations	Necessary annunciations shall be provided for UPS,mains and reserve supply wherever applicable, with accept, reset and test facilities. Visual and audio annunciation shall be provided as per manufacturer's standard (Digital/microprocessor based LCD Display)
5.11.9	Panel	
5.11.10	Location	Control room
5.11.11	Enclosure	2mm thick folded sheet steel
5.11.12	Degree of protection	IP 41 minimum
5.11.13	Paint and final color (Ref. 13ES 900	Epoxy painting. Final colour shall be shade 632 of IS 5.
5.12	BATTERY	
5.12.1	Type	SMF-VRLA
5.12.2	Set Voltage	To be furnished by Vendor
5.12.3	Ampere hour capacity at 27° C	To be furnished by Vendor (Sufficient to provide energy for satisfactory operation of the inverter for 30 minutes at full rated output)
5.12.4	Mounting Arrangement	On Powder coated steel racks
6.0	**ALTERNATORS AND ACCESSORIES**	
6.1	Type of Generator	Diesel Engine driven
6.2	Location	Outdoor.Truss with Zincalum sheet roof shall be provided for the DG set.
6.3	Rated output at site conditions	To be furnished by the vendor(Shall be adequate to meet the emergency load as per process requirement and lighting)

6.4	Voltage and frequency,and power factor	415V,50Hz,three phase ,four wire,0.8P.F lag
6.5	Method of alternator neutral earthing	Solidly earthed
6.6	Regulation (with AVR)	± 2% maximum for DG set
6.7	Adjustable voltage range	± 10% of the rated generator voltage at no load
6.8	Wave form deviation	5% max.
6.9	Steady state frequency variation	Alternator shall be suitable for continuous operation at rated load for frequency variation of +/- 5%
6.10	Transient voltage drop	Alternator voltage drop shall not exceed 15% of rated voltage when largest rated motor with starting current 600% of full load current and starting time approximately 15s is started in DOL when the set is already loaded with all the other emergency loads..
6.11	Short circuit withstand capacity	The alternator shall be capable of withstanding without damage a three phase L to L, L to E or 2L to E short circuit for 3s when operating at rated MVA & pf, +/- 10% voltage variation and fixed excitation
6.12	Connected load	Industrial, mainly induction motors; lighting loads, UPS, battery charger etc.
6.13	Type	Screen protected drip proof
6.14	Degree of protection	IP23 as per IS 4691
6.15	Cooling system of alternator (Clause 7.1.0 of 13ES921)	Self ventilated
6.16	No. of Poles of alternator	To match prime-mover speed
6.17	Class of insulation	Class H
6.18	Type of excitation	Brush less
6.19	Type of AVR	Microprocessor based
6.20	Voltage and excitation monitor	Required
6.21	Control Panel/desk	required, housing Metering, indication, excitation systems, Automatic Mains Failure controls, alarms, interlocks etc. including auxiliary relays, timers, annunciators etc.
6.22	Battery & Battery Charger	Required.SMF battery and charger for diesel engine starting
6.23	Metering	A composite numerical meter shall be provided to monitor all the essential parameters of the Generator, including, voltmeter &ammeter with selector switch(analog and digital),kW,kVAR,Frequency,RPM,PF,kWh,field ammeter,running time counter,DC voltmeter
6.24	Protection	Generator protection relay with protection as per manufacturer's standard shall be provided.
6.25	DG set shall be provided with acoustic enclosure to limit the sound level within CPCB guidelines.	
7.0	**BATTERY AND BATTERY CHARGER**	
7.1	Type of Battery	Sealed maintenance free (lead acid)
7.2	Number of battery sets required	One

7.3	Rated DC load bus voltage	**110V**
7.4	Ampere-hour capacity at 27^0C	To be furnished by the vendor(shall meet 110V DC control supply requirement of 3.3KV switch board, MCC and critical lighting in Switch board room etc.) Back up time for continuous load shall be 2hours
7.5	Special requirement if any, on end voltage /cell of the battery	During discharge of battery the voltage across the load shall not fall more than 7.5% of the rated load voltage at the end of discharge for the specified back up time.
7.6	Number of charger units required	One set consisting of float cum Boost charger, standby float cum boost charger
7.7	AC mains- supply voltage and frequency	415 V ± 10 % and 50 Hz ± 5%,4 wire
7.8	Fault level	35MVA
7.9	Mounting arrangement of Battery	Properly Pretreated Painted Steel Structure
7.10	**Audio / visual annunciation facilities required**	Annunciation scheme with necessary relays shall be provided for the following and other necessary condition. All the alarms shall be provided through electronic display card, audio alarm through hooter, visual indication through LEDs. Alarm Acknowledgement/ Reset provision shall be through push buttons. Mains ON,Float ON,Boost ON,Mains over/under voltage,phase failure,battery over and under voltage,DC load bus voltage high and low,over load trip,Earth fault, and AC mains failure
7.11	Enclosure and degree of protection	2mm (minimum) thick folded sheet steel, IP41 minimum
7.12	DCDB	Required with adequate number of outlets
8.0	**LOCAL CONTROL STATIONS (Required for motors if)**	
8.1	Material of construction (Clause 8.1.0)	Cast Aluminium
8.2	Enclosure and degree of protection (Cl. 8.1.0)	
	a) Non Hazardous	IP 55 weather proof for outdoor
	b) Hazardous	Flame proof suitable for Zone-1 class IIA/IIB,
8.3	Ammeter (Cl. 8.4.0)	Required for motors rated 15KW and above
8.4	Accuracy class (Cl.8.4.0.0)	Class 1.5
8.5	Local/Remote selector switch	shall be provided as per process/operation requirement
8.6	Indication lamps – cluster type LED lamps	Not required
8.7	Foundation bolt for LCS	Required
9.0	**CABLES & CABLING**	
9.1	Type of cable and material of conductor (Cl. 9.1.0)	
	a) Power cables - MV	Aluminium conductor with XLPE insulated ,PVC inner sheathed,armoured PVC FRLS outer sheathed for cable sizes equal to and above 4sqmm. Cable sizes below 4sqmm shall be Copper conductor, XLPE insulated, PVC inner sheathed armoured PVC FRLS outer sheathed as per IS:7098

	- HV	aluminium conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type, as per IS: 7098 (Part 2). HV cables shall be of unearthed type as per IS:7098		
	b) Control cables	Copper conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type as per IS:7098 All cables for Instrumentation interface shall be stranded 1.5Sq.mm copper cable.		
9.2	Table of minimum cable sizes of Power cables (Cl. 9.8.0) Vendor shall provide adequate cable sizes to limit the running voltage drop to 3%).Sizes indicated are for Aluminium cables .Equivalent size of copper cable can be provided.			
	Motors ≤ 3.7 kW	1 # of 3 x 4 sq.mm Cu		
	Motors>3.7kW ≤7.5 kW	1 # of 3 x 6 sq.mm .Al		
	Motors>7.5kW ≤11 kW	1 # of 3 x 10 sq.mm	Motors>75kW ≤90 kW	1 # of 3 x 240 sq.mm
	Motors>11kW ≤15 kW	1 # of 3 x 16 sq.mm	Motors>90kW ≤110 kW	1 # of 3 x 300 sq.mm
	Motors>15kW ≤22 kW	1 # of 3 x 25 sq.mm	Feeders 32A	4 x 10 sq.mm Al.
	Motors>22kW ≤30 kW	1 # of 3 x 35 sq.mm	Feeders 63A	3.5 x 35 sq.mm Al
	Motors>30kW ≤37 kW	1 # of 3 x 50 sq.mm	Feeders 100A	3.5 x 70 sq.mm Al.
	Motors>37kW ≤45 kW	1 # of 3 x 70 sq.mm	Feeders 200A	3.5 x 240 sq.mm Al.
	Motors>45kW ≤55 kW	1 # of 3 x 95 sq.mm	Feeders 250A	3.5 x 400 sq.mm Al.
	Motors>55kW ≤60 kW	1 # of 3 x 150 sq.mm	Feeders 400A	2RX3.5 x 240 sq.mm Al.
	Motors>60kW ≤75 kW	1 # of 3 x 185 sq.mm	Feeders 800A	4RX3.5 x 400 sq.mm Al.
9.3	Minimum sizes of control cables (Cl. 9.11.0)			
	a) Size in sq.mm	2.5		
	b) Minimum No. of cores for MV Motors (for LCS)	As reqd. with 1 core, spare		
	c) Minimum No. of cores for HV Motors (for LCS)			
	d) Interlock/ Interconnection cables to control panels/ eqpt etc.	Upto 7 core – 1 core spare, More than 7 core – 2 cores spare		
9.4	Type of cabling (Cl. 9.12.0) a) MV equipment	1) Incoming cabling up to Vendor's switch board shall be done by other agency .Cable termination on switch board shall be done by the LSTK contractor. 2) RCC cable trenches shall be provided for cabling inside plant area and MCC room. Cabling outside plant area shall be through over head cable trays/RCC cable trenches .GRP /FRP cable trays shall be provided for cable laying.		
10.0	**EARTHING(CLAUSE 10.0.0)**			
10.1	Main incoming earth bus	1000sq.mm PVC insulated Al.Cable		
10.2	Plant main earth bus if any	* Vendor to furnish		
10.3	Equipment earthing (Cl. 10.4.0)-Type & material			

10.4	Equipment earthing (Cl. 10.4.0)-Table of minimum sizes			
	3.3KV switch board	150 sq. mmAl. cable		
	MCC / Switchboards, fuse/ current limiting type MCCB protected	2R 120sq.mm Al. cable	Static Earthing of Process equipment/Tanks	1Rx120Sq.mm Al cable.
	Motors ≤ 30KW & local control stations	2Rx16 sq.mm Al		
	Motors >30KW, ≤37KW	2Rx35 sq.mm Al		
	Motors >37KW, ≤55KW	2Rx50 sq.mm Al		
	Motors >55kW, ≤65kW	2Rx 70Sq.mm Al		
	Motors>65kW, ≤75kW	2Rx120Sq.mm Al		
	Motors rated 75 KW and above	2Rx150Sq.mm Al		
10.5	Size of static earthing minimum (Cl. 10.4.0)	16 sq mm Aluminium cable		
10.6	Lightning protection (Cl. 10.5.0)	Shall be provided as per IS/IEC-62305		
	CI plate electrode earth pits as per IS 3043 as required shall be provided by the vendor and shall be connected to the earthing system in existing Ammonia storage area at minimum two points. Inter connection of earth pits shall be with 1000sq.mm PVC covered Al. cable. Sufficient number of Earth pits shall be provided by the vendor for limiting the maximum value of earth resistance to 1.0 ohm after connecting to the existing plant earth grid.			
11.0	**SAFETY ITEMS (CLAUSE 11.0.0)**			
11.1	Danger Notice plates	Required		
11.2	CO_2 Fire Extinguisher (4.5kg)	Required		
11.3	Insulation mat in front of MCC/ switchboards	3.3KV and 1.1 kV grade insulation mat as per IS 15652:2006 of thickness not less than 2.5 mm and 1000 mm width shall be provided		
11.4	Fire buckets (1 gallon)	-		
11.5	Resuscitation charts	Required		
12.0	Area Classification (Cl. 11.0.0)	Hazardous area Zone 1,gas group IIA/IIB		
13.0	Weatherproof protection (hood) for outdoor equipment (Clause 13.5.0) Motors & PB stns.	Required with Aluminium sheet		
14.0	Responsibility of getting approval from Electrical Inspectorate (Cl. 14.1.0)	Vendor shall be responsible for getting approval from Electrical Inspectorate(CEA)		
15.0	Lighting (Clause 15.0.0)	Required using LED type lighting fixtures in MCC/switch gear room, control room, cooling tower, tank compressor houses etc.. Flame proof well glass LED type lighting fixtures shall be provided for hazardous area. Area lighting as required shall also be provided.		
16.0	Painting (Deviations if any on those specified in 13ES900)	Epoxy painting		

17.0	MAKE (Cl. 16.0.0)	Refer sub vendor list (Electrical)
18.0	**OTHER REQUIREMENTS**	
18.1	'Emergency' or 'essential' loads shall be identified on the criteria that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or the quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus section in the respective Switchboards/ MCCs	

1.0	**MOTORS**	
1.1	Make	
1.2	Equipment No. / Name	
1.3	Type of Motor	
1.4	Motor rating	
1.5	Speed in RPM (Syn.)	
1.6	Frame size	
1.7	Class of Insulation	
1.8	Enclosure, Degree of Protection & Type of cooling	
1.9	Direction of rotation	
1.10	Full load current (Amps)	
1.11	Starting Current (%FLC)	
1.12	Slip (Percentage) at Full load	
1.13	Efficiency (%) and power factor	
	a) At full load	
	b) AT ¾ load	
	c) At ½ Load	
1.14	Locked rotor withstand time	
	a) Hot (seconds)	
	b) Cold (seconds)	
1.15	Starting time of motor on DOL with driven equipment coupled	
	a) At 100% voltage	
	b) At 80% voltage	
1.16	Minimum voltage required for starting with the equipment and corresponding starting time	
1.17	Allowable number of starts with driven equipment coupled	
	a) Consecutive cold starts	
	b) Consecutive Hot starts	
	c) Equally spaced starts/Hr.	
1.18	Guaranteed temperature rise under worst conditions of voltage and frequency	
1.19	Speed Vs. Torque curve	
1.20	Current Vs. time curve	
1.21	Current Vs. Speed curve	
1.22	Thermal withstand characteristics (hot & cold)	
1.23	Start withstand time	

	a) Hot (seconds)	
	b) Cold (seconds)	
1.24	Margin between starting time and locked Rotor withstand time hot (Clause 5.3.1 of 13ES924)	
1.25	CIMFR Certificate (for Flame-proof motors)	
1.26	Bearings	
	a) Drive end bearing No. & type	
	b) Non-drive end bearing No. & type	
	c) Make of bearings	
1.27	Lubricant	
	a) Make	
	b) Type	
	c) Lubrication Schedule of motor	
1.28	Weight of Motor	
2.0	**LOCAL CONTROL STATIONS**	
2.1	Maker's Name	
2.2	Works at which units will be fabricated	
2.3	Material of construction	
2.4	Enclosures & Degree of protection	
2.5	Technical details, leaflets etc	
2.6	Standards applicable	
2.7	Ammeter range & Accuracy class	
2.8	CIMFR certificate for flame proof equipment	
2.9	Type of Local control stations	
3.0	**CABLES**	
3.1	Make	
3.2	Type & Material	
	Power Cable	
	Control cable	
3.3	Standards applicable	
	Power cable	
	Control cable	
4.0	**EARTHING CONDUCTORS**	
4.1	Make	
4.2	Type & Material	
4.3	Standards applicable	
5.0	**OTHER DETAILS**	

6.0	**MOTOR CONTROL CENTRES**	
6.1	Number of MCCs	
6.2	Incomer Rating	
6.3	Maker's name	
6.4	Works at which the boards will be fabricated	
6.5	Type of switchboards	
6.6	Max. Temperature rise over ambient	
6.7	Sizes of phase and neutral bus bars of the following ratings along with supporting calculations	
	a) 100A	
	b) 200A	
	c) 400A	
	d) 630A	
	e) 800A	
6.8	Short time (1 sec.) rating of bus bars in KA(Rms)	
6.9	Type, make, ratings/range/ratios and relevant details of individual components	
6.10	Technical details, leaflets and type test certificates for the following items.	
	a) Heavy duty type switches	
	b) Air Break contactors (Power &Auxiliary)	
	c) HRC link type fuses (Power and Control)	
	d) Bus bars	
	e) Current transformers	
	f) Bimetallic thermal overload relays	
	g) Meters	
	h) Indicating lamps	
	i) Timers	
	j) Single phasing annunciators	
6.11	Overall dimensions in mm of each switchboard	
6.12	Weight of each switchboard in Kg. (Dynamic loading if any shall be furnished)	
6.13	Material and area of cross section of conductors of	
	a) Bus bars to switch of each rating	
	b) Switch to fuses of each rating	
6.14	Material and voltage class (grade) of insulation of above conductors if insulated	

6.15 COMPONENT / FEEDER DETAILS

Motor KW/ Fdr. rating	Full Load Amps	Mod-ule size	Switch/MCCB			HRC Fuse		Contactor				Over load relay range (A)	Size of wire used in modules		Rating of terminals in Amps.		
			Type	AC22 rating (A)	AC23 rating (A)	Therm-al rating (A)	Let through energy	Type	Therm-al rating (A)	AC3 rating (A)	1sec. Rating (A)		Power	Control	Draw-out	Fixed	Outgoing
0.25																	
0.37	1.2																
0.55	1.6																
0.75	1.8																
1.1	2.6																
1.5	3.5																
2.2	5.0																
3.7	7.5																
5.5	11																
7.5	14																
9.3	19																
11	21																
15	28																
18.5	35																
22	40																
30	55																
37	66																
45	80																
55	100																
75	135																
90	165																
110	200																
132	230																
150	275																
Switch fuse/MCCB feeder	63																
	100																
	200																
	250																
	400																
	630																

7.0	**VARIABLE FREQUENCY DRIVES**	
7.1	Make	
7.2	Model Number	
7.3	Country of manufacture	
7.4	Type of reference	
7.5	Standards to which the VVFD conforms to	
7.6	Weight	
7.7	Drive type	
7.8	Dynamic Response	
	a) Speed fluctuation band	
	b) Speed recovery time after 100% torque step	
	c)Type of feed-back for speed control	
	d)Speed control accuracy	
7.9	Waveform distortion factor (% harmonics) in output / input waveform (Number of harmonics and magnitude of each harmonic generated shall be furnished)	
7.10	Rating expressed at (torque)	
7.11	Speed control range	
7.12	Overload capacity	
7.13	Rating declared at (temp.)	
7.14	Switching frequency at declared rating	
7.15	Overload capability of converter	
	a) 115% In(for variable torque) for	
7.16	Overall efficiency of drive (excl. motor) at	
	a) 100% load	
	b) 75% load	
	c) 50% load	
7.17	Overall power factor of drive (excl. motor) at	
	a) 100% load	
	b) 75% load	
	c) 50% load	
7.18	Control mode	
7.19	Acceleration time (Adjustable)	
7.20	Deceleration time (Adjustable)	
7.21	Operation mode	
7.22	Speed reference signal	
7.23	Braking	
7.24	Frequency setting	
7.25	Communication protocols	
7.26	PID function	
7.27	Type of power converter	
7.28	Type of cooling system provided	
7.29	Type of output filter provided	

7.30	Panel Construction	
	a)Material of construction	
	b)Thickness	
	c)IP Rating	
7.31	Cooling	
	i) Type	
	ii) Redundancy in cooling units	
7.32	Panel space heater rating	
7.33	Maximum noise level from the drive at 1-meter distance	
7.34	Dimensions	
	a) Length	
	b) Height	
	c) Depth	
	d) Weight of cubicle	
7.35	Earth bus	
7.36	Size	
7.37	Minimum fault current capacity	

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the requirements for design, manufacture, testing and supply of indoor type high voltage switch board for industrial applications comprising of circuit breaker, isolators, bus bars, operating mechanism, CTs, VTs, meters, protective relays, auxiliary relays, push buttons, indicating lamps, wiring etc. designed to give reliable and continuous operation at the load rating specified in the data sheet/ single line diagram.

2.0.0 REFERENCES

2.1.0 The following documents shall be read in conjunction with this specification:

2.1.1 **Engineering Specification and Data Sheet of General requirements for Electrics**.

2.1.2 **Data Sheet of High Voltage Switchboards.**

2.1.3 **Technical Particulars of High Voltage Switchboards.**

3.0.0 STANDARDS

3.1.0 Requirements laid down in the latest revisions of the following Indian Standards and other relevant standards shall be strictly adhered to.

IS: 13118	Circuit breakers
IS: 3427	Metal enclosed switchgear and control gear for voltages above 1000 V
IS: 5578	Guide for marking of insulated conductors
IS: 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
IS: 10601	Dimensions of terminals of high voltage switchgear and control gear
IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS: 1248	Direct acting analogue electrical measuring instruments and their accessories
IS: 1901	Visual indicator lamps
IS: 2551	Danger Notice Plates

IS: 2705	Current Transformers
IS: 3043	Code of practice for earthing
IS: 3156	Voltage Transformers
IS: 3231	Electrical relays for power systems protection
IS: 3842	Application guide for electrical relays for ac systems
IS: 4146	Application guide for Voltage Transformers
IS: 4201	Application guide for CTs
IS: 4483	Preferred panel cutout dimensions for electrical relays
IS: 6875	Push buttons and related control switches (for voltages up to and including1000V ac and 1200 V dc)
IS:8828	Electrical accessories- Circuit breakers for over current protection for house hold and similar installations
IS: 8686	Static protective relays
IS: 9124	Guide for maintenance and field testing of Electrical relays
IS: 13010	A C watt-hour meters class 0.5, 1.0 and 2.0- Specification
IS: 13779	AC static watt-hour meter, class 1.0 and 2.0- specification
IS: 8530	Maximum demand indicators, class 1.0
IS: 14415	Volt ampere hour meter for restricted power factor range- specification
IS: 14390	Volt ampere reactive hour meter, class 3.0
IS: 14372	Volt ampere hour meter for full power factor range

4.0.0 SUPPLY CONDITIONS

4.1.0 The equipment to be supplied shall be designed to operate satisfactorily at rated load under the supply conditions specified in the data sheet.

5.0.0 CONSTRUCTION

5.1.0 GENERAL

5.1.1 The switchboard shall be of minimum. 2 mm. thick folded sheet steel construction, fully enclosed, dust, damp and vermin proof, floor mounted and free standing type with draw out features. The degree of protection shall be as specified in the data sheet. Vertical units shall be assembled to form a continuous line up of uniform height and front lineup.

5.1.2 Front access with hinged doors shall be available to all components in the cubicle, which require adjustment, maintenance or replacement.

5.1.3 Rear access shall be available to cable box, cable glands, multi core terminal block etc. with bolted covers.

5.1.4 All doors shall be hinged at one end and shall be bolted (knob type) on the other end. All hinges shall be of concealed design for elegant appearance.

5.1.5 All barriers used shall be manufactured from non-inflammable material. All hardware shall be corrosion resistant. Doors & openings shall be provided with neoprene gaskets.

5.1.6 Each Circuit Breaker shall be housed in a separate compartment and shall be enclosed on all sides. Adequate provision shall be made for escape of hot gases by providing louvers. The louvers shall be covered with perforated sheets and shall be so located as to direct the hot gases away from operating personnel.

5.1.7 Switchboard comprising of a number of Circuit Breaker panels, shall be of unit construction to enable the board to be broken down into sections for shipping to site and to be correctly reassembled and erected on prepared foundations without skilled supervision.

5.1.8 The construction of switchboard shall be reliable, safe, self contained, compact, interchangeable, accessible, easily extensible at both ends and complete with all positive mechanical interlocks.

5.1.9 Adequate lifting facilities shall be provided on each section. Lifting eyes may be of removable/foldable design. When removed, these shall not leave any openings on the boards.

5.2.0 MOVABLE SECTION

5.2.1 Movable truck of the draw out type circuit breaker, as specified in the data sheet, mounted on suitable rollers, shall be complete with circuit breaker poles, operating mechanism, plug in connectors, etc.

5.2.2 If independent poles are envisaged for the circuit breakers for housing Circuit Breaker contacts and the rupturing chamber, it shall be fixed to the rigid sheet steel chassis on the movable truck.

5.2.3 Circuit Breakers and Contactors shall be of vacuum or SF6 type. Excessive over voltage shall be prevented by design of switching devices. The SF6 Switching devices shall be of sealed for life and maintenance free type. Pressure monitoring device shall be provided in SF_6 breaker.

5.2.4 The vacuum bottles of switching devices shall be of robust construction and shall withstand impacts and vibrations under service conditions. The chamber shall be able to maintain a minimum level of vacuum guaranteed by the manufacturer for at least 20 years.

5.2.5 All other switchgears not directly fed from generator and transformers shall have rating at least equal to the maximum demand under any circuit configuration plus a provision for 10% future load growth. Incomers of these switchgears shall be designed to cater to the complete load including 10% margin for future load growth.

5.2.6 Adequate provision shall be made / surge absorbers shall be provided, in vacuum / SF6circuit breaker / vacuum contactor feeders, for motor switching to limit the over voltage to 2.2pu rated peak line to earth voltage.

5.2.7 If vacuum circuit breakers are used as interrupting device of the motor, the motors shall be designed to withstand impulse voltage (peak) phase to earth for the system voltages (specified in the data sheet) for such duration as per relevant standards. The values shall be indicated in the technical particulars.

5.2.8 For oil circuit breakers and minimum oil circuit breakers, circuit breaker shall be complete with required quantity of oil for extinguishing the arc. Oil level indicator shall be provided for verification of the level of oil with recommended normal and minimum oil levels. In case of independent poles, each pole shall have an oil level indicator.

5.2.9 Closing and opening mechanism, interlocks, connecting links, coils for close and trip etc. shall be provided on the movable chassis.

5.2.10 An arrangement in which the panel door is integral with the circuit breaker truck is not acceptable. It shall be possible to close the panel door after the circuit breaker is fully drawn out of the panel. If an arrangement is possible by which the panel door can be closed, even when the circuit breaker truck remains inside the panel in the isolated position, the same will be preferred.

5.3.0 FRONT COMPARTMENT RECEIVING THE MOVABLE TRUCK

5.3.1 This compartment shall include automatically operated shutters for automatically screening the stationary plug in connections, with facility for padlocking the shutters in closed position.

5.3.2 Proper guide rails for easy insertion and withdrawal of the circuit breaker shall be provided. Different positions of the Circuit Breaker like 'SERVICE', 'TEST', and 'ISOLATED' positions shall be clearly marked.

5.3.3 Adequate barriers shall permit personnel to work safely within an empty breaker compartment, with the bus bars energized.

5.4.0 CABLE HEAD COMPARTMENT

5.4.1 Cable head compartment of the Circuit Breaker shall be so designed to receive, in addition to cable incoming/ outgoings, wound or bar primary current transformers etc.

5.4.2 Cable compartment shall be complete with required number of cable boxes / glands of the type and size suitable for the cables specified in the data sheet / single line drawing enclosed. Suitable cable termination kit, cable lugs, nuts, bolts, washers shall also be supplied if specified in the data sheet.

5.4.3 Compartment for cable connection shall allow cable pulling; termination and connection work with switchgear energized.

5.4.4 Suitable arc propagation barriers shall be provided between the panels. Independent pressure release flaps shall preferably be provided for different compartments shall be arranged in such a way that it will not cause any accidental hazards to the operating personnel.

5.5.0 BUS BAR COMPARTMENT

5.5.1 Bus bars shall be housed in a separate compartment and shall be accessible for inspection only with special tools. In the bus bar compartment of the Circuit Breaker, the triple pole bus bars shall be arranged on supports like araldite epoxy resin, to provide long air insulation distance and creepage path. Bus bar carriers and supports shall have suitable resistance to hygroscopic and tracking effects.

5.5.2 The bus bar compartment shall be provided with bolted covers. Necessary extra precaution like additional covers, caution signs etc. shall be provided to prevent inadvertent contact with live busbars.

5.6.0 LOW VOLTAGE COMPARTMENT

5.6.1 This compartment shall be fitted with all protection relays, auxiliary relays, instruments etc. It shall preferably be mounted on topside of the front compartment receiving the movable section of the Circuit Breaker.

5.6.2 All relays and meters mounted on this compartment shall be flush type and different items shall be logically laid out on the front of this compartment. Relays which require adjustment/resetting shall be mounted at reasonable operating height from the floor level. Maximum operating height shall be 1900 mm (max) and 400 mm (min) from the floor level.

5.6.3 Mounting of relays & meters on the rear is not acceptable.

5.7.0 ACCESSIBILITY

5.7.1 Checking and removal of components shall be possible without disturbing adjacent equipment. All auxiliary equipment shall be easily accessible.

5.7.2 It shall be possible to set all 'measuring' relays 'in situ' without de-energizing the switchboard.

5.7.3 Access to busbar chamber, CTs, etc. shall be through rear bolted covers.

6.0.0 CIRCUIT BREAKER

6.1.0 The Circuit Breaker shall be of suitable type and rating as mentioned in the data sheet and suitable for indoor use. The Circuit Breaker shall be of three poles, horizontal draw out, low surge type, unless otherwise specified in the data sheet. The ratings specified shall be for operating condition inside the panel, at site.

6.2.0 Rated operating duty shall normally be O-3min-CO-3min-CO. For circuit breakers intended for motor duty and rapid auto-reclosing, the operating duty shall be O-0.3sec-CO-3min-CO.

6.3.0 All parts of the Circuit Breaker shall be liberally dimensioned to have high factor of safety to withstand electrical and mechanical stresses during the normal operation of the breaker and during short circuits.

6.4.0 Shock absorbers shall be provided on the breaker to cushion the impact of closing and opening.

6.5.0 The type of circuit breakers offered for capacitor feeders should have undergone type tests for capacitor switching function.

6.6.0 Breakers of same rating shall be interchangeable. Wiring and termination of plug in contacts shall be identical in all interchangeable breakers.

6.7.0 CIRCUIT BREAKER CONTACTS

6.7.1 The Circuit Breaker contacts shall be adjustable to allow for wear, be easily replaceable and shall have the minimum movable parts and adjustments, which accomplish these results.

6.7.2 The breaker isolating contacts shall be of self aligning type and shall have ample area and contact pressure for carrying the rated current and short circuit currents such that there is no excessive temperature liable to bring about pitting or welding and it shall not show tendency to "blow off" when carrying rated short circuit currents.

6.7.3 A minimum of 3 sets of reversible and adjustable auxiliary contacts are to be provided on breaker operating mechanism as spare, exclusively for the use of purchaser. Multiplication shall be done only mechanically. All auxiliary contacts shall be wired to the terminal block. Auxiliary contacts and limit switches shall be in dust tight enclosures.

6.8.0 OPERATING MECHANISM

6.8.1 The operating mechanism of the Circuit Breaker shall be quick make, quick break type and trip free as per relevant code of practice.

6.8.2 Circuit breaker shall be provided with either electrically operated motor charged spring closing mechanism or solenoid-closing mechanism, as specified in the data sheet.

6.8.3 The closing solenoids and coils and other auxiliary devices shall operate satisfactorily between 85 and 110% of the rated auxiliary supply voltage indicated in the data sheet. Trip coils shall operate satisfactorily at all voltages between 70 and 110% of the rated auxiliary volt age.

6.8.4 In motor charged spring closing mechanism, the charging of the closing spring shall be automatically initiated after every closing operation. It shall be ensured that the closing operation shall be possible only when the springs are fully charged. Suitable protection circuit, limit switches, etc. shall be provided for protection of the spring charging motor and to cut out the motor when the springs are fully charged.

6.8.5 Irrespective of the mode of operation of the breaker, independent manual closing arrangements shall also be provided as a standard feature, for emergency and testing purposes. Necessary operating handles shall also be supplied. The electrical circuit for spring charging motor shall cut off on initiation of manual charging.

6.8.6 Closing and tripping devices for both electrical and mechanical arrangements shall be provided & shall be located in the front of Circuit Breaker.

6.8.7 A mechanical interlock shall be provided for preventing any inadvertent, undesired operation. For instance, closing the breaker when the springs are being charged.

6.8.8 Anti pumping relay & circuitry / anti pumping feature shall be provided in the closing circuit of the Circuit Breaker to ensure that it does not reclose automatically after a tripping or in the case of failure to close, even if the closing impulse is maintained.

6.8.9 The control circuit shall be suitable for local as well as remote control. Each control circuit tapping shall be provided with fuses.

6.8.10 The control and other auxiliary connections from the Circuit Breaker to the cubicle shall be through plugs and sockets, rated for 10A (minimum), 650V located at either ends and connected through flexible jumpers. The jumper shall have sufficient number of spare cores to utilize all the spare auxiliary contacts and it shall be long enough to maintain connection in the test position of the truck. The multi pin plug provided shall have scraping earth terminal.

6.9.0 CIRCUIT BREAKER POSITIONS & INDICATION

6.9.1 There shall be three distinct positions for circuit breaker, viz. "SERVICE POSITION", "TEST POSITION" and "ISOLATED POSITION" and these positions shall be clearly marked and provided with mechanical stops at each position. Circuit breaker shall be electrically and mechanically trip free in all positions. The "TEST POSITION" shall have locking device. Fully racked in, racked out, and isolated positions shall also be clearly marked.

6.9.2 It shall be possible to release the mechanical stop of the truck in the "TEST POSITION" in order to draw out the truck fully after severing the control connections. Cable and busbar isolating connections shall be automatically screened by the automatically operated shutters, before the Circuit Breaker reaches isolation position.

6.9.3 An automatic visual indication shall be provided to indicate "SPRING CHARGED" / "DISCHARGED" positions, in the case of circuit breaker with spring charging mechanism.

6.9.4 Red / Green / Amber / Clear indicating lamps shall be provided for ON /OFF / TRIPPED ON FAULT / BREAKER READY FOR ON indications respectively. Blue lamps shall be provided in the case of non-trip alarms and DC failure alarms. A White lamp and test button shall also be provided for 'TRIP CIRCUIT HEALTHY' indication. Indication circuit shall be through separate contacts only. For remote operation, remote indication facilities shall be provided in the Circuit Breaker panel, if specified in the data sheet.

6.10.0 POSITIVE INTERLOCKS OF THE CIRCUIT BREAKER

6.10.1 It shall not be possible to close the circuit breaker unless it is fully "plugged in" (truck in service position) or fully isolated (truck in the test position) or has been completely removed from the cubicle.

6.10.2 It shall not be possible to discharge the closing spring if the Circuit Breaker is in closed position already.

6.10.3 It shall not be possible to close the circuit breaker unless the closing spring is fully charged.

6.10.4 Interlock shall be provided to prevent pushing in/ drawing out of the breaker truck when the breaker is in the closed position.

6.10.5 Suitable interlocks shall be provided to prevent faulty operation such as,
a) Plugging in a breaker with earthing isolator closed.
b) Closing of earthing isolator with the breaker plugged in.
c) Pulling out the auxiliary circuit / plug with breaker in service position.
d) Pushing in the breaker to service position with auxiliary circuit plug not in position.
e) Opening or closing of panel door with the isolating switch in ON position.

6.10.6 Castle key interlocks shall be provided to facilitate mechanical interlocking with any other equipment.

6.10.7 The above positive mechanical interlocks are the minimum requirements. Manufacturers can include any other safety interlocks, which maybe necessitated by the particular design feature of the Circuit Breaker.

6.11.0 VACUUM CONTACTOR MOTOR FEEDERS

6.11.1 If vacuum contactors are specified in the datasheet / single line diagram, the same shall be with suitable HRC fuse, in fully draw out execution (with features similar to those of circuit breaker feeders).

6.11.2 The fuses shall have adequate rating to suit starting and running conditions of equipment. Fuses shall have striker pin /necessary arrangements to trip the breaker in the event of failure of any one of the fuses. Necessary fuse failure alarm & annunciation shall also be provided.

6.11.3 Co-ordination of protection between motor characteristics, fuse characteristics, contactor characteristics and relay characteristics shall be ensured by vendor.

6.12.0 Adequate provision shall be made / surge absorbers shall be provided, in vacuum contactor feeders, for motor switching to limit the over voltage to 2.2pu rated peak line to earth voltage.

7.0.0 **BUS BARS**

7.1.0 The arrangement of bus bars shall be as per relevant standards. All phase bus bars shall be of uniform cross-section through out the switchboard.

7.2.0 Bus bars shall be of high conductivity aluminium/ copper as specified in the data sheet. Busbars shall be continuously rated for the rated current and service conditions specified. Busbars and busbar jumpers shall be provided with heat shrinkable PVC insulated sleeves and busbar joints shall be shrouded. Maximum allowable current density for busbars shall be 1.25 A / sq mm for copper conductor and 0.78 A / sq mm for aluminium conductor.

7.3.0 The horizontal and vertical bus bars shall be rated for the same fault level specified in the data sheet.

7.4.0 Rigid insulating barriers / protection guards /wire meshes shall be provided between the group of line busbars and other parts, so as to eliminate danger to personnel due to accidental contact.

7.5.0 Thermal design of the bus bars shall be based on installation of the switchgear in poorly ventilated conditions. The cooling air volume shall take into account only the bus enclosure.

7.6.0 The busbar supports shall be non-hygroscopic, glass reinforced plastic material with anti tracking features to prevent flashovers. These shall have high tracking index and be mechanically strong. Hylam is not acceptable.

7.7.0 The bus bars and busbar supports shall withstand the dynamic, thermal & magnetic stresses and strains due to the maximum short circuit current corresponding to the fault level indicated in the data sheet, without any deformation, deterioration or damage.

7.8.0 Suitable provisions shall be made for the expansion and contraction of the bus caused by temperature variation and due consideration shall be given for reactance, proximity and skin effects also, while choosing the sizes and spacing of busbars

7.9.0 It shall be possible to extend the busbars on either side without any further fabrication /modification on the existing busbars. Removable end covers with fixed nut & bolting arrangement shall be provided on either end and the ends of the bus bars shall be suitably drilled.

7.10.0 Appropriate identification marking / labels shall be provided on the busbars and tapings for distinguishing the various phases.

7.11.0 Due allowance shall be given in the sizing of the busbars in case of insulated busbars

8.0.0 INSTRUMENT TRANSFORMERS

8.1.0 CURRENT TRANSFORMER

8.1.1 CTs shall conform to relevant Indian Standards and shall be cast resin insulated. They shall be mounted on switchgear stationary part.

8.1.2 CTs shall withstand the maximum short circuit current for a minimum of one second and it shall be designed to withstand stresses resulting from the maximum short circuit currents.

8.1.3 CTs for metering and protection shall be selected suitably to meet the individual requirements of meters and relays specified in the datasheet. Low reactance CTs shall be used for protection.

8.1.4 CTs for metering purposes shall have adequate capacity to cater for 130% of full load conditions. Instrument security factor for metering CTs shall not be more than 5 and shall have an accuracy class of 1, unless otherwise specified.

8.1.5 CTs for protection purposes shall have sufficient accuracy, burden and accuracy limit factor for necessary co-ordination/discrimination for clearing the faults. Accuracy limit factor for protection shall not be less than 10 and accuracy class shall be 5P. CTs for differential protection shall be of class 'PS'.

8.1.6 Separate CTs/cores shall be used for metering and protection. Dual purposes CTs are not acceptable

8.1.7 CTs shall be provided with polarity markings, adjacent to terminals, both for primary and secondary. These shall be legible even after years of service.

8.1.8 CTs shall be provided with insulation class as indicated in the data sheet.

8.1.9 Unused CT terminals must be short-circuited.

8.1.10 The CT terminals, which have been used, shall be provided with links to facilitate shorting as and when required (when load / burden on CT is disconnected.)

8.1.11 All live terminals shall be shrouded to prevent accidental contact.

8.2.0 VOLTAGE TRANSFORMER

8.2.1 VTs shall conform to relevant Indian Standards and shall be cast resin insulated.

8.2.2 VTs shall have suitable accuracy and capacity for the satisfactory operation of the protection, instrumentation and metering specified in the data sheet / drawings enclosed. The class of accuracy and the burden of VTs selected shall be adequate for the destined different purposes.

8.2.3 Voltage transformer shall be of fully draw out type and shall be provided with HRC fuses on both HV & LV sides. The draw out mechanism shall disconnect the bus bars and shall earth the VT primary and secondary terminals. The primary connection shall be disconnected before the VT or its primary fuses become accessible.

8.2.4 Voltage transformer with residual connection or five limbed VT is required for Directional Over-Current and Earth Fault relays.

8.2.5 The primary rated voltage shall be equal to the rated voltage of the system and unless other-wise specified, secondary voltage shall be110V.

9.0.0 RELAYS, INDICATING INSTRUMENTS, LAMPS, ETC.

9.1.0 RELAYS

9.1.1 Relays shall conform to relevant Indian Standards.

9.1.2 Relays shall be flush mounted and of a type and make approved by the buyer. Make of the relay shall be from the list of acceptable makes and communication protocol as indicated in the data sheet.

9.1.3 Relays shall have hand reset type flag indicators and initiating contacts. It shall be possible to reset the flag without opening the relay case.

9.1.4 When hand reset type flag indicators are not available in primary relays, additional auxiliary relays with flag indicators and initiating contacts shall be provided in conjunction with the primary relays.

9.1.5 Flag indicators shall be visible from the front side of the Circuit Breaker panel.

9.1.6 LED indicators with labeling on panel front shall be provided, in case flag indicators are not available for visual identification of the faults.

9.1.7 Protection relays shall be suitable for the CT/ VT secondary currents/voltages and other auxiliary relays shall be rated for the auxiliary voltage available.

9.1.8 Protection relays shall be back connected, draw out / plug-in type suitable for flush mounting and fitted with dust tight covers.

9.1.9 In the case of electromechanical relays, the relay cases shall have provision for insertion of test plug at the front for 'Testing and Calibrating' using an external power supply, without disconnecting the permanent wiring. It shall be possible to short the CTs through the test plugs.

9.1.10 A comprehensive microprocessor motor protection relay with a wide current setting range and selectable thermal operating characteristics shall be provided for each motor.

9.1.11 Functions shall include:
a) Thermal inverse time over-current manual reset with ambient temperature compensation. In accordance with IEC 60255-8.
b) Instantaneous high set over-current (for circuit breakers)
c) Single phase unbalance
d) Earth fault (core balance type) other features shall be provided as required in the data sheet.

9.1.12 Additionally trip protection shall operate through a manually reset lock-out relay. The sensitivity of earth fault protection shall be 5% or less of full load motor current or 10 Amps whichever is greater.

9.1.13 Winding temperature monitoring using stator resistance temperature detectors (RTD) shall be provided if specified in the data sheet.

9.1.14 The time-current characteristics of overload relays shall be given in the offer for each extreme value of current and time setting. Overload relays for use with type Exe motors shall be appropriately selected and shall have a current/time characteristic below the maximum locked rotor time (Te) and shall be certified by an approved testing authority.

9.1.15 Non-protective relays can be fixed execution type.

9.1.16 All the relays shall have minimum 2nos.of potential free auxiliary contacts in required combination.

9.1.17 It shall be ensured, by checking with the relay manufacturer, that with the accuracy limit factor indicated / chosen, the thermal withstand capability of the relays will not be exceeded for the fault levels specified.

9.1.18 Thermal withstand characteristics of motors will be furnished on receipt from motor manufacturer. Selection of most suitable version of motor protection relay, based on the motor characteristics, to provide adequate protection to the motor, shall be the responsibility of the switchboard supplier. Necessary application checks shall be carried out by the vendor in consultation with the relay manufacturer.

9.2.0 INDICATING INSTRUMENTS

9.2.1 Meters shall be flush mounted and of a type and make approved by the buyer.

9.2.2 Meters shall be of reputed make and shall conform to relevant Indian Standards.

9.2.3 Voltmeter, if specified, shall be moving iron type complete with suitable selector switch and control fuses and it shall be of class 1 accuracy as per IS: 1248. Voltmeter shall have initial suppressed scale for the lower values in the range.

9.2.4 Ammeter, if specified, shall be of moving iron type complete with selector switch. Ammeters for motor feeders shall have uniform scale up to rated full load current and suppressed scale at the end to indicate the motor starting current. A red mark shall be provided on the ammeter dial to indicate rated full load. Calibration of the ammeter shall tally with the ratio of the CT. Ammeters shall be of Class 1.5 accuracy as per IS: 1248, unless otherwise specified.

9.2.5 Energy meter, Kilowatt meter, power factor meter and frequency meter, if specified, shall be operated through CTs and VTs only. The rating shall correspond to full load requirements. The multiplication factor, if any, for these meters shall be clearly exhibited by the side of the meter.

9.2.6 Cushion stoppers and zero correction screws shall be provided for all meters. Meters shall have knife-edge pointer and preferably with anti parallax mirror.

9.2.7 All meters shall be square type of size 96 mm x96 mm. unless otherwise specified. Dials shall be white with black numerals and letters.

9.2.8 All control / selector switches used shall be of rotary type, spring loaded and of robust construction. The operating handle of these switches shall be knob type and of black Colour. The switches shall have 3 ways with OFF position. Necessary facia plates shall be black anodized aluminium with white lettering.

9.2.9 Digital type meters shall be provided wherever specified in the data sheet.

9.2.10 All digital meters should have communication facility if specified in the data sheet

9.2.11 All auxiliary equipment such as shunts, transducer, etc., as required, shall be included in the supply of switchboard.

9.3.0 PUSH BUTTON

9.3.1 Colour of push button knobs shall be as per relevant Indian Standard.

9.3.2 All push buttons shall be provided with legend plates to identify the function or operation.

9.3.3 All push buttons shall have minimum 1 NO + 1NC contacts, unless otherwise specified in the data sheet.

9.4.0 INDICATING LAMPS

9.4.1 Indicating lamps shall be of long life LED type and shall be indigenously available.

9.4.2 Necessary preventive measures shall be ensured to avoid any malfunction of the connected circuit in the case of any fault in the indicating LED's.

9.4.3 All signaling lamps must have clarity of colour .The colour shall be in LED and not as an applied coating.

9.5.0 **ANTICONDENSATION HEATER**

9.5.1 Anti-condensation heaters shall be provided within the assembly. Anti-condensation heaters shall be thermostatically controlled if necessary to prevent overheating. All internal heaters and thermostats shall be completely internally wired and the wiring shall be brought out at a common terminal block.

9.5.2 Necessary ON / OFF isolator, MCB protection and thermostat shall be provided for the heater.

9.5.3 Heater shall be provided inside the panel in easily accessible position for removal / replacement.

9.5.4 Wiring of space heater shall be isolated or separately bundled from other internal wiring.

10.0.0 ANNUNCIATION SCHEMES FOR TRIP, NON-TRIP & DC FAILURE ALARMS

10.1.0 Separate visual and audible annunciation scheme shall be available for;
a) Automatic tripping on fault conditions
b) D.C. failure condition
c) Non-trip alarm conditions

10.2.0 Common facilities and accessories for the trip annunciation scheme & DC failure annunciation scheme like flasher relay, hooter, buzzer, push buttons, etc, shall be mounted on one of the bus coupler panels. Alarm operation and cancellation relays for trip annunciation scheme shall be mounted on the respective panels, wherever indicated in the data sheet. The trip annunciation schemes shall be rated for D.C. auxiliary supply indicated in the data sheet covering the switchboard.

10.3.0 TRIP ANNUNCIATION SCHEME

10.3.1 In the event of a fault in any one of the feeders, the relay sensing the fault shall cause actuation of the flag indication and initiate trip annunciation scheme in that panel in addition to initiating the tripping of the circuit breaker concerned. The amber lamp provided on the panel starts flashing on the flasher bus (derived from flasher relay) and the common hooter starts sounding. When the alarm accepts Push Button is pressed the hooter shall stop and the amber lamp shall glow steady. After resetting the flags and contacts on the protective relay, which initiated the alarm, the alarm scheme can be reset by pressing the reset. Now the amber lamp, which was glowing steady till then, shall go off.

10.3.2 The annunciation scheme shall be repetitive and shall be ready to receive and initiate systematically a second or third fault, irrespective of whether the alarm due to first or second fault in other panels is in 'initiated' or 'accepted' or 'relay reset' condition prior to fully resetting of the annunciation scheme.

10.3.3 It shall be possible to check the healthiness of all amber lamps by pressing the lamp test Push Button.

10.3.4 Necessary interlock shall be provided to prevent closing of the circuit breaker before resetting the alarm in that panel, by using suitable contact of the alarm operation and cancellation relay in the closing circuit of the circuit breaker. Contacts for this purpose shall also be available.

10.4.0 DC FAILURE ANNUNCIATION SCHEME

10.4.1 For DC failure annunciation scheme instantaneously operated DC under voltage relay shall sense the DC failure and shall initiate the flag indication and the DC failure annunciation scheme. The indicating lamp comes ON and the buzzer is initiated. On pressing the 'accept' Push Button, the audible alarm shall stop. When DC is restored, the scheme shall get automatically reset.

10.4.2 The DC failure sensing relay shall have hand reset flag indication.

10.4.3 It shall be possible to test the whole DC failure scheme. A push button shall be provided in the sensing relay circuit to simulate DC failure and test the scheme.

10.5.0 NON-TRIP ANNUNCIATION SCHEME

10.5.1 Non- trip annunciation scheme is required in all transformer feeders and in motor feeders if specified in data sheet. Window type 4point / channel alarm facia shall be fitted. Accept, Reset, Test Buttons shall preferably be common to the entire switchboard. Audio alarm shall be common bell.

10.5.2 Technical details of alarm facia as below:

Power supply:	DC voltage as specified in data sheet
No. of lamps per channel:	Two
Initiating contacts:	Potential free, Normally open, Close on fault.
Display choice:	Full window
Window material:	White acrylic sheet
Fault inscription:	Engraved black letters
Type of Facia:	Push fit / plug in type, flush mounted with panel front
Window size:	65 mm x 50 mm approx.
Lamps per window:	Two connected in parallel
Facility for replacement of lamps:	Required from the front side of lamps

10.5.3 Sequence of operation shall be as below:

Field condition	Visual alarm	Audible alarm
Normal	OFF	OFF
Abnormal	Flash	ON
Accept	Steady ON	OFF
Return to normal	Steady ON	OFF
Reset	OFF	OFF
Test	Flash/ steady ON	ON
Reset before normal	Flash	ON
Second channel abnormal (Irrespective of conditions in first channel)	Flash	ON

10.6.0 AUTO TRANSFER SCHEME

10.6.1 Interlock for the auto transfer scheme shall be as follows.
If an under voltage is detected on a healthy bus section, the automatic change over shall take place, provided the following conditions are met.
i) The bus coupler AUTO-MANUAL-INDEPENDENT-OFF control switch is in AUTO mode.
ii) The voltage on the other bus section is healthy- more than 80%
iii) The under voltage is caused not due to short circuit or bus earth fault.
iv) The residual voltage on the bus to be transferred is below 30%

v) The corresponding incomer has been tripped by instantaneous under voltage relay with timer.
vi) Upstream under voltage trip of an incomer shall only takes place if supply is healthy on other incomer.
vii) Auto changeover shall takes place only if both line voltage and bus voltage are unhealthy.
viii) In case of total power failure incomer and bus coupler feeders shall remain in the same position.
ix) When AUTO-INDEPENDENT –MANUAL selector switch is in independent mode, check the status of other two breakers and ensure that one and only one breaker is in service –ON position-R1
x) Trip selector switch shall be provided for momentary paralleling.

11.0.0 CABLE TERMINATION & WIRING

11.1.0 CABLE TERMINATION

11.1.1 Termination of wiring for external connection shall be done using terminals of reputed make and of proven design for long trouble free life.

11.1.2 Terminals shall be compact and shall have very high dielectric strength so as to prevent flashover and have thermal strength to prevent deterioration.

11.1.3 The moulding material of the terminal body shall preferably be melamine formaldehyde having high anti tracking properties.

11.1.4 Identification / numbering / lettering shall be provided for each terminal. Such marks shall be legible even after years of service.

11.1.5 Cable boxes and compartments shall be sufficiently large to permit the setting and termination of the specified cable size, complete with stress relief when required

11.1.6 Not more than one incoming / outgoing cable is to be connected per terminal.

11.1.6 Minimum 20% spare terminals shall be provided on each terminal block.

11.1.7 Facilities shall be available for temporary or permanent short circuiting of terminals for earthing and testing.

11.1.8 Shorting links shall be provided for all CT terminals.

11.1.9 Conductors shall be terminated with adequately sized compression type tinned copper lugs for connection to equipment terminals and strips. Stranded conductors shall be soldered at the ends before connections are made to the terminals.

11.1.10 All auxiliary equipment terminals shall be made with pressure type terminals.

11.1.11 Terminal strips shall be preferably separated from power circuits by metal barriers or enclosures.

11.1.12 All terminals shall be shrouded with plastic covers to prevent accidental contact.

11.1.13 Sufficient clearance shall be available between terminals where terminal lugs are fitted to them.

11.1.14 Terminals shall be designed to avoid bimetallic corrosion and breaking of strands due to excess pressure.

11.1.15 Terminal strip for outgoing control cable connections shall be accessible to facilitate working and testing with breaker in test / service condition and while the switchboard is energized.

11.1.16 Cable entries shall be from the base unless specified otherwise and a suitable gland plate shall be fitted to accommodate all cables. Single core cables shall be provided with a gland plate of non-magnetic material

11.2.0 WIRING

11.2.1 Control and power wiring shall be kept separate. Segregation shall be maintained between a.c. and d.c. circuits.

11.2.2 Terminals operating at different voltages or performing different functions shall be segregated from each other.

11.2.3 Bus wiring shall be independently routed and not pass through the busbar compartment, and shall be readily accessible.

11.2.4 Unless otherwise specified on the data sheet secondary wiring shall be carried out in black PVC insulated single core stranded cable to IEC 60227 with a minimum cross sectional area of 1.5 sq.mm.

11.2.5 The wiring shall be of suitable grade and shall have flame resisting insulation. The insulation grade shall be 1100V / 650V min.

11.2.6 Wiring shall be terminated in easily accessible terminal blocks.

11.2.7 The wires shall be arranged neatly and the two ends of each wire and the terminal blocks shall bear the circuit number by using unbreakable ferrules for identification purposes.

11.2.8 Control wiring wherever terminated shall be in single layer formation.

11.2.9 Wiring between terminals shall be continuous, joints are not permitted. All wiring shall be carried out in such a way as to avoid damage from over-tensioning, abrasion from sharp edges, insulation failure due to heat sources, etc. Crimped terminations shall be used.

11.2.10 All inter panel control wiring shall be taken through PVC sleeves and this shall be done by the switchgear manufacturer with identification of wires and terminals for interconnection.

11.2.11 All wiring taken to components on a hinged door shall be provided with additional protection such as flexible conduit.

11.2.12 Whenever a VT is mounted on the breaker carriage, all auxiliary wiring shall be done in conduits.

11.2.13 All spare contacts of aux. relays, timers, etc. shall be wired up to the terminal block.

12.0.0 INSULATION

12.1.0 The insulation between phases and between phases & ground for power or control conductors shall be made of suitable insulating material resistant to heat, dust and dampness. It shall be non-hygroscopic, mould proof and treated with suitable varnishes.

12.2.0 Minimum clearance between phases, or between connections of same phases separated electrically from each other, or between phases and ground, shall be as per relevant standards

13.0.0 EARTHING

13.1.0 Earthing arrangement shall be in accordance with relevant Indian Standards.

13.2.0 Continuous earthing strips of material and size specified in the data sheet shall be provided for the complete length of the switchboard. Strips shall be connected to the body of the switchboard by means of integral bolts, spring washers and nuts.

13.3.0 Earthing terminals shall be provided on the trucks to earth the body of the truck when pushed into the cubicle.

13.4.0 A minimum of 2 terminals shall be provided on the strip for external connections to earth grid.

13.5.0 One of the secondary terminals of CTs shall be earthed.

13.6.0 All doors and movable parts shall be connected to earth bus with flexible copper connection.

13.7.0 All non-current carrying metallic parts of the equipment shall be earthed.

13.8.0 Earth bus shall be extended up to each cable compartment and earthing bolts shall be provided to ground cable armours.

14.0.0 PAINTING AND LABELLING

14.1.0 The sheet steel housing and all the metal surfaces shall be properly cleaned and coated with two coats of anticorrosive paint over two coats of suitable primer. A final coat in gloss finish with the colour indicated shall also be given to the switchboard.

14.2.0 All panels shall have, on the front and the rear sides, nameplates in large sized letters, giving feeder details.

14.3.0 Painted MIMIC DIAGRAM shall be provided on all the panels of the switchboard, unless otherwise specified in the data sheet.

14.4.0 Special warning plates shall be provided on all removable covers or doors giving access to high voltage cables / bus bars and inside the switchboard also wherever considered necessary.

14.5.0 Nameplates shall be fastened by "screws" and not by adhesives.

14.6.0 Nameplates shall be of Non corrosive metal like stainless steel with letters engraved in it.

14.7.0 A nameplate with the switchgear designation shall be fixed at the top of the central panel

14.8.0 Name plates shall be provided for each equipment, such as lamps, Push Buttons, switches, relays, aux. contactors etc., mounted on the switchboard, indicating the operation / function

14.9.0 The size of the letters giving switchboard designation shall be 25 mm that for feeder details 20mm and for components 6 mm, unless otherwise specified in the data sheet.

15.0.0 FOUNDATION BOLTS

15.1.0 Necessary foundation channels (if not integral), bolts and nuts shall be supplied along with the switch board.

16.0.0 TEST CORDS AND TESTING PLUGS

16.1.0 Flexible test cord 2m long with plug and socket for testing the breakers in the withdrawn position shall be supplied in a separate case. Alternatively flexible cord used for test position shall have sufficient extra length to test the breaker in the withdrawn position also.

16.2.0 Earthing and testing plugs for cables and bus bars shall be supplied in a separate box.

17.0.0 EARTHING TRUCK

17.1.0 One number each Earthing Truck shall be supplied, unless otherwise specified in data sheet, for each switchboard. The Earthing truck shall be fully draw out pattern, complete with necessary

earthing links to facilitate earthing on the cable side. Locking facility shall be available. Earthing links shall be of size to withstand the fault current specified in the single line diagram/data sheet.

17.2.0 As an alternative to the above, vendor may offer integral earthing switch in each outgoing feeder of the switchboard. Such earthing switches shall be fitted with interlocks such that circuit breakers cannot be made "ON" while earthing switch is in the 'earth position'.

17.3.0 Earthing Truck shall be provided with Audio - Visual Annunciation, to prevent earthing of live cable.

18.0.0 SPARES AND SPECIAL TOOLS

18.1.0 Spare parts and special tools recommended for keeping in stock for trouble free operation of Circuit Breaker panel for a minimum period of 2 years shall be supplied. List and catalogue numbers of these spare parts shall also be furnished.

19.0.0 DRAWINGS

19.1.0 All drawings and documents as per Vendor Data Requirement shall be furnished. The control circuits shall be prepared by the manufacturer and the drawings shall be neat, legible and incorporating all requirements. The rating of all components such as voltage, ampere and wattage/VA shall be clearly indicated in component list.

1.0	**CIRCUIT BREAKER**	
1.1	Make	
1.2	Country of manufacture	
1.3	Type of reference	
1.4	Type of circuit breaker (VCB/MOCB/SF6)	
1.5	Conformity to standards	
1.6	Rated voltage	
1.7	Maximum permissible operating voltage	
1.8	Rated current	
1.9	Rated frequency	
1.10	Number of poles	
1.11	Rated insulation level – (a) Indoor (b) Outdoor	
1.12	Rated line charging breaking current	
1.13	Rated cable charging breaking current	
1.14	Rated capacitor breaking current	
1.15	Rated small inductive breaking current	
1.16	Rated symmetrical short circuit breaking capacity	……..KA / ……MVA
1.17	Rated asymmetrical short circuit	
1.18	Rated transient recovery voltage	
1.19	Rated making current (KA peak)	
1.20	Rated short time current - (a) 1 Sec. (b) 3 Sec.	
1.21	Rated duty cycle	
1.22	Opening time	
1.23	Arc duration	
1.24	Total breaking time at rated Short Circuit capacity	
1.25	Closing time	
1.26	No. of breaks per phase	
1.27	Total length of break per phase	
1.28	Type of main contact	
1.29	Type of arcing contact	
1.30	Type of arc control employed	
1.31	Minimum clearance in oil / vacuum / SF6	
	(a) Between phases	
	(b) Live parts to earth	
1.32	Minimum clearance in air	

	(a) Between phases	
	(b) Live parts to earth	
1.33	Whether phase barriers are provided	
1.34	Quantity of oil in complete 3-phase circuit breaker	
1.35	No. of permissible operations on fault before oil charging	
1.36	Whether oil level indicator is provided	
1.37	No. of aux. Contacts (NO+NC) (Without multiplying contactor)	
1.38	Method of power closing offered	
1.39	Whether manual closing & tripping facility is available, in addition to the power closing & tripping	
1.40	Whether this extra manual closing be used for switching	
1.41	Whether the circuit breaker is fitted with fixed trip or trip free mechanism	
1.42	Whether contact touches and part when CB tried to close with tripping impulse prevailing or do not touch at all	
1.43	Normal voltage of the spring charging motor	
1.44	Power at normal voltage required for spring charging motor	
1.45	Time taken to charge the spring completely by the motor	
1.46	Normal and minimum operating voltage of closing mechanism	
1.47	Power at normal voltage required for closing coil	
1.48	Normal and minimum voltage required for trip coil	
1.49	Power at normal voltage required for trip coil	
1.50	Normal & minimum voltage required for operation of solenoid closing mechanism	
1.51	Current at normal voltage, required for solenoid operation	
1.52	Whether antipumping relays and circuitry provided along with solenoid operating mechanism	
1.53	Short circuit type test certificate No. or report No.	
1.54	Short circuit type test certificate or report enclosed	
2.0	**BUS BARS**	
2.1	Conformity to standards	
2.2	Material & grade of bus bars	
2.3	Bus bars PVC covered or not	
2.4	Type of covering	

2.5	Continuous current rating	
2.6	Whether the size of bus bars is same throughout switchboard	
2.7	Size of bus bars – Horizontal Vertical	
2.8	Colour coding	
2.9	Type of insulation	
2.10	Type of insulation at joints / tap-offs	
2.11	Derating factor applied in view of PVC covering	
2.12	Peak dynamic withstand capacity	
2.13	Details of bus bar supports	
2.14	Rated short time current for 1 second	
2.15	Rated short time current for 3 second	
2.16	Guaranteed temp. rise at rated current for bare bus bars	
2.17	Guaranteed temp. rise at rated current for PVC bus bars	
2.18	Short Circuit Type Test Certificates attached or not	
2.19	Provision for extension of the switch board	
2.20	Clearance of bus bars in air	
	a) Phase to phase	
	b) Phase to neutral	
	c) Phase to earth	
3.0	**CURRENT TRANSFORMERS**	
3.1	Conformity to standards	
3.2	Make	
3.3	Bar primary / wound Type	
3.4	VA capacity	
3.5	Insulation class	
3.6	Epoxy resin cast or other type with details	
3.7	Knee point voltage (V_k)	
	Excitation current at $V_k/2$	
3.8	Accuracy Class for O/C & E/F protection	
3.9	Accuracy Class for metering	
3.10	Accuracy Class for special protection (REF/Diff)	
3.11	Short time current rating	
3.12	Duration of rated short time current	
3.13	Short circuit type test certificate attached or not	
3.14	Accuracy limit factor for protection class CTs	
3.15	Instrument security factor for metering CTs	
3.16	Guaranteed temperature rise at rated current	
4.0	**VOLTAGE TRANSFORMERS**	
4.1	Conformity to standards	
4.2	Oil immersed / resin cast type	

4.3	VA capacity	
4.4	Withdrawable or not	
4.5	Connection	
4.6	Accuracy Class	
4.7	Quantity of oil required	
4.8	Current limiting resistor provided or not?	
4.9	VTs connected to cable side or bus bar side	
4.10	Mounted on top of switchboard or in separate PT panel	
5.0	**RELAYS**	
5.1	Conformity to standards	
5.2	Make	
5.3	Auxiliary voltage	
5.4	Withdrawal features provided or not	
5.5	Contact - Hand reset / self reset?	
5.6	Communication protocol	
5.7	Whether hand reset flags available?	
5.8	Mounting – Flush / Projection	
5.9	Attach catalogues of different types of relays with details of VA consumption, operating data, Contact arrangement etc.	
6.0	**METERS**	
6.1	Conformity to standards	
6.2	Make	
6.3	Type	
6.4	Mounting: flush / projection	
6.5	Size of meters	
6.6	Scale size	
6.7	Accuracy Class	
6.8	VA consumption of different meters	
6.9	Communication protocol	
7.0	**INDICATION LAMPS**	
7.1	Conformity to standards	
7.2	Make	
7.3	Type	
7.4	Watts rating at specified auxiliary voltage	
7.5	Protective resistors provided or not	
8.0	**PARTICULARS OF THE EQUIPMENT**	
8.1	Material and area of cross section of conductor between	
	a) Bus bars and circuit breaker / switch or switch fuse (if any) of each rating	
	b) Switch and fuses of each rating	
8.2	Material and voltage class (grade) of insulation of above conductors, if insulated	
8.3	Size & material of earth bus bar	

8.4	Thickness of panel doors (mm)	
8.5	Thickness of load bearing members (mm)	
8.6	Thickness of base frame (mm)	
8.7	Weight of CB truck complete with oil (Kg)	
8.8	Weight of switchgear complete with CB (Kg)	
8.9	Weight of each S/B (kg) (Dynamic loading, if any, shall be furnished)	
8.10	Shipping weight of the largest consignment and size	
8.11	Size of each panel / W x D x H	
8.12	Minimum distance required on the front side for withdrawal of circuit breaker	
8.13	Whether the equipment dust, damp and vermin proof	
8.14	Details of steps taken to render equipment dust, damp and vermin proof	
8.15	Details of anti corrosive treatment to make eqpt. suitable for the environment	
8.16	Technical details / catalogues / /leaflets & type test certificate of components / items enclosed	
8.17	Details of earthing truck	
8.18	Rating details & technical particulars of vacuum contactor (if any)	
8.19	Rating details & technical particulars of HV fuses (if any)	
8.20	Technical particulars of surge absorbers (if any)	
9.0	**SPECIAL FEATURES OF SF6/VCB BREAKERS**	
9.1	Normal working pressure of SF6 gas	
9.2	Material of contacts	
9.3	Number of operation of breaker on fault before changing the SF6 bottle	
9.4	Number of operation of breaker at rated current	
9.5	Maximum and minimum pressure of SF6 for safe operation	
9.6	Material of shutter / contact barrier	
9.7	Guaranteed leakage of SF6 gas / annum	
9.8	Special features provided for the breaker panel	

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for design, manufacture, testing and supply of Medium Voltage Switch boards like Power Control Centres (PCC), Motor Control Centres (MCC), Power cum Motor Control Centres (PMCC), Auxiliary switch boards, Lighting Switchboards, etc.

2.0.0 REFERENCES

2.1.0 Following documents shall be read in conjunction with this specification:

2.1.1 **Engineering specification and Data sheet** of **General requirements for Electrics**

2.1.2 **Data sheet** of **Medium Voltage Switchboards**

2.1.3 **Technical Particulars** of **Medium Voltage Switchboards**

3.0.0 STANDARDS

3.1.0 Requirements laid down in the latest revisions of the following Indian Standards and other relevant standards & regulations shall be strictly adhered to:

IS: 8623(Part I)	Specification for Low- Voltage Switchgear & Control gear Assemblies
IS/IEC60947-1	Low voltage switch gear and control gear :part 1-General rules
IS/IEC60947-3	Low voltage switch gear and control gear :part 3-Switches, disconnectors,Switch disconnectors and fuse combination units

IS: 5578 Guide for marking of insulated conductors
IS: 11353 Guide for uniform system of marking and identification of conductors and apparatus terminals
IS: 10118 Code of practice for selection, installation, and maintenance of switchgear and control gear
IS: 13118 Circuit breakers
IS:13703 Specification of low voltage fuses for voltages not exceeding 1000V-AC or1500V-DC
IS:13947:part4:sec:1 Specification for low voltage switchgear and control gear -Part 4;Contactors and motor starters-Sec-1:Electro mechanical contactors and motor starters

IS: 2705 Current Transformers
IS: 4201 Application guide for CTs
IS: 3231 Electrical relays for power systems protection
IS: 3842 Application guide for electrical relays for ac systems
IS:13947:part5:sec:1 Specification for low voltage switchgear and control gear -Part 5-control circuit devices and switching elements-sec1:Electromechanical control circuit devices
IS:8828 Electrical accessories- Circuit breakers for over current protection for house hold and similar installations

IS: 1248 Direct acting electrical indicating instruments
IS: 13010 A C watthour meters class 0.5,1.0 and 2.0- Specification
IS: 13779 AC static watthour meter ,class 1.0 and 2.0- specification
IS: 8530 Maximum demand indicators , class 1.0
IS: 14415 Volt ampere hour meter for restricted power factor range- specification
IS: 14390 Volt ampere reactive hour meter, class 3.0
IS: 14372 Volt ampere hour meter for full power factor range
IS: 1901 Visual indicator lamps
IS: 2551 Danger notice plates
IS: 732 Code of practice for electrical wiring installations
IS: 900 Code of practice for installation and maintenance of induction motors
IS: 3043 Code of practice for earthing

4.0.0 SERVICE CONDITIONS

4.1.0 The equipment shall be designed to operate satisfactorily at rated load under the service conditions and power supply conditions specified in the data sheet of " General requirements for electrics" and data sheet of "Medium voltage switch boards".

5.0.0 CONSTRUCTION & GENERAL REQUIREMENTS

5.1.0 All switchboards shall comply with the requirements of IS:8623 applicable for Low-Voltage Switchgear and control gear assemblies.

5.2.0 The switchboard shall be of folded sheet steel construction, fully compartmentalized, floor mounted, free standing type and dust, damp &vermin proof. The degree of protection shall be as specified in the data sheet. Vertical units shall be assembled to form a continuous line up of uniform height and front line up.

5.3.0 Thickness of sheet steel shall not be less than 2 mm except for certain non load bearing members like instrument plates, partitions, doors, etc. for which a minimum thickness of 1.6 mm shall be ensured.

5.4.0 Doors and openings shall be provided with neoprene gaskets. All hardware shall be corrosion resistant.

5.5.0 All doors shall be hinged at one end and shall be bolted (knob type) on other end. All hinges shall be of concealed design for elegant appearance.

5.6.0 Adequate lifting facilities shall be provided on each section. Lifting eyes may be of removable/foldable design. When removed, these shall not leave any openings on the boards.

5.7.0 All barriers used shall be manufactured from non-inflammable material.

5.8.0 Bus bars shall be housed in separate metallic compartment (horizontal bus bar chamber & vertical bus bar chamber) and shall be accessible for inspection only with special tools.

5.9.0 Individual feeder modules shall be housed in independent and separate enclosed compartments separated from each other by metallic barriers. Each vertical row of modules shall have independent vertical bus bars, vertical bus bar chambers, and cable alleys.

5.10.0 The design of the switchboard shall be such as to allow for extension of vertical panels at both the ends. The ends of the busbars shall be suitably drilled and the side covers of the horizontal bus bar chambers at extreme ends shall be provided with opening, which shall be covered with a gasketted plate screwed to the panel.

5.11.0 In the case of single front panels without rear access (as specified in the data sheet), access to all components, cable connections, bus bars, etc. shall be from the front only.

5.12.0 The equipment shall be designed to ensure complete safety during operation, inspection, connection of cables, relocation of outgoing circuits and maintenance even with the bus bar system energized. Features which prevent shorting of power and / or control terminals due to accidental dropping of maintenance tools etc., inside the switchboard shall be provided. Checking and removal of components shall be possible without disturbing adjacent components. All auxiliary equipment / components shall be easily accessible.

5.13.0 All exposed live terminals in the cable alley and incomer terminals inside modules shall be covered or shrouded to prevent accidental contact.

5.14.0 The incoming power connection shall be through bus trunking or cables as specified in the data sheet. Ample space for connection of these cables / bus trunking shall be provided.

5.15.0 For lighting and auxiliary switchboards, the neutral conductors & bus bars shall have the same current carrying capacity as that of the phase conductors & busbars.

5.16.0 Mechanical castle key interlocks and electrical interlocks shall be provided between the incomers and bus couplers to prevent paralleling of incoming feeders, if specified in the data sheet.

5.17.0 Necessary foundation bolts, nuts and washers shall be supplied along with the equipment.

5.18.0 For additional / special requirements of **Drawout switch boards (non breaker panels) refer clause 24.0.0** and for requirements of **Circuit breaker panels refer clause 25.0.0**below.

5.19.0 **Temperature rise test** if specified (in Scope of inspection and tests / Data sheet), shall be conducted on one unit of each type of MV switchboard, before despatch. Test shall be conducted for the specified full load rating of the bus bars. Test shall be done for both power and neutral bus in both horizontal and vertical bus bar system. Diversity factor given in Table 1 of IS:8623 shall not be applicable. Tests shall comply with he requirements of IS:8623,Clause 8.2.1, verification of temperature rise limits. Testing procedure to be adopted shall be furnished in the bid. Bus bar temperature rise shall be limited to 40 ^{o} C. Tests shall be conducted in the presence of FEDO/ owner representatives.

6.0.0 **BUS BARS**

6.1.0 Busbars shall be of high conductivity aluminum/copper as specified in the data sheet. Insulating sleeves complete with necessary joint shrouds shall be provided for bus bars, if specified in the data sheet.

6.2.0 Maximum allowable current density for busbars shall be 1.25 A/mm^2 for copper and 0.78 A/mm^{2}for Aluminium.

6.3.0 The horizontal and vertical bus bars shall be rated for the same fault level specified in the data sheet.

6.4.0 Horizontal busbars shall be of uniform cross section throughout the length of the switchboard. Vertical busbars of all vertical panels of the switch board shall also be of uniform cross section.

6.5.0 The bus bars and bus bar supports shall withstand the dynamic, thermal & magnetic stresses and strains due to the maximum short circuit current corresponding to the fault level indicated in the data sheet, without any deformation, deterioration or damage.

6.6.0 Rigid insulating barriers / protection guards /wire meshes shall be provided between the group of live bus bars and other parts, so as to eliminate danger to personnel due to accidental contact.

6.7.0 The bus bar supports shall be of non-hygroscopic material with anti tracking features to prevent flashovers. These shall have high tracking index and be mechanically strong. Hylam is not acceptable.

6.8.0 Appropriate identification shall be provided on the busbars for distinguishing the various phases, neutral and control / auxiliary buses.

7.0.0 FEEDER ARRANGEMENT

7.1.0 Feeder module / compartment sizes shall be integral multiples of one or two basic sizes.

7.2.0 Indicating lamps, meters and push buttons shall be mounted flush with the front-hinged cover.

7.3.0 The control components, except those coming on doors, shall be mounted on a base plate, fixed on the frame of the module.

7.4.0 The incoming feeder shall be arranged preferably in the middle of each group of feeders, in such a way that loads are distributed equally on either side.

7.5.0 The feeder arrangement shall be such that the operating height (ie. operating handle, switches, push buttons, etc.) lies **within 1828 mm, but above 300mm**, from the floor level.

8.0.0 CABLE COMPARTMENTS

8.1.0 Cable compartments / cable alleys shall be provided for easy termination of all incoming and outgoing cables. The width of this cable alley shall be sufficient to accommodate all the cables and shall have free access for cable terminations and in any case shall not be less than 150mm. Cable alleys shall be provided with suitable doors. It shall be possible to carry out maintenance work safely on cable connections to anyone circuit, with the bus bars and adjacent circuit live.

8.2.0 Adequate supports and facilities for clamping shall be provided for cables, wherever necessary.

8.3.0 A horizontal wire way, extending over the entire length, shall be provided at the top / bottom for inter panel wiring.

8.4.0 Removable gland plates, having a minimum thickness of 2mm, shall be provided. Gland plates for glanding for single core cables shall be made of nonmagnetic material.

8.5.0 Cable glands shall be supplied loose along with the equipment for fixing them at site, if specified in the data sheet.

9.0.0 CABLE TERMINATION

9.1.0 All terminal blocks shall have adequate current carrying capacity, heavy duty & break resistant.

9.2.0 Terminals shall be compact and shall have high dielectric strength so as to prevent flashover and have thermal strength to prevent deterioration. All terminals shall be mounted on aluminium rails, with provision for addition of terminals.

9.3.0 Direct conductor termination type terminals of approved make will be acceptable up to 10mm^2 size. Bolted type terminals with crimping type lugs shall be provided for all cable connections greater than 10mm^2.

9.4.0 Sufficient clearances shall be available between terminals when terminal lugs are fitted to them.

9.5.0 Not more than two wires (one incoming & one outgoing) shall be connected per terminal.

9.6.0 Minimum 10% spare terminals shall be provided on each control terminal block, subject to a minimum of two.

9.7.0 Shorting links shall be provided for CT terminals.

9.8.0 Identification numbering / lettering shall be provided for each terminal.

9.9.0 Necessary hardware required for cable termination like nuts ,bolts, washers, spacers etc. for incoming and outgoing feeder shall be fitted and supplied.

10.0.0 WIRING

10.1.0 The switchboard shall be completely pre-wired and ready for external connections at site.

10.2.0 All control wiring shall be carried out through common wire ways. These shall not cross the bus bar chamber. All control wiring shall be easily accessible for maintenance.

10.3.0 Necessary colour codes shall be adopted for power and control wiring for easy identification.

10.4.0 Power wiring shall be carried out with PVC insulated, stranded copper conductors of 650 Volts grade having adequate current carrying capacity. Minimum size of conductor for power wiring shall be 4mm^2 copper.

10.5.0 Control wiring shall be carried out with 650 V grade, PVC insulated, copper conductor of size not less than 1.5 mm^2. Circuits involving current transformers shall have 2.5mm^2 ,1100 V grade conductors.

10.6.0 Wiring shall be terminated in easily accessible terminal blocks. The wires shall be arranged neatly and the two ends of each wire and terminal block shall bear identification number/letter using unbreakable ferrules.

10.7.0 Control wiring wherever terminated shall be in single layer formation.

10.8.0 All inter panel control wiring shall be taken through PVC sleeves and this shall be done by the switch board manufacturer with the identification of wires and terminals for interconnection.

11.0.0 INSULATION

11.1.0 All insulating materials shall be non-hygroscopic, mould proof and treated with suitable varnishes. Hylam shall not be used.

12.0.0 EARTHING

12.1.0 A continuous earth bus as specified in the datasheet shall be provided for the entire length of the switchboard.

12.2.0 A minimum of 2 terminals shall be provided on the bus for external connection to earth grid.

12.3.0 All panels shall be properly connected to the earth bus.

12.5.0 All non-current carrying metallic parts of the equipment shall be earthed.

12.6.0 All hinged doors and covers shall be provided with suitable flexible earthing connections.

13.0.0 NAME PLATE

13.1.0 A nameplate with the switchboard designation shall be fixed at the top of the central panel. Separate nameplates, giving feeder designation shall be provided on each compartment.

13.2.0 Necessary functional nameplate shall be provided for each component such as lamps, PBs, relays, switches, etc. mounted on the panel front.

13.3.0 Nameplates shall be of Non corrosive metal like stainless steel with letters engraved in it.

13.4.0 The component nos. shall be painted / suitably identified inside the panel at appropriate points to give a permanent marking.

14.0.0 MOULDED CASE CIRCUIT BREAKERS

14.1.0 Where moulded case circuit breakers are used for feeder circuit protection, rating and characteristics shall be chosen in such a way as to ensure proper discrimination with other upstream and downstream protective devices within the assembly.

14.2.0 The MCCB should be current limiting type with trip time of less than 10 milli second under short circuit conditions. The MCCB should be either 3 or 4 poles as specified in data sheet.

14.3.0 MCCB shall comply with the requirements of the relevant standards IS13947 – Part 2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

14.4.0 MCCB shall comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses

14.5.0 The breaking capacity of MCCB shall be as specified in the schedule of quantities. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCB's for motor application should be selected in line with Type-2 Co-ordination as per IS 13947-2. The breaker as supplied with ROM should meet IP54 degree of protection.

15.0.0 FEEDER LOAD BREAK SWITCHES

15.1.0 The switches shall be of air break type, AC22 /AC23 utilization category as per IS. MinimumAC22 rating of the switch used shall be 63 A.

15.2.0 The switches shall have a quick-make, quick-break, fault-make, load-break mechanism operated by an external insulated earthed handle, complete with ON-OFF position indicator/ dial plates.

15.3.0 Load break switches of motor starter feeders shall have AC23 rating corresponding to full load current of the motor connected. Also theAC22 rating of the switches used shall not be less than the rating of the HRC fuses in the feeder.

15.5.0 The switch fuse feeders shall be provided with load break switches of AC22 utilization category.

15.6.0 Bolted type removable copper links of adequate size shall be provided for neutral, in all incomer feeders and outgoing feeders with TPN switch fuse units.

15.7.0 The cubicle door shall be interlocked with the switch mechanism so that the door cannot be opened unless the switch is in the OFF position.

15.8.0 Padlocking facility in OFF position shall be provided for feeder switches.

15.9.0 In the event of an independent control circuit supply to the coils of the contactors, the main switch shall be provided with necessary auxiliary contacts to disconnect this control supply as well, when the switch is turned to 'OFF' position for isolating the main supply.

16.0.0 MINIATURE CIRCUIT BREAKERS (MCB)

16.1.0 Miniature Circuit Breaker shall comply with IS-8828. Miniature circuit breakers shall be quick make and break type for 240/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection.

16.2.0 The breaking capacity shall not be less than 10 KA at 415 Volts AC. MCB's shall be DIN mounted. The MCB shall be Current Limiting type (Class-3). MCB's shall be C Type as per their Tripping Characteristic curves defined by the manufacturer, unless otherwise specified in the data sheet.

16.3.0 The MCB shall have the minimum power loss (Watts) per pole defined as per the IS/IEC and the manufacturer shall publish the values. MCB shall ensure complete electrical isolation & downstream circuit or equipment when the MCB is switched OFF.

16.4.0 The housing shall be heat resistant and having high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP, TPN and 4 Pole miniature circuit breakers shall have a common trip bar independent to the external operating handle.

17.0.0 FUSES

17.1.0 All fuses shall be HRC link type , suitable for industrial application conforming to IS: 13703 Part II.

17.2.0 Selection of fuses for motor feeders shall be as per IS: 900.

17.3.0 All power and control fuses shall be provided with distinct operation indicators, to show whether they have operated or not.

17.4.0 For all fuses provided in the fuse holders, necessary viewing aperture shall be provided on the fuse holder for locating the blown out fuses.

17.5.0 Fuse holders and fuse bases shall be made of unbreakable non-inflammable and non-hygroscopic material, preferably of phenolic mouldings.

17.6.0 Fuse pullers of different sizes required for inserting and removing HRC fuses shall be supplied for each switchboard.

18.0.0 STARTER-CONTACTORS

18.1.0 Starter contactors shall be electromagnetic, air break type, suitable for uninterrupted duty and of AC3 / AC4 utilization category as specified in data sheet, conforming to relevant standards.

18.2.0 The operating coil shall be vacuum impregnated, with special varnish, to remove all traces of air and moisture. Alternatively, it can be of resin cast material as well.

18.3.0 The holding coils shall be rated for the control voltage specified in the data sheet.

18.4.0 If specified in data sheet, the holding coils shall be provided with delayed (up to 5 seconds) under voltage release features.

18.5.0 Contactors shall preferably have switching position operation indicator.

18.6.0 A minimum of 1 N/O and 1 N/C spare auxiliary contacts, in addition to those required for control circuits, shall be available for each contactor. (If necessary, add on blocks or auxiliary contactor can be provided.)

18.7.0 Wherever control voltage is DC, necessary series economy resistors shall be provided in the control circuits, to reduce the DC load on the battery / rectifier.

18.8.0 Type of co-ordination between contactor, overload protective device and short circuit protective device shall conform to **Type II** as per relevant standards.

19.0.0 OVERLOAD RELAYS

19.1.0 All overload relays shall be designed to nullify the effects on settings due to changes in ambient temperature and humidity and they shall have adjustable accurately calibrated settings.

19.2.0 Overload protection shall be available for all the phases.

19.3.0 The over load relay shall be manual / auto reset type as specified in the data sheet. For manual reset type, reset knob / push button shall be provided on the cubicle door, if specified in the data sheet.

19.4.0 Overload relays shall be either direct connected or CT operated, depending on the rating of motor. In the case of CT operated relays, cast resin insulated CTs shall be included in the scope of supply of vendor.

19.5.0 Thermal bimetallic overload relays provided for motor feeders shall have integral / built in **single phasing preventing feature**. If built in feature is not available, separate current operated type single phasing preventor shall be provided.

19.6.0 If separate single phasing preventor (SPP) is provided, the same shall be fail safe type and shall function without any external power supply. In case of failure of internal wiring, the relay shall trip the motor. The SPP shall be suitable for protection of the nonreversible as well as reversible motors.

19.7.0 Thermal over load relays for motor feeders of blowers, fans, agitators, crushers, compressors and mills shall be of **heavy duty, delayed action type** to allow for more starting time. If required heavy-duty overload relays are not available, necessary bypass contactor & timer arrangement circuit shall be provided to allow for more starting time.

19.8.0 Contactor and overload relay shall be selected so as to withstand the let through energy of the connected HRC fuse and MCCB's in the feeder, and consequent thermal and dynamic effects.

20.0.0 CURRENT TRANSFORMERS

20.1.0 Current Transformers (CTs) shall be of cast resin insulated type, and shall conform to relevant standards like IS: 2705 & IS: 4201.

20.2.0 Ratings of CTs provided shall match the specific requirements of the meters and protective relays involved.

20.3.0 CTs provided in circuit breaker panels shall withstand the maximum short circuit current for a minimum of 1 second. However for motor feeders the minimum duration can be 0.6seconds.

20.4.0 Separate CTs / cores shall be used for metering and protection. Dual purpose CTs are not acceptable.

20.5.0 CTs for metering purposes shall have adequate capacity to cater for 130% of full load conditions. Metering CTs shall have an Instrument Security Factor not more than 5 and an accuracy class not more than 1.5 unless otherwise specified.

20.6.0 CTs for protection purposes shall have sufficient accuracy, burden and accuracy limit factor for necessary coordination / discrimination for clearing faults. Accuracy limit factor for protection CT shall not be less than 10 and accuracy class shall be 5 P. CTs for differential / REF protection shall be of class 'PS'.

20.7.0 All CT terminals and terminals to remote meters shall be provided with links to facilitate shorting as and when required.

20.8.0 CTs shall be provided with polarity markings adjacent to terminals, both for primary and secondary. These shall be legible even after years of service.

20.9.0 1 No. current transformer with 1 Amp secondary rating shall be provided for each motor feeder having a motor rating of **15 KW and above**, unless otherwise specified in the data sheet, for remote ammeter. Burden of this CT shall be sufficient to compensate for the lead burden and for the burden of remote ammeter. As per data sheet, if same CT is used for local and remote meters, it shall have adequate burden to meet the total requirement.

20.10.0 If standby earth fault protection (earth leakage protection) and / or restricted earth fault protection are provided on **incoming breaker panel**s, one number ground CT with suitable VA and ratio for standby earth fault protection and one number ground CT with suitable ratio, knee point voltage and exciting current for restricted earth fault protection, shall be supplied loose, per incomer, in weatherproof enclosure fitted with cable glands.

21.0.0 RELAYS

21.1.0 Relays shall conform to IS 3842 & IS 3231.

21.2.0 Protective relays shall be flush mounted drawout type. The type and manufacture of the relays shall be approved by the buyer.

21.3.0 All relays shall have hand reset type operation indicators and initiating contacts. Indicators shall be visible from front side of the panel. It shall be possible to reset them without opening the relay case.

21.4.0 Protective relays shall be suitable for the CT secondary current.

21.5.0 The relay shall have provision for insertion of test plug at the front for **testing and calibration** purposes. It shall be possible to test the relays without disconnecting the wiring and without withdrawing the relay. The insertion of the test plug shall automatically short circuit the CTs and permit extension of external power supply to the relay.

21.6.0 Circuit breaker feeders with protective relays shall be provided with **high speed master tripping relay** of the lock out type with hand reset feature and coil cut off contact.

21.7.0 It shall be ensured, by checking with the relay manufacturer, that with the accuracy limit factor of current transformer provided, the thermal withstand capability of relays will not get exceeded for the fault level prescribed.

21.8.0 If **composite motor protection relays** are prescribed in the data sheet for motor feeders, thermal withstand characteristics of motors will be furnished on receipt from motor manufacturer. Selection of most suitable version of motor protection relay based on the motor characteristics, to provide adequate protection to the motor, shall be the responsibility of the switchboard supplier. Necessary application checks shall be carried out by vendor in consultation with the relay manufacturer and recommended settings along with calculations shall be submitted.

21.9.0 Vendor shall furnish complete **relay coordination** details applicable. This is required to check the adequacy of CT ratios, VA ratings, relay types and characteristics, etc. and to determine the optimum settings to be adopted for ensuring selectivity and backup protection. While selecting the settings, manufacturing tolerances of devices shall be considered. Settings for all adjustable devices shall be

tabulated. Graphs shall also be drawn to match motor characteristics with motor protection relay characteristics.

22.0.0 CONTROL TRANSFORMERS

22.1.0 Control transformer shall be provided on each module unless otherwise specified in the datasheet, wherever control voltage specified / required is different from the mains voltage.

22.2.0 Control transformer shall be cast resin-insulated type.

22.3.0 Control transformer shall have ± 5% voltage tappings on the primary side and with center tap of secondary winding earthed. Where common control transformer is specified in data sheet for bus section additional tappings of ± 2.5% shall also be provided.

22.4.0 All Control transformers shall have HRC fuse protection on primary side and double pole MCB on secondary side. Where common control transformer's are specified in the data sheet for bus section, suitable switch fuse unit shall be provided on the primary side.

22.5.0 Control transformer provided in individual module shall have adequate capacity to feed the control loads of the feeder as well as the inrush VA of the contactors & relays of the feeder.

22.6.0 Where common control transformers are specified in the data sheet for each bus section, each unit shall have adequate capacity to feed all control loads (including those of spare panels) of particular bus section and any one of the adjacent bus sections as well as the inrush VA of contactors & relays applicable. In the event of failure of the control transformer of one bus section, control transformer feeding any one of its adjacent bus sections shall be capable of feeding the same also, in addition to its own loads, by temporary interconnection.

22.7.0 Where control transformers are provided bus section wise, the compartment housing the control transformer shall preferably be located towards the bottom of the switchboard, to facilitate maintenance and replacement.

22.8.0 Wherever module control transformers are envisaged in draw out switchboards, a separate control transformer (complete with switch fuse on primary, double pole MCB on secondary and centre tap of secondary winding earthed) for test supply shall be provided along with associated wiring and accessories.

22.9.0 Where common control transformers are provided, the control supply to module shall get automatically isolated when the feeder switch is switched OFF.

23.0.0 INDICATING INSTRUMENTS

23.1.0. Meters shall be flush mounted and of a type and make approved by the buyer.

23.2.0 All meters shall be square type of size 96mm x 96 mm unless otherwise specified in the datasheet. Dials shall be white with black numerals and letters.

23.3.0 A moving iron voltmeter having a range of 0-500Volts AC shall be provided, along with a suitable selector switch, to read all line to line voltages on the incoming side of incoming feeders. The selector switches shall have 3 way and OFF positions. Necessary facia plates to denote switch positions shall be provided. Necessary control fuses shall be provided in the voltmeter circuit.

23.4.0 Voltmeter shall be of Class 1.5 accuracy as per IS and shall have suppressed scale for the lower values in the range.

23.5.0 Ammeters shall be of accuracy Class 1.5 as per IS unless otherwise specified.

23.6.0 Ammeter having suitable range shall be provided along with ammeter selector switch to read line currents in the incomer feeders. The selector switches shall have 3 way and OFF position. Necessary

facia plates to denote switch positions shall be provided. These ammeters shall have approximately uniform scale up to about full load current and suppressed end scale from 100% to at least for 150% full load.

23.7.0 Ammeter, if provided for motor feeders as per data sheet, shall have suppressed overload range (cramped end scale), to read the starting current of 600-800% and 200-400% of normal full load current of motors for DOL starting and for star delta starting respectively.

23.8.0 A red mark shall be provided on the ammeter dial, corresponding to the full load current.

23.9.0 All ammeters shall be operated through current transformers and not directly connected. Calibration of the ammeters shall tally with the ratio of the current transformers.

23.10.0 Cushion stoppers and zero correction screws shall be provided for all meters.

23.11.0 Energy meter, kilowatt meter and power factor meter, if provided as per data sheet, shall be operated through current transformer only. The rating shall correspond to full load requirements. The multiplication factor, if any, shall be furnished and exhibited by the side of the meter.

23.12.0 All lighting feeders shall be provided with CT operated ammeter with selector switch and energy meter suitable to measure unbalanced loads on a 3-phase 4 wire system.

23.13.0 All selector switches shall be of rotary type, spring loaded and of robust construction. The operating handle of these switches shall be knob type and of black colour.

23.14.0 Digital type meters shall be provided wherever specified in the data sheet.

23.15.0 All auxiliary equipment such as shunts, transducers, CTs, VTs, etc. that are required shall also be included in the supply of the switchboard.

24.0.0 INDICATING LAMPS, PUSH BUTTONS, CONTROL SWITCHES, ETC.

24.1.0 INDICATING LAMPS

24.1.1 Indicating lamps shall be of long life LED type and shall be indigenously available..

24.1.2 Necessary preventive measures shall be ensured to avoid any malfunction of the connected circuit in the case of any fault in the indicating LED's.

24.1.3 All signaling lamps must have clarity of colour .The colour shall be in LED and not as an applied coating

24.1.4 Necessary protective fuses shall be provided for the lamp circuit in breaker feeders with shunt trip arrangements.

24.2.0 PUSH BUTTONS

24.2.1 Number of PBs like START, STOP, REVERSE etc. required are given in the data sheet. Colour of push buttons knobs shall be as per relevant IS.

24.2.2 All push buttons shall have 1 N/O + N/C contacts, unless otherwise required.

24.2.3 All push buttons shall be provided with legend plates to identify the function or operation.

24.3.0 **Local / Remote change over switch** shall be provided, if specified in the data sheet, when starting is envisaged from more than one location.

24.4.0 All **Control switches** shall be preferably of rotary type with operating knob. They shall have proper designation plates.

25.0.0 ANTICONDENSATION HEATERS

25.1.0 Anti condensation heater of adequate capacity, rated for 240 V AC, shall be provided in every vertical panel, in easily accessible position. For double front switchboards, heaters shall be provided on both the fronts.

25.2.0 Necessary two pole ONOFF switch with HRC fuse & neutral link (or two pole MCBs) shall be provided for each anti condensation heater circuit along with suitable thermostat for automatic temperature control.

25.3.0 Heater supply to individual panel heaters in each bus section shall be availed through a separate switch fuse feeder complete with suitably rated two pole switch, HRC fuse, neutral link, associated heater supply bus/wiring, etc.

25.4.0 Wiring of anti condensation heaters shall be isolated or separately bundled from other internal wiring , preferably using a different colour.

25.5.0 If anti condensation heater is specified in data sheet, space heater supply shall be taken from the outgoing end of motor isolator and shall be wired through an MCB and separate auxiliary contactor, coil supply of it shall be through the NC contact of the main contactor.

26.0.0 DRAWOUT SWITCHBOARDS

26.1.0 The feeders shall be fully draw out type.

26.2.0 All draw out modules shall have distinct and stable TEST position, SERVICE position & ISOLATED (WITHDRAWN) position.

26.3.0 All power contacts (both on bus bar side and cable side) shall be of fully draw out, self aligning, plug in design, which get automatically disconnected when the draw out module is withdrawn from the connected (SERVICE) position. Removable male and female contacts preferred.

26.4.0 Wiring for neutral may be in the fixed portion of the compartment. Where neutral connection is required for control purposes within the module, they shall be through draw out contacts providing full draw out facility.

26.5.0 All control contacts also shall be fully draw out self aligning type which get automatically connected/ disconnected depending on the circuit requirements, when draw out module is withdrawn to TEST / ISOLATED positions.

26.6.0 Manual plug-in plug-out arrangement for control contacts is not acceptable.

26.7.0 The design of the contacts shall be such as to increase the contact pressure during starting and short-circuiting conditions.

26.8.0 Necessary separation barriers shall be envisaged between pairs of power contacts to prevent flashovers.

26.9.0 Draw out arrangement shall be designed in such a way that withdrawing and plugging in of the trolley are achieved with smooth and reliable operation and without causing any damage or thrust to the plug in type contacts.

26.10.0 Withdrawable trolley/ chassis shall be preferably with screw cranking arrangement and/or guide vanes, such that trolley movement is positively guided and self aligning type. The trolley must move on low friction rolling mounts.

26.11.0 Trolley pad locking switch and latch /trolley clamping captive screw shall be provided for the fully inserted position.

26.12.0 There shall be positive indication for the various positions of the trolley.

26.13.0 Wiring for components within the draw out module shall be identical in layout, ferrule numbering, sequencing of secondary isolating contacts, colouring etc. to achieve maximum interchangeability.

26.14.0 In the case of double front panels, the module trolleys shall be interchangeable from one front to another front in such a manner that direction of rotation of motors are kept unaltered. Such interchanging shall not require rearranging /connecting cables.

26.15.0 Identical feeder types shall be interchangeable with each other. Also all modules shall carry labels identifying KW rating & type of control wiring

26.16.0 Necessary earthing arrangements shall be provided for the truck in the‘ TEST’ and‘ SERVICE’ positions. The earth connection shall make before the main power and control contacts make and break after the power and control contacts are disconnected. Earthing connection through manual plug & socket connection will not be acceptable.

26.17.0 Provision of control supply in the test position of draw out modules (feeders which require control supply) shall be available. In draw out switchboards with module control supply, required test control supply feeder, associated test supply bus/ wiring, etc. shall be provided.

27.0.0 MEDIUM VOLTAGE CIRCUIT BREAKERS

27.1.0 GENERAL & CONSTRUCTIONAL FEATURES

27.1.1 Circuit Breakers, if any, shall conform to IS: 13118.

27.1.2 All CBs shall be suitable for uninterrupted duty as per IS.

27.1.3 CBs provided for control of motors, capacitors, etc. shall be suitable for the specific duty involved.

27.1.4 If different ratings of circuit breakers are used in the switch board, they shall preferably belong to the same family. The individual units of same ratings in a continuous switchboard shall be interchangeable.

27.1.5 Circuit breaker enclosure shall be same as that of main equipment.

27.1.6 Circuit breaker shall be of forward draw out construction. The cradle shall be so designed and constructed as to permit the smooth withdrawal and insertion of the breaker into it. The movement shall be free of jerks, easy to operate and shall preferably be on steel balls / rollers and not on flat surfaces. Horizontal draw out type truck is preferred.

27.1.7 Each CB shall be housed in a separate compartment and shall be enclosed on all sides. Adequate provision shall be made for escape of hot gases by providing louvers. The louvers shall be covered with perforated sheets and shall be so located as to direct the hot gases away from the operating personnel. Multi-tier arrangement can be provided, if adequate space for maintenance is ensured.

27.1.8 Sheet steel barriers shall be fitted between the tiers in a vertical section and between two vertical sections in the breaker compartment.

27.1.9 The hinged lockable door of the draw out type of CB shall not form an integral part of the draw out portion, so that entry of foreign materials / things into the cubicle is not possible when the CB is drawn out.

27.1.10 The door shall be of such a design that it shall allow the breaker to be kept withdrawn up to the ‘TEST’ and ‘ISOLATED’ positions with the CB door closed.

27.1.11 The CB door shall be interlocked with the breaker positions such that:
a) The door cannot be opened unless the breaker is in ISOLATED position and
b) The breaker cannot be racked into the SERVICE position unless the door is closed.

27.1.12 The following four positions of the CB shall be distinctly marked and locking arrangements shall be made:

a) **SERVICE position**:
The main disconnecting contacts shall be fully gripped on both sides, namely the bus bar side and the load side (both main and secondary isolating contacts in service).
b) **Test position**:
The truck shall be perfectly isolated from the live busbars in order to test for proper performance (main isolating contacts separated and secondary isolating contacts in service / test position).

c) **ISOLATED position**:
It shall be able to withdraw the truck from the cubicle for inspection and maintenance (both main and secondary isolating contacts isolated).
d) **MAINTENANCE position**:
It shall be possible to draw out / take out the circuit breaker fully outside the cubicle for maintenance purposes.

27.1.13 The above first three positions of the CB shall be positive, achieved only through the turning /racking motion of the draw out mechanism and not by trial and error. There shall be an indicator clearly showing the first three positions listed above, and the same shall be visible from the front without opening the front door.

27.1.14 It shall not be possible to close the CB unless it is positively in one of the following positions:

a) Truck in 'SERVICE' position
b) Truck in 'TEST' position
c) When the truck is in completely 'ISOLATED' position.

27.1.15 The interlocks mentioned above are the minimum requirement. Manufacturers shall include any other safety interlocks, which may be required by the particular design feature of the switchgear offered.

27.1.16 Necessary earthing arrangements shall be provided for the truck in the' TEST' and' SERVICE' positions. The earth connection shall make before the main power and control contacts make and break after the power and control contacts are disconnected. Earthing connection through manual plug & socket connection will not be acceptable.

27.1.17 Separate and adequate accommodation shall be provided for instruments / meters, indicating lamps, auxiliary contactors, timers, control fuses, CTs, VTs, protective and auxiliary relays, auxiliary switches, control transformers if any, etc. These shall be easily accessible for testing and maintenance, without any danger of accidental contact with live parts of the CB. All the above accessories, bus bar connections, wire ways, cable space, painting and other general requirements of CB shall conform to relevant clauses mentioned elsewhere in this specification.

27.1.18 Truck/trolley shall be provided for handling the circuit breaker

27.2.0 CIRCUIT BREAKER CONTACTS

27.2.1 CB contact assemblies shall include easily replaceable arcing contacts. Main current carrying contacts shall be of low resistance, arc resistant and adjustable to compensate wear.

27.2.2 Contact fingers shall be spring loaded to reduce contact bounce.

27.2.3 The isolating contacts shall be self-aligning and able to carry rated short circuit current, without any tendency for the contacts to 'blowoff'.

27.2.4 In case of air circuit breakers, the arc chutes shall be removable for routine inspection of the contacts.

27.2.5 In case of air break contacts, the arcing contacts shall have anti-sticking and burn resistant properties.

27.2.6 Wiring and termination of secondary isolating contacts shall be interchangeable in all identical breakers.

27.3.0 OPERATING MECHANISM

27.3.1 It shall be possible to close and trip the circuit breaker without opening the CB compartment door. The operating handle and the mechanical trip push button shall be at the front of the breaker and integral with it. Arrangements with operating handle fitted on the door independently of the breaker, and connected through a set of links to the breaker, are not acceptable.

27.3.2 CB shall be fitted with hand / direct motor / motor charged spring / solenoid closing mechanism, as specified in the data sheet. Whatever be the mode of operation of the breaker, it shall have hand closing provision to be operated in emergencies and during testing.

27.3.3 Operating mechanism shall be mechanically and electrically trip free in all positions of CB.

27.3.4 It shall be possible to mechanically trip the CB mechanism by a distinctively marked push button.

27.3.5 In “manually operated breaker”, the design of the handle and operating mechanism shall be such as not to require large open slots in the front door for the movement of the handle. Manual closing mechanism shall be of independent manual type.

27.3.6 In “electrically operated breakers”, remote closing facility shall be provided. The type of electrically operated mechanism and the voltage of operation shall be as indicated in the data sheet.

27.3.7 The breaker shall be provided with suitable anti pumping feature to ensure that it does not reclose automatically after a tripping, even if the closing impulse is maintained.

27.3.8 When the breaker is in the closed position, a closing operation of an initiating control device shall not result in further operation of the breaker closing mechanism or discharging of the closing spring.

27.3.9 Closing of CB shall be prevented, unless the spring is fully charged.

27.4.0 OTHER REQUIREMENTS

27.4.1 The auxiliary wiring between the switchgear receptacle and the truck unit shall be established by means of a plugging / sliding unit, consisting of minimum 10 pairs of contacts rated for 10A, 650V grade, which get automatically disconnected when the drawn out module is withdrawn from the test position.

27.4.2 A mechanical ON-OFF indicator, appropriately marked, shall be provided at the front of the CB.

27.4.3 A mechanical interlock shall be provided between the circuit breaker and isolator, if any, directly connected to CB to prevent operation of the isolator when the CB is in closed position.

27.4.4 The closing coils and other auxiliary devices shall operate satisfactorily at all voltages between85-110% of the rated control voltage specified in the data sheet. Trip coils shall operate satisfactorily at all voltages between70-110% of the rated trip voltage mentioned in the data sheet.

27.4.5 Auxiliary power supply for control, indication and space heaters shall be as indicated in the datasheet. For auxiliary power supply, necessary control switch fuse / MCB of required ratings shall be provided, unless otherwise specified in the data sheet.

27.4.6 **Releases**:

Releases shall be provided, if specified in the data sheet. Type of releases provided and their characteristics shall be furnished by the vendor. If provided, the releases shall have the following features:

a) The overload release shall be provided with a setting range of 70% to 110% of the breaker rated current or as specified in the data sheet.

b) The short circuit release shall be provided with minimum two settings corresponding to 750% and 1000% of the rated current, with adjustable time delay range of 25ms to350 ms or as specified in the data sheet.

c) Earth fault releases shall be provided with a setting range of 10% to 40% of the rated current, or as specified in the data sheet.

d) In PCCs/ PMCCs, where two breakers are connected in series they shall be fitted with releases permitting discrimination.

1.0	Maker's name				
2.0	Works at which the boards will be fabricated				
3.0	Switch board type designation				
4.0	Rated voltage				
5.0	Rated insulation voltage				
6.0	Maximum permissible operating voltage				
7.0	Nominal current rating of board				
8.0	Maximum temperature rise over ambient				
9.0	Bus bar details				
9.1	Type of bus bar	a) Horizontal phase bus bars	b) Horizontal neutral bus bars	c) Vertical phase bus bars	d) Vertical neutral bus bars
9.2	Nos. of				
9.3	Rated current in amps				
9.4	Short circuit withstand current in KA for 1 sec				
9.5	Material & grade				
9.6	Quantity & size				
9.7	Colour coding				
9.8	Type of insulation				
9.9	Type of insulation at joints and tap-offs				
9.10	Type of bus bar support				
9.11	Location of bus bar w.r.t board				
9.12	Peak dynamic withstand capacity				
9.13	Provision for future extension				
9.14	Clearance of bus bar in air-Phase to phase				
9.15	Clearance of bus bar in air-Phase to neutral				
9.16	Clearance of bus bar in air-Phase to earth				
10.0	**Constructional details**				
10.1	Thickness of door in mm				
10.2	Thickness of load bearing members in mm				
10.3	Thickness of base frame in mm				
11.0	Overall dimensions of each switchboard (Length X Depth X Height) in mm				

4				**PROJECT**	**Ammonia Storage system**
3					
2				**CLIENT**	**M/s. FACT-CD**
1				**P.O. NO.**	
0				**VENDOR**	
REV.	**DATE**	**DESCRIPTION**	**SIG. OF VENDOR**		

12.0	Weight of each switchboard in KG (Dynamic Loading if any shall be furnished)						
13.0	Dimension and weight of each shipping section						
14.0	**Air circuit breaker Feeder Number**						
14.1	Rating in amps.						
14.2	Make & type						
14.3	Breaking capacity at 500 V, p.f 0.1						
14.4	Symmetrical (RMS) in KA						
14.5	Asymmetrical (RMS) in KA						
14.6	Making capacity (peak) in KA						
14.7	Opening time in milliseconds						
14.8	Making time in milliseconds						
14.9	Time in seconds for which the breaker can carry its rated breaking current						
14.10	Short time (1sec.) rating in KA						
14.11	Minimum mechanical life in no. of operations						
14.12	Arcing contact life at rated current in number of operations						
14.13	Operating power & voltage for opening						
14.14	Operating power & voltage for closing						
14.15	Operating power & voltage for spring charging						
15.0	**Moulded Case Circuit Breaker**						
15.1	Rating in Amps (In)						
15.2	Make and Type						
15.3	Rated Service Short circuit breaking capacity(Ics)						
15.4	Rated Ultimate Short circuit breaking capacity(Icu)						
15.6	Rated short time withstand current(Icw) for 1Sec						
15.7	Type of protection: Thermal magnetic/Electronic/Earth leakage module						
15.8	Auxiliary contact						
15.9	Trip alarm contact						
15.10	Shunt release						
15.11	Under voltage release						
15.12	Other specific details if any						

16.0	**Material and area of cross section of Busbar connections**						
16.1	Busbar to switch / switch fuse of each rating						
16.2	Switch to fuses of each rating						
16.3	Material and voltage class (grade) of insulation of above conductors if insulated						
17.0	1 second short circuit withstand capacity of switches offered						
18.0	Technical details, catalogues & type test certificates of components / items enclosed	ACBs,MCCB,MCB Relays, Switches, Contactors, Fuses, CTs, Overload Relays, Meters, Indicating lamps, Timers, etc.					

19.0 COMPONENT / FEEDER DETAILS

Motor KW/ Feeder. rating	Full Load Amps	Mod-ule size	Switch/ MCCB			HRC Fuse		Contactor				Over load relay rang e (A)	Size of wire used in modules		Rating of terminals in Amps.		
			Type	AC22 rating /I_{cs}(A)	AC23 rating /I_{cu}(A)	Therm-al rating (A)	Let through energy	Type	Therm-al rating (A)	AC3 rating (A)	1sec. Rating (A)		Power	Control	Draw-out	Fixed	Outgoing
0.25																	
0.37	1.2A																
0.55	1.6A																
0.75	1.8A																
1.1	2.6A																
1.5	3.5A																
2.2	5.0A																
3.7	7.5A																
5.5	11A																
7.5	14A																
9.3	19A																
11	21A																
15	28A																

18.5	35A																
22	40A																
30	55A																
37	66A																
45	80A																
55	100A																
75	135A																
90	165A																
110	200A																
132	230A																
150	275A																
Switch fuse feeder	63A																
	100A																
	200A																
	250A																
	400A																
	630A																

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for design, manufacture, testing and supply of high voltage induction motors.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification and Data Sheet** of **General requirements for electrics**
2.1.2 **Data sheet** of **High Voltage Induction Motors**
2.1.3 **Technical particulars** of **High Voltage Induction Motors**

3.0.0 STANDARDS

3.1.0 All motors shall comply, wherever applicable, with the latest issues of the following Indian Standards and other relevant standards.

IS: 325 Three Phase Induction Motors
IS: 1231 Dimensions of three phase foot mounted Induction motors
IS: 1271 Classification of insulating materials
IS: 2223 Dimensions of flange mounted AC Induction Motors
IS: 2253 Designations for types of construction and mounting arrangements of rotating electrical machines
IS: 2254 Dimensions of vertical shaft motors for pumps
IS: 2968 Dimensions of slide rails for electric motors
IS: 4029 Guide for testing three phase induction motors
IS: 4691 Degrees of protection provided by enclosure for rotating electrical machinery
IS: 4722 Rotating electrical machines
IS: 4728 Terminal markings and direction of rotation for rotating electrical machinery
IS: 4889 Methods of determination of efficiency of rotating electrical machines
IS: 6362 Designation of methods of cooling of rotating electrical machines

IS: 6381 Construction and testing of electrical apparatus with type of protection "e"
IS: 7389 Pressurized enclosures of electrical apparatus for use in explosive atmospheres
IS: 8223 Dimension & output ratings for foot mounted rotating electrical machine with frame numbers 355 to 1000
IS/IEC60079-0 Electrical apparatus for explosive gas atmospheres: part 0-General requirements
IS/IEC60079-1 Electrical apparatus for explosive gas atmospheres: part 1-Flame proof enclosures ”d”
IS/IEC60079-2 Electrical apparatus for explosive gas atmospheres: part 2-Pressurized enclosures ”p”
IS/IEC60079-7 Electrical apparatus for explosive gas atmospheres: part 7-Increased safety”e”
IS/IEC60079-15 Electrical apparatus for explosive gas atmospheres: part 15-construction, test and marking for type of protection "n"
IS: 8789 Values of performance characteristics for three phase induction motors
IS: 12065 Permissible limits of noise levels for rotating electrical machines
IS: 12075 Mechanical vibration of rotating electrical machines with shaft heights from 56 & higher measurement, evaluation and limits of vibration severity
IS: 12615 Energy efficient motors

4.0.0 GENERAL REQUIREMENTS

4.1.0 All machines shall be continuous maximum rated (Class S1 as per IS:325) under the operating conditions specified in the data sheet, and shall be suitably protected for operation under the service conditions stated in data sheet.

4.2.0 Motors for hazardous areas shall be of a design for which approval has been obtained from the Central Institute of Mining and Fuel Research (CIMFR), Dhanbad(Earlier CMRI), for use in the particular areas specified. All motors approved as above, shall have a separate nameplate carrying the details of such approval, fixed on the body adjacent to the main nameplate. The approval / certification shall be latest.

4.3.0 The motor coupled to its driven machine shall start and operate successfully under full load even if the voltage at the motor terminals is lowered to 80 % of rated voltage for 30 seconds.

4.4.0 Critical speeds should be either well below or well above the normal running speeds of the motor.

4.5.0 Slip at rated load shall not exceed 3% at rated voltage and frequency.

4.6.0 The motors shall be liberally designed as regards their pullout torque, pullout voltage and their ability to ride through voltage dips during system disturbances. They should, if required, be suitable for automatic restart under full load after a momentary lack of supply voltage, with the possibility of the restored supply voltage being out of phase with respect to the motor residual voltage. The extent to which the motor has to withstand out of phase residual voltage (in percentage) shall be as specified in the data sheet.

4.7.0 If vacuum circuit breakers are used as interrupting device of the motor, the motors shall be designed to withstand impulse voltage (peak) phase to earth for the system voltages (specified in the data sheet) for such a duration as per relevant standards. The values shall be indicated in the technical particulars.

5.0.0 STARTING CURRENT AND TORQUE

5.1.0 All motors are envisaged to be started direct-on-line across full line voltage unless otherwise specified in the data sheet. The rotor shall be squirrel cage type unless otherwise specified in the data sheet. The rotor shall be dynamically balanced with fan and half key on the rotor shaft.

5.2.0 The starting characteristics of the machine shall be carefully selected as to:
5.2.1 Satisfy the torque requirements of driven machine, even where reduced voltage starting is specified in the data sheet.

5.2.2 Have starting time which is less than locked rotor withstand time (hot) of the motor by at least two seconds, at the rated conditions of voltage and frequency specified, with driven machine coupled.

5.2.3 Ensure that starting current is not normally more than 600% of full load current at the rated voltage and frequency (subject to IS tolerance) unless otherwise specified in the data sheet.

5.2.4 Ensure that accelerating torque is not too large to cause stressing of the transmission elements and the driven machine

5.2.5 Ensure that motor is suitable for starting at 80% of the rated voltage against torque speed characteristics of the driven equipment.

6.0.0 NUMBER OF STARTS

6.1.0 The motor shall be suitable for the number of starts specified in the data sheet .If nothing is specified in data sheet, then the motor should be suitable for Direct-on-line starting with minimum number of starts stated below:
a) Two successive cold starts
b) One hot start
c) Three uniformly spaced starts per hour

7.0.0 INSULATION

7.1.0 Insulation class shall be class B or class F with temperature rise limited to class B as specified in the data sheet.

7.2.0 Motor winding shall be done using copper conductor only.

7.3.0 The winding shall be tropicalised.

7.4.0 All windings shall be treated with humidity, acid and alkali resisting protective coating like epoxy gel to withstand service in a plant atmosphere described in data sheet.

8.0.0 CONSTRUCTION

8.1.0 The motor shall be able to withstand the corrosive atmosphere mentioned in data sheet. External screws and bolts shall be protected particularly against corrosion by passivation.

8.2.0 The enclosure shall provide the required degree of protection, viz IP 55(Indoor) / IPW55 (Outdoor) / Flameproof / Flameproof weatherproof, etc. as specified in data sheet.

8.3.0 Vibration and noise levels shall not exceed those given in the relevant IS.

8.4.0 Motor frame sizes shall be in accordance with IEC recommendation in the absence of Indian Standards. For a particular motor, required frame sizes as per IS/IEC or higher size shall only be supplied, unless otherwise specified in the data sheet.

8.5.0 The shaft shall be generously proportioned for transmitting continuous full load torque and any specified overload or duty which may be created by the driven machine. In designing the motor shaft and bearing systems, the manufacturer shall take full account of the characteristics, thrust, shaft system and bearing system of the driven machine and also the type of coupling proposed, so as to give a completely satisfactory shaft and bearing system.

8.6.0 The motors shall be suitable for connecting capacitor at the motor terminals, if specified in the data sheet. Rating of capacitor shall be as indicated in the data sheet. If there is any limitation/ inadequacy with regard to the rating of the capacitor that can be connected to the motor, the findings shall be clearly substantiated in the Technical Particulars.

8.7.0 Condensate drains shall be provided where water may collect. Drain holes shall also be provided, where required.

8.8.0 Foundation rails if any, foundation bolts, nuts; washers, etc. shall be supplied unless otherwise specified in the data sheet.

9.0.0 VENTILATION

9.1.0 Motors upto and including 650 kW shall be self-ventilated, unless otherwise specified in the data sheet.

9.2.0 For motors with higher ratings, necessary ventilation shall be provided as per manufacturer's standards, unless otherwise specified in the data sheet, to ensure the performance guaranteed. Complete details and confirmations regarding the ventilation arrangement shall be furnished in the Technical Particulars.

9.3.0 Materials of construction of fans, tubes, etc. used shall be suitable for the environment specified in the data sheet.

9.4.0 Motors shall normally be bi-directional, ie., suitable for either direction of rotation. If the motor cooling system design is such that the fan can rotate only in one direction, it should be boldly and indelibly marked on the body of the motor and mentioned in Technical Particulars. The direction of rotation shall be clockwise when viewed from the drive end, unless otherwise specified in the data sheet.

9.5.0 The fans shall be suitable for rotation in either direction. If this is not so, it shall be possible to reverse the fan without affecting the balancing of the motor.

9.6.0 Filters shall be fitted for cooling air, if specified in the data sheet. The filters should be easily accessible for inspection and removal for cleaning and reuse, etc. The material of the filter and support trays shall be rustproof and protected against corrosive environment specified.

9.7.0 Joints between the heat exchanger and the main body of the motor shall be sealed by weatherproof gaskets.

10.0.0 BEARINGS AND LUBRICATION

10.1.0 The bearings shall be of reputed manufacture and of a type interchangeable with bearings from other sources.

10.2.0 The method and type of lubrication shall be selected by the manufacturer and shall be suitable for the rated KW, speed and duty involved.

10.3.0 Excess grease escape devices shall be provided.

10.4.0 Grease migration to winding shall be prevented.

10.5.0 Necessary grease nipples for online lubrication from outside shall be provided for both Drive End & Non Drive End bearings. Whenever grease nipples are provided, these shall be associated, where necessary, with appropriately located relief devices to ensure passage of grease through the bearings.

10.6.0 Name and grade of lubricant shall be given in the motor nameplate.

10.7.0 Lubrication schedule for the motors shall be indicated in the nameplate or shall be furnished separately in the maintenance manual.

10.8.0 For oil lubricated bearings, dial type thermometers with alarm contacts and oil level indicators shall be provided.

10.9.0 Details of bearings shall be furnished in the test certificates, to facilitate ordering of spares.

10.10.0 SHAFT VOLTAGE BEARING INSULATION

10.10.1 The shaft voltage of the motors shall not normally exceed 250 mV rms for roller and ball bearings and 400 mV rms for sleeve bearings. This shall be tested on all motors without any extra cost. The bearing shall be insulated if required. Lube oil pipe, if any, to the bearings shall be insulated.

10.10.2 The insulated bearing end, shield or pedestal shall bear a prominent warning and the manufacturer shall provide detailed drawing showing insulation arrangement.

11.0.0 WEATHERPROOFING

11.1.0 The motors for outdoor installation and service shall be suitable for operation in direct sun and rain, without further protection (like canopy, hood, etc.) from weather. However, vertical motors shall be provided with a hood over the fan cover, as an integral part of the motor.

12.0.0 TERMINAL BOXES AND TERMINATIONS

12.1.0 The machine shall be complete with suitable cable glands, sealing boxes, armour clamps, etc. for the armoured PVC / XLPE main power cables, as specified in the data sheet.

12.2.0 All the six winding ends shall be brought out and marked, three to one terminal box for power supply connections, and three to another terminal box on the opposite side for star connection, unless otherwise specified in the data sheet. Both the terminal boxes shall be identical in all respects.

12.3.0 The terminal boxes shall be suitable for withstanding the system fault level for 0.25 seconds unless otherwise specified the in data sheet. The terminal boxes shall be amply sized to accommodate the cable sizes specified in data sheet. The terminal box shall be provided with pressure relief device if necessary.

12.4.0 It shall be possible to rotate the terminal box in steps of 90 degrees to enable cable entry from any direction.

12.5.0 Live terminals shall be insulated from the frame with material resistant to tracking.

12.6.0 Flameproof double compression type cable glands shall be provided for flameproof motors approved by CIMFR, Dhanbad.

12.7.0 For anticondensation heater, temperature detectors, etc. separate terminal boxes shall be provided, suitable for the cable sizes specified in data sheet, complete with compression type cable glands. These terminal boxes shall be flameproof for flameproof motors.

12.8.0 Main terminal box shall be located on the right hand side of the motor, when viewed from its drive end, unless otherwise specified in the data sheet.

12.9.0 Phase segregated type main and star terminal boxes shall be provided for power connections, unless otherwise specified in the data sheet.

12.10.0 In case capacitors are envisaged to be connected to the motor terminals, as indicated in the data sheet, the terminal box shall be of a special design by which sufficient creepage space between terminals is available. The terminal box shall also be provided with two sets of cable glands.

13.0.0 EARTHING

13.1.0 All motors shall have two suitable earth studs, capable of with standing the fault level, integral to the motor frame for motor earthing. The studs should be adequate for accepting lug of the earthing conductor specified in the data sheet.

14.0.0 NAME PLATES

14.1.0 Two stainless steel nameplates shall be provided, fastened by SS fasteners. One should be fixed on the non-removable external part of the motor and one inside the terminal box. In addition to the data required to be furnished on the name plate as per IS, locked rotor current, temperature rise, type of enclosure, direction of rotation (if unidirectional), weight, grade of lubricant, bearing sizes and ambient temperature for which the motor is designed shall also be indicated.

14.2.0 A stainless steel warning label with indelible red inscription shall be provided on the motor to indicate that isolation of main power supply alone is not sufficient and that space heater supply shall also be isolated before carrying out any work on the motor.

15.0.0 LIFTING FACILITIES

15.1.0 Facility for lifting the complete motor shall be provided on the motor frame.

16.0.0 COUPLINGS

16.1.0 The motor shall be supplied with bare, single shaft extension and key unless otherwise specified in the data sheet. The couplings shall be supplied and fitted by the driven machine supplier.

17.0.0 ANTICONDENSATION HEATERS

17.1.0 The motors shall be provided with anti condensation heaters to prevent condensation when the motor is kept idle for long period. The anti condensation heaters shall be rated for single phase 240V, 50 Hz., unless otherwise specified in the data sheet.

18.0.0 PROTECTION

18.1.0 Embedded temperature detectors or thermistors, hot air thermostats, etc. shall be provided in the motor if specified in the data sheet. Motors provided with filters for cooling shall be provided with embedded temperature detectors or thermistors.

18.2.0 Where embedded temperature detectors are envisaged, a minimum of three detectors (one per phase) shall be provided between the coil sides to measure the winding temperature and three (one per phase) at the base of the slots to measure the core temperature, each phased at 120 degree apart.

18.3.0 Bearing temperature detectors shall be provided for motors with output greater than 750 KW.

18.4.0 Embedded temperature detectors (winding / core) and bearing temperature detectors shall be of RTD Pt100 ohm type and suitable temperature scanner / monitoring relays with alarm and trip contacts shall be supplied loose (in a weather proof cast aluminium enclosure or in an enclosure suitable for panel mounting) as specified in data sheet.

18.5.0 Where thermistors are provided, thermistor control relay shall be supplied loose in a suitable weatherproof enclosure of cast aluminium.

18.6.0 Vibration detectors shall be provided for motors with output 300KW and above unless otherwise specified in the data sheet. Alarm and trip contacts shall be wired to a terminal box. For sleeve type bearings, non-contact vibration probes of approved make shall be used.

18.7.0 For motors with high starting time, zero speed switches with 1NO+1NC contacts shall be provided if specified in data sheet.

18.8.0 3 numbers CTs shall be provided in large capacity motors in neutral side terminal box for differential protection and 3 nos. matching CTs shall be supplied loose for mounting in starter panel, if specified in the data sheet.

19.0.0 RECIPROCATING COMPRESSOR FACTOR

19.1.0 Supplier of motors for driving reciprocating compressors shall liaise with the purchaser and the compressor manufacturer to ensure that the compressor factor chosen is sufficient to have a satisfactory degree of current pulsations.

20.0.0 MOTOR SUPPLIED AND ORDERED ALONG WITH THE DRIVEN MACHINE

20.1.0 When a motor is supplied as a combined unit with the driven machine, the driven machine supplier shall ensure proper co-ordination in the selection of motor and its characteristics. The driven machine supplier is also responsible for the suitability of the motor for the equipment and shall guarantee a reasonable defect liability period.

20.2.0 The driven machine supplier shall also ensure the correctness of the motor test certificates, couplings, etc.

21.0.0 ADDITIONAL ACCESSORIES / REQUIREMENTS

21.1.0 The motors shall be provided with additional accessories / requirements, if any, specified in the data sheet

21.2.0 Where any special requirement such as degree of protection to enclosures, thermal cutout, special cable boxes, extra starting torque, supply of half coupling, etc. are specified, these details shall be clearly recorded in the test certificates or in an attached supplement.

22.0.0 DESPATCH

22.1.0 Before despatch, opening in the motor like cable entry should be sealed to prevent entry of moisture and dust during transit and storage.

1.0	Make of motors	
2.0	Applicable codes / standards	
3.0	Equipment No.	
4.0	Continuous rating in KW (Clause 4.1.0)	
5.0	Rated voltage & frequency	
6.0	Speed in RPM (sync)	
7.0	Frame size (Clause 8.4.0)	
8.0	Method of starting	
9.0*	No load current	
10.0*	No load power input	
11.0	Full load current	
12.0	Starting current (%FLC) (Clause 5.2.3)	
13.0	Full load torque (Nm)	
14.0	Starting torque (%FLT)	
15.0	Pull up torque (%FLT)	
16.0	Pull out torque (%FLT)	
17.0	Slip (%) (Clause 4.5.0)	
17.1	At full load	
17.2*	At pull out torque	
18.0	Efficiency (%) and power factor	
18.1	At full load	
18.2	At 3/4 load	
18.3	At 1/2 load	
19.0*	No load power factor	
20.0*	Power factor at starting	
21.0*	Stator resistance	
22.0*	Total resistance (with respect to stator)	
23.0*	Total leakage reactance (w.r.t stator)	
24.0*	Short circuit impedance	
25.0	Locked rotor current	
26.0	Locked rotor withstand time	
26.1	Hot (seconds)	
26.2	Cold (seconds)	
27.0	Starting time of motor on Direct -On-Line with driven equipment coupled	
27.1	At 100% voltage	
27.2	At 80% voltage	

28.0	Minimum voltage required for starting with equipment and corresponding starting time	
29.0	Pull out voltage at full load	
30.0	Allowable number of starts with driven equipment coupled (Clause 6.0.0)	
30.1	Successive start from cold condition	
30.2	Successive start from hot condition	
30.3	Uniformly spaced starts per hour	
31.0	Time interval required for restarting the motor after the permissible successive starts	
31.1	Cold	
31.2	Hot	
32.0	Guaranteed temperature rise under worst conditions of voltage and frequency	
33.0*	Maximum allowable sustained voltage drop and time in seconds the motor can be kept running with full load without exceeding the permissible temperature rise	
34.0*	Design class of rotor as per NEMA standards	
35.0	GD^2 value of rotating parts in Kg/m^2 at rated speed	
36.0	Speed v/s Torque curve	
37.0*	Current v/s Time curve (with driven machine)	
38.0*	Current v/s Speed curve	
39.0*	Thermal withstand characteristics (hot & cold)	
40.0	Start withstand time	
40.1	Hot (seconds)	
40.2	Cold (seconds)	
41.0*	Thermal time constants (seconds)	
41.1*	Stator time constants	
41.2*	Rotor time constants	
42.0	CIMFR Certificates (for Flame - proof motors)	
43.0	Capacitors	
43.1*	Maximum rating of capacitors in KVAR that can be connected to motor terminals (Clause 8.6.0)	
43.2	Terminal box for capacitor (Clause 12.10.0)	
44.0*	Bearings (Clause 10.0)	
44.1*	Drive End bearing No. & type	
44.2*	Non – Drive End bearing No. & type	
44.3*	Make of bearings	
44.4*	Maximum bearing temperature	
45.0*	Lubricant (Clauses 10.2.0, 10.6.0 & 10.7.0)	
45.1*	Make	
45.2*	Type & grade	

45.3*	Lubrication schedule of motor	
45.4	Method of lubrication	
46.0*	Percentage residual voltage reconnection allowed (Clause 4.6.0)	
47.0	Slip ring motors	
47.1	Rotor open circuit voltage	
47.2	Rotor current	
47.3*	Make of brush	
47.4*	Grade of brush	
47.5	Details of starting resistance	
47.6	Type of rotor winding	
48.0	Net weight of motor	
49.0*	Shipping weight of motor	
50.0*	Shipping volume of motor	
51.0*	Loading details for foundation design	
51.1*	Static load	
51.2*	Dynamic load	
51.3*	Short circuit load	
51.4*	Dynamic load on push pull condition	
51.5*	Dynamic load on starting condition	
52.0*	Critical speed (Clause 4.4.0)	
53.0*	Open circuit time constant	
54.0	Margin between starting time and thermal withstand time (hot) as per clause 5.2.2	
55.0	Material of external screws, bolts & nuts (Clause 8.1.0)	
56.0	Maximum vibration and noise levels (Clause 8.3.0)	
57.0	Ventilation (Clause 9.0.0)	
57.1	Method of ventilation (Clause 9.1.0 & 9.2.0)	
57.2	Material of construction of fans & tubes (Clause 9.3.0)	
57.3	Whether bidirectional, if not, direction of rotation (Clause 9.4.0)	
57.4	Suitability of fan for rotation in either direction (Clause 9.5.0)	
57.5	Filter (Clause 9.6.0)	
58.0	No. of auxiliary terminal boxes and their purpose (Clause 12.7.0)	
59.0	Anti condensation heaters (Clause 17.0.0)	

60.0	Details and type of following accessories (Clause18.1.0)	
60.1	Thermistor and thermistor control relay	
60.2	Winding / core temperature detector (RTD)	
60.3	Bearing temperature detector (RTD)	
60.4	Temperature scanner / Monitoring relay for winding / core / bearing temperature detector	
60.5	Vibration detector	
60.6	Zero speed switch	
60.7	Hot air thermostat	
60.8	Differential CTs	
61.0	Shaft voltage (Clause 10.10.1)	
62.0	Terminal box fault level rating (Clause 12.3.0)	
63.0	Insulation class of winding (Clause 7.1.0)	
64.0	Protective coatings / treatments provided (Clause 7.4.0)	
65.0	Enclosure (Clause 8.2.0)	
66.0	Mounting	
67.0	Special requirement (Clause 8.5.0)	
68.0	Foundation rails, nuts, bolts, etc (Clause 8.8.0)	
69.0	Additional accessories / requirements (Clause 21.0)	
70.0	Suitability of the motor for VCB control(Clause 4.7.0)	
71.0	Impulse voltage (peak) phase to earth (min.) the motor can withstand & its time duration (Clause 4.7.0)	
72.0	Coupling / pulley (Clause 16.1.0)	

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for design, manufacture, testing at Works, supply, installation and commissioning of Uninterruptible Power Supply (UPS) system for feeding AC power to critical loads / duty listed in the data sheet.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification and Data sheet** of **General requirements for electrics**

2.1.2 **Data sheet** of **Uninterruptible Power Supply system**

2.1.3 **Technical particulars** of **Uninterruptible Power Supply system**

3.0.0 STANDARDS

3.1.0 The equipment shall conform to the latest revision of the following Indian standards and other relevant standards that are applicable.

IS: 11260 Stabilised power supplies AC output
IS: 5469 Code of practice for the use of semi conductor junction devices
IS: 3700 Essential rating and characteristics of semiconductor devices
IS: 1651 Stationary cells and batteries, Lead acid type with tubular positive plate
IS: 1652 Stationary cells and batteries, Lead acid type with Plante' positive plate
IS: 6304 Stationary cells and batteries, Lead acid type with pasted positive plate
IS: 10918 Vented type Nickel Cadmium battery
IS: 8623 Specification for low voltage Switchgear and Control gear Assemblies
IS: 13947 Specification for low voltage switchgear and control gear
IS: 9224 Low voltage fuses
IS: 11171 Dry type transformers

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4.0.0 GENERAL REQUIREMENTS

4.1.0 The equipment shall be designed for input voltage, output voltage, frequency, output capacity and energy storage capacity as specified in the data sheet. The data sheet will also specify special operating conditions and maximum ambient temperature in which the equipment must operate.

4.2.0 The equipment shall be designed to furnish an uninterruptible, automatic, self regulated source of alternating current power to critical loads described in the data sheet.

4.3.0 The system shall be designed for the following mode of operations.

4.3.1 During normal mode a source of alternating current power will supply energy to the system. The rectifier section shall receive power from supply lines and rectify the power and furnish energy to the inverter and also to the storage battery at required voltage. The inverter section shall receive the output of the rectifier section and generate alternating current in the form of sine wave with low harmonic content.

4.3.2 During failure of the alternating current input power or rectifier section, the energy shall be fed to the load without interruption from the battery through the inverter section at the voltage, frequency and for the back up time specified in the data sheet.

4.3.3 During failure of the inverter section or persistent overload exceeding the limits applicable for components of the inverter, the system shall transfer the load from inverter to a reserve supply arrangement specified in the data sheet. Retransfer to inverter shall be manual / automatic as specified in the data sheet.

4.4.0 The UPS is intended for equipment those are very critical by way that shut down of these equipment results in heavy financial losses apart from the safety aspects of personnel and equipment. Hence the UPS supplied shall maintain very high standards with respect to reliability and quality of power output.

4.5.0 The UPS shall have, as standard equipment, RS 232 or equivalent communication facility to interface the UPS status information to a host computer.

5.0.0 SYSTEM COMPONENTS

5.1.0 The UPS system shall be complete in every respect and shall comprise following major sections.

5.1.1 Battery set
5.1.2 Rectifier section
5.1.3 Inverter section
5.1.4 Static switch
5.1.5 Reserve supply arrangement
5.1.6 Cooling arrangement
5.1.7 Distribution board

5.2.0 The scope of supply of UPS shall also include equipments/items such as battery mounting arrangement, transformers, control devices, meters, indicators, interconnecting cables, protection devices, etc. necessary for satisfactory performance, protection and control of UPS system.

5.3.0 All materials and parts used in the UPS system shall be brand new, of reputed make and shall not have been used in prior service except as required during factory testing.

5.4.0 Components used shall be of adequate rating with sufficient factor of safety for ensuring high reliability.

6.0.0 BATTERY

6.1.0 The battery shall be suitable for the satisfactory operation of the UPS system. It shall be of the type and construction specified in the data sheet and shall conform to the standards applicable.

6.2.0 The number of cells and ampere-hour capacity shall be suitable for delivering full rated output to the load at the voltage and for the time period specified in the data sheet, without detrimental drop in voltage at the battery terminals.

6.3.0 The lead acid battery when discharged, the end voltage on completion of design duty cycle of the UPS shall not be less than 90% of nominal battery voltage. For Nickel Cadmium battery, it shall not be less than 85% of the nominal battery voltage.

6.4.0 While sizing the battery capacity, factors such as aging, temperature, inverter efficiency, and derating of nominal capacity on higher discharges, etc. shall be taken into consideration to have adequate margin on the capacity.

6.5.0 The battery shall have adequate short time current rating to meet the short time current duty of inverter specified in the data sheet.

6.6.0 The battery shall be complete with inter-cell, inter-row, inter-tier connections and end take off. Interconnecting cables from battery to UPS panels are to be supplied along with battery.

6.7.0 The lead acid batteries shall be supplied in dry uncharged condition with necessary quantities of electrolyte and distilled water in separate sealed containers. Other batteries shall be supplied with electrolyte filled in condition.

6.8.0 The battery shall be complete with all accessories and mounting arrangement as specified in the data sheet. The mounting arrangement shall be given proper anti-corrosive treatment.

7.0.0 RECTIFIER SECTION

7.1.0 The rectifier section shall consist of mains transformer and full wave fully controlled rectifier with online float and boost charging facilities with selector switch, for maintaining the battery at fully charged condition.

7.2.0 The alternating current main supply will be made available at the UPS panel by the purchaser, unless otherwise specified in the data sheet.

7.3.0 Float and boost chargers shall be separate circuits, if so specified in the data sheet.

7.4.0 Both Manual and Auto modes with selector switch shall be provided for boost charging. In the Auto mode, the solid-state circuits provided shall sense the demand for more charging current persisting beyond a preset time and the charging operation shall go automatically to boost mode. Boost charging shall automatically return to float charging after a preset time.

7.6.0 The float and boost chargers shall be suitable for charging the battery at the maximum charging current allowable, while the charger is supplying the continuous load specified in the data sheet. The boost charger shall be capable of charging completely discharged batteries to full charged condition in about 8 hour duration.

7.7.0 The rectifier unit shall consist of semi conductor controlled devices and shall be capable of precise regulation of voltage with low ripple content to prevent damage to the battery.

7.8.0 Unless otherwise specified in the data sheet, the voltage regulation at rectifier output bus shall be within ± 2% of the float / boost voltage applicable for the specified mains voltage and frequency variations.

7.9.0 The charger units shall have current limiting capability incorporating reliable quick response solid-state circuits.

7.10.0 The mains transformer shall be double wound, vacuum impregnated and dry type.

7.11.0 Soft start feature shall be incorporated in the rectifier control circuits to reduce the in rush currents in supply lines, during power 'ON'.

8.0.0 INVERTER SECTION

8.1.0 The inverter shall be suitable for supplying power to the loads specified for the UPS.

8.2.0 The inverter shall be of pulse width modulation type and shall employ IGBT technology with high frequency switching of thyristor or power transistor based circuits as specified in the data sheet.

8.3.0 Regulation of the output voltage shall be within ± 2% of the rated voltage for the specified load power factor, unless otherwise specified in the data sheet. Facility to adjust the output voltage to compensate the line drop shall be provided.

8.4.0 The inverter shall have synchronous mode and asynchronous mode of operations with selector switch. In the asynchronous mode the inverter shall operate at the free running frequency with regulation as specified in the data sheet. In the synchronous mode the inverter frequency shall follow the reserve supply frequency as long as the later is within ± 1% of the free running frequency for enabling synchronized transfer of load between inverter and reserve supply. When reserve supply frequency exceeds the above limits the inverter shall delink from the mains frequency and shall operate at the free running frequency, and will return back to synchronous mode once the frequencies are within the above limits. The frequency changes shall take place smoothly without any break in power supply or transients. Facility for manual adjustment of free running frequency within ± 3% of specified value shall be provided.

8.5.0 The inverter voltage and frequency regulation shall be within the specified limits under the following conditions.

a) 0% to 100% load variations
b) Ambient temperature variations as specified
c) Minimum to maximum DC bus voltage variation
d) Failure of cooling system employed for step load changes of 50% value, the voltage variation shall be within ± 10% and recovery shall be within 5 cycles unless other wise specified in the data sheet.

8.6.0 The inverter shall be capable of supplying overload currents specified in the data sheet for the period indicated therein. For greater currents or longer durations, the inverter shall have current limiting protection to prevent damage to components.

8.7.0 Maximum harmonic distortion in the output voltage wave form shall be limited to 5%, unless otherwise specified in the data sheet.

8.8.0 The circuits of the inverter shall be designed so that, parallel operation of two or more inverters with common battery and output bus is possible in future.

8.9.0 The output transformer shall be vacuum impregnated and dry type.

8.10.0 The three phase inverters shall be designed for 50% unbalance load unless otherwise specified in the data sheet.

9.0.0 STATIC SWITCH

9.1.0 The static switch shall consist of solid-state devices for automatic transfer of load from inverter to the reserve supply in the following cases.

a) Minimum and maximum voltage limits of the inverter exceeded.
b) On Inverter failure
c) On Inverter overload exceeding limits
d) On manual push button operation

9.2.0 The transfer / retransfer between inverter and reserve supply shall take place with in 1/4 cycle without interruption in supply and transients, if the two supplies are synchronised.

9.3.0 Suitable provisions shall be incorporated in the system, to handle transfer/ retransfer between asynchronised supplies without generation of transients.

9.4.0 Manual / Automatic retransfer facility with selector switch shall be provided as specified in the data sheet.

9.5.0 Manual transfer and retransfer through static switch shall be by actuation of push button like device.

9.6.0 Possibility of hunting in the automatic mode of operation between inverter and reserve supply shall be prevented by suitable means. The thermal characteristics of the semi conductor devices shall be taken into consideration to prevent damage of these devices due to over heating during frequent transfer/ retransfer on over load.

9.7.0 Manual by pass switch / circuit breaker shall be provided unless otherwise specified in the data sheet to connect the reserve supply directly to the output bus, bypassing the static switch. The manual bypass switch shall be make before break type and of adequate rating for operation on full output capacity of the UPS. Suitable arrangement shall be provided to prevent operation of this switch when supplies are not synchronised.

10.0.0 RESERVE SUPPLY ARRANGEMENT

10.1.0 The reserve supply arrangement shall consist of separate alternating current source transformer and static voltage stabiliser unless otherwise specified in the data sheet. The reserve supply at the output shall be of the same phase, sequence and voltage as that of the inverter out put.

10.2.0 The AC source for the reserve supply will be made available by the purchaser at the UPS panel. The input supply details will be furnished in the data sheet.

10.3.0 The ratings of components in the reserve supply arrangement shall be adequate for handling the full rated capacity of the UPS.

10.4.0 The voltage regulation of the static voltage stabilizer supply shall be within ± 2% , when the input AC voltage variation is within ± 10% and frequency variation is within ± 5%, unless otherwise specified in the data sheet.

10.5.0 The static voltage stabilizer shall be fully solid state and shall be suitable for the load specified for the UPS.

10.6.0 The power transformer used on the input side of the reserve supply arrangement shall be double wound, vacuum impregnated and dry type.

11.0.0 COOLING ARRANGEMENT

11.1.0 The UPS shall be suitable for the ambient temperature and other site conditions specified in the data sheet, without the need of air conditioning.

11.2.0 Natural cooling is preferred to forced cooling.

11.3.0 Cooling fans if provided shall be adequate for dissipating the heat at maximum load and ambient temperature conditions. The fans shall be of low noise type.

11.4.0 The supply for fans shall be availed from the UPS system, but this shall not reduce the specified power output of the UPS.

11.5.0 Fans shall have redundancy if so specified in the data sheet.

12.0.0 DISTRIBUTION BOARD

12.1.0 The UPS shall be complete with Distribution Board with outlets as specified in the data sheet for distributing the UPS output.

13.0.0 PARALLEL OPERATION

13.1.0 If specified in the data sheet, the system shall consist of two or more Inverters each rated for full UPS capacity, connected in parallel across common battery and output bus and sharing the load equally. Each Inverter shall be suitable for parallel operation.

13.2.0 Solid-state circuits along with breakers shall be incorporated for quick and reliable isolation of the faulty inverters.

14.0.0 PROTECTION

14.1.0 Equipment components shall be selected to provide sufficient voltage capability and ample current carrying capacity to furnish a reasonable margin for handling over currents and voltage variations.

14.2.0 Transient suppressing circuits and high speed fuses shall be used to protect the semi conductor devices. Suitable filters shall be provided at input and output ends of the UPS to suppress radio frequency interference.

14.3.0 All semi conductor circuits shall be fuse or breaker protected so as to prevent cascade or sequential semi conductor failures.

14.4.0 UPS shall have all the necessary built in protections such as those against input over/ under voltages, phase failures, over load, output over/under voltages, battery over/under voltages, surges induced by primary AC source, surges at output due to load transfer, short circuits and earth faults.

14.5.0 The UPS shall be designed for the fault level specified in the data sheet.

14.6.0 The UPS shall be short circuit stable by ensuring safety of various components of the system during short circuits.

14.7.0 Breakers along with fast acting solid-state protection circuits shall be used to fully isolate the faulty sections.

14.8.0 Air break switches / circuit breakers of adequate duty and number of poles shall be provided for fully isolating AC incomers, battery, rectifier, inverter and reserve supply, static switch, etc. for service and maintenance without the need of total shut down of the UPS.

14.9.0 The battery shall be given separate short circuit protection, unless otherwise specified in the data sheet.

15.0.0 METERING AND INDICATIONS

15.1.0 The UPS shall comprise of all necessary meters, audio / visual alarm annunciations not limited to those given in the data sheet.

15.2.0 Additional contacts shall be wired up to a common terminal block in the UPS system for remote indication of the following unless other wise specified in the data sheet.

a) Inverter by passed
b) Battery in operation
c) Low battery DC voltage
d) Low UPS output voltage

15.3.0 Frequency meters shall be of digital type, and ammeters & voltmeters shall be of analog type with class 1.5 accuracy and of size not less than 72mm X 72mm.

15.4.0 Fault diagnostic unit shall be provided if specified in the data sheet.

16.0.0 PANELS

16.1.0 The rectifier section, inverter section, static switch, reserve supply arrangements, output distribution board and all other accessories shall be accommodated in separate self contained, self standing, floor mounted, damp and vermin proof, sheet steel cubicles in folded construction with requirements as specified in the data sheet. The cubicles shall be of equal height and depth.

16.2.0 The battery set shall also be accommodated inside cubicles if specified in the data sheet.

16.3.0 Cubicles shall have doors on concealed hinges with handle and locking facility. All doors and removable covers shall be gasketed all round with non-aging gasket.

16.4.0 All controls and indicating instruments shall be flush mounted on the front and shall be arranged so as to give a neat appearance. Labels shall be used for designating each component mounted on the panel front.

16.5.0 All the components shall be mounted with ample clearance in between them for convenience of operation, inspection and maintenance.

16.6.0 All internal wiring shall be done with insulated copper conductors of minimum size of 1.5 sq.mm and shall be neatly laid out and clamped. Both ends of wires shall be provided with numbered ferrules for identification.

16.7.0 Printed circuit boards shall be of fibreglass epoxy with plug in type arrangement and with test options brought out for ease of circuit checking and servicing.

16.8.0 The power conductors shall be PVC insulated and of adequate size to carry the power cur rents.

16.9.0 The maximum permissible current density shall be 1.25A / mm^2 and 0.78A / mm^2 for copper and aluminium bus bars respectively. The bus bars shall be colour coded and PVC sleeved. The bus bar supports shall be of non-hygroscopic material and shall be designed to withstand stresses due to short circuits.

16.10.0 The panels shall be complete with inter connecting cables, wires and necessary compression type cable glands, and shall be ready to receive the incoming and outgoing cables.

16.11.0 Cable entry shall be from bottom with removable gland plate, unless otherwise specified in the data sheet.

16.12.0 The live parts shall be shrouded to ensure safety to personnel when panel doors are opened for inspection.

16.13.0 Necessary nameplates giving relevant particulars of the equipment shall be provided on individual equipment/component.

16.14.0 Duplicate earthing terminals and earth bus at the bottom shall be provided for each panel.

16.15.0 Ventilation louvers provided shall have dust filters.

16.16.0 Panels shall be provided with internal panel lamps and plug outlets with ON OFF switches.

16.17.0 Necessary foundation bolts, nuts, washers, etc. shall be supplied along with the panels.

16.18.0 The **painting** shall be done as specified in 13ES 900 / data sheet.

16.19.0 Facility for handling the equipment at site, such as lifting lugs, shall be provided.

17.0.0 INSTALLATION, TESTING AND COMMISSIONING

17.1.0 If specially mentioned in the data sheet, the installation, testing and commissioning of the complete UPS system at site ,shall be in the scope of the supplier and the same shall be carried out as per standard codes of practice.

17.2.0 The installation scope shall include handling, assembly, erection, inter panel wiring, etc.

17.3.0 Testing and commissioning, if included in the scope, shall consist of electrolyte filling if applicable, charging and discharging of battery as per manufacturer's recommendations, site tests and submission of test reports.

1.0	**UPS – GENERAL**	
1.1	Output voltage with regulation	
1.2	Output frequency with regulation	
1.3	No. of phases / wires at output	
1.4	Continuous output rating	
1.5	Battery back up time	
1.6	Maximum and minimum ambient temperature	
1.7	Whether AC required?	
1.8	Standards to which UPS conform to?	
1.9	Walk in current and time	
1.10	Heat loss BTU / Hr	
1.11	Noise level and distance	
1.12	Whether diagnostic panel provided?	
1.13	MTBF of UPS system	
1.14	Whether isolated earth pits required?	
1.15	Radio frequency interference	
2.0	**RECTIFIER**	
2.1	Type	
2.2	Make	
2.3	Connection	
2.4	Whether full wave full controlled	
2.5	Power control device – type / make / designation	
2.6	Maximum / minimum voltage at rectifier output Bus at extreme conditions of input voltage, frequency, and load	
2.7	Charging facilities provided	
2.8	Whether selector switch provided for float and boost charger?	
2.9	Whether float and boost charger are separate units?	

2.10	Whether boost charger unit has got auto / manual facility?	
2.11	Preset time for reverting back to float mode after boost charging	
2.12	Whether boost charging & trickle (float) charging currents can be manually adjusted?	
2.13	Time required for boost charging the completely discharged battery to fully charged condition	
2.14	Maximum continuous current output of float charger / boost charger	
2.15	Max. short time current output and duration	
2.16	Whether current limit feature provided in each charger circuit?	
2.17	Type, make, rating of mains transformer	
2.18	Whether breaker / isolators provided at rectifier input and output end?	
2.19	Supply mains phase / voltage	
2.20	Mains frequency and range	
2.21	Input line current (maximum)	
2.22	Float charger - output voltage and range	
2.23	-do- current range	
2.24	-do- method of voltage control	
2.25	Boost charger - output voltage and range	
2.26	-do- current range	
2.27	-do- method of voltage control	
2.28	Harmonic content in AC mains at rated load with battery connected / disconnected	
2.29	-do- at 50% load	
3.0	**INVERTER**	
3.1	Type	
3.2	Make	
3.3	Static power control device (Type / make)	
3.4	Output voltage	
3.5	Phase / No. of wires	
3.6	Voltage regulation	
3.7	Output frequency	
3.8	Free running frequency regulation	
3.9	Power factor range	

3.10	Rated power	
3.11	Output of the inverter in case of cooling fans fails	
3.12	Harmonic distortion	
3.13	Recommended maximum / minimum DC input bus voltage	
3.14	Duration in minutes of permissible over load of 10%	
3.15	Duration in minutes of permissible over load of 25%	
3.16	Duration in minutes of permissible over load of 50%	
3.17	Over current permissible for 10 cycles	
3.18	No load input current	
3.19	Efficiency at rated load	
3.20	Efficiency at 75% load	
3.21	Efficiency at 50% load	
3.22	Transient response in terms of output voltage variation for step load changes of ± 50%	
3.23	Recovery time to ± 15%, ± 5%, ± 2% of rated voltage for the above step variation	
3.24	Transient response in terms of output voltage variation for step load changes of ± 100%	
3.25	Recovery time to ± 15%, ± 5%, ± 2% of rated voltage for the above step variation	
3.26	Output voltage regulation while charger is in boost mode	
3.27	Whether both synchronous and asynchronous operation with selector switch available?	
3.28	Adjustable frequency range in synchronous / asynchronous modes	
3.29	Whether facility for manual adjustment of output voltage provided? If yes, furnish range	
4.0	**STATIC SWITCH**	
4.1	Whether static switch is zero break type?	
4.2	No. of poles / phases and voltage	
4.3	Rating	
4.4	Switching device	
4.5	Whether both manual and automatic transfer facility with selector switch provided?	
4.6	Whether push button provided for manual transfer operation of static switch?	
4.7	Time for synchronous transfer / retransfer	

4.8	Frequency range in which the synchronous transfer / retransfer is permitted	
4.9	Can the static switch transfer / retransfer the load automatically if the frequencies are out of the permitted range? If yes, furnish the minimum time delay provided.	
4.10	Whether inhibit circuit is provided to prevent zero break transfer, if frequencies are not within the permitted range?	
4.11	Whether both manual and automatic retransfer facility are provided?	
4.12	If automatic retransfer facility is provided, how is hunting between inverter and reserve supply prevented?	
4.13	Whether manual bypass switch is provided? If yes, state number of poles and make	
4.14	Furnish voltage, current ratings of the manual bypass switch	
4.15	Is manual bypass switch make before break type?	
4.16	Panel in which static switch is located	
4.17	Location of manual bypass switch	
5.0	**RESERVE POWER SUPPLY**	
5.1	Name major components in the reserve supply line	
5.2	Is the mains transformer double wound, vacuum impregnated and dry type?	
5.3	Mains transformer – Make	
5.4	Mains transformer – Voltage ratio	
5.5	Mains transformer – KVA rating	
5.6	Mains transformer – Tappings provided	
5.7	Stabiliser – Type, Make	
5.8	Stabiliser – KVA rating	
5.9	Stabiliser – voltage	
5.10	Stabiliser – No. of phases	
5.11	Output voltage regulation for specified variation in voltage and frequency of AC input supply	
5.12	Transient response in terms of output voltage variation with recovery time for step load changes of	
	(a) ± 50%	
	(b) ± 100%	

6.0	**COOLING ARRANGEMENT**	
6.1	Method of cooling	
6.2	Fan – make	
6.3	Fan – voltage / power rating	
6.4	Fan – RPM / sweep	
6.5	No. of fans and redundancy provided	
6.6	Source of supply for cooling fans	
7.0	**DISTRIBUTION BOARD**	
7.1	Mounting	
7.2	Number and rating of outlets	
7.3	Outlets controlled by?	
7.4	Make	
7.5	Dimensions	
7.6	Rating and making of DB main switch	
7.7	Enclosure and degree of protection	
7.8	Whether distribution board is part of UPS panel or located separately?	
8.0	**PARALLEL OPERATION**	
8.1	Whether inverters are suitable for parallel operation?	
9.0	**PROTECTION**	
9.1	Name protections provided for rectifier	
9.2	Name protections provided for inverter	
9.3	Name protections provided for static switch	
9.4	Name protections provided for reserve supply scheme	
9.5	Make and rating of isolator / breaker provided	
	a) Between AC mains and rectifier	
	b) For battery	
	c) At inverter output	
	d) For AC mains for reserve supply	
	e) At static switch output bus	

10.0	**METERS AND INDICATIONS**	
10.1	Furnish list of frequency meters	
10.2	Furnish list of Ammeters	
10.3	Furnish list of Voltmeters	
10.4	Furnish list of visual annunciations	
10.5	Furnish list of visual / audio annunciations	
10.6	Furnish list of remote annunciations	
10.7	Details of fault diagnostic unit, if provided	
11.0	**PANELS**	
11.1	List of panels	
11.2	Panel enclosure	
11.3	Degree of protection	
11.4	Panel dimensions	
11.5	Are PCB's plug – in – type	
11.6	Power bus size and material	
11.7	Earth bus material and size	
11.8	Whether anti – condensation heater provided? If yes, voltage and power rating	
11.9	Whether lamp provided inside the panels?	
11.10	Minimum size of control wires	
11.11	Cable entry	
11.12	Paint and colour	

12.0	**BATTERY**	
12.1	Type	
12.2	Make	
12.3	Cell designation	
12.4	Construction	
12.5	Backup Time for rated output	
12.6	Type of connection between cells	
12.7	Number of cells	
12.8	Rated voltage of the set battery terminal	
12.9	Maximum / Minimum voltage of the set at battery terminal	
12.10	Ampere hour capacity at 27ºC and 40ºC	
	a) At 10 hour rate of discharge for lead acid batteries	
	b) At 5 hour rate of discharge for Ni-Cd batteries	
	c) De-rating factor provided (overall)	
12.11	Nominal voltage of cell	
12.12	End voltage of the cell	
	a) The value used in battery sizing calculation	
	b) The value recommended by the manufacturer	
12.13	Float charge voltage of the cell	
12.14	Maximum boost charge voltage of the cell	
12.15	Normal continuous current output	
	a) At 10 hour rate of discharge for lead acid batteries	
	b) At 5 hour rate of discharge for Ni-Cd batteries	
12.16	Maximum continuous current output during specified battery backup duration without dropping of voltage below end voltage of clause 13.12(a) above	
12.17	Momentary current output capacity without exceeding a voltage drop of 15%	
12.18	Short time current rate for 1 minute	
12.19	% voltage drop while supplying the aboveshort time current	
12.20	Type of positive plate and number of plates/ cell	
12.21	Type of negative plate and number of plates/ cell	
12.22	Type of material of separators	

12.23	Type of material and thickness of containers	
12.24	Standards to which container conforms to	
12.25	Type of electrolyte and quantity per cell	
12.26	Maximum permissible electrolyte temperature for continuous operation	
12.27	-Do- for short time operation	
12.28	Recommended specific gravity at the end of full charge	
12.29	Expected specific gravity at the end of discharge	
12.30	Temperature sensors on the cells	
	a) Whether provided	
	b) No. of cells in which temperature sensors provided	
12.31	Cycle life of each cell (50% and 100% loads)	
12.32	Internal resistance of / cell	
12.33	Total resistance across battery set output terminals	
12.34	Recommended starting and finishing rate of charge	
12.35	Voltage per cell at the end of charge at the finishing rate	
12.36	Recommended maximum period of storage before the first charge	
12.37	Overall dimensions of each cell (L X W X D)	
12.38	Weight of each cell complete with electrolyte	
12.39	Quantity and specific gravity of electrolyte / cell for first filling	
12.40	Space requirement for battery installation (Typical arrangement to be furnished)	
12.41	Whether separate battery room required?	
12.42	Minimum recommended battery room dimensions	
12.43	No. of recommended air changes per hour for battery room	
12.44	Mounting arrangement applicable	
12.45	Overall dimensions of mounting arrangement	
12.46	Size and length of inter connecting cable from battery to inverter	

TECHNICAL PROCUREMENT SPECIFICATION	SCOPE OF WORK MECHANICAL	32686- 13-PS-921 SW(MECH)
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TPS NO.	32686-13 -PS-002
ITEM :	**DIESEL ENGINE**
EQPT. Nos.	-

The scope of work for the equipments listed above shall include design,manufacture, Tests, supply of materials, erection, and engineering work as detailed below.

Sl. No	Description	Reqd.	Remarks
1.0	Diesel Engine complete with	✓	As per BS - 5514
	Fuel oil system	✓	
	Lube Oil system	✓	
	Jacket water system	✓	
	Air Intake and Exhaust system	✓	With supprts and thermal insulation for personal protection for exhaust
	Governing system	✓	
	Radiator	✓	
2.0	Engine Starting system	✓	D.C Motor starting
2.1	Automatic starting by battery powered electric motor having automatic and repeat start facilities		
2.2	Manual starting		
	Electric starter motor / crank handle		
2.3	Automatic starting facility	✓	
	Pressure switches		
2.4	Repeat start facility	✓	
3.0	Instrument and controls	✓	
	RPM / indicator / Tachometer	✓	
	Local indications / Alarms	✓	
	Diesel engine controller	✓	
	Control panel	✓	

REV.NO.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	30.03.21	Re-issued	LA	SK	AAN
0	05.10.20	For Enquiry	LA	SK	AAN

Sl. No	Description	Reqd.	Remarks
4.0	Batteries	✓	
4.1	Battery charger	✓	
5.0	Interconnecting cables	✓	
6.0	Spares	✓	
	Mandatory Spares	✓	
	For two years operation	✓	Owner may order such spares
	For commisioning	✓	
7.0	Special Tools	✓	If any
8.0	Inspection and Testing	✓	As per "Scope of inspection and Tests"
9.0	Painting	✓	
	Prime coat only		
	Prime coat with finish paint	✓	
10.0	Packing	✓	
	Domestic	✓	
	Export		
	Rust prevention for long term storage	✓	For Six months
11.0	Erection and commisioning	✓	
12.0	Drawings and documentation	✓	as per VDR

1.0 INTRODUCTION

1.1 This specification covers the design, manufacturing, supply, erection and commissioning of one number of **Diesel engine** for the D.G Set to be installed in 10,000 MT Ammonia Storage Facility for FACT-CD located at Ambalamedu, Kochi.

1.2 The scope of work shall include the Design, Manufacture, Inspection, Testing, Painting, Supply, Erection & Commissioning of the equipment with all accessories, Performance Guarantee Test Run (PGTR), Training of owner's personnel and Handing over the system to FACT-CD as per the Technical Procurement Specification and connected drawings.

2.0 GENERAL

2.1 All documents as detailed in 'Vendor Data Submission Procedure" & "Vendor Data Requirements" shall be submitted by Vendor for review by FEDO.

2.2 All items indicated in "Scope of Work" attached shall be included in the Scope of Vendor. Any item required for the safe and efficient operation of the system whether specifically mentioned or not, shall be provided by the Vendor without extra cost.

2.3 Inspection / Tests shall be carried out by Vendor as detailed in "Scope of Inspection and Tests". Witnessing of tests where specified will be done by Client / FEDO or their authorized representative. Test certificates of the shop tests shall be submitted after tests and before supply (During vendor data review).

2.4 Data sheets of Diesel Engine are enclosed. Vendor shall submit the data sheets duly filled up along with other documents/drawings indicated in "Vendor Data Requirements", along with the offer. Changes if any required for meeting system /operational requirements shall be indicated along with reasons thereof.

2.5 Bidders or Representative of bidders shall visit the site and familiarize themselves of the site conditions before submitting their bid with prior permission from FEDO/Client. The bidder shall collect the necessary additional data as well as purchaser's requirements before quoting so that full coverage of the scope will be ensured in the offer itself.

2.6 First Fill of Lubricant, Mandatory Spares, Start-up and Commissioning spares, spares for two years normal operation and Consumables for Testing, Commissioning and establishing Guarantees shall be included in the scope of the Vendor.

3.0 Site Conditions

3.1 Refer to Process/Electrical Specification for Site Conditions

4.0 Technical Details

4.1 Diesel engine shall be suitable for the specified site conditions.

4.2 The entire power rating shall be arrived at after taking into consideration the following factors:

(i) De-rated power at working conditions
(ii) Efficiency of generator
(iii) Over-load condition (see 4.3 below)
(iv) Safety Margin (10 %)

4.3 The engine shall be capable of sustaining 10% over-load for one hour in a 12-hour running period.

4.4 Vendor shall indicate the Guaranteed fuel consumption (In lit/hr. considering sp. gr. of HSD as 0.85) of Engine without positive tolerance (inclusive of all tolerances) when generating required power at 0.8 power factor at generator terminals at specified site conditions.

4.5 Supply of all consumables including diesel oil and lubrication oil required for initial startup, commissioning, trial run including commissioning spares shall be in the scope of vendor.

4.6 If required, acoustic Enclosure shall be provided to control the noise level. The noise level shall not exceed 85dB at a measuring distance of 1 meter from Engine.

4.7 Non-sparking coupling guard and anti-vibration mounts shall be provided for the engines.

4.8 The fuel tank shall be sized for 6 hours running of the engine on full load.

4.9 Exhaust pipe shall be taken outside the DG set room and terminated at a suitable height in conformation to statutory regulations. Necessary pipe with supports and insulation shall be in vendor's scope.

4.10 The connection between exhaust manifold and silencer unit shall be flexible.

4.11 Engine's catalogues and list of previous supplies shall be furnished along with the offer.

5.0 Spare Parts

5.1 General

5.1.1 The bidder shall include in his scope of supply all the start-up and commissioning spares, mandatory spares and recommended two years operation spares and indicate these in the relevant schedules. The general requirements pertaining to the supply of these spares is given below:

5.1.2 The Vendor shall also indicate the unit wise population of each item and the service expectancy period for the spare parts under normal operating conditions before order placement.

5.1.3 All spares supplied under this contract shall be strictly interchangeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site, e.g. small items shall be packed in sealed transparent plastic bags with dissector packs as necessary.

5.1.4 Each spare part shall be clearly marked or labeled on the outside of the packing with the description. When more than one spare part is packed in single case, a general description of contents shall be on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purpose of identification.

5.1.5 The Bidder shall provide the purchaser all the addresses and specification of his sub-suppliers while placing the order on vendors for items / components / equipment covered under purchase order and will further ensure with his vendors that the purchaser, if so desires, will have the right to place order for spares directly on them on mutually agreed terms based on offers of such vendors.

5.1.6 No recommended spares for 2 years will be used during startup and commissioning of the equipment .

5.2 MANDATORY SPARES PARTS

5.2.1 The list of mandatory spares, which are considered essential by the purchaser, is indicated in attachment **32686-13-PS-001 SPR1(MECH)** of this specification.

5.2.2 The prices of mandatory spares indicated by the bidder in the Bid Proposal shall be used for bid evaluation purposes.

5.3 RECOMMENDED SPARES FOR 2 YEARS OPERATION

5.3.1 The Bidders shall submit the list including unit & quantity of recommended spares for two years normal operation & maintenance in un-priced part as per format **32686-13-PS-001 SPR2(MECH)** and item wise price shall be submitted in priced part.

5.3.2 The Purchaser reserves the right to buy any or all recommended spares.

5.3.3 Prices of recommended spares will not be used for the evaluation of Bids. Prices of Spares shall remain valid for two years from the end of Warrantee period; Owner may order such spares any time during this period.

5.4 START-UP & COMMISSIONING SPARES

5.4.1 Start-up commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. All spares used until the system is handed over to the Purchaser shall come under this category. The Vendor shall procure and supply spare parts for start-up and commissioning and shall be included in his scope of work without any extra cost to purchaser. The Lump sum quoted price in the price bid (supply) shall be deemed to be inclusive of provision for such spares and additional spares.

6.0 Performance Guarantee Test Run

6.1 Performance guarantee test run (PGTR) shall be in vendor scope in all respect including fuel, lubricants, tools and tackles for the same. Vendor shall conduct necessary tests, trial run, and performance run after site erection. Any defects / non-performance of the supply items during runs at site shall be rectified by vendor at his own cost.

6.2 Vendor shall submit a procedure/methodology for the Performance Guarantee Test Run (PGTR) in the offer stage itself. The equipment with all accessories shall be guaranteed for performance at the operating conditions specified. Capacity shall be guaranteed without negative tolerance. Any equipment / part of the system found defective or shortfall in performance beyond acceptable values shall be rectified by vendor within a reasonable time, free of cost to Purchaser. If vendor fails to carry out the rectifications within a reasonable time, Purchaser shall have the right to carry out necessary rectification at the risk and cost of vendor. The equipment and parts shall be guaranteed against defects in design, material, workmanship and performance for a period stipulated in the commercial conditions of the enquiry.

7.0 WARRANTEE

7.1 All items / equipment and system covered in the above specification shall be warrantied against any defect in material, manufacturing, assembly, testing, painting, etc, for a period of 1 year from the date of final acceptance after commissioning. **Warrantee-time maintenance shall be without any extra cost implication.**

****

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					PROJECT	10,000 MT Ammonia Storage Facility at CD
					CLIENT	FACT-CD
1	30.03.21	LA	SK	AAN	P.O No.	
0	05.10.20	LA	SK	AAN	VENDOR	
Rev	DATE	PRPD.	CHKD.	APPRD.		

FACT ENGINEERING AND DESIGN ORGANISATION

01FT013C/94

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TECHNICAL PROCUREMENT SPECIFICATION	EQUIPMENT LUBRICATION DATA DIESEL ENGINE	32686- 13-PS-002 LD(MECH) PAGE 1 OF 1

PROJECT : 10,000 MT Ammonia Storage Facility at CD

PROJECT NO : 32686 LOCATION : Ambalamedu, Cochin

TPS NO : 32686-13 -PS-002 VENDOR :

CLIENT : FACT-CD

SL No	DESCRIPTION	ITEM NO
1	Type of Lubrication System (State Grease-Gun, Grease Packed, Drip, Splash, Continuous)	
2	Recommended Lubrication for Break in (list two Indian alternatives by trade name and number)	
3	Quantity of Lubricant required for initial fill (Litres or Kg)	
4	Recommended Break - in period for Initial application (Hours)	
5	Recommended Lubrication for normal operation (List two Indian alternatives by trade name and number)	
6	Refill quantities if different from initial charge (Litres or Kg)	
7	Quantity of Lubricant shipped with initial order (Litres or Kg)	
8	Recommended time between changes of Lubricant (Hours)	
9	Expected annual consumption of Lubricant (Litres or Kg)	

Remarks :

REV NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	30.03.21	Re-issued	LA	SK	AAN
0	05.10.20	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION

CONTENTS

1.0 .0 SCOPE

This specification together with attached data sheets, scope of work and scope of inspection and tests covers the design, construction, supply and inspection and testing of Diesel En gines.

2.0.0 GENERAL

2.1.0 No deviation or exception from this specification shall be per mitted without the written approval of the purchaser. All devia tions from the requirement of this standard shall be clearly mentioned in the tender with reference to relevant paragraph number of this standard. Deviations if any shall be listed by the vendor supported by reasons, for the consideration of the purchaser. Unless specifically mentioned in the offer, all the clauses of this standard shall be deemed to be acceptable to the tenderer.

3.0.0 DESIGN/PERFORMANCE

3.1.0 Engine shall be of continuous duty, industrial type, multi- cylinder with direct fuel system suitable for cold starting fully conforming to BS:5514 and other relevant standards.

3.2.0 The following items (but not limited to) shall be included.

(1) Governor
(2) Air cleaner - Dry type
(3) Safety controls
(4) Turbo charger and after cooling if necessary
(5) Suitable exhaust silencer
(6) Starter (DC motor/compressed air)
(7) Sufficiently heavy fly wheel to limit cyclic variation in speed
(8) Emergency STOP facility near the engine
(9) Necessary cooling system
(10) Coupling
(11) Baseplate vibration isolators and foundation bolts

3.3.0 Fuel oil system

3.3.1 The fuel oil system shall be complete with fuel oil pump on the engine, fuel oil tank of capacity specified in the data sheet, hand operated fuel transfer pump for transferring fuel oil from barrels to the fuel oil tank, fuel oil filter, piping and fittings etc.

3.3.2 Fuel day tank shall be complete with graduated fuel oil level indicator with low level alarm contacts, filler cap, drain cock, vent pipe and floor mounting pedestals/structural supports. Vent pipe shall be provided with two layers of SS304 wire mesh of mesh size not less than 11 per square centimetre.

3.3.3 The fuel oil system shall meet with the approval of statutory authorities like inspector of Explosives, where applicable.

3.3.4 Fuel oil day tank shall have low level and high level switches for automatic start and stop of the pump feeding to day tank.

3.4.0 Cooling system

3.4.1 Cooling system shall be of mounted radiator type with engine driven fan and water circulation pump unless otherwise specified in the data sheet. The water jacket system shall be compact with all necessary fittings and controls.

3.5.0 Lubricating oil system

3.5.1 Lube oil system shall be complete with engine shaft driven lube oil pump, engine mounted lube oil cooler if required (to cool the oil when the engine is in operation) lube oil filter and neces sary fittings and controls. Lube oil system shall have suitable electrical heater required for cold starting of the engine.

3.6.0 Exhaust system

3.6.1 Heavy duty high attenuation residential type silencer and suit able expansion joint with necessary supports shall be provided. Silencer shall be provided with spark arrestor. Vendor shall indicate the noise level at grade 1.0m from the silencer stack. Preferred noise level is 80 dBA at grade at 1.0M.

3.6.2 Suitably sized exhaust piping complete with flanges and fitting shall be provided to pipe out exhausts to outside of the building. Flexible connection shall be provided between exhaust manifold and silencer unit.

3.6.3 Exhaust pipe for portion below 2.5m from floor shall be insulated with mineral wool and aluminium cladding, for personal protec tion.

3.7.0 Mounting system

3.7.1 The engine and the driven unit shall be directly coupled through a set of flexible couplings and shall be positioned on a rigid common fabricated skid base frame with necessary lifting holes and eyes.

3.7.2 Necessary safety/protective guards and foundation bolts and anti- vibration mounts shall be supplied.

3.7.3 Earthing terminals shall be provided on the base frame on op posite sides.

3.7.4 The bed plate for the driver unit shall be provided with drain connection to drain off any accumulated liquids.

3.8.0 Starting system

3.8.1 Starting system shall be of electric motorised unit type. (See requirements in the electrical specifications).

3.9.0 Engine protection

3.9.1 Engine protection shall include the following.

(a) Engine over speed

(b) Engine fails to start

(c) Low level in the fuel tank

(d) Low lube oil pressure

(e) High water temperature

(f) Low air pressure, in case of, compressed air starting

3.10.0 General requirements

3.10.1 The following items shall be supplied along with the engine.

(a) A set of tools for carrying out periodical maintenance.

3.10.2 Spares for two years normal operation with item-wise list and unit price shall be quoted. Spares for commissioning shall be quoted separately.

3.10.3 Supply of all consumables including diesel oil and lubrication oil required for initial start up, commissioning and trial runs for one hour.

3.10.4 Initial charging of the starting battery, including supply of acid and distilled water.

3.10.5 All drawings and documents shall be submitted, as per VDR, for purchaser's approval, along with relevant design calculations, wherever applicable. However, such approvals by the purchaser shall not relieve the vendor from his obligations under the contract.

3.10.6 The following test shall be conducted on the diesel engine and accessories.

(a) Diesel engine

No load running - 1 hour

(b) Fuel tank - Routine tests including hydro test.

3.10.7 Rotation arrow

Direction of rotation arrow shall be permanently attached to the body of the engine so that they cannot be tampered with later.

3.10.8 Painting

All equipments (non SS parts) shall be painted as below:

Coat	Type of paint	No. of coats	Dry film thickness /coat
Primer	Enamel paint suitable for operating temp.	2	20 microns
Finish coat	-do-	2	20 microns

Painting shall be done as per manufacturer's standards.

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for design, manufacture, testing and supply of Alternators (turbine driven/diesel engine driven) and its accessories like excitation system, automatic voltage regulator, control panel/desk with metering, protection, controls, indications, alarms and synchronizing facility, line & neutral cubicles, etc.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.
2.1.1 **Engineering specifications and Data sheet of General requirements for Electrics.**
2.1.2 **Data Sheet of Alternators and accessories**
2.1.3 **Technical Particulars of Alternators and accessories**

3.0.0 STANDARDS

3.1.0 Requirements laid down in the latest revisions of the following standards and other relevant standards and regulations shall be adhered to:

IS: 5422	Specification for turbine type generators
IS/IEC:60034	Rotating electrical machines.
IS: 4889	Methods of determination of efficiency of rotating electrical machines
IS: 6362	Designation of methods of cooling for rotating electrical machines
BS EN: 55014	Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus.
IS: 11726	Requirements for instruments for measuring vibration severity of rotating and reciprocating machines
IS: 12065	Permissible limits of noise levels for rotating electrical machines
IS: 12075	Mechanical vibration of rotating electrical machines with shaft heights from 56mm & higher- Measurement, evaluation and limits of vibration severity
IS/IEC 60947	Low Voltage switch gear and control gear
IS: 8623	Low voltage switchgear and control gear assemblies.
IS: 2705	Current Transformers
IS: 4201	Application guide for CTs
IS: 3231	Electrical relays for power systems protection
IS: 3842	Application guide for electrical relays for AC systems

IS: 13947 Part:5 Low voltage switchgear and control gear- Part-5 Control circuit devices and switching elements.
IS: 1248 Direct acting indicating analogue Electrical measuring instruments and their accessories
IS: 1901 Visual indicator lamps
IS: 1766 Time Switches for metering and load control
IS: 5834 Electrical timer relays for industrial purposes
IS: 5469 Code of practice for use of semiconductor junction devices
IS:13703 Fuses for voltages not exceeding 1000V AC or 1500V DC

4.0.0 GENERAL REQUIREMENTS

4.1.0 The alternator shall be continuous maximum rated conforming to IS: 5422, IS/IEC:60034 and BS EN: 55014 unless specified otherwise in data sheet for Alternator attached. The alternator shall be suitably protected for operation under the service conditions stated in the **Data Sheet of General requirements for Electrics.**

4.2.0 The generator shall be self regulating brushless salient pole three phase synchronous type with exciter and electronic automatic voltage regulator (AVR) and control panel.

4.3.0 Excitation and voltage regulation arrangement shall be suitable for maintaining the terminal voltage within ±5% of the rated voltage from no load to full load and for the complete range of temperature and power factor. Transient voltage dip during starting of motors shall not exceed the limit prescribed in the data sheet.

4.4.0 Radio interference suppression arrangement conforming to BS EN 55014 shall be provided where prescribed in the data sheet.

4.5.0 Noise level and vibrations shall be within limits specified in the relevant Indian Standards.

4.6.0 The direction of rotation of the rotor of the machine shall match with that of the prime mover. A clear indication of the direction of rotation of the machine shall be marked on either end of the machine.

4.7.0 A stainless steel rating plate shall be fixed on the alternator frame containing the following minimum information.

-Manufacturer's name
-Applicable standard
-Year of manufacture
-Serial number, type & frame
-Rated output in KVA and KW
-Duty
-Rated power factor
-Overload rating
-Rated frequency
-No. of phase/type of connection
-Rated stator current
-Rated speed in RPM
-Class of insulation (stator)
-Temperature rise (stator)
-Direction of rotation (viewed from Drive End)
-Weight in kg of rotor & stator
-Excitation current & voltage at rated output
-Direct axis sub-transient, transient and synchronous reactances (in %)

4.8.0 One set of special tools required for maintenance and necessary foundation bolts for alternators and accessories shall be supplied.

5.0.0 STATOR

5.1.0 STATOR FRAME

5.1.1 The stator frame shall be built from steel plates welded together. The frame construction shall be such that deformation and vibration are prevented.

.

5.1.2 The design of stator frame shall facilitate effective cooling of both core and windings.

5.1.3 The stator frame shall accommodate heat exchangers in the sides, if required.

5.2.0 STATOR CORE

5.2.1 The stator core shall be built up from low loss magnetic sheet steel. The coil slots provided on these steel segments shall be designed to allow easy removal and re-assembly of the winding.

5.2.2 The sheet steel shall be provided with heat resistant insulation on both sides giving an effective and permanent insulation between the sheets.

5.2.3 Necessary air ducts/arrangement shall be provided to ensure uniform temperature distribution within the stator winding.

5.3.0 STATOR WINDING

5.3.1 The armature winding shall be formed by insulated bars, assembled in the stator core slots, joined at the ends to form coils and connected in the proper phase belts by connection rings at the end of the winding.

5.3.2 The stator bars shall be constituted of insulated solid copper bars. They shall be so assembled with necessary transposition arrangement such that all strands share the load current equally and minimize the stray losses.

5.3.3 The end windings shall be carefully braced to prevent vibrations and distortions under short circuit conditions.

5.3.4 The waveform deviation shall be within the limits if any specified in the data sheet.

5.4.0 WINDING INSULATION

5.4.1 The insulation system shall comply with the requirements of the temperature class B, F or H as specified in the data sheet.

5.4.2 Winding shall be impregnated with a high quality synthetic epoxy resin under vacuum system, so as to withstand corrosive and tropical service conditions. The coils shall be given a complete corona protection on the slot portion and for a short distance outside the stator core in the form of special anti-discharge varnishes.

5.4.3 The winding insulation shall have the following characteristics:

a) High electrical breakdown strength
b) High mechanical strength
c) Low dielectric losses
d) Good resistance to impulse voltages
f) Excellent resistance to oil, moisture, dirt etc.
g) Good dimensional and thermal stability

5.5.0 TERMINALS

5.5.1 Six leads, ie. Ends of each phase shall be brought out through suitably insulated flat copper bus bars.

5.5.2 Necessary current & voltage transformers required for the alternator protection devices specified in data sheet shall be mounted on the stator terminal bushings in a separate enclosure outside the generator casing. The above shall include the CTs required on the either ends of the winding to provide differential protection for the alternator, if specified in data sheet.

5.5.3 A star connection shall be applied on the 3 leads on the neutral side after the above differential CTs and the 4 leads (3 phase and one of neutral) shall be brought out to facilitate further connections.

5.5.4 The above CT housing/terminal boxes shall be complete with flanges/facilities suitable for terminating 3 phases & neutral enclosed bus trunking/ cables as specified in data sheet.

5.5.5 In the case of alternators rated for 3300V and above separate terminal boxes shall be provided for phase and neutral. Phase terminal box shall be phase-segregated type.

5.5.6 The terminal boxes shall be of fabricated sheet steel and shall be suitable for withstanding maximum fault current for 3 seconds.

5.5.7 Necessary clearances/creepage distance shall be provided between live parts and between live parts to earth. Live terminal shall be insulated from the frame with material resistant to tracking.

6.0.0 ROTOR

6.1.0 ROTOR CORE

6.1.1 The Rotor core shall be made from a single steel forging subject to necessary tests for strength and ductility.

6.1.2 The rotor core shall be made up of laminated stampings.

6.1.3 The rotors shall be designed for a maximum over speed specified in the data sheet.

6.2.0 SHAFT ENDS

6.2.1 The two shaft ends shall be of forged steel, one shall be provided with a flange for coupling to the turbine. These shaft ends shall be solidily bolted to the rotor core from which they shall be magnetically insulated.

6.3.0 ROTOR WINDING

6.3.1 The rotor conductors shall be of copper.

6.3.2 The coils shall be wound in the rotor core and connected to each other by means of bracing. It shall be ensured that thermal stresses during operation are reduced to achieve a stable winding.

6.4.0 ROTOR BALANCING

6.4.1 Before leaving the manufacturer's works the rotor shall be dynamically balanced adequately and shall be run at specified over speed and high temperature without appreciable vibration and shaft deflection. Facilities for fastening balancing weights shall be provided at each end of the rotor.

7.0.0 COOLING SYSTEM

7.1.0 The alternator shall be provided with an adequate cooling system of type specified in the data sheet.

7.2.0 In cases where totally enclosed air circuit machines with air as the external cooling medium (CACA) is specified, a totally enclosed type enclosure with an air/air heat exchanger shall be provided.

7.3.0 In cases where totally enclosed air circuit machines with water as the external cooling medium (CACW) is specified, a totally enclosed type enclosure with an air/water heat exchanger shall be provided.

7.4.0 In cases as mentioned in 7.2.0 and 7.3.0 above, where external heat exchangers are specified, if the heat exchanger goes out of order, requiring maintenance, the totally enclosed type enclosure shall still be capable of continuous operation by dismantling part of the enclosure cover to make itself open type. The limitation, if any, in generator load to be adopted in such cases shall be indicated by the supplier.

7.5.0 Adequate provisions shall be made for draining possible condensate from the cooling air.

8.0.0 BEARINGS

8.1.0 Bearings provided for the generator and the exciters shall be designed to restrain the axial floating of the shaft as well as relieve the elongation of the shaft due to heat. If necessary, thrust-bearing pads should be fitted to take up axial thrust from turbine bearings.

9.0.0 EMBEDDED TEMPERATURE DETECTORS

9.1.0 Necessary number of resistance type embedded temperature detectors shall be provided to maintain a continuous surveillance of the temperatures in different parts of the generator as specified in data sheet. These temperature detectors shall be wired upto the terminal boxes on the stator frame.

9.2.0 The number and position of the temperature detectors shall be as listed below; unless otherwise specified in the data sheet.

a) 6 nos. in the stator winding (2 per phase)
b) 2 nos. for incoming cooling air & 1 no. for outgoing cooling air
c) 3 nos. for main and exciter bearings (1 per bearing) & 4 nos. for the thrust bearing pads (if provided)

10.0.0 ANTI-CONDENSATION HEATERS

10.1.0 Necessary anti-condensation heaters shall be provided for the alternator windings. The location and maximum surface temperatures of the heaters shall be such that no damage can be caused to any insulation.

10.2.0 The leads of the heaters shall be brought out to a separate terminal box**.**

10.3.0 These heaters shall be suitable for operation on a single phase 240V, 50Hz, AC supply.

11.0.0 EXCITATION SYSTEM

11.1.0 The excitation system of the alternator shall be brush less type assuring very easy maintenance. The excitation system shall be complete with necessary rotary armature type AC exciter direct coupled to the generator, rotating rectifier, pilot exciter, etc. as applicable.

11.2.0 The exciter requirement shall be at least 20% more than the maximum requirement at any time and the rated voltage must be at least 110% of the full load machine excitation voltage.

11.3.0 AC EXCITER

11.3.1 AC exciter shall be constructed of the stator for the field and rotor for the armature similar to rotary armature type generator. The AC exciter shall be overhung on the main generator-bearing bracket on the opposite coupling side.

11.3.2 The pole of the AC exciter shall be salient type and made of layers of sheet steel boiled to the yoke. The core shall be made of layers of punched silicon steel sheets and mounted on the rotor hub as one unit.

11.3.3 The windings shall be insulated with non-hygroscopic class F insulating material, unless otherwise specified in the data sheet.

11.4.0 ROTATING RECTIFIER ASSEMBLY

11.4.1 Rotating rectifier assembly shall rectify the three-phase current from the a.c. exciter and feed it into the alternator field winding.

11.4.2 The rectifier shall be pressed out and keyed to the alternator's shaft extension and balanced together with the alternator's rotor.

11.4.3 The rotor rectifier shall be composed of silicon diode with surge absorbers comprising of resistors and capacitors. All semi conductor elements shall be pre-stressed and all contact surfaces shall be prepared to guarantee high reliability and stability of the rectifier during operation with practically no maintenance requirement.

11.4.4 The rating of the Diode Bridge and armature shall be such that the full load current can be supplied with one diode in operation.

11.5.0 PILOT EXCITER

11.5.1 The pilot exciter shall be permanent magnet generator with permanent magnets mounted on its rotor function as revolving field type AC generator. The magnets shall be so designed that demagnetisation can never take place even during removal of rotor from the stator.

12.0.0 AUTOMATIC VOLTAGE REGULATOR

12.1.0 Necessary automatic voltage regulator to work in conjunction with the excitation system shall be provided complete with all associated accessories and circuitry so as to ensure the voltage regulation specified.

12.2.0 The AVR shall have quick response, high reliability, high safety, easy maintenance features and shall be of solid state type.

12.3.0 The AVR shall have a droop characteristic and be provided with a manual override mounted on the face of the generator control panel.

12.4.0 One number ON-Line standby AVR shall also be provided, if so specified in the data sheet.

12.5.0 The AVR shall operate with the voltage variation parameters (ie. regulation & adjustable voltage range) specified in the data sheet.

12.6.0 The AVR panel shall house the field breaker, discharge resistors and all other accessories/protection equipment required for field circuit.

12.7.0 The automatic voltage regulator provided for alternator of rating 2500KVA and above shall have the following minimum features:

a) Under frequency protection circuit
b) Protection against short circuit

c) Manual voltage regulator with auto follower
d) Over voltage protection
e) Minimum excitation protection
f) Over excitation protection
g) Stator current limiter
h) Flux limiter
i) Soft start facility (voltage build up circuit)
j) Quadrature current compensation for parallel operation
k) Null balance indicator
l) Change over to manual control in case of AVR limit crossing
m) Monitoring system of diode failure
n) Power factor control, voltage monitor & excitation monitor, as specified in data sheet
0) IEEE model and type of excitation system

13.0.0 CONTROL PANEL/DESK

13.1.0 A composite control panel/desk shall be supplied along with the generator housing all control, indication and protection devices of the alternator set, which shall operate in conjunction with the main power circuit breaker switchboard. Unless otherwise specified, the main power circuit breaker switchboard shall be excluded from the scope of supply of the alternator.

13.2.0 The control panel/desk shall be in conformity with the **Engineering Specification of Control panel/desk** (13ES928) and its data sheet.

13.3.0 If AVR is housed in separate panel, the control desk where provided shall also house all standard excitation control devices in addition to the optional excitation control devices, if any.

13.4.0 The control panel/desk shall also house all standard electrical metering and protective devices & circuitry, auxiliary relays, indication lamps & alarms, control/selector switches, fuses/MCBs etc. for the generator control & protection in addition to those specified in the data sheet,

13.5.0 **All accessories and/or facilities required for synchronizing the alternator supply with external sources shall be provided in the control panel/desk, if specified in the data sheet.**

13.6.0 Secondary instruments, with automatic scanning arrangement required for monitoring the temperature in conjunction with the various embedded temperature detectors shall also be provided in the control panel/desk.

13.7.0 The protective relays provided shall be flush mounted, draw out type and shall have reset type operation indicators & initiating contacts. The relays shall have provision for insertion of test plug at the front for testing and calibration purpose, using an external power supply without disconnecting the permanent wiring. Vendor shall furnish complete relay coordination details with settings applicable.

13.8.0 Adequate number of potential free contacts shall be provided on the control panel/desk for any remote control/monitoring of alternator set.

13.9.0 All auxiliary equipment such as shunts, transducers, interposing/auxiliary CTs & VTs etc. that are required shall be provided.

13.10.0 The control panel/desk shall be complete with all auxiliary facilities for the alternator set including a common audio and visual alarm annunciation system with TEST, ACCEPT and RESET features.

14.0.0 SPECIAL REQUIREMENTS FOR DIESEL GENERATING SET

14.1.0 The DG Set shall form a very compact integral and “ready-to-run” unit comprising of engine, alternator, control panel and all other accessories and auxiliaries**.**

14.2.0 The DG set shall be suitable for continuous duty, capable of delivering the required output at the site conditions, as specified in data sheet.

14.3.0 During starting of motors connected to the DG set there shall neither be any undue speed reduction nor be any undue voltage drop also there shall not be delay in the **engine speed** recovery.

14.4.0 The engine and the alternator shall be mounted on common skid base frame. The supplier shall suggest a suitable foundation to render the installation free of vibrations.

14.5.0 Necessary safety/protective guards, foundation bolts and anti-vibration pads shall be supplied for the DG set.

14.6.0 STARTING SYSTEM

14.6.1 If electric motor starting is specified for diesel engine, suitable DC starting motor shall be provided on the engine. Storage battery having ampere hour capacity for a minimum of 6 consecutive starts, placed on floor mounted frame along with terminals, links, lead cables for connecting the battery to the engine and to the control panels, and battery charging equipment for float and boost charging shall be provided. The battery charging unit consisting of transformer, rectifier with necessary regulator, DC ammeter, DC voltmeter, charging rate selector switch (OFF/Trickle/Boost), etc. shall be provided in control panel/separate panel.

14.6.2 If compressed air starting is specified for engine, compressed air storage bottles, sized for a minimum of 6 starts, complete with instrumentation for indication and controls (including pressure gauge mounted on the bottle) shall be provided. Duplicate bottles shall be provided if specified in the data sheet. Compressed air at a pressure indicated in the data sheet will be made available by the purchaser. Where specified in data sheet, necessary compressed air system (complete with compressors, drive motors, controls, accessories etc.) shall also be provided by the vendor.

14.7.0 MODE OF OPERATION

14.7.1 The DG set shall be suitable for manual/automatic & manual mode of operation as specified in the data sheet. In any mode of operation of emergency DG set, when the normal supply is healthy, the DG set will be at rest and the emergency loads will be met by the mains.

14.7.2 If “Automatic start on mains failure” feature is specified in the data sheet, the operating sequence shall be as follows:
When the normal supply fails, the DG Set is started either by a voltage monitor relay provided in the control panel, or by an initiating contact provided elsewhere if indicated in data sheet. When the duration of the main supply failure exceeds a pre-set value (adjustable between 1 sec and 5 sec) the DG set starts. As soon as the diesel generator set reaches the operating speed and the alternator its operating voltage, the main supply feeder is automatically disconnected and the alternator supply feeder is connected to the load bus, provided the main supply has not been restored within this period. However, in case, main supply is restored within that time, or alternator fails to reach its operating voltage by some reason, the main supply feeder remains connected to the load bus, and the engine is shut down manually. Thus the feeding arrangement of the emergency loads shall be automatically changed from normal mains supply to the emergency Diesel Generator supply on the occurrence of mains failure. Then the diesel generator shall continue to run and feed the emergency loads until, after restoration of the main supply, the operator manually re-transfers these loads to the mains and stops the diesel set. Automatic re-transfer of the loads from the generator supply to be main supply. and automatic shut down of the diesel generator after restoration of the main supply shall not be provided. After the above manual transfer to loads and the shut down of the set, the diesel generator set shall revert to stand-by condition and shall be ready to start, should the mains supply fail again.

14.7.3 If “Automatic stop-on mains restoration” feature is specified in the data sheet in addition to “Automatic-start-on-mains failure” feature, the DG set shall start automatically as above and

automatically stop-on mains restoration thereby changing connected loads from set-source to mains supply.

14.7.4 If manual mode of operation is also specified in the data sheet in addition to automatic operation, operating sequence shall be as follows:
In the manual mode of operation, which shall be selected by means of an operation selector switch, the diesel generator set shall be arranged to be started up manually by the operator by pressing “START” push button. In this case, connecting the load to the generator supply after reaching the rated speed and voltage shall also be done manually by pressing “CLOSE” push button. Arrangement shall also be made for manual tripping by means of “TRIP” push button. It shall also be possible to shut down the engine manually by pressing “STOP” push button. The manual mode of operation shall be independent of the conditions of the mains supply and thereby the same shall enable conducting test-runs of the diesel generator set without effecting any transferring of connected loads to the generator supply.

14.7.5 Three attempt starting facility shall be provided for the diesel generating set and in case of the unlikely event of the diesel engine failing to start and reach operating speed with 3 attempts of starting, it shall get disconnected and locked out automatically and this fault shall annunciated with indication “SET FAILS TO START”

14.8.0 4 pole circuit breakers/contactors & switch fuses on main side and on alternator side shall be provided in DG set control panel (AMF panel) if specified in data sheet.

14.9.0 Emergency stop facility near engine & required safety controls for the engine shall be provided.

14.10.0 For details/requirements of Diesel engine and its accessories refer mechanical specifications.

1.0	**Alternator details**	
1.1	Name & country of manufacturer	
1.2	Model of alternator	
1.3	Type of alternator	
1.4	Design rating	
1.5	Continuous output rating	
1.6	Maximum rating	
1.7	Power factor	
1.8	Rated voltage	
1.9	Rated current / phase	
1.10	Rated speed	
1.11	Critical speed	
1.12	Frequency	
1.13	Field current at rated output and voltage	
1.14	Maximum output without cooler	
1.15	Maximum permissible capacitive loading	
1.16	Maximum permissible inductive loading	
1.17	Continuous negative sequence capability / I^2t	
1.18	Direction of rotation when viewed from coupling end	
1.19	Moment of inertia ($GD^2/4$) of rotating mass of the alternator	
1.20	Radius of gyration	
1.21	Enclosure of alternator	
	a) Type	
	b) Degree of protection	
1.22	Type of cooling of alternator	
1.23	Mounting arrangement	
1.24	Bearings	
	a) Nos. and location	
	b) Type of bearing	
	c) Type of lubrication	
1.25	Insulation class & temp. rise over ambient temp.	
	a) Stator of generator	
	b) Rotor of generator	
	c) Armature of main exciter	
	d) Field of main exciter	

	e) Armature of pilot exciter	
1.26	Details of stator terminals & terminal box	
1.27	Anti condensation heater	
	a) Nos. & Location	
	b) Rating (in watts) & rated voltage	
1.28	Temperature detectors	
	a) Nos. & Location	
	b) Type details	
1.29	Generator parameters	
	a) Synchronous parameters (Xd)	
	b) Transient reactance (Xd')	
	c) Sub Transient Reactance (Xd")	
	d) Zero sequence reactance (Xo)	
	e) Negative sequence reactance (X2)	
	f) Open circuit field time constant (T sec.)	
	g) Resistance of field winding at operating temperature	
	h) Resistance of stator winding at operating temperature	
	i) Short circuit ratio	
	j) Short circuit withstand capacity & time	
	k) Sustained 3 phase short circuit current	
1.30	Performance guarantee for alternator	
	a) Maximum temperature rise over ambient	
	b) Full load losses	
	c) Armature copper losses	
	d) Core losses	
	e) Stray losses	
	f) Efficiency at full load (Rated PF / UPF)	
	g) At 3/4 load (Rated PF / UPF)	
	h) At 1/2 load (Rated PF / UPF)	
	i) At 1/4 load (Rated PF / UPF)	
	j) Overload capacity and duration	
	k) Time taken to develop rated voltage when started from cold conditions	
	l) Performance curves (to be attached)	
	m) Voltage regulation with AVR	
	n) Voltage range at which AVR set point can be adjusted	

	o) Voltage rise / dip when full load is thrown off / suddenly applied with AVR	
	p) Transient voltage dip on sudden application of rated load at 0.3 PF	
	q) Voltage recovery time for 100 % step load change	
	r) Inherent voltage regulation at rated PF	
1.31	Largest motor rating that can be started with terminal voltage not going below 85 %	
2.0	**Exciter**	
2.1	Type of excitation	
2.2	Capacity	
2.3	Rated voltage	
2.4	Rated current	
2.5	Ceiling voltage at rated current & rated speed	
2.6	Excitation system response ratio	
2.7	Type of enclosure	
2.8	Mounting	
2.9	Anti condensation heater for exciter	
3.0	**Weight and schedule**	
3.1	Weight of alternator (including rotor)	
3.2	Weight of rotor	
3.3	Weight of exciter	
3.4	Overall dimensions of alternator and accessories mounted on base frame	
3.5	Total shipping weight , Volume and size	
4.0	**Current transformers & Voltage transformers of alternator**	
4.1	CT specification (No. of CTs, purpose, ratio, burden, accuracy class, knee point voltage / secondary resistance, etc.)	
4.2	VT specification (No., ratio, burden, accuracy class, etc.)	
4.3	Location of CTs & VTs mounting	
5.0	**Automatic voltage regulator**	
5.1	Make	
5.2	Type details	
5.3	Voltage regulation	
5.4	Sensitivity of the regulator	
5.5	Whether on-line standby AVR is provided	
5.6	Whether AVR is housed in composite control Panel / desk or in separate panel	

5.7	Overall dimension of AVR panel	
5.8	Weight of AVR panel	
5.9	CT specification for AVR (No. of CTs, ratio, accuracy class, knee point voltage / secondary resistance)	
5.10	Features provided for AVR	As per clause 11.6.6 of spec.13S921 / As listed below :-
6.0	**Details of specific components / accessories on control panel / desk**	
6.1	Synchronising unit	
	a) Make & type	
	b) List of accessories	
6.2	Excitation control devices provided in control desk	
6.3	Details of meters & indicating instruments provided in control panel / desk :	
6.4	Details of relays provided in control panel / desk :	
6.5	Details of control switches & push buttons provided in control panel / desk :	
6.6	Details of alarms & indications provided in control panel / desk :	
6.7	Features provided in AMF panel, with component details &rating (in case of emergency DG set) :	
6.8	Size of bus bars & short circuit rating of AMF panel with power circuit breaker / contactor (in case of emergency DG set)	
6.9	Features & component details of battery charger for DC starting motor, if any (In case of DG set)	
7.0	Type & rating of B**attery for DC starting motor**, if any, for DG set	

8.0	Specification & details of **Surge protection** provided for alternator	
9.0	Features & details of **CO2 fire extinguishing system** provided for alternator	
10.0	Specification & component details of **line & neutral cubicle**	
11.0	Specification & details of DC **motor starter cubicle with starting resistor** (in case of any aux. drive with DC motor)	
12.0	Specification / Technical particulars of DC motor, if any, for aux. drive	

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for design, manufacturing, testing, supply, etc. of battery and battery charging equipment. The type of the battery and number of sets required shall be as furnished in the data sheet.

2.0.0 REFERENCES

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification and Data Sheet** of **General requirements for electrics**
2.1.2 **Data sheet** of **Battery and battery charger**
2.1.3 **Technical particulars** of **Battery and battery charger**

2.0.0 STANDARDS

2.1.0 The battery and battery charger shall comply with the latest issue of the following standards and other applicable standards.

IS: 1651 Stationary cells and batteries, lead acid type (with tubular positive plates)
IS: 1652 Stationary cells and batteries, lead acid type (with Plante' positive plates)
IS: 6304 Stationary cells and batteries, lead acid type (with pasted positive plates)
IS: 10918 Vented type Nickel cadmium battery
IS: 226 Sulphuric acid
IS:2026 Power Transformers
IS:11171 Dry Type Transformers
IS: 14901 Semiconductor devices -Discrete devices and integrated circuits
IS: 5469 Code of practice for use of semi conductor junction devices
IS/IEC60947-3 Low voltage switch gear and control gear :part 3-Switches, disconnectors, Switch disconnectors and fuse combination units
IS: 13703 Specification of low voltage fuses for voltages not exceeding 1000VAC or1500VDC
IS: 13947 Specification for low voltage switchgear and control gear
IS: 8623 Specification for Low voltage switchgear and control gear assemblies
IS:1146 Rubber and plastic containers for lead acid storage batteries
IS:6619 Safety code for semiconductor rectifier equipment

4.0.0 GENERAL REQUIREMENTS

4.1.0 The scope shall include supply of battery with required number of cells, electrolyte, battery stand, inter connectors, battery chargers, DC outlets and all other accessories necessary for the efficient and trouble free operation of the battery and chargers.

4.2.0 The scope shall include installation, testing at site and commissioning of the battery and chargers, if specified in the data sheet.

4.3.0 The battery together with the chargers shall be suitable to meet the DC load requirements of switch gears, control panels, emergency lights, auxiliary drives, etc. as specified in the data sheet.

4.4.0 The battery and battery charger are very critical by way that shutdown of these equipment results in heavy financial losses apart from the safety aspects of personnel and other equipments. Hence the equipment offered shall be of proven design and shall maintain very high standards with respect to reliability and quality of power output.

5.0.0 BATTERY

5.1.0 The battery shall be stationary type, unless otherwise specified in the data sheet.

5.2.0 The type of battery shall be either lead-acid, sealed maintenance free lead-acid or vented nickel- cadmium as specified in the data sheet. The Battery and Battery Charger offered shall be suitable for the load conditions furnished in the data sheet.

5.3.0 The battery construction shall be as per the Indian Standard applicable for the type of battery specified. Special requirements if any, shall be furnished in the data sheet.

5.4.0 The number of cells and ampere-hour capacity shall be as specified in the data sheet.

5.5.0 If the number of cells and ampere-hour capacity are not specified in the data sheet, the same shall be selected to suit the load conditions furnished in the data sheet. The number of cells selected shall be such that the rated voltage across the load will not fall more than the value specified at clause 6.2.4 below, when the battery is discharged due to mains failure or charger failure. The ampere-hour capacity selected shall be on the basis of specified continuous and short time load currents and backup time, with suitable margin for aging, temperature, high discharges, etc.

5.6.0 The ampere-hour capacity shall be on the basis of 10-hour discharge rate for lead acid batteries and 5 hour discharge rate for nickel cadmium batteries, unless otherwise specified in the data sheet.

5.7.0 When the battery discharges to the specified loads for the specified backup time, the end voltage/cell shall not fall below the value detrimental to the life of battery.

5.8.0 The battery offered shall have adequate short time current rating to meet the short time current duty specified in the data sheet.

5.9.0 The lead acid battery shall be supplied in dry uncharged condition with necessary quantities of electrolyte and distilled water in separate sealed containers, unless otherwise specified in the data sheet.

5.10.0 All battery sets shall be complete with suitable inter cell, inter row, inter tier, mid point, end cell cut off and end take off connections as applicable and conforming to standards.

5.11.0 The accessories to be supplied along with each battery set shall be as indicated in the data sheet.

5.12.0 For mounting the battery suitable wooden / steel / PVC racks or painted sheet steel cubicles as specified in the data sheet shall be supplied. The materials used for the construction of battery mounting arrangement shall be given suitable anticorrosive treatment.

6.0.0 BATTERY CHARGER

6.1.0 GENERAL

6.1.1 Each battery set shall have separate charger, suitable for the characteristic of the battery and the load requirements applicable as per the data sheet.

6.1.2 The battery charger shall have separate float charger and boost charger circuits, unless otherwise specified in the data sheet.

6.1.3 The charger shall be suitable for the AC mains supply specified in the data sheet. The AC mains supply will be made available by the Owner at the charger panel, unless otherwise specified in the data sheet.

6.1.4 The float and boost charging circuits shall be complete with mains transformers, solid state full wave rectifiers, voltage / current controllers, DC outlets, suitably rated control switches and HRC fuses, contactors, necessary ammeters, voltmeters, indicating lamps, alarms, hooters, relays, etc. for the efficient operation of the charger and battery set.

6.1.5 If specified in the data sheet, the battery charger shall have facility to receive at its DC bus an auxiliary DC supply specified in the data sheet. Two pole air break switches of adequate rating shall be provided for isolating this supply, if applicable.

6.1.6 Battery terminals and connectors shall be insulated to prevent accidental short circuits from metal objects dropped across the terminals. Individual battery cells shall be accessible for maintenance. Battery cells or groups of cells shall be numbered.

6.1.7 The following isolators shall provided as the minimum requirement:
- Incoming power supply isolator
- Battery isolator
- Load Isolator
- Control circuit Isolator

The isolating device shall include on-load switches, fully shrouded withdrawable links and fuses.

6.1.8 If the configuration is float cum boost charger with standby float charger, the operation shall be as follows:-
When the main float charger in float cum boost charger fails, the standby float charger shall automatically take care of the loads and also float charge the battery. The boost charger shall automatically take care of the load when both the float charger fails. On resumption of main float charger, the load shall be automatically transferred to this float charger

6.1.9 During boost charging mode the load voltage is maintained by proper tapping at the battery side. Adequate number of rated dropper diodes in required steps shall be provided in the load circuit.

6.1.10 An Auto/Manual selector switch shall be provided (float and boost) for change over to manual operation of the charger in the case of failure of Auto operation.

6.2.0 VOLTAGE REGULATION

6.2.1 The AC input voltage and DC output voltage rating of the battery charger shall be as specified in the data sheet.

6.2.2 During float charging, the DC output voltage across the load bus shall be maintained within ± 1% of the specified output voltage for all loads between no load and full load and under simultaneous AC input voltage variation of ± 10% and frequency variation of ± 3%, unless otherwise specified in the data sheet.

6.2.3 During boost charging the voltage across the load bus shall not exceed 5% above the rated output voltage, unless otherwise specified in the data sheet.

6.2.4 During discharge of battery due to failure of the AC mains supply or battery charger, the voltage across the load shall not fall more than 7.5% of the rated load voltage at the end of discharge to specified loads for the specified backup time.

6.2.5 When power supply AC mains is ON, the maximum permissible momentary voltage variation across the load bus , for step load changes like motor starting , energisation of breaker closing solenoids, etc. shall be within ± 10% , unless otherwise specified in the data sheet.

6.2.6 There should not be a failure of DC supply at load bus in the event of mains failure during boost charging or float charging. This shall be ensured by suitable DC link between battery and load.

6.2.7 If specified in the data sheet, soft start feature shall be provided in the charger so that when the charger is switched ON, the output voltage shall increase gradually from zero to final value without any voltage over shoot.

6.3.0 CHARGING CIRCUIT FEATURES

6.3.1 The float charger circuit for lead acid battery shall be suitable for floating the battery at about 2.15V per cell while supplying continuous load specified in the data sheet. The float charger circuit for nickel cadmium batteries shall be suitable for floating the battery at about 1.40V per cell while supplying the continuous load current specified in the data sheet. Facility shall be provided for minor adjustment of float voltage to regulate the trickle charging current and / or compensate line drop voltage.

6.3.2 The boost charger circuit shall be suitable for charging the battery at the maximum charging current allowable for the battery. The boost charger shall have facility to charge at constant current and / or at constant voltage with selector switch, as specified in the data sheet.

6.3.3 If float cum boost charger is specified in the data sheet, it shall be rated for supplying the maximum allowable charging current while supplying the continuous load specified in the data sheet.

6.3.4 The rectifiers shall be of full wave bridge type consisting of solid state devices. Special requirements if any shall be as furnished in the data sheet.

6.3.5 Charger units shall have automatic voltage controllers to regulate the voltage at the set value and to limit the output voltage variations within the permissible levels specified under clause 6.2.0 above by means of solid state circuitry incorporating devices like silicon controlled rectifiers, Zener diodes etc.

6.3.6 If specified in the data sheet, the battery charger shall have both Auto and Manual modes with selector switch. In the Auto mode the solid-state circuits provided shall sense the demand for more charging current persisting beyond a preset time and the charging operation shall go automatically to boost mode. Boost charging shall automatically return to float mode after another preset time.

6.3.7 In the Manual mode of operation the boost charger shall have facility for stepless control of the output current and voltage.

6.3.8 The performance characteristic of the charger units shall be such that the chargers at no time shall be overloaded. The overload shall be automatically passed on to the battery by means of load limit feature incorporating reliable quick response solid-state circuitry. Facility shall be provided to adjust the limiting current, if so specified in the data sheet.

6.3.9 Charger voltages in excess of the specified load voltages shall be dropped using silicon controlled devices, cell cutting, etc. and shall not be passed on to the load.

6.3.10 The mains transformer shall be double wound, vacuum impregnated and dry type, and shall be suitable for the AC mains supply specified. To facilitate selection of correct mains voltage, suitable tappings shall be provided on the primary side of the mains transformer with necessary selector switches.

6.3.11 Suitable filter circuits shall be provided to limit the ripple content of the DC to 1% and to suppress radio frequency interference.

6.3.12 The Vendor shall state the maximum harmonic currents drawn by the unit and whether a harmonic filter is supplied.

6.3.13 The battery charger shall have standby charger units, if specified in the data sheet.

6.4.0 PROTECTION

6.4.1 The components shall be selected to provide sufficient voltage capability and ample current carrying capacity to furnish a reasonable margin for handling over currents and voltage variations and to limit temperature rise of components to safe values.

6.4.2 Transient suppressing circuits and high speed fuses shall be used to protect the semi conductor devices.

6.4.3 All semi conductor circuits shall be protected using fuse or breaker so as to prevent cascade or sequential semi conductor failures.

6.4.4 The battery charger shall be designed for the fault level specified in the data sheet.

6.4.5 The battery charger shall have all the necessary built in protections such as those against input over/ under voltages, phase failures, over load, output over / under voltages, battery over / under voltages, surges, short circuits, earth faults, etc.

6.4.6 The battery shall be given separate fuse protection.

6.4.7 Air break switches / circuit breakers of adequate rating and suitable number of poles shall be provided to fully isolate the charger from supply mains, battery and load.

6.5.0 DC DISTRIBUTION OUTLETS

6.5.1 DC Distribution outlets shall be arranged in the Battery Charger panel itself, unless otherwise specified in the data sheet. The charger control and accessories and DC Distribution outlets shall be segregated from each other to the extent possible. Number and rating of outlets shall be as indicated in the data sheet.

6.5.2 Two pole DC isolation switch with HRC fuses or Two pole MCB of adequate ratings shall be provided for the purpose of isolation of DC distribution bus.

6.5.3 All DC distribution outlets shall be provided with necessary two pole control switches and HRC fuses or MCBs of adequate ratings.

6.6.0 ANNUNCIATIONS

6.6.1 Repetitive type visual and audible alarm shall be provided for various conditions of the Battery charger system specified in the data sheet.

6.6.2 Alarm scheme provided shall have ACCEPT, RESET and TEST facilities by means of Push Buttons.

6.6.3 Earth leakage circuit shall consist of an earth leakage relay, variable resistance, center zero milli ammeter, isolating switch, indicating lamps, auxiliary relay for alarm initiation, etc.

6.6.4 The charger failure detection circuit shall consist of an under voltage sensing device / relay (which can be adjusted to get preset values), auxiliary relay for alarm initiation, indicating lamp, etc.

6.6.5 All auxiliary relays for alarms shall have flag indications with hand reset facilities and shall be of flush mounted type.

6.6.6 Facility for transmitting the alarm impulses to attended locations shall be provided if specified in the data sheet. For this, necessary contacts shall be wired upto the terminal block in the charger panels.

6.7.0 HRC FUSES

6.7.1 All fuses shall be of link type HRC fuses provided in phenolic molding fuse base and carrier with necessary viewing aperture.

6.7.2 All important fuses shall be mounted on front surface of the cubicle, unless otherwise specified in the data sheet.

6.7.3 Ratings of back up fuses shall be such as to provide sufficient grading between successive stages wherever applicable.

6.8.0 SWITCHES

6.8.1 All the switches provided shall be of normal duty Air break type and shall be flush mounted on the front surface and neatly arranged with the respective fuses in logical manner.

6.8.2 Indicator plates shall be provided for the switches for easy identification of “ON/OFF” positions.

6.9.0 METERS

6.9.1 All meters shall be of square type and sizes of the meters shall not be less than 72mm x 72mm.

6.9.2 All meters shall be flush mounted at a height not less than 1250mm from the floor level.

6.9.3 Required number of Ammeters shall be provided to measure the following currents accurately,

a) Trickle charging current during float operation
b) Boost charging current
c) Load current
d) Battery discharge current

6.9.4 AC Voltmeter with selector switch to measure Power supply mains voltages and DC voltmeter with selector switch to measure the following DC Voltages shall be provided.

a) Charger DC output voltages (Boost and Float)
b) Voltage across the Battery
c) Voltage across the tap from battery, if any
d) Voltage across the DC load bus

6.10.0 CONSTRUCTION

6.10.1 The main transformers, charging circuits, DC outlets, switches, fuses, contactors, relays, hooters and all other accessories of each charger shall be accommodated in a separate self

contained, self standing, floor mounted, damp and vermin proof, sheet steel cubicle of folded construction.

6.10.2 The enclosure and protection of the cubicles shall be as specified in the data sheet. Special requirements applicable if any on cubicle dimensions, shall be furnished in the data sheet.

6.10.3 The battery shall also be accommodated inside cubicles, if specifically mentioned in the data sheet. These cubicles shall be of construction similar to that of the charger cubicles.

6.10.4 Wherever common cubicle for battery and charger is specified, the battery portion and the charger portion shall be segregated by means of a barrier between them. Cubicle containing battery shall be protected from acid / alkali corrosion by providing suitable anti corrosive lining / sheets with materials like PVC.

6.10.5 The cubicles shall have hinged doors with locking facility. All doors and removable covers shall be gasketed all round with non-aging rubber/ neoprene gaskets. The hinges shall be of concealed type.

6.10.6 Switches for the DC outlets shall be mounted on the front side, unless otherwise specified in the data sheet. Labels shall be provided for designating each outlet.

6.10.7 All controls and indicating instruments shall be flush mounted on the front side and shall be arranged so as to give a neat appearance. Labels shall be provided for designating each component mounted on the panel.

6.10.8 All components shall be mounted with ample clearance in between them for convenience of operation, inspection and maintenance.

6.10.9 Cubicles shall be provided with necessary internal panel lamps, with ON and OFF switches and HRC fuses/MCB.

6.10.10 Anti condensation heater (suitable for AC mains supply specified) shall be provided inside the cubicles with ON/OFF control switches and HRC fuses/MCB with thermostat.

6.10.11 The cubicles shall be designed suitable for the maximum ambient temperature specified in the data sheet. Natural cooling is preferred for the cubicles.

6.10.12 All internal wiring shall be done with insulated copper conductors of minimum size of 1.5 sq mm and shall be neatly clamped together and laid out nicely. Both ends of wires shall be provided with numbered ferrules for identification.

6.10.13 Printed circuit boards shall be of fiberglass epoxy, with plug in type arrangement, with test options brought out for ease of circuit checking and servicing.

6.10.14 The power cables shall be PVC insulated with adequate conductor size to carry the power currents.

6.10.15 The maximum permissible current density shall be 1.25A/sq mm for copper busbars and 0.78A/sq mm for aluminium busbars. The bus bars shall be colour coded and PVC sleeved. The busbars and busbar supports shall be designed to withstand the effects of short circuit currents. The busbar supports shall be of non-hygroscopic materials.

6.10.16 The cubicles shall be complete with inter connecting cables, wires, and necessary cable glands for incoming and outgoing cables.

6.10.17 Cable entry shall be from bottom with removable gland plate unless otherwise specified in the data sheet. Cable sizes shall be as indicated in the data sheet.

6.10.18 The live parts shall be shrouded to ensure safety to personnel when panel doors are opened for inspection.

6.10.19 Necessary nameplates giving relevant particulars of the equipment shall be provided on individual equipment / component.

6.10.20 Duplicate earthing terminals shall be provided for each panel. Earth bus at the bottom shall be provided through out the panel.

6.10.21 Ventilation louvers provided shall have dust filters.

6.10.22 Necessary foundation bolts, nuts, washers, etc. shall be supplied along with the panels.

6.10.23 The painting shall be as specified in 13ES900. The paint and final colour shall be as specified in the data sheet.

6.10.24 Facility for handling the equipment at site, such as lifting lugs, shall be provided.

7.0.0 INSTALLATION, TESTING AND COMMISSIONING

7.1.0 If specifically mentioned in the data sheet, the installation, testing and commissioning of the battery sets and charger panels shall be included in the scope of the supplier.

7.2.0 The installation shall be carried out as per manufacturer's recommendations, standards, rules and regulations applicable for electrical installation works.

7.3.0 Testing and commissioning scope shall include handling, assembly, electrolyte filling, charging, discharging as per manufacturer's recommendations, testing and submission of test reports.

1.0	GENERAL	
1.1	Rated DC bus voltage	
1.2	Ampere-hour capacity at 5 hour/10 hour rate of discharge	
1.3	Normal continuous current output and back up time	
1.4	Momentary current capacity without exceeding a voltage drop of 10%	
1.5	Momentary current capacity without exceeding a voltage drop of 15%	
1.6	Short time current rating for 1 minute	
1.7	Voltage drop while supplying the above short time current	
1.8	Guaranteed percentage voltage regulation at the load bus (for float, boost, battery discharge operations)	
2.0	**BATTERY**	
2.1	Type and make	
2.2	Ampere-hour capacity at 27º C and 40º C	
2.3	Overall margin provided for ampere-hour capacity in battery sizing calculations	
2.4	Cell designation	
2.5	Number of cells per Battery	
2.6	Standards to which the battery conforms to	
2.7	Type of positive/negative plate & number of plates/cell	
2.8	Type and material of separators	
2.9	Material of containers	
2.10	Standards to which the container conforms to	
2.11	Overall dimensions of the cell	
2.12	Weight of each cell complete with electrolyte/ cell for first filling	
2.13	Quantity and specific gravity of electrolyte/ cell for first filling	
2.14	Internal resistance per cell	
2.15	Total resistance across the output terminals (including resistance of leads and battery set).	
2.16	Method of connection between cells	

2.17	Recommended starting and finishing rate of charge and trickle charge current	
2.18	Voltage per cell (Recommended by manufacturer) for the following;	
	a) Voltage per cell at the end of charge at the finishing rate	
	b) Float voltage per cell	
	c) Boost voltage per cell	
	d) End voltage per cell	
2.19	Voltage per cell (used in sizing / calculations / design)	
	a) Float voltage	
	b) Boost voltage	
	c) End voltage	
2.20	Recommended specific gravity of the electrolyte at the end of a full charge	
2.21	Expected specific gravity of the electrolyte at the end of a discharge at the 10 hour rate (5hr rate for Ni-Cd battery)	
2.22	Recommended maximum period of storage before the first charge.	
2.23	Space requirement of the Battery installation. (General arrangement drawing to be furnished).	
2.24	Whether separate battery room is required?	
2.25	Minimum recommended battery room dimensions.	
2.26	Number of recommended air changes per hour for Battery Room	
2.27	Weight & dimensions (LxWxD) of the the battery	
2.28	Total weight of battery filled with electrolyte	
2.29	Whether temp. sensors are provided in the battery cells? If yes, on how many cells?	
2.30	Cycle life of cells (at 50% and 100% loads)	
3.0	**MOUNTING ARRANGEMENT FOR THE BATTERY SET**	
3.1	Material used for the stand / cubicle	
3.2	Details of treatment on the wood used/or painting of steel racks	
4.0	**BATTERY CHARGER & DC DISTRIBUTION BOARD**	
4.1	Make and type of charger units	
4.2	Charging facilities provided	
4.3	Whether separate float and boost chargers are provided?	
4.4	Max. rated current of the charger circuitry	
	a) float	
	b) boost	
	c) float cum boost	
4.5	Whether separate transformer and rectifier circuit employed for float service	

4.6	Maximum current output	
4.7	Method of charging and mode of operation of charger	
4.8	Whether static automatic voltage regulator is provided? (if not, furnish details of the type offered).	
4.9	Details and salient features of the voltage regulator employed.	
4.10	Type of load limit circuit	
4.11	Details of load limit circuit	
4.12	Response time or time delay for the load limit circuit to become effective	
4.13	Whether facility to adjust float voltage is provided? What is the range? Where is it mounted?	
4.14	Whether facility to adjust boost voltage is provided? What is the range? Where is it mounted?	
4.15	Whether facility to adjust limiting current is provided? Where is it mounted?	
4.16	Maximum boost charging rate	
4.17	Initial charging current, the unit is capable of	
4.18	Whether boost charging is arranged automatically or manually? Whether selector switch is provided?	
4.19	Preset time for auto operation of the booster	
4.20	Preset time to revert back to float mode	
4.21	Whether facility provided to adjust the above preset time	
4.22	Time required to boost charge completely discharged batteries	
4.23	Voltage variation at the load terminals while the battery is being boost/float charged	
4.24	-do- across the full batteries	
4.25	Details of steps employed to limit the voltage at the load during boost charging	
4.26	-do- if any for float charging	
4.27	Write-up on the scheme for earth leakage and charger-failure alarms (attach schematic drawing).	
4.28	Type and make of relays employed	
4.29	Overall dimensions of the charger cubicle (General arrangement drawing to be furnished)	
4.30	Weight of the charger-cum-distribution board	
4.31	Whether operational requirement as per the clause 6.1.8 in 13ES907/14 is satisfied or not?	
5.0	**MAINS TRANSFORMERS**	
5.1	Make and type of transformers	

5.2	KVA capacity of the transformers	
5.3	Standards to which the transformer conforms to	
6.0	RECTIFIER	
6.1	Type and make of the rectifier	
6.2	Connections	
6.3	Protections provided	
6.4	Percentage ripple content in the output (RMS value) during	
	a) Float Operation	
	b) Boost Operation	
6.5	Efficiency of the system during	
	a) Float operation	
	b) Boost operation	
7.0	OTHER DETAILS	
7.1	Rating of fuses on	
	a) Battery side	
	b) AC incoming side	
	c) DC side of the rectifier	
	d) DC load bus	
7.2	Rating of space heater (power/voltage)	
7.3	Whether auxiliary supply required? Whether it is 3 phase or single phase AC?	
7.4	Dimensions of the battery cubicle if applicable	
7.5	Bus bar size, material	
7.6	Bus bar support material	
7.7	List of annunciations and meters provided	

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the requirements for design, manufacture, testing and supply of overhead Busbar trunking system (Bus trunking) for industrial applications, comprising of busbars, metallic enclosure, insulating supports, bimetallic connections, flexible connections, adapter chambers, bus trunking termination flanges etc. to give reliable and continuous operation at the load ratings specified.

2.0.0 REFERENCES

2.1.0 The following documents shall be read in conjunction with this specification

2.1.1 **Engineering specification and Data sheet** of **General requirements for Electrics**

2.1.2 **Data sheet** of **Bus trunking**

2.1.3 **Technical particulars** of **Bus trunking**

3.0.0 STANDARDS

3.1.0 Requirements laid down in the latest revision of the following standards and other relevant standards shall be strictly adhered to:

IS: 8623 Part (II) Factory built assemblies of switchgear and control gear for voltage up to and including 1000 V AC & 1200 V DC Particular requirements for Busbar trunking system
IS: 8084 Interconnecting busbars for AC voltage above 1 KV up to and including 36 KV
IS: 11353 Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS: 5578 Guide for marking of insulated conductors.
IS: 1271 Thermal evaluation and classification of electrical insulation
IS: 10026 Insulating varnishes containing solvents
IS: 3043 Code of practice for Earthing

4.0.0 SERVICE CONDITIONS

4.1.0 The equipment shall be designed to operate satisfactorily under the service conditions and power supply conditions specified in the **Data sheet** of **General Requirements for Electrics** and **Data sheet** of **Bus trunking.**

5.0.0 CONSTRUCTIONAL REQUIREMENTS OF BUSBARS AND BUSBAR SUPPORTS

5.1.0 Bus bars shall be of uniform cross section, high conductivity, high quality extruded aluminum / copper, continuously rated for the rated current and service conditions specified in the data sheet.

5.2.0 The busbars and busbar supports shall withstand the maximum of dynamic, thermal and magnetic stresses and strains due to the maximum short circuit current corresponding to the fault level indicated in the data sheet, without any deformation, deterioration or damage.

5.3.0 Suitable provisions shall be made for the expansion of the busbars caused by temperature variation. Due consideration shall be given to proximity and skin effects and reactance while choosing the sizes of the busbars and spacing.

5.4.0 Bus trunking shall be designed in such a way that mechanical forces of the conductors shall not be transmitted on to the terminals of the equipment connected at either ends.

5.5.0 Appropriate identification markings/labels shall be provided on the busbars and tapings for distinguishing the various phases and neutral.

5.6.0 Suitable busbar supports shall be mounted on to the enclosure at specific intervals, allowing sufficient tolerance to prevent strain on to the busbars and supports.

5.7.0 Additional busbar supports for the bus bars shall be provided at all bends.

5.8.0 Busbar supports provided shall be guaranteed to withstand the stresses due to short circuits.

5.9.0 Busbar supports and insulators shall be non-hygroscopic type glass reinforced plastic material with anti tracking features to prevent flashovers. Hylam shall not be used for this purpose.

6.0.0 BUSBAR JOINTS

6.1.0 All joints of busbars shall have effective treatment for maintaining the conductivity of the joints as per relevant standards.

6.2.0 Bimetallic joints shall be made between copper and aluminum conductors for the prevention of any electrolytic corrosion.

6.3.0 Sufficient clearances shall be ensured at all joints. Also facilities for inspection of joints, bends, busbars etc. shall be provided in the bus trunking by providing removable covers.

7.0.0 ENCLOSURE

7.1.0 Material of enclosure shall be mild steel (MS) sheet.

7.2.0 Composition of material of enclosure shall be chosen to avoid any possible hysteresis effect on the bus trunking. Sheathing should not be electrically continuous to prevent heating by eddy currents.

7.3.0 Bus trunking enclosure and its terminations on the equipment shall be designed in such a way that vibrations of the transformer/ DG set / Alternator shall not be transmitted to them.

7.4.0 The entire bus trunking shall be made dust and vermin proof. Trunking installed outdoors shall be weather proof.

7.5.0 In the case of weather proof bus trunking, due consideration shall be given to the severe monsoon and high humidity of the location, while designing the enclosure. Special type of hood

(canopy) shall be provided on all exposed portions of the bus trunking for preventing any moisture getting inside.

7.6.0 Special care shall be taken while designing the joints of bus trunking system to prevent any moisture getting inside through joints.

7.7.0 The enclosure shall be coated with two coats of suitable anti-corrosive paint over two coats of primer suitable for anti-corrosive paint to give protection against action of chemical fumes present in the environment.

7.8.0 Power supply to anti condensation heaters (as required in the data sheet) shall be provided through a marshaling box.

7.9.0 Breather with silica gel shall be provided for each closed section of bus trunking.

8.0.0 TRUNKING ENDS

8.1.0 The bus trunking termination ends shall be suitable for proper and easy connection to the transformer, alternator or switchgear, as the case may be.

8.2.0 Suitable flexible connections shall be provided for all termination ends of the busbars. These shall be of bimetallic type wherever necessary. They shall be designed to carry the rated current and withstand short circuit condition.

9.0.0 BENDS

9.1.0 Bends shall be designed to provide head room clearance not less than 1.829M below the bus duct for passage.

9.2.0 Provision shall be made for additional supports at bends.

10.0.0 EARTHING

10.1.0 Earthing arrangement shall be given in accordance with IS:732 and IS: 3043.

10.2.0 Duplicate continuous earthing strips of material and size specified in the data sheet shall be provided on the entire length of the trunking. Strips shall be connected to the body of trunking by means of integral bolts, spring washers and nuts. The hardware used shall not cause any corrosion due to bimetallic action.

10.3.0 The size of the strip shall be adequate in accordance with voltage level, fault level and the jointing conditions adopted.

10.4.0 A minimum of two terminals shall be provided on the strip for external connections to earth grid.

10.5.0 If the size of strip is indicated in the data sheet both earth strips shall have the size specified.

1.0	**Manufacturer**	
1.1	Name of Manufacturer	
1.2	Works at which the bus trunking is fabricated	
2.0	**Busbars**	
2.1	Material	Aluminium/Copper
2.2	Size	
2.3	Principal insulation	
2.4	Bus bar Supports	
2.5	Open or Enclosed Type	
2.6	Type of Phase Segregation	
2.7	**Rating of Bus bars**	
2.7.1	No. Of Buses	
2.7.2	Rated Voltage	
2.7.3	Maximum permissible operating voltage	
2.7.4	Normal Current of Bus bars and connections	
2.7.5	Frequency	
2.7.6	Short time Current- 1Sec	
2.7.7	Short time current- 3Sec	
2.7.8	Max. Temperature rise over anbient	
3.0	**Earth bar (Duplicate Entire length)**	
3.1	Material	
3.2	Size of each earth bar	
4.0	**Bus Enclosure**	
4.1	Size of bus enclosure	
4.2	Thickness of sheet steel enclosure	
5.0	**Painting**	
5.1	Busbars	
5.2	Interior of bus enclosure	
5.3	Exterior of Bus enclosure	
6.0	**Anti condensation heater**	
6.1	Voltage	
6.2	Wattage	
6.3	No. of Elements	

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6.4	Thermostat details	
7.0	**Flexible connection details**	
7.1	Material	
7.2	Size	
7.3	Quantity	
8.0	**Silica gel breather**	
9.0	**Wall frame assembly**	
10.0	**Standards Applicable**	

CONTENTS

1.0.0 SCOPE

1.1.0 The scope of this specification covers the design, manufacture, testing at works, supply, receiving materials at site, storage, transportation at site, erection, testing and commissioning of all electrics required for the safe and smooth working of Electric Overhead Traveling (EOT) crane specified in the mechanical specification attached.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification and Data Sheet** of **General requirement for Electrics**

2.1.2 **Data Sheet** of **Electrics of EOT crane**

2.1.3 **Technical particulars** of **Electrics of EOT crane**

3.0.0 STANDARDS

3.1.0 The electrics of the crane shall comply with the Indian Electricity Rules, Regulations, Acts, statutory requirements applicable for the place of installation and shall conform to the latest edition of relevant Indian Standards particularly the following:

IS: 325	Three phase induction motors.
IS: 398	Aluminium conductors for overhead power transmission.
IS: 3177	Code of practice for electrics of overhead traveling crane and gantry crane other than steel work cranes.
IS:8130	Specification for conductors for insulated electric cables and flexible cords
IS:9968	Elastomer insulated cables
IS/IEC60079-0	Electrical apparatus for explosive gas atmospheres: Part 0-General requirements
IS/IEC60079-1	Electrical apparatus for explosive gas atmospheres: Part 1-Flame proof enclosures ”d”

IS/IEC60079-7 Electrical apparatus for explosive gas atmospheres: part 7-Increased safety"e"

IS/IEC60079-11 Electrical apparatus for explosive gas atmospheres: part 11-Equipment protection by intrinsic safety"I"

IS/IEC60079-15 Electrical apparatus for explosive gas atmospheres: part 15-construction, test and marking for type of protection "n"

IS/IEC: 60947 Low voltage switchgear and control gear

4.0.0 POWER AND CONTROL SUPPLY

4.1.0 Electrics of the crane shall be suitable for power system particulars specified in data sheet.

4.2.0 Control supply shall be at reduced voltage as specified in data sheet. The supply to these circuits shall be from the secondary winding of an isolating transformer or an isolating transformer & rectifier. One pole of this supply shall be earthed and the contactor and relay coils shall be connected to this pole, or other equally effective means shall be adopted to prevent maloperation due to earth faults etc.

4.3.0 The purchaser will be terminating the incoming power supply and earthing leads to the switch unit provided by the purchaser near the crane at an operating height of 1.5metre from floor. Taking power to the crane equipment and interconnections from this switch is included in the scope of the vendor.

5.0.0 MOTORS

5.1.0 GENERAL REQUIREMENTS

5.1.1 Insulation - Class B, unless otherwise specified in data sheet.

5.1.2 Enclosure - TEFC, IP55 unless otherwise specified in data sheet.

5.1.3 Make - The motor shall be of reputed make specified in data sheet.

5.1.4 Duty - To match the class of crane duty stipulated in Mechanical specifications.

5.2.0 Motor shall be suitable for reversing, frequent acceleration and mechanical braking.

5.3.0 Unless steps are taken to limit the main motor speeds to two and one-half times the rated speed or 2000 rpm whichever is less the motors shall be specially designed for the higher speeds.

5.4.0 The motor winding shall be provided with suitable impregnation to withstand corrosive atmosphere and mechanical bracing to withstand frequent starts.

5.5.0 Normally squirrel cage induction motors to suit the load torque requirements of driven equipment shall be provided. In cases where special type of speed control drives like slip ring motors with resistance controllers or other thyristor controlled drives are recommended by the vendor to ensure smooth acceleration / speed control of the loads, the same shall be provided complete with all required electrics and controls.

5.6.0 Motors provided shall have adequate performance characteristics such as starting torque, pull out torque, speed torque curve, thermal withstand curve etc. for meeting the driving and starting duty.

5.7.0 Unless otherwise specified in the data sheet, motors of rating 37 KW and above shall be provided with anti-condensation heater suitable for 240V, 50Hz single phase AC.

6.0.0 RESISTANCES

6.1.0 The resistances, if provided shall be designed as per relevant Indian standard and shall be air cooled, rustless, unbreakable grid type rated for minimum 10 minutes suitable for operation in

conjunction with drum controllers and mounted in a separate sheet steel housing with ventilated side covers. The resistor grid shall be cast iron/ stainless steel/ Ferro-chrome Al alloy. The details of resistances and number of steps for cutting the resistances shall be furnished

7.0.0 CONTROLS AND PROTECTION

7.1.0 The method of control of the crane, shall be as specified in the data sheet.

7.2.0 The protective panel shall include, but not limited to, the following items:

7.2.1 Main isolating switch interlocked with panel door.

7.2.2 Main contactor and contactors for individual motors.

7.2.3 Isolating switches for individual motors.

7.2.4 Triple pole time lagged thermal overload relays for individual motors with single phasing protection.

7.2.5 HRC fuses/MCBs for individual motor circuits and control circuit.

7.2.6 Indication lamps as specified in the data sheet.

7.2.7 Control supply transformer with fuses on both sides.

7.2.8 Plug and socket for connection to hand lamp suitable for the voltage specified in the data sheet.

7.2.9 Anti-condensation heater for panel, rated for 240V, 50Hz single phase AC supply.

7.2.10 Control switches for anti-condensation heaters of motors and panel.

7.2.11 Hooter/ horn and its wiring and termination, if so specified in the data sheet.

7.2.12 All controls, accessories, wiring and termination for special type of speed control drives offered.

7.3.0 If inching duty is specified in the data sheet for any of the motors, all electrics shall be suitable for the same. Inching operation shall be achieved by VVVF control.

7.4.0 An electro magnetically operated contactor with inherent under voltage protection or a manually operated circuit breaker with under voltage protection shall be provided for each motor circuit. The circuit breaker or the main contactor shall be rated to carry at least the combined full load currents of two motions having the largest wattage.

7.5.0 On all pendant controlled cranes, facility shall be provided to prevent inadvertent operation from floor while maintenance work is being carried out.

7.6.0 If cabin operated, the START and STOP push buttons for individual motions and emergency STOP push button shall be accommodated in the protective panel. If the cabin is closed type, a fan shall be provided.

7.7.0 If pendant controlled, the controller shall consists of forward / reverse push buttons for individual motions. The push buttons shall be spring returned to off. ON and OFF pushbuttons are to be provided to make and break the main contactor/ circuit breaker. The STOP button shall be lockable type so that the control power is switched off in positive manner when the crane is not in use.

7.8.0 All reversing contactors shall be electrically and mechanically interlocked.

7.9.0 Connections for the pendant controller shall be taken through a flexible metallic hose or braided cable (with necessary earth wires inside) supporting the pendant controller in such a way that its weight does not appear on the cables. The pendant station should be located at a height convenient for operation.

7.10.0 RADIO REMOTE CONTROL

7.10.1 Radio remote control facility shall be provided if specified in the Data Sheet

7.10.1 Radio controls should be designed so that if the control signal for any crane motion becomes ineffective, that crane motion will stop, and conversely signals received from any source other than the transmitter will not result in operation of any motion of the crane. The crane must not take off on its own or respond to or generate false commands. In case electricity failure occurs the crane must stop.

7.10.2 Transmitter should be hand held push button type with sophisticated microprocessor technology and surface mounted electronics.

7.11.0 The protective panel shall be dust tight and vermin proof. The degree of protection for enclosure shall be as specified in the data sheet.

7.12.0 Slip ring motors, if any, shall be controlled by resistance controller/ drum controller shall control any, and the cage motors by push button operated Direct-On-Line starters.

7.13.0 The mushroom head emergency STOP push button provided shall be so located as to be readily available for prompt use by the operator. The number of emergency STOP push button shall be as specified in the data sheet.

7.14.0 Electrical interlocking shall be provided to prevent inadvertent starting of the motors without the controller being brought to the OFF position.

8.0.0 LIMIT SWITCHES AND BRAKES

8.1.0 Self-resetting type limit switches shall be provided for all motions. Series type limit switches shall be provided for the hoist motion and shunt type for all other motions.

8.2.0 The hoisting motion shall be fitted with an electromechanical brake. Positive acting brakes shall be provided for all other motions, as per the mechanical specifications.

8.3.0 Irrespective of the controller position all electromechanical brakes shall be applied immediately on operating an emergency STOP push button or switch.

8.4.0 Brakes shall be designed to fail safe whenever the current is interrupted either intentionally or by failure of the main supply.

9.0.0 CURRENT COLLECTION SYSTEM

9.1.0 The current collection system shall be as specified in the data sheet for all motions. However, in hazardous areas, current collection system using bare conductors shall not be used.

9.2.0 When cable drag chain /Power chain is specified in the data sheet for LT, CT the cables used for drag chain shall be flexible, multi strand copper conductor suitable for drag chain system.

9.3.0 FESTOON CABLE ARRANGEMENT

9.3.1 Festoon cables in the form of loops suspended from guy rope by rings free to slide along guy wire with all necessary auxiliaries or any other suitable arrangement like cable reeling drum etc. shall be included in the scope of vendor.

9.3.2 Metallic chains shall be provided between the rings / supports along with the cables but shorter in length so as to avoid tension on cables during travel of the crane.

9.3.3 The flexible trailing cable should have ample length and should be supported by means of properly designed movable clamps. These clamps should be fitted with rollers and should run freely on guide rails allowing relative movement of bridge and trolley without undue stress or wear on the suspended cables.

9.4.0 BARE BUS BAR ARRANGEMENT

9.4.1 For current collection system with bare busbar arrangement, adequately sized busbars of material specified in data sheet, with all accessories required such as current collection arrangements, supports, etc. shall be included in the scope of the vendor.

9.5.0 Complete details and general arrangement drawing of the current collection system envisaged shall be furnished. Also the type and size of festoon cable / busbars used shall be furnished along with supporting calculations to prove the adequacy of sizes selected.

10.0.0 CABLE GLANDS

10.1.0 Compression type cable glands suitable for cable sizes used shall be provided for all electrics. Flameproof double compression type cable glands shall be provided for flameproof electrics.

11.0.0 LIGHTING

11.1.0 One hand lamp suitable for the voltage specified in suitable enclosure as specified in the data sheet with sufficient length of 3 core flexible cable (minimum 15metre) shall be supplied.

11.2.0 One under-bridge flood light (adjustable) shall be provided on the crane to enable operation during night, if so specified in data sheet.

11.3.0 The protective panel shall be provided with a lamp to carry out maintenance works.

12.0.0 EARTHING

12.1.0 Crane structure, motor frame and metal cases of all electrical equipment including metal conduits or cable glands shall be provided with duplicate earthing by means of conductors of materials specified in the data sheet and conforming to the latest revision of IS: 3043.

12.2.0 Both the rails shall be earthed

12.3.0 The earthing system to be supplied shall be connected to the main earth conductors in duplicate provided by the purchaser.

12.4.0 When the crane is connected to the supply by flexible cord or flexible cable, the crane shall be connected to earth by means of an earthing conductor with the current carrying conductors within the flexible cord or flexible cable.

13.0.0 ENCLOSURE

13.1.0 All electrics of the crane such as motors, resistances, controls and protections, limit switches and brakes, current collection system, lighting, cable glands etc. shall be suitable for the hazardous area if so specified in the data sheet.

13.2.0 The electrics of the crane offered shall be suitable for the environmental conditions specified in the **Data Sheet of General Requirements for Electrics.**

14.0.0 ERECTION

14.1.0 Complete erection materials required for the erection of electrics of EOT crane such as all accessories for cable jointing, cable terminations, cable racks, supporting steel structures, clamps, compression type cable glands, insulating materials etc. shall be in the scope of supply of vendor. Necessary grouting fixtures etc. also shall be arranged by the vendor.

15.0.0 APPROVAL FROM ELECTRICAL INSPECTORATE

15.1.0 All electrical installation work shall be carried out through Electrical Contractor holding valid contractor's license issued by Electricity Licensing Board of the State.

15.2.0 All electrical items supplied as well as the installation of the same shall meet with the approval of the Chief Electrical Inspector and any modification necessary in this respect shall be arranged by the vendor free of cost.

16.0.0 TESTS

16.1.0 All test applicable as per relevant standards and "Scope of Inspection and Tests" shall be conducted on all electrics before despatch from the manufacturer's Works.

16.2.0 After erection but before the crane is connected to the supply, the insulation of the electrical equipment shall be tested and any defects observed shall be rectified.

16.3.0 After the supply have been connected, and before the complete crane installation is put into commercial service, tests shall be carried out to prove the following:

16.3.1 The satisfactory operation of each controller, switch, contactor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavorable conditions.

16.3.2 The correctness of all circuits and interlocks and sequence of operation.

16.3.3 The satisfactory operation of all protective devices.

17.0.0 SPARES

17.1.0 The vendor shall quote spares for electrics for two years of trouble free operation.

18.0.0 DOCUMENTS

18.1.0 All documents shall be furnished as per the **Vendor Data Requirements** sheet attached.

1.0	Function of motor – Main/Micro-hoisting/long travel/cross travel	
2.0	Make of motor	
3.0	Type of motor (Squirrel cage/slip ring)	
4.0	Motor rating	
5.0	Speed of motor in RPM	
6.0	Class of duty of motor as per IS:325	
7.0	CDF (Cyclic duration factor) of motor	
8.0	Full load current of motor	
9.0	Starting current motor	
10.0	Full load torque of motor	
11.0	Starting torque of motor	
12.0	Pull up torque of motor	
13.0	Pull out torque of motor	
14.0	GD2 value of motor	
15.0	Speed toque of motor	
16.0	Thermal withstand characteristics of motor (hot and cold)	
17.0	**Efficiency and power factor**	
17.1	At full load	
17.2	At ¾ load	
17.3	At ½ load	
18.0	Class of insulation of motor	
19.0	Type of enclosure of motor	
20.0	Whether flameproof/increased safety/ordinary?	
21.0	Type of cable glands provided	
22.0	Bearings of motor	
22.1	Drive end bearing No.	
22.2	Non-drive end bearing No.	
22.3	Make of bearings	

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FACT ENGINEERING AND DESIGN ORGANISATION

23.0	Method of speed control	
24.0	Whether thyristor speed control is provided?	
25.0	No. of steps of motor resistances, if provided	
26.0	Resistance material	
27.0	Control supply voltage	
28.0	Control transformer rating	
29.0	Whether rectifier is provided with control transformer?	
30.0	Whether one pole of control supply earthed?	
31.0	Whether cab/pendant type control?	
32.0	Rating of circuit breaker/main contactor	
33.0	Type of limit switches	
33.1	For hoisting	
33.2	For long travel	
33.3	For cross travel	
34.0	System of current collection (cable reeling drum/festoon cables/bare busbar/others)	
35.0	Type and size of festoon cables used	
36.0	Earthing cable size	
37.0	Earthing conductor material	
38.0	Type of micro speed facility	
39.0	Additional facilities, if any	

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the general requirements for erection, testing and commissioning of lighting system as per the Schedule of items of work/ drawings/ documents/ data sheets and general conditions of contract, including supply of required materials and accessories.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification** and **Data Sheet** of **General requirements for Electrics**.
2.1.2 **Data sheet** of **Lighting Installation**
2.1.3 **Technical particulars** of **Lighting Installation**

3.0.0 STANDARDS

3.1.0 Lighting installation shall fully comply with the requirements of the Indian Electricity Rules, Regulations, Acts and other statutory regulations that are in force in the place of installation and also carried out in accordance with the latest editions of relevant Indian Standards, particularly the following.

IS: 732	Code of practice for electrical wiring installations
IS: 6665	Code of practice for industrial lighting
IS: 3043	Code of practice for earthing
IS: 1554(Part I)	PVC insulated (Heavy duty) electric cable.
IS: 694	PVC insulated cables
IS: 1293	Plugs & socket outlets
IS: 3854	Switches for domestic and similar purposes
IS: 371	Ceiling roses
IS: 2412	Link clips for electrical wiring
IS: 3837	Accessories for rigid steel conduits for electrical wiring
IS: 3480	Flexible steel conduits for electrical wiring
IS: 3419	Fittings for rigid non-metallic conduits
IS: 9537(Pt II &III)	Conduits for electrical installations
IS: 1332	Precast reinforced concrete street lighting poles
IS: 2193	Precast prestressed concrete street lighting poles
IS: 2713	Tubular steel poles
IS: 2551	Danger notice plates
IS:4736	Hot dip Zinc coatings on mild steel tube
IS:14768	Conduit fittings for Electrical installations
OISD 149	Design aspect for safety in Electrical system

4.0.0 GENERAL REQUIREMENTS

4.1.0 Scope of work shall include installation of lighting fixtures, fans, plug socket outlets, distribution boards (DB) etc. with all associated accessories and materials required to make the installation complete in all respects even in cases when such items are specifically not mentioned. Cost of all such miscellaneous items shall be included in the price of installation quoted, unless specifically excluded from the scope.

4.2.0 All items shall be of makes specified in the data sheet. Wherever makes are not specified, the items offered shall be of reputed make and got approved by purchaser/ engineer in charge at site, before ordering.

4.3.0 Wherever cables/ wires are to be passed through masonry works, road crossings, cement floors etc. they shall be protected by taking through GI pipes/ conduits (metallic/ PVC). After wiring up, the walls, floorings etc. shall be restored to the original condition.

4.4.0 All exposed metal parts are to be coated with primer and paint as specified in the data sheet.

4.5.0 Utmost care shall be taken to avoid scratches kinks and cuts on the conductor while transporting the wires/ cables to site during installation. Suitable inhibiting grease shall be liberally applied to bare Aluminium conductors, before connecting them up.

4.6.0 The junction boxes, cable end boxes etc. wherever provided shall have sufficient wiring space in relation to the size of cable/ wire specified. Items supplied shall be complete with cable glands, cable boxes, conduit entries, terminals etc. and other accessories, which are necessary for the satisfactory installation/ operation of the lighting system.

4.7.0 Cables to and from lighting switchgear/ distribution board shall be laid in trenches/ racks/ trays available along with power cables. In other areas cables shall be clamped properly on steel surface using MS spacers. (MS spacers shall be welded to the surface). On concrete surface cable shall be directly clamped. Cables leaving or entering cable trenches other than buried shall be taken through GI pipes to 1.2m above ground/ floor level. The cables taken over walls/ columns/ racks shall be properly clamped using Aluminium clamps of 16SWG sheet, with width varying from 12.5 to 25mm.

4.8.0 The contractor should possess a contractor's license (valid up to date) issued by the State Electricity Licensing Board. The work should be got carried out only by licensed wireman under the supervision of licensed supervisors.

4.9.0 Wooden materials shall be coated with good quality varnish.

4.10.0 Sufficient number of earth pits shall be provided if found necessary or if specified in the drawing/data sheet and interconnected so as to have the resistance of the earthing installation within the limits as per relevant Indian Standard.

4.11.0 All distribution boards shall be marked LIGHTING or POWER as the case may be and also marked with the voltage and number of phases of the supply. Each DB shall be provided with the drawing giving details of each circuit with its control, the current rating of the circuit, the rating of the fuse elements/ MCBs and all-important details given in the circuit diagram. The drawing shall be made on durable material like PVC and pasted inside the front cover of the DB.

4.12.0 Locations of lighting fixtures, ceiling fans, plug sockets etc. shown in the drawing are indicative. They shall be located to suit the site conditions subject to the approval of purchaser's engineer in charge.

4.13.0 All switches and plug socket outlets shall be mounted at a height of 1.5m above floor level unless otherwise specified in the drawing.

4.14.0 All emergency DBs shall have the words " Emergency AC/ DC" (as the case may be) painted on it in large letters in RED paint. Emergency lighting fixtures shall be marked "E" in RED.

4.15.0 Serial numbers if any allotted to each DB in the drawing shall be painted on it in RED for emergency DBs and in WHITE for other DBs.

4.16.0 Respective circuit numbers shall be painted on the lighting fixture at a conspicuous place if so specified in the data sheet.

4.17.0 All fuses shall be of HRC type unless otherwise specified in the drawing/ data sheet.

4.18.0 The scheme followed for circuit numbering is as given below unless otherwise specified.

4.18.1 First two digits indicate the serial number of the DB
4.18.2 Third digit indicates the serial number of the circuit (way) in each phase.
4.18.3 The letter after the digit indicates the phase of the circuit.

4.19.0 DBs, main switches etc. shall be mounted on painted MS angle frames or MS boxes.

4.20.0 Where ceiling fans are provided, lighting fixtures shall be suspended by means of conduits such that the fan blades and lighting fixtures are at the same level.

4.21.0 On walls/ columns/ handrails, lighting fixtures shall be mounted on suitable GI pipes/ MS angle frames. On ceilings the fixtures shall be mounted on suitable MS brackets, wooden blocks etc.

4.22.0 Fan hooks shall be provided on RCC slabs/beams by chipping the concrete and hooking to the reinforcing rod if indicated in the drawing. The slab /beam surface shall be restored to the original condition after providing the hook.

4.23.0 Similar parts of all switches, lamp holders, distribution fuse boards, ceiling roses brackets, pendants, fans and all other fittings shall be so chosen that they are of the same type and interchangeable in each installation.

4.24.0 Lighting installation in oil and gas installations shall be as per OISD 149.

4.25.0 Aviation warning lights shall be in accordance with the convention of the International Civil Aviation Organisation (ICAO) Publication Annex 14 and to Indian standards, together with the approval of the local aviation authority.

5.0.0 WIRING

5.1.0 GENERAL

5.1.1 Looping back system of wiring shall be adopted. Looping of cables shall be carried out only from control gears / junction boxes / ceiling roses and not from lighting fixtures.

5.1.2 Control switches and plug socket outlets shall be mounted on painted MS box / PVC box as indicated in the data sheet. Front plate of these boxes shall be of the material specified in the data sheet.

5.1.3 Junction boxes shall be of PVC/ painted MS box/ cast aluminium as specified in the data sheet.

5.1.4 Flush type ceiling roses shall be provided if indicated in the drawings. Ceiling roses shall have terminals for connecting 3-core cable.

5.1.5 More than two wires shall not be connected to a terminal of ceiling rose/ switch/ plug socket outlet etc.

5.1.6 The number of stranded conductor cables drawn into or laid into an enclosure of a wiring system shall be such that no damage is caused to the cable or to the enclosure during their installation.The maximum number of stranded conductor cables that can be drawn through a conduit shall be as per IS:732

5.2.0 CABLE WIRING

5.2.1 Use 1.1kV grade heavy duty PVC-A-PVC Aluminium/ Copper cable of size and number of cores indicated in the drawing for circuit mains (ie. from DB to control gear/ junction box of the first point in the circuit) and distribution (ie from control gear/ junction box of the first point to the control gear/ junction box of the adjacent point in the circuit and so on). 3 core 1.5 sq mm PVC insulated and sheathed unarmoured stranded copper cable shall be used for connecting fans / non flameproof lighting fixtures to the control gear/ junction box. In the case of flameproof lighting fixtures 1.5 sq mm PVC-A-PVC copper cable shall be used.

5.2.2 In the case of street light fixtures mounted on concrete/ steel poles, wiring from DB to the junction box provided at the bottom of the pole and looping back to the junction box of the adjacent pole in the circuit shall be done using 1.1kV grade PVC-A-PVC Aluminium/ Copper cable of size indicated in the drawing. The incoming cable shall be connected to a terminal block to be provided in the junction box by the contractor. Wiring from the terminal block to the lamp shall be done through a 2A HRC fuse using 3core 1.5 sq mm PVC insulated and sheathed stranded copper cable. (The third core is used for earthing the fixtures)

5.2.3 240V, 15/5A, 3 pin plug socket outlets shall be wired using 1.1kV grade 3 core PVC-A-PVC Aluminium/ Copper cable of size indicated in the drawing.

5.2.4 Armoured cables shall be terminated using flameproof cadmium plated brass cable glands in the case of flameproof equipment and ordinary cable glands in the case of non flameproof equipment. Crimping type tinned copper lugs shall be used for conductors of $6mm^2$ and above.

5.2.5 Lighting cables shall be identified by providing tags (Aluminium discs 3mm thick) at 10m intervals. Circuit numbers indicated in the circuit diagram shall be punched on these tags.

5.3.0 CONDUIT WIRING

5.3.1 Rigid/ flexible PVC conduits or rigid steel conduits or rigid flow-coat metal conduits with ISI mark and of suitable sizes shall be used as specified in the data sheet.

5.3.2 Use PVC insulated single core Aluminium/ Copper cable of size and number of cores indicated in the drawing for circuit mains (ie. from DB to control gear/ junction box/ ceiling rose of the first point in the circuit) and distribution (ie from control gear/ junction box of the first point to the control gear/ junction box/ ceiling rose of the adjacent point in the circuit and so on). Use 3 core PVC insulated and sheathed unarmoured 24 strand (each strand having 0.2mm dia. minimum) copper cable for connecting lighting fixture/fan to ceiling rose.

5.3.3 240V, 15/5A, 3 pin plug socket outlets shall be wired using single core PVC insulated Aluminium/ Copper wires of sizes specified in the drawing.

5.3.4 Circuits of different phases shall not be drawn in the same conduit. However balanced 3-phase circuit and neutral can be drawn in the same circuit.

5.3.5 The entire system of metallic conduit work, including the outlet boxes and other metallic accessories, shall be mechanically and electrically continuous by proper screwed joints, or by double check nuts at terminations. The conduit shall be continuous when passing through walls or floors.

5.4.0 TRUNKING CABLE MANAGEMENT SYSTEM

5.4.1 Adaptable trunking shall be used for power cables and data cables to run parallel in two different compartments with partition.

5.4.2 PVC insulated cables and / or other approved insulated cables to IS: 694-1990 shall be used in this type of work.

5.4.3 Preferred size of the mini trunking (Casing wiring) should be 25x16 mm, 32x16 mm, 40x25 mm, 40x40 mm and for adaptable trunking it should be 100x34 mm or 100x50 mm or 160x50 mm or 200x50mm for making upto four isolated compartments.

5.4.4 Trunking should be equipped with rail on its surface on which clip-on partition can be clipped which should accept frames/plates for wiring devices upto 6/8 modules.

5.4.5 The mini trunking and adaptable trunking shall be of the same material, viz. either PVC or anodized aluminium in extruded sections.

5.4.6 The mini trunking shall have a square or rectangular body. The trunking cover shall be “CLIP-ON” type with double grooving in the case of PVC wire-ways, and CLIP-ON type for the metallic wire ways. All surfaces shall have smooth finish inside and outside. The top of the side walls of the body shall be suitable for the above types of fixing arrangement of trunking. PVC trunking or Aluminium trunking should have uniform thickness throughout its length and shall be of factory finish. The thickness of the mini trunking & adaptable trunking shall be 1mm minimum.

5.4.7 The mini trunking and adaptable trunking shall be fixed by means of suitable screws to approved type of asbestos or fiber fixing plugs, at intervals not exceeding 60 cm for all sizes for mini trunking. In case of Adaptable trunking, the screwing distance shall be such that the weight of the trunking & cable hold firmly on the wall or ceiling. On either side of the joints, the distance of the fixing arrangement shall not exceed 15 cm from, the joint.

6.0.0 EARTHING

6.1.0 All DBs shall be provided with an earth bus of the same size in addition to three buses for the phases and one for the neutral, which shall be connected in duplicate to the main earthing system using PVC insulated/ bare Aluminium/ Copper conductor of size indicated in the data sheet.

6.2.0 All DBs and main switches shall be earthed in duplicate using PVC insulated/ bare Aluminium/ Copper conductor of size indicated in the data sheet.

6.3.0 Lighting fixtures, E point of plug socket outlets, control switches junction boxes etc. shall be earthed using conductors specified in data sheet.

6.4.0 Where 3 core cables are specified for wiring, the third core shall be used for earthing.

6.5.0 All earth wires shall be connected to the main earthing system. If earth pits are provided specifically for the lighting installation in the drawings, they shall be interconnected using conductors specified in the data sheet and also linked to the main earth system.

6.6.0 A protective (earth continuity) conductor shall be drawn inside conduits and trunking for earthing of all metallic boxes of the installations as well as for connections to the earth pin of the socket outlets.

7.0.0 TESTING

7.1.0 The following tests shall be conducted satisfactorily, by the contractor at his own cost, in the presence of the purchaser's representative; test results shall be submitted and results got approved.

7.1.1 Insulation test
7.1.2 Earth resistance test
7.1.3 Earth continuity test
7.1.4 Continuity test.
7.1.5 Operation of ELCB.

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the standard requirements for erection, testing and commissioning of cabling installation as per the drawings, specification, data sheets and other details enclosed.

1.2.0 Supply of required cables shall also be included under the scope, only if specifically indicated in the data sheet for cabling.

1.3.0 The term cable shall mean power / control / lighting cable for this specification.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification** and **Data Sheet** of **General requirements for Electrics**

2.1.2 **Data sheet** of **Cabling installation**.

3.0.0 STANDARDS AND REGULATIONS

3.1.0 Cabling installation shall be carried out in accordance with the latest editions of relevant Indian Standards and the installation shall fully comply with the requirements of the Indian Electricity Rules & Acts and other Statutory Regulations that are in force at the place of installation.

4.0.0 STANDARD REQUIREMENTS

4.1.0 HANDLING & LAYING OF CABLES

4.1.1 When unloading cable drums, they shall be carefully lifted and placed on the ground. For removing the cable from the drums, the drum should be properly mounted on jacks on a cable wheel, making sure that the spindle is strong enough to carry the weight without bending and that it is lying horizontally in the bearings so as to prevent the drum creeping to the one side or the other while it is rotating. The drums should be carefully rolled down from a suitably arranged ramp or rails in the direction of arrow marked on the drum. Under no circumstances should a drum be dropped to the ground as the shock may cause heavy damages to the inner layers of cable.

4.1.2 On transporting over a long distance from stores to work spots, the drums should be placed on cable drum wheels strong enough to carry the weight of the drums which are pulled by means of ropes, or alternatively they may be placed on a trailer or a vehicle with a low loading platform for transporting to the destination.

4.1.3 Cable rollers shall be used for laying of cables and cables shall be properly handled while laying to avoid any damages.

4.1.4 Cables shall be cut to required lengths only after assessment of correct lengths required by actual measurement at site. The contractor shall ensure that wastage of cables is minimum by resorting to most economical cable cutting schedules prepared by the contractor.

4.1.5 The cables shall be laid on trays, racks, risers, walls, structures, etc. and in trenches as shown in the Power lay out (cable layout) drawings.

4.2.0 CLAMPING

4.2.1 Power and Control cables shall be properly segregated while doing the laying and clamping.

4.2.2 MV power cables of 400 sq.mm and above and H.V. cables shall be laid with a clearance of 70mm in between and shall be clamped individually. Other cables can be laid touching and clamped in groups.

4.2.3 Cables shall be clamped at every 1500mm interval on the horizontal trays / racks and at 750mm interval on the vertical trays/ risers, bends, at take off points, and at 400mm interval for cables laid on walls, columns and other structural works.

4.2.4 Cables leading to cable box of an equipment shall be supported at a distance of 450mm from cable gland / cable box.

4.2.5 Cables shall be clamped only after the cables are neatly laid, dressed and kept in position.

4.2.6 Types of cable clamps, fixing bolts / nuts / washers and materials of cable clamps shall be as specified in the data sheet for cabling.

4.3.0 CABLES IN PIPES

4.3.1 Wherever cables are taken through GI pipes, suitable bushes shall be provided at both ends to avoid sharp edges of the pipes damaging the cables.

4.3.2 Wherever cables pass through masonry or concrete work, they shall be taken through suitable PVC / GI pipes. For road crossings GI/ Hume pipes of suitable size shall be provided.

4.3.3 After drawing the cables in the GI / PVC pipes, the ends shall be sealed with cable compound.

4.4.0 CABLE LAYING DIRECT IN GROUND

4.4.1 For laying cables direct in ground, suitable trenches shall be excavated in the soil to the required sizes and at location shown in drawings attached / applicable. Cables shall be laid directly in the excavated trench on the sand bed. After laying cables as per cable/ power layout drawings, the excavated trenches shall be back filled with layers of sand, well burnt bricks and riddled soil respectively as shown in the cross sectional details given in the drawings attached.

4.4.2 A clearance equal to one diameter of the bigger cable shall be maintained between two adjacent power cables buried underground and no such clearance need be provided for control and lighting cables, unless otherwise specified in the data sheets / drawings.

4.4.3 There shall not be any cross over of cables when laid in the ground.

4.4.4 Inspection chambers constructed from brick and masonry complete with suitable RCC slab cover shall be provided for all power and control cable joints in the through run of the cables. Jointed cable shall be looped in the inspection chamber to provide extra length of cable for the purpose of rejoining in future in case original cable joint fails. Cable identification tags shall be provided inside the cable chamber.

4.4.5 Wherever buried cable enters the building the same shall be taken through PVC / GI pipes embedded at the entry portion. After taking cables through the above pipes, the same shall be sealed by using suitable compound so as to avoid ingress of water.

4.4.6 Necessary cable marker plates made out of Cast iron shall be fixed at every 15Metres interval and at all bends along the route of buried cable trench at central line of the trench. Voltage rating of the cables shall be engraved on the marker plates.

4.4.7 The depth of cable laying shall be as per clause 6.3.2 of IS:1255

4.4.8 The minimum segregation for direct buried cables from other services shall be as given in the table below:-

MINIMUM CLEARANCE				
	11/66kV Circuits	**6.6kV Circuits**	**415V Circuits**	**240V Circuits**
Instrument, communication and other low signal cables.	4000mm	1250mm	750mm	500mm
600/1000V cables	300mm	300mm	None	None
All piped services below ground and Hot pipe services above ground	500mm	300mm	300mm	300mm

4.5.0 LAYING OF SINGLE CORE CABLES

While designing layout with single core cable installations following factors shall be considered

4.5.1 Cables shall be laid as a general practice in trefoil formation touching each other or flat formation with spacing as per requirement.

4.5.2 When cables are laid in a flat formation, the individual cable fixing clamps, and spacers shall be of non magnetic material.

4.5.3 As a general practice, the sheath of single core cables shall earthed to keep sheath at earth potential. However depending on the current the cable has to carry, the feeder length and permissible sheath potential, various methods of sheath bonding are employed, viz. single point bonding, bonding at middle, sectionalised bonding etc., for which cable manufacturers recommendations shall be followed.

4.6.0 CABLE JOINTING

4.6.1 During the preliminary stage of laying the cable, consideration should be given to proper location of the joint position so that when the cable is actually laid, the joints if any, are made in the most suitable places. Joints shall not be made at passageways and at road crossings.

4.6.2 In cable trenches or in any other cable route where there are two or more cables laid together, the joints, if any shall be arranged to be staggered by two or more metres so as to reduce the possibility of one joint failure affecting the other.

4.6.3 Before jointing is commenced the insulation resistance of both section of the cable to be jointed shall be measured using suitable megger.

4.6.4 In jointing of armoured PVC cables, hot pouring compound shall not be used. Only cold sealing compound shall be used.

4.6.5 Individual conductors in cables shall always be jointed number-to-number or colour to colour of the insulation over the conductors.

4.6.6 All materials required for cable jointing such as jointing kit, compounds, insulation tapes, cable lugs, glands, fittings etc. and other consumable materials shall be supplied by the contractor wherever necessary.

4.7.0 CABLE TERMINATION

4.7.1 Cable glands necessary for cable termination on the equipment will be supplied along with equipment. However, the contractor shall supply suitable glands for all other requirements.

4.7.2 Wherever necessary holes are not drilled on the gland plate of the switch boards or on the cable boxes of the equipment for fixing of cable gland, suitable holes shall be drilled at convenient locations by the contractor for fixing the cable glands.

5.0.0 GENERAL

5.1.0 Lighting cables shall be installed in compliance with engineering specification for lighting installation also, if attached.

5.2.0 The armour of the PVC-A-PVC cables shall be effectively earthed at both end terminations through separate earthing of cable glands.

5.3.0 As far as possible, joints at intermediate points in the through run of the cable should be avoided.

5.4.0 The power, control and lighting cables shall be provided with identification tags fixed to them at every 10 m interval. The tags shall be made from full hard aluminum discs not less than 3mm, thick and of size 50mm x 75mm for all cables of size 400mm^2. and above and proportionately smaller sizes of tags (but 3mm thick) for all other sizes of cables. Tags shall have 4 holes, 2 holes on either side for tying around the cable by using suitable binding wire. The cable numbers assigned in the cable schedule and circuit numbers for lighting distribution cables shall be punched on these tags.

6.0.0 TESTING OF CABLES

6.1.0 All cables shall be tested before and after jointing/ termination as per relevant Indian Standards. Jointing/termination shall be redone, if found unsatisfactory without any extra cost to the owner.

6.2.0 All cables shall be megger tested, and H.V. cables shall be pressure tested (HV dielectric test) in addition to megger test, before commissioning.

6.3.0 The cable cores should be tested for continuity, absence of cross phasing, insulation resistance to earth and insulation resistance between conductors.

6.4.0 All tests shall be carried out in the presence of owner's representatives and tabulations of observations shall be furnished.

6.5.0 The contractor shall make his own arrangement for necessary testing meters and equipments.

CONTENTS

1.0.0 SCOPE

1.1.0 This specification covers the standard requirements for supply of earthing materials and accessories and erection, testing and commissioning of Earthing system, as per the drawings and data sheets for earthing.

1.2.0 If design of earthing system is also included in the scope of vendor, the same shall be as per details in the **Data sheet** of **Earthing** and relevant design calculations shall be furnished by vendor for purchaser's approval.

2.0.0 REFERENCE

2.1.0 The following documents shall be read in conjunction with this specification.

2.1.1 **Engineering specification and Data Sheet** of **General requirements for Electrics**
2.1.2 **Data sheet** of **Earthing**
2.1.3 **Technical particulars** of **Earthing**

3.0.0 STANDARDS AND REGULATIONS.

3.1.0 Earthing shall be carried out in accordance with the latest edition of following standards and shall fully comply with the requirements of the Indian Electricity Rules , Indian Electricity Act, Petroleum rules (where applicable), and also to the Regulations laid down by CEA/ Electrical Inspectorate, OISD, Central/state/ local/ insurance authorities, that are in force at the place of installation.

IS: 3043	Code of practice for Earthing
IS: 7689	Guide for control of undesirable static electricity
IS: 2309	Protection of Buildings and allied structures against Lightning- Code of practice
IS: 732	Code of practice for Electrical wiring installations
OISD110	Recommended practices on Static Electricity
OISD 147	Inspection and safe practices during Electrical installations
OISD149	Design aspect for safety in Electrical system
OISD173	Fire prevention and protection system for Electrical installations
OISD180	Lightning Protection

Where conflict exists between standards and codes, the more stringent shall govern.

4.0.0 STANDARD REQUIREMENTS

4.1.0 Duplicate earthing (two separate and distinct connection with the earth) shall be employed for all electrical equipments. The plant earthing system shall have an earthing network with required number of earth electrodes connected to it. The following shall be earthed:

- System Neutral
- Current and potential transformer secondary neutral.

- Metallic non-current carrying parts of all electrical apparatus such as transformers, Switchgears, motors, lighting/power panels, terminal boxes, control stations, lighting fixtures, receptacles etc.
- Steel structures, loading platform etc.
- Cable trays and racks, lighting mast and poles.
- Storage tanks, spheres, vessels, columns and all other process equipment.
- Electrical equipment fencing (e.g transformer yard etc.)
- Cable shields and armour.
- Flexible earth provision for wagon,truck.
- Pump handling Hydrocarbon if it's base plate is separate from motor's base plate.
- Turbo driven pump handling Hydrocarbon.

4.2.0 Earthing cables / strips shall be taken along with the power cables on the cable trays / racks / risers. All earthing shall be done on the body of the equipment and not on the detachable part.

4.3.0 Earthing cables shall be clamped at every 1500mm. interval on the horizontal trays / racks, 750mm interval on vertical trays / risers, 400mm interval on walls / columns / on structural using spacers, and at bends / take off points. Bare earthing strips shall be clamped at 3000mm interval on horizontal trays / racks, 1500mm interval on vertical trays / risers, 800mm interval on walls / columns, and at bends / take off points.

4.4.0 Metallic cable trays / risers shall be earthed in duplicate. Continuity of earthing throughout the tray shall be ensured. GI strips, if used for cable tray earthing, shall not be welded to trays, to prevent corrosion.

4.5.0 Wherever insulated earth conductors are taken out from the cable trenches, walls / through floor, etc. they shall be taken through non-metallic or GI pipes. In the case of bare earth conductors, non-metallic pipes shall be used.

4.6.0 Wherever earth conductor crosses the road, it shall be taken through GI pipes / non-metallic pipes / formed cable trenches. In the case of bare earth conductors metallic pipes shall not be used.

4.7.0 At all terminations of earth conductors on equipment, sufficient length shall be left for easy movement of the equipment from its position for alignment purposes.

4.8.0 Wherever not detailed, the route of the conductor and location of the earth pit shall be arranged, so as to avoid obstructions, crossing, etc. according to convenience at site and shall be got approved by the Engineer in charge at site or his representative.

4.9.0 Wherever required, earthing cables / strips shall be buried along with power cables.

4.10.0 Earthing cables / bare earth strips used for interconnection of earth pits, run as ring main shall be buried in ground at a depth of 500 mm below finished grade level.

4.11.0 Wherever looping earth connections are envisaged between motor and local push button stations, the same shall be done using common lug at motor end as shown in IS: 3043.

4.12.0 Unless adequately connected to earth elsewhere, all utility and process pipelines should be bonded to a common conductor by means of earth bars or pipe clamps and connected to the earthing system at a point where pipelines enter or leave the hazardous area except where conflicting with the requirements of cathodic protection.

4.13.0 Steel pipe racks in the process units and offsite area shall be earthed at every 25 metres.

4.14.0 Tanks, piping and process vessels and equipment containing flammable liquids or gas shall be earthed by a connection to the earth network, or by bonding to an earthed metal structure for protection against static electricity.

4.15.0 The sheath of single core cables shall earthed to keep sheath at earth potential. However depending on the current the cable has to carry, the feeder length and permissible sheath potential, various methods of sheath bonding are employed, viz. single point bonding, bonding at middle, sectionalised bonding etc., for which cable manufacturers recommendations shall be followed.

5.0.0 LIGHTNING PROTECTION

5.1.0 Lightning protection shall be provided for the equipment, structures and buildings as per the requirements of IS: 2309.

5.2.0 An independent earthing network shall be provided for lightning protection and this shall be bonded with the main earthing network below ground, minimum at two points.

5.3.0 Lightning protection for the plant structures, storage tanks and columns in the hydrocarbon industry shall be carried out as per OISD 180.

5.4.0 An earth electrode should be connected to each down conductor. Each of these earth electrode should have a resistance not exceeding the product given by 10 Ohm multiplied by the number of earth electrodes to be provided. The whole of lightning protective system including any earth ring shall have a combined resistance to earth not exceeding 10 ohm without taking account of any bonding.

6.0.0 EARTH PITS

6.1.0 The arrangement of earth pit shall be as given in IS: 3043 unless otherwise specified in the data sheet. Necessary provisions for terminating main earth conductors on to the earth electrodes shall be ensured.

6.2.0 All accessories required for the earth pits such as electrodes, clamps, clips, bolts, nuts, washers, GI pipes, funnel, valve and the masonry works of the pits including supply of necessary materials, cement and excavation and refilling of soil for providing earth pits shall come under the scope of the contractor.

6.3.0 Water supply for watering of earth pits will be given by Purchaser at one point. Common valve for isolating and 1" distribution pipe to earth pits shall be provided by the contractor. Individual taps shall be provided for each earth pit, if specified in the data sheet.

7.0.0 JOINTS / TERMINATIONS

7.1.0 The joints of bare earth strip shall be bolted/ riveted / brazed / welded as stipulated in IS: 3043. All such joints shall be given necessary coatings of suitable compound to prevent corrosion.

7.2.0 In the case of PVC insulated earth conductors proper joints shall be made and the entire joint shall be fully sealed by suitable compound so that no metallic part is exposed.

7.3.0 Crimping type of lugs shall be used for termination of earth conductors. However in the case of bigger size of earth conductors where crimping type of terminations are not feasible, soldering type of lugs may be used.

7.4.0 The contractor shall make his own arrangement for the necessary equipment, drilling / welding machines and all other tools and tackles which are necessary for completing the installation.

8.0.0 TESTING OF EARTH CONDUCTORS / ELECTRODES.

8.1.0 All earth conductors shall be tested before and after jointing / termination as per relevant Indian Standards. Jointing / termination shall be redone, if found unsatisfactory, without any extra cost to the purchaser.

8.2.0 Earth pits shall be checked & tested for proper connections / terminations.

8.3.0 Each Earth electrode shall be tested as per relevant Standards and results tabulated.

8.4.0 Effective resistance of the earthing system shall be tested and tabulated.

8.5.0 All tests shall be carried out in the presence of Engineer -in- charge or his representative and tabulations furnished.

8.6.0 The contractor shall make his own arrangement for the meters and equipments necessary for the testing.

5.2	**DIESEL GENERATOR SET**	
1	CUMMINS INDIA LIMITED	INDIA
2	MITSUBISHI CORPORATION	JAPAN
3	TOYO DENKI POWER SYSTEMS PVT. LTD.	INDIA
4	TOYO ELECT. MFG. CO. LTD.	JAPAN
5	WARTSILLA INDIA LTD. MAHINDRA	INDIA INDIA
5.3	**EHV / HV SWITCHES / ISOLATORS**	
	ASEA BROWN BOVERI LTD.	INDIA
	BHEL (ELECTRICAL MACHINES DIVN.)	INDIA
	SIEMENS LTD.	INDIA
5.4	**INDUCTION MOTORS – LV (415 V) (SAFE / HAZARDOUS AREA)**	
1	ASEA BROWN BOVERI LTD.	INDIA
2	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
3	SIEMENS LTD.	INDIA
4	TOSHIBA CORPORATION	JAPAN
5.5	**INDUCTION MOTORS – HV (6.6 KV) (FOR SAFE / HAZARDOUS AREA)**	
1	ASEA BROWN BOVERI LTD.	INDIA
2	BHEL (ELECTRICAL MACHINES DIVN.)	INDIA
3	CROMPTON GREAVES LTD.	INDIA
4	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
5	JEUMONT INDUSTRIE	INDIA
6	KIRLOSKAR ELECTRIC CO. LTD.	INDIA
7	MITSUBISHI CORPORATION	JAPAN
8	PEEBLES ELECTRICAL MACHINES	UK
9	SIEMENS LTD.	INDIA
10	TOSHIBA CORPORATION	JAPAN
11	WESTINGHOUSE ELECTRIC CORPORATION	USA
5.6	**HT / LT POWER & CONTROL (11 KV, 6.6 KV & 415V) POWER CABLES**	
1	NICCO CORPORATION LIMITED	INDIA

2	TORRENT CABLES LIMITED	INDIA
3	UNIVERSAL CABLES LTD.	INDIA
5.7	**HV SWITCHBOARD**	
1	ABB LTD.	INDIA
2	AREVA	INDIA
3	SIEMENS LTD.	INDIA
5.8	**SWITCHBOARDS – LV (415 V) (MCC / PCC / PMCC)**	
1	ABB LTD.	INDIA
2	LARSEN & TOUBRO LTD.	INDIA
3	SIEMENS LTD.	INDIA
5.9	**UPS SYSTEM**	
1	ASEA BROWN BOVERI	SWEDEN
2	AEG TELEFUNKEN AG	GERMANY
3	EMERSON NETWORK POWER (INDIA) PVT. LTD.	INDIA
4	GENERAL ELECTRIC CO.	USA
5	GUTOR	SWITZERLAND
5.10	**BATTERY CHARGER**	
1	CHHABI ELECTRICALS PVT. LTD.	INDIA
2	HBL NIFE POWER SYSTEMS LTD.	INDIA
3	UNIVERSAL INDUSTRIAL PRODUCTS	INDIA
5.11	BATTERY (NI-CD / LEAD ACID TUBULAR)	
1	AMCO POWER SYSTEMS LTD.	INDIA
2	EXIDE INDUSTRIES LIMITED	INDIA
3	HBL NIFE POWER SYSTEMS LTD.	INDIA
5.12	**AC VARIABLE FREQUENCY DRIVE / SOFT STARTERS**	
1	ANSALDO ROBICON	ITALY
2	ASEA BROWN BOVERI LTD.	INDIA
3	BROWN BOVERI CORPORATION	SWITZERLAND
4	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
5	LARSEN & TOUBRO LTD. YASKAWA	INDIA
6	SIEMENS AG	GERMANY
7	SIEMENS LTD.	INDIA
5.16	**HT CABLE JOINTING KITS**	

1	RAYCHEM RPG LTD.	INDIA
5.17	**FLAMEPROOF / HOSEPROOF LOCAL CONTROL STATION, JUNCTION BOX, LIGHTING FITTING, PLUG, SOCKET, HAND LAMP, ACCESSORIES LIGHTING, DISTRIBUTION BOARD & CONTROL PANEL**	
1	BALIGA LIGHTING EQUIPMENTS LTD.	INDIA
2	FCG FLAMEPROOF CONTROL GEARS PVT. LTD.	INDIA
3	FLAMEPROOF EQUIPMENTS PVT. LTD.	INDIA
4	R. STAHL	INDIA/GERMANY
5.18	STREET / FLOOD LIGHTING FIXTURES	
1	PHILIPS INDIA LTD.	INDIA
5.19	LIGHTING POLES	
1	BAJAJ ELECTRICALS LTD.	INDIA
2	CROMPTON GREAVES LIMITED	INDIA
3	PHILIPS INDIA LTD.	INDIA
5.20	**FLAMEPROOF / HOSE PROOF INDUSTRIAL LIGHTING FIXTURES**	
1	BALIGA LIGHTING EQUIPMENTS LTD.	INDIA
2	FCG FLAMEPROOF CONTROL GEARS PVT. LTD.	INDIA
3	FLAMEPROOF EQUIPMENTS PVT. LTD.	INDIA
4	R. STAHL	INDIA/GERMANY
5.22	**HV / MV BUS DUCTS**	
1	BEST & CROMPTON ENGG. CO.	INDIA
2	CONTROLS & SWITCHGEAR CO. LTD.	INDIA
3	CROMPTON GREAVES LTD.	INDIA
4	INTERLEC	INDIA
5	POWERGEAR LIMITED	INDIA
6	SPACEAGE SWITCHGEARS LIMITED	INDIA
5.23	**DISTRIBUTION BOARDS**	
1	CONTROLS & SWITCHGEAR CO. LTD.	INDIA
2	ELECMECH CORPORATION	INDIA
3	INTRELEC	INDIA
4	LOTUS POWERGEAR PVT. LTD.	INDIA
5.24	**PAGING EQUIPMENT / PA SYSTEM**	
1	NEUMANN GMBH ELEKTRONIK	GERMANY

5.26	**CATHODIC PROTECTION**	
1	CCS	INDIA
2	CORTECH	INDIA
3	SSS	INDIA
5.27	**CAPACITORS**	
1	CROMPTON GREAVES LTD.	INDIA
2	SHREEM CAPACITORS PVT. LTD.	INDIA
3	SIEMENS LTD.	INDIA
4	UNIVERSAL CABLES LTD.	INDIA
5.28	**PROTECTIVE RELAYS**	
1	AREVA	INDIA
2	ASEA BROWN BOVERI LTD.	INDIA
3	SIEMENS LTD.	INDIA
4	THYSSENKRUPP	INDIA
6.12	**GAS & FIRE DETECTION SYSTEM**	
1	ANDREW YULE & COMPANY LTD. (FIRE)	INDIA
2	HONEYWELL AUTOMATION INDIA LIMITED (GAS)	INDIA
3	J B BODA AND BROTHERS PVT. LTD. (GAS MAKEINTERNATIONAL SENSOR TECHNOLOGY)	INDIA
4	POLLUTION PROTECTION SYSTEM MUMBAI PVT LTD (GAS)	INDIA
5	TELEDYNE FLUID SYSTEMS (GAS)	THAILAND
6	GENERAL MONITORS (GAS)	U.K

Sl. No.	Description	Quantity	Unit Price	Total Price
Note: Vendor shall also furnish additional recommended list of spares if any required for two years trouble free operation.				
1.0	**Vacuum Circuit Breaker**			
1.1	Control fuse	5nos. of each rating		
1.2	Breaker control switch	-		
1.3	Closing coil	1No		
1.4	Tripping coil	1No		
1.5	Closing spring	1No.		
1.6	Tripping spring	1No		
1.7	Indication lamp assembly	1Nos		
1.8	Indication lamps	3Nos		
1,9	Spring charging motor	1No.		
1.10	Bus support insulator	3Nos		
2.0	**DG SETS**			
2.1	**Alternators**			
2.2.1	DE and NDE bearings of alternator	1 set		
2.3.2	Rotating rectifier	1 set		
2.4.3	Power transistor	1 set		
2.5.4	Rectifier bridge	2 sets		
2.2	**AMF Panel/ Control Panel**			
2.2.1	Control fuses	3 nos. of each rating		
2.2.2	Auxiliary relays	1 no. in each type		
2.2.3	Auxiliary contactors with DC coil & 2 N/O + 2 N/C contacts	2 nos.		
2.2.4	Indicating lamps complete with bulb, lens and holder	4 nos.		
2.2.5	Push button assembly complete with actuator and contacts	2 nos.		
2.3	**Battery Charger**			
2.3.1	Diodes	1 set		
2.3.2	Other spares as recommended by Vendor			

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPRD.
0	19.04.2021	Original issue	SM	IK	IK

Sl. No.	Description	Quantity	Unit Price	Total Price
3.0	**MV SWITCH BOARD**			
3.1	Arc chute for ACB	1 set for each rating		
3.2	Moving contact for ACB	1 set for each rating		
3.3	Fixed contact for ACB	1 set for each rating		
3.4	Spring charging motor for ACB	1 no.		
3.5	Shunt trip coil for ACB	1 no.		
3.6	Closing coil for ACB	1 no.		
3.7	Limit switch for ACB a) Service/Test position b) Spring charging	 1No. 1No.		
3.8	1NO + 1NC auxiliary contact for MCCB	5Nos		
3.9	MCB for control supply	2 nos. of each rating		
3.10	Auxiliary contactor	2 nos.of each rating		
3.11	Indication lamp assembly and lamps	3nos. of each type		
3.12	Power Contactor	1 no. of each rating		
4.0	**BATTERY AND CHARGER**			
4.1	AC input fuse(float)	3Nos.		
4.2	AC input fuse(boost)	3Nos.		
4.3	DC fuse float	2Nos.		
4.4	HRC fuse for filter circuit (float)	1 No.		
4.5	HRC fuse for filter circuit (Boost)	1 No.		
4.6	Thyristor (float)	3Nos.		
4.8	Thyristor (Boost)	3Nos.		
4.9	Diode (float)	3Nos		
4.10	Diode (Boost)	3Nos		
4.11	Dropping Diode	2Nos		
4.12	Control card float	1 set		
4.13	Control card boost	1 set		
4.14	Filter capacitor for float	1No.		
4.15	Filter capacitor for boost	1No.		
4.16	Semi conductor fuse link for rectifier bridge (float)	3Nos		
4.17	Semi conductor fuse link for rectifier bridge (boost)	3Nos		
4.18	Indication lamps	5 Nos.		
4.19	Control fuses	5Nos		
4.20	DCDB fuse 32A	4Nos		
4.21	DCDB fuse 16A	2Nos.		
4.22	DCDB incomer fuse	2Nos.		
4.23	Intercell connector for battery	3Nos		

Sl No	Description	Suggested Quantity (%)	Quantity	Unit Price	Total Price
1	Corrosion resistor elements	100			
2	Corrosion resistor plate	100			
3	Filter assembly	100			
4	Air cleaner elements	100			
5	Gaskets	300			
6	Oil seals	100			
7	V Belts	100			

Wherever suggested Quantity is less than 100%, minimum 1 set or 1 No: shall be provided

REV NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	30.03.21	Re-issued	LA	SK	AAN
0	05.10.20	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION

(Vendor to suggest)

Sl No	Description	Suggested Quantity (%)	Quantity	Unit Price	Total Price
1					
2					
3					
4					
5					
6					
7					

REV NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
1	30.03.21	Re-issued	LA	SK	AAN
0	05.10.20	For Enquiry	LA	SK	AAN

ELECTRICAL DEPARTMENT	SCHEDULE OF ITEMS OF WORK TECHNICAL SPECIFICATION FOR ELECTRICAL INSTALLATION			32686-13-PS-02BQ			
SL No	DESCRIPTION OF ITEM	QTY	UNIT	AMOUNT			
				Rate (₹)	Amount (₹)	IGST (₹)	Total Amount(₹)
	ELECTRICAL-UPS Comprhensive Annual Maintenance Contract (CAMC)						
	a) The vendor has to quote separately in the bill of quantities, for 5 years comprehensive annual maintenance contract (CAMC) charges including all spares, consumables etc. in after the warrantee period. UPS supplied shall be covered under post warranty Comprehensive Annual Maintenance Contract (CAMC) for 5 years.						
	b)For this, OWNER may enter into separate contract with respective OEMs before expiry of Defect liability period at the rates agreed by LSTK and OEMs. The price, terms and conditions shall be as agreed by the LSTK contractor in his offer. Scope of comprehensive AMC will include deputing of technical personnel for servicing/ maintenance with supply of required spares.						
	c)The AMC Charges quoted shall be inclusive of all the charges for Transportation, Lodging, Boarding, all insurances including third party insurance, all Taxes /Duties / Cess / Levies / Fees and all other incidental charges etc. but excluding GST which shall be payable extra at actual on Submission of Invoice as per GST Invoicing rules. Owner will not have any liability, whatsoever, over and above the quoted prices.						
	c) In the event of breakdown of the UPS, the OEM's engineer shall report to site at the earliest but not later than 24 hours from the time of first intimation to attend the problem						
	d) Any parts/ components that may be found defective by the customer due to manufacturing defects, faulty parts/ components and workmanship within the guarantee/ AMC period, should be replaced or repaired immediately in good working condition free of cost by the vendor.						
	e) The vendor shall carry out regular (monthly) preventive maintenance also during the guarantee/ AMC period. Documents such as guarantee card for the above mentioned years, equipment catalogue etc., shall be handed over to client during the time of installation.						
	f)Price quoted shall be considered for evaluation also						

ELECTRICAL DEPARTMENT	SCHEDULE OF ITEMS OF WORK TECHNICAL SPECIFICATION FOR ELECTRICAL INSTALLATION			32686-13-PS-02BQ			
SL No	DESCRIPTION OF ITEM	QTY	UNIT	AMOUNT			
				Rate (₹)	Amount (₹)	IGST (₹)	Total Amount(₹)
1.0	Comprehensive Post Warrantee Annual Charges for maintenance of UPS of all types after Defect Liability Period comprising of deployment of minimum one Supervisor including supply of spare parts and deployment of extra personnel required for repair or replacement of the above systems for the following periods:						
	Refer clause No: 20 of Doc. No:32686-13-TP-02 DP						
1.1	CAMC charges for First year	1	LS				
1.2	CAMC charges for Second year	1	LS				
1.3	CAMC charges for Third year	1	LS				
1.4	CAMC charges for Fourth year	1	LS				
1.5	CAMC charges for Fifth year	1	LS				
	TOTAL						
	Say						
0 24.03.21	SREENATH.M-DM(Elec)	INDULEKHA.K-DGM(Elec)	INDULEKHA.K-DGM(Elec)	FACT ENGINEERING AND DESIGN ORGANISATION			
REV DATE	PREPARED	CHECKED	APPROVED				

TECHNICAL PROCUREMENT SPECIFICATION	**INDEX**	32686-14 -PS-002
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TPS No. 32686-14 -PS-001

Sl. No.	Doc. No.	Description	No. of pages	Rev. No. with issue			
				1	2	3	4
1	32686-14 -PS-002 SW INST	SCOPE OF WORK	1	0			
	32686-14-PS-002 SIT INST	SCOPE OF INSPECTION AND TESTS	4	0			
2	32686-14-PS-002 VDR INST	VENDOR DATA REQUIREMENTS	4	0			
3	32686-01 -PS-002 SPL INST	SPECIAL REQUIREMENT OF THE PROJECT	42	0			
4	32686-14-DA- 002	DATASHEET FOR PLC	9	0			
5	32686-14-PS-002 SPR INST	MANDATORY SPARES	4	0			
6	32686-14-PS-002 SPR INST A	2 YEARS OPERATION AL SPARES	3	0			
7	32686-14-PS-002 SV INST	SUB VENDOR LIST	24	0			
8	32686-14-MD-002	CONTROL SYSTEM ARCHITECTURE	1	0			
	ATTACHMENTS						
1	14ES008/15	FIELD INSTRUMENT ERECTION SPECIFICATION	30	0			
2	14ES009/15	DCS /PLC/SCADA/SYSTEM ERECTION SPECIFICATIONS	4	0			
3	14ES010/15	GENERAL SPECIFICATION FOR FIELD INSTRUMENTATION	12	0			
4	14ES011	TANK FARM MANAGEMENT SYSTEM	25	0			
5	14ES013/18	INSTRUMENTATION PANEL	4	0			

REV.	DATE	DESCRIPTION	PRPD	CHCKD	APPD
0	16/04/21	FOR ENQUIRY	DCK	MKZ	MS

00FT011/00

FACT ENGINEERING AND DESIGN ORGANISATION

`PROJECT:	New 10000 MT Double wall double integrity Ammonia storage tank and associated facilities For FACT-CD, Ambalamedu on LSTK Basis.
CLIENT:	FACT-CD
ITEM:	INSTRUMENTATION SYSTEM FOR AMMONIA TANK
STATUS	ENQUIRY/ ~~COMMITMENT~~
PO NUMBER	-

The scope of work include the following

Sl.No	Description	Required	Remarks
1.	Supply of hardware (Field instruments, Erection material, Control system, Mandatory spares)	✓	
2.	Inspection, testing and quality assurance services	✓	
3.	Erection, integration of control system for existing facility and commissioning	✓	
4.	Documentation	✓	
5.	Training	✓	

Note:- The above mentioned scope is only for preliminary understanding only. Detailed scope is mentioned in subsequent documents and attachments of this tender document.

0	16/04/21	FOR ENQUIRY	DCK	MKZ	MS
REV	DATE	DESCRIPTION	PRPD	CHKD	APPRD

PROJECT: New 10000 MT Double wall double integrity Ammonia storage tank and associated facilities For FACT-CD, Ambalamedu on LSTK Basis.

ITEM : As indicated below

EQPT NO.

The following inspection and test shall be conducted and records submitted

Sl.No	Description	Inspection. Required	Witness Reqd	Remarks
A.	**ELECTRONIC TRANSMITTERS**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Performance test accuracy	$	$	
4.0	Material test certificate (For diaphragm seal)	$	*	
5.0	Certificate for electric code	$	*	
6.0	Hydraulic test	$	$	
7.0	SIL certificate	$	*	
8.0	W&M (India)	-	-	
B.	**ANALYSERS**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Performance test accuracy	$	$	
4.0	Material test certificate	$	*	
5.0	Certificate for electric code	$	*	
6.0	Pressure/ leakage test	$	$	
7.0	Weather proof certificate	$	*	
C.	**AIR FILTER REGULATORS**			
1.0	Visual inspection	$	$	
2.0	Performance test accuracy	$	$	
D.	**RADAR/ SERVO LEVEL TRANSMITTERS**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Performance test accuracy	$	$	
4.0	Material test certificate	$	*	
5.0	Certificate for electric code	$	*	
6.0	Hydraulic test	$	$	
7.0	Weather proof certificate	$	*	
8.0	SIL certificate	$	*	
9.0	W&M India certificate			
10.0	IBR certificate (If applicable- for guided wave)	$	*	

REV	DATE	DESCRIPTION	PRPD	CHKD	APPRD
0	16/04/21	FOR ENQUIRY	DCK	MKZ	MS

Sl.No	Description	Inspection. Required	Witness Reqd	Remarks
11.0	Functional test- Alarm contacts, communication with host/ accessories etc	$	$	
E.	**INSTRUMENT TUBES/ PIPES/ FITTINGS**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection (note 1)	$	$	
3.0	Material test certificate	$	*	
4.0	Hydraulic/ pneumatic test report (note 2)	$	*	
Note –1 ID of ferrule by GO/NOGO gauge, pipe thread by plug and ring gauge, interchangeability of ferrule nut.				
Note-2 Also ferrule tightening test to be carried out.				
F.	**INSTRUMENT VALVES (CONTROL AND ON-OFF)**			
1.0	Visual inspection for valve assembly	$	$	
2.0	Dimensional inspection for valves and accessories	$	$	
3.0	Material test certificate for valve(and accessories if applicable)	$	*	
4.0	Hydraulic test (Shell test, seat leakage test etc)	$	$	100%
5.0	Certificate for electrical code (SOV, positioner, Limit switches, cable glands, inbuilt junction boxes, intrinsic safe certificate for any barriers in case of Namur sensors etc)	$	*	
6.0	Weather proof certificate (SOV, positioner, Limit switch Cable glands, junction boxes if any etc)	$	*	
7.0	Functional test (SOV, positioner, limit switches, partial stroking, Position transmitter, other contacts if any etc)	$	$	
8.0	Bought out item test certificates- (Solenoid valve, positioner, air filter regulator etc) from OEM	$	*	
G.	**CABLES**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Performance/ insulation resistance	$	$	
4.0	Routine tests as per national/ international standard referred in the data sheet/ QAP	$	$	
5.0	Type test report	$	*	

REV	DATE	DESCRIPTION	PRPD	CHKD	APPRD
0	16/04/21	FOR ENQUIRY	DCK	MKZ	MS

Sl.No	Description	Inspection. Required	Witness Reqd	Remarks
H.	**ELECTRICAL FITTINGS AND JUNCTION BOXES**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Certificate for electrical code	$	*	
4.0	Weather proof certificate	$	*	
5.0	Type test report	$	*	
6.0	Routine test	$	$	
I.	**PRESSURE GAUGES**			
1.0	Calibration Certificate	$	*	
2.0	Material Test certificate for diaphragm seal	$	*	
3.0	Weatherproof certificate	$	*	
	TEMPERATURE GAUGES			
1.0	Calibration Certificate	$	*	
2.0	Material Test certificate for thermowell	$	*	
3.0	Weatherproof certificate	$	*	
4.0	Wake frequency calculation	$	*	
J.	**THERMOCOUPLE (With thermo-well and Head)**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Accuracy test	$	$	
4.0	Material test certificate	$	*	
5.0	Insulation resistance test	$	$	
6.0	Weather proof certificate	$	*	
7.0	Ex proof certification	$	*	
8.0	Wake frequency calculation	$	*	
	If thermocouple wires are bought out item to the vendor, then certificate of conformance to IS-8018 (Pt and Pt alloy wires) shall be issued by vendor in vendor's test certificate. The vendor shall review the QAP and test report for the bought out wires from the sub-vendor and reports shall be readily available if requested by FEDO.			
K.	**FLOW METER- MAGNETIC/ VORTEX/ TURBINE/ TARGET/ CORIOLIS/ ULTRASONIC**			
1.0	Visual inspection	$	$	
2.0	Dimensional inspection	$	$	
3.0	Performance test accuracy	$	$	
4.0	Material test certificate	$	*	
5.0	Certificate for electric code (If electronic)	$	*	
6.0	Hydraulic test	$	$	

REV	DATE	DESCRIPTION	PRPD	CHKD	APPRD
0	16/04/21	FOR ENQUIRY	DCK	MKZ	MS

Sl.No	Description	Inspection. Required	Witness Reqd	Remarks
7.0	Weather proof certificate	$	*	
8.0	~~W&M~~ / calibration certificate	$	*	

$ - Manufacturer shall conduct their standard inspection as part of their 'quality assurance' program and shall furnish inspection reports for review. If required, witness inspection will be conducted by purchaser's representative.
*Report review

General notes

Witnessed inspections at the factory for each instrument shall be as follows:

a) Inspection method for all instruments shall be in accordance with client/consultant approved QAP.
b) Verify that the instruments comply with the approved specification(s) and datasheet(s).
c) Visual inspection shall include check of labeling, legal stamping and nameplates, Painting, connection sizes and general workmanship etc as applicable.
d) Pressure test shall be carried out by Manufacturer as per the design pressure indicated on the specification data sheets and codes requirements.
e) Pressure test certificates shall be delivered by the Vendor at the time of equipment inspection and delivery.

INSTRUMENTATION DEPARTMENT	VENDOR DATA REQUIREMENTS	32686-14-PS-002 VDR INST	
		Page 1 of 4	R0

PROJECT:	New 10000 MT Double wall double integrity Ammonia storage tank and associated facilities For FACT-CD, Ambalamedu on LSTK Basis.
CLIENT:	M/s FACT-CD
ITEM:	Package items- Ammonia Storage and Handling System
STATUS	ENQUIRY/ ~~COMMITMENT~~
PO NUMBER	

SL NO.	GRP. CODE	DESCRIPTION	OFFER	AFTER COMMITMENT				FINAL
			QTY	QTY	Lead Time In Weeks			QTY
					Req.	Prop	Agrd	
A		**From package vendor**						
1.	B	Deviation list	1P+1S					
2.	C	Documents and drawings index	~~1P+1S~~	1P+1S	2			3P+1S
~~3.~~	~~B~~	~~Bidder's checklist (Filled)~~	~~1P+1S~~					
4.	B	Control system Make/ model details		1P+1S	2			3P+1S
5.	B	Control system Architecture		1P+1S	2			3P+1S
6.	B	Instrument schedule		1P+1S	2			3P+1S
7.	B	Spare parts list	~~1P+1S~~	1P+1S	2			3P+1S
8.	B	Instrument specifications		1P+1S	2			3P+1S
9.	B	Instrument design philosophy		1P+1S	2			3P+1S
10.	B	Instrument installation diagram (loop schematic diagram)		1P+1S	4			3P+1S
11.	B	Instrument location &cable panel arrangement/wiring drawings		1P+1S	4			3P+1S
12.	B	Bill of material		1P+1S	4			3P+1S
13.	B	Control panel & inter lock panel arrangement/wiring drawings.		1P+1S	6			3P+1S
14.	B	Marshalling box(termination box) drawings		1P+1S	6			3P+1S

REV	DATE	DESCRIPTION	PRPD	CHKD	APPRD
0	16/04/21	FOR ENQUIRY	DCK	MKZ	MS

FACT ENGINEERING AND DESIGN ORGANISATION	FEDO

14FT910/15

15.	B	Junction box schedule/ connection drawings		1P+1S	6			3P+1S
16.	B	Cable schedule		1P+1S	4			3P+1S
17.	B	Interlock scheme &write up		1P+1S	6			3P+1S
18.	B	Control room layout		1P+1S	4			3P+1S
19.	B	IO List of PLC (Including the existing IO)		1P+1S	4			3P+1S
20.	B	Grounding details		1P+1S	4			3P+1S
21.	B	Air distribution drawings		1P+1S	4			3P+1S
22.	B	Instrument hookup drawings (Process Hookup, Electrical hookup, Pneumatic Hookup)		1P+1S	6			3P+1S
23.	B	Instrument/ junction box installation drawings with supports and canopy		1P+1S	6			3P+1S
24.	B	Test procedures for instrument, lines etc		1P+1S	6			3P+1S
25.	B	Pre-commissioning and commissioning checklist, Procedure etc		1P+1S	10			3P+1S
26.	C	Loop folders (All connected drawings of every instrument loop in a folder)			4$			3S
27.	C	All documents and drawings in CDs/DVDs (Editable copy)		3S	2$			3S
28.	C	As built drawings		1P+1S	4$			3P+1S

Group code:

A- For review and detailed engineering,
B- For review,
C- For information and record document type:
R- Reproducible,
P- Print,
M- Microfilm
S- Soft (CD/DVD)
$- Counts from Date of Startup

Notes:

@ Vendor shall fill in proposed lead-time if different from the required lead-time.
@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and dispatched with the equipment.

SL NO.	GRP. CODE	DESCRIPTION	OFFER QTY	AFTER COMMITMENT QTY	Lead Time In Weeks			FINAL QTY
					Req.	Prop	Agrd	
B		**Vendor data requirement from instrument manufactures**						
1.	C	Manufactures catalogue with model code no.		1P+1S	12			3P+1S
2.	B	Manufactures technical specification indicating range, material, utility requirements		1P+1S	12			3P+1S
3.	B	Quality assurance plan		1P+1S	12			3P+1S
4.	B	FAT/ SAT Procedure for PLC/ SCADA		1P+1S	4BDM			3P+1S
5.	B	Control valve sizing & noise level calculations		1P+1S	12			3P+1S
6.	B	Thermowell wake frequency and sizing calculation			12			3P+1S
7.	B	Flow element sizing		1P+1S	12			3P+1S
8.	B	Dimensioned outline drawings for instruments/ Junction boxes, panel etc		1P+1S	14			3P+1S
9.	B	Control panel/ interlock panel drawings		1P+1S	14			3P+1S
10.	B	Wiring drawings		1P+1S	14			3P+1S
11.	B	Control panel/ interlock panel detail fabrication drawing		1P+1S	14			3P+1S
12.	B	Termination, wiring & power supply distribution drawings		1P+1S	12			3P+1S
13.	B	Instrument assembly drawing		1P+1S	14			3P+1S
14.	B	Performance curves/test certificates		1P+1S	2BDM			3P+1S
15.	C	Third party (IBR, CMRS etc) certificates		1P+1S	2BDM			3P+1S
16.	C	Detailed spare parts manual		1P+1S	12			3P+1S
17.	C	Operation, installation, maintenance, service manual for each instrument		1P+1S	(1)			3P+1S

18.	B	Material test report		1P+1S	2BDM			3P+1S
19.	C	Weather proof Certificates		1P+1S	2BDM			3P+1S
20.	C	Hydro test certificates, Leakage test certificates		1P+1S	2BDM			3P+1S
21.	B	General Arrangement drawings of panels		1P+1S	14			3P+1S
22.	C	All documents and drawings in CD		1S	4$			1S

(1)-dispatched along with instrument/ system
BDM- Before dispatch of material

1.0. INTRODUCTION

M/s FACT CD is proposing to install a new 10000MT Ammonia Tank and associated facilities adjacent to the existing 5000MT Ammonia Tank and Ammonia Handling facility at Ambalamugal, FACT-Cochin Division. The entire project is on LSTK basis. The following covers the broad scope of instrumentation for the LSTK job:

2.0. ABBREVIATIONS

PLC	Programmable Logic controller
FAT	Factory acceptance Test
SAT	Site acceptance test
OEM	Original Equipment Manufacturer
QAP	Quality assurance protocol
BOM	Bill of Material
SCADA	Supervisory Control and Data Acquisition
OWS	Operator's work station
EWS	Engineer's Work station
HWC	Hard wired Console
UPS	Un-interrupted Power Supply
SIL	Safety Integrity Level
MCT	Multi Cable Transit
FM	Factory Mutual
UL	Underwriters Laboratory
BASEEFA	British Approval Service for Electrical Equipment in Flammable Atmospheres
PESO	Petroleum and Explosives Safety Organisation
CCOE	Chief Controller Of Explosives (India)
CIMFR	Central Institute of Mining and Fuel Research
ERTL	Electronics Regional Test Laboratory
SLPC	Single Loop Process Controller
EIC	Engineer In-Charge

KSPCB Kerala State Pollution control board
CPCB Central Pollution control board.

3.0. DEFINITIONS

Client M/s FACT-CD (M/s FACT-Cochin Division)
Owner M/s FACT-CD
PMC M/s FEDO
LSTK The turnkey Contractor
Vendor Either the LSTK Contractor / its sub contractor as the case may be

4.0. FACILITY DESCRIPTION

At present, FACT-CD is operating 5000MT ammonia tank with associated facilities such as refrigeration compressors, instrument air compressors, Flare, barge unloading facilities etc. The new 10000MT tank and associated facilities are planned adjacent to the existing facilities. The present control room is with conventional control such as SLPC for analog closed loop control and annunciators, panel mounted instruments for other monitoring/ open loop control. The existing compressors are operated from local relay panels presently, which are being upgraded to Individual PLC based control for each compressor by Owner.

5.0. SCOPE OF WORK

The scope of instrumentation works include Detailed design, Procurement, Inspection, supply, testing and calibration, erection and commissioning of all instruments and control system for the safe and smooth operation and shutdown of the New Ammonia and associated facilities on Turnkey responsibility. The scope also includes the integration of existing ammonia tank and associated facilities to the new control system supplied by LSTK. The word integration with reference to existing tank and associated facility is meant to accommodate the existing monitoring, controls and logics of the existing facility to the new control system supplied and no process integration in control system is required. The detailed scope of work is mentioned in the following sub-sections:

5.1. GENERAL

5.1.1. The scope of work of vendor is given under but not limited to

- Design of the Instrumentation system for new Ammonia tank and associated facilities.
- Furnish hazardous area classification drawing/ details.
- Detailed engineering activities such as,
  - preparation of instrument specifications
  - sizing calculations
  - Preparation of erection drawings and documents such as
    - Cable routing drawings
    - Air routing drawings
    - Loop drawings
    - Hookup drawings
    - Erection BOM preparation from the same etc.
- Inspection and Quality assurance services such as
  - QAP
  - inspection procedures for all instruments and valves etc
  - Inspection at OEM shops and at site
  - Field installation quality assurance
- Supply of field instruments and control valves for the safe and efficient operation as per the latest specifications.
- Supply of cables, cable glands, cable trays, Junction Box / local panel and other erection materials like ferrules, fittings etc
- Erection/Installation of instruments, Junction boxes, laying of branch cables in the field up to the Junction boxes, Calibration of instruments, Termination and loop Checking in co-ordination with Purchaser's personnel
- Factory acceptance test, Dispatching
- Site Acceptance test
- Integration of existing system to the new control system supplied.
- Preparation/ modification of interlock, logic diagrams, control write-up for the new system as well as for the existing system. Preparation of all the Engineering input for incorporating in the existing control system such as I/O list, trip/ alarm settings, graphics, configuring customized reports
- Commissioning of the complete system
- Guarantee run for the instruments.
- Training & documentation as required for the operating& maintenance personnel.

- Suitable interlocks are to be implemented, for the safe functioning of the proposed new system as well as for the existing system.
  The new Tank will be constructed adjacent to the existing tank and facilities. The new tank and associated facilities shall have one new control room. This control room shall have additional spares in both hardware and software for accommodating the process and shutdown signal/ commands of the existing system as well. Scope of the LSTK contract includes instrumentation and automation for the new tank as well as incorporating the controls and associated instrumentation of old tank to the new control system. **No new instruments / cable need to be supplied outside control room by LSTK for the purpose of integration of existing facilities** and the same will be supplied / erected till control room including glanding and termination at marshalling panel by client.

5.2. CONTROL ROOM REQUIREMENTS

5.2.1. CONTROL SYSTEM

a) New common control room shall be constructed at the battery limits for new tank as well as for the existing tank and associated facilities. (LSTK CIVIL SCOPE)
b) The control system suggested is PLC based system with SCADA based operator stations. The detailed data sheet for the same is attached. The PLC shall have redundancy for Processor, IO modules ((For all Critical IO, which includes All control loop input and outputs, all interlock inputs and outputs),), communication and Power supply. The CPU, communication and power supply cards shall be hot standby. Non Critical IO includes Annunciator alarms, Pushbuttons in control room etc. All IO modules used shall be supporting HART protocol.
c) Console allocation and other hardware suggested is given below:
   I. OWS-1: One Operator work station shall be provided for the new tank
   II. OWS-2: One Operator station shall be provided for the existing Tank.
   III. One EWS/ OWS- This shall be for the engineering applications as well as for the operation. All the functions of both OWS 1 and OWS 2 shall be possible from this common console in addition to the Engineering activities.
   IV. One alarm printer and one Log printer shall be provided at the control room - Network printers shall be supplied. (Laser printer, A4, Black and white)

V. Alarm annunciator with hooter shall be provided for the critical trip/ alarm indication which shall be of solid state type. All further acknowledgement/ Reset/ Test shall be from Operator consoles for logging purposes. A hardwired console also shall be provided near the control desk to manually activate trips if any on emergency situations and for important indications. Both annunciator and hardwired console shall be separate for new as well as existing facility to distinguish the process area clearly.

d) The operator stations/ Engineering stations shall be with latest operating system (Windows 10) with original license for Operating system and all other software used. Antivirus software, MS office etc also shall be supplied in all the stations. All the stations shall be of same make and model industrial grade server PCs with Tower mount CPU and historisation of all parameters shall be provided in all PCs through software.

e) The marshalling panels shall be completely separate for both existing facilities as well as for new facilities so as to have maximum isolation maintained between new and existing system.

f) The servo level transmitter contacts, Tank pressure transmitter etc shall be connected to PLC through suitable SIL certified repeaters mounted in cabinets inside control room. One of the contacts shall be kept terminated in a terminal block for future use, other one shall be connected to PLC for shutdown activation purpose/ Alarms. Details of repeaters required are given below.

Existing Tank:

a. Tank Level (Analog)-2 No
b. Pressure(Analog)-2 No

New Tank

a. Servo level Transmitter -2Nos
   Digital contact-Low -1 No per Transmitter
   Digital contact-High -1 No per Transmitter
   Total = 4Nos.
b. Pressure (Analog) - X Nos. (X- No of pressure transmitters)

Number of repeaters required for existing & new tank is total 8+ X Nos.(Including analog and Digital)

g) Graphics

Each process inputs shall be assigned to multiple graphic pages as per requirement. This shall be finalized during detailed engineering. All the graphic pages shall be arranged in a tree structure for easy navigation. Both system wise and Equipment wise Graphic pages shall be available. (Ie, Tank Page shall show Level, Temperature, Volume, Gas detector, valve positions etc and Gas detector layout shall show all gas detectors in a single page). Tentative Tree structure is as below:

- Tank -5000MT (Old)
  -10000MT (New)
- Compressor -Ammonia Compressor 1 (New)
  -Ammonia Compressor n (New)
  - Ammonia Compressor 1 (Old)
  -Ammonia Compressor n (Old)
- Flare - New
  -Old
- Gas detectors
- Utilities -UPS
  -Instrument air
  -MCP layout
  -DG Set

5.2.2. HARD WIRED CONSOLE (HWC)

Hard wired console shall be provided in control room for important indications and pushbuttons of emergency nature/ actions. This includes the

- Major valves status, Open/ Close Pushbuttons etc
- Pump/ compressor trip indications, Start (case to case basis)/ stop Pushbuttons
- Major trip indications of process units, Trip initiating switches, Bypasses etc

Hard wired Console shall be separate for new ammonia tank installation and existing ammonia tank installation.

5.2.3. ANNUNCIATOR

Two number hardwired annunciator shall be provided in control room to indicate important trip/ alarm status. This includes:

- Tank level, pressure alarms
- Compressor/ Pump trip/ Valve status etc

The detailed list of IO for HWC and Annunciator shall be finalised during detailed engineering stage in consultation with the Owner/ PMC. Note that the annunciator logic shall be implemented in PLC itself. The annunciator front facia may be mounted on HWC preferably.

5.2.4. CONTROL ROOM FURNITURE

The following furniture shall be supplied for the control room:

- Closed type consoles for EWS and OWS
- Chairs for consoles- (3nos.)
- Printer Tables (2 Nos, with integral paper rack)
- Documentation racks (2 No.)- Sufficient for storage of 1 set of all as built documents and drawings of the plant. (One for Log reports, One for Plant documentation and OEM data of equipments)

All the furniture shall be of reputed make and shall withstand the normal service/ handling expected within control room and shall be matching to control room aesthetics. The same shall be approved by Owner before placing order by LSTK.

5.2.5. PACKAGE ITEM INTEGRATION

All sub systems supplied in this LSTK package shall be integrated to the central PLC through hardwired/ serial communication as the case may be depending on the criticality and based on client/ PMC approval. This includes the following systems and signals and the list is not exhaustive, but not all the systems may be present:

c. UPS Signals- UPS trip, main failure, UPS changeover, battery Charge Low etc

d. Flare- Control and monitoring signals (Flame feedback, pilot ON/ trip etc)- Local panel shall be provided for flare
e. Instrument air compressor- Important Parameters
f. Ammonia compressor (Holding and unloading)- Important Parameters
g. Gas detection system/ Manual call points
h. DG set- Important Parameters
i. Fire fighting system - Important Parameters as applicable

The package items shall have distributed PLCs/ OEM Microcontroller based control unit (OEM Controllers Mainly for Instrument air compressor). The package item design shall ensure that the system shall function even in case of complete communication failure (Serial communication) from control room central PLC and shall run independently if there is an emergency. The package item shall depend the control room PLC only for minimal control/ monitoring. A trip of central control room PLC shall not hinder the package item from running its own locally. Necessary bypass provision shall be included in design for Compressor PLC, Instrument air compressor and Flare packages.

All package PLCs shall communicate to central PLC through non-redundant serial link for non critical data exchange and provision shall be provided for the same at both ends. A failure of this communication link shall not trip the package unit. In case of Critical I/Os from package PLCs to central PLC which shall be through hardwired only.

All the local panel shall be provided with lamps /pushbuttons/ hardwired annunciator etc for human interface. Use of Software based HMI is not recommended and will be subject to Owner/ Client discretion.
All the package PLC shall be provided with necessary connectivity provision for programming changes if any to a laptop.

5.2.6. CONTROL SYSTEM ARCHITECTURE

Typical control system architecture proposed is attached along with the tender document. Note that this architecture is for preliminary understanding only and not intended for 'Good for Construction'. The contractor shall develop the architecture in detail and submit for PMC/ Owner approval. .
It is to be noted that the existing ammonia tank and the proposed new tank related controls shall be separate except the central PLC processor module,

communication module and Power supply. A failure of one module other than Processor, communication or power supply shall not affect both existing and new Ammonia tank systems at a time. (ie no single IO modules shall be used for both the tanks)

5.3. FIELD INSTRUMENTATION

5.3.1. GENERAL SPECIFICTAION OF INSTRUMENTS

The general specification to be followed for the various instruments is attached as a separate document 14ES010.

5.3.2. SYSTEM PACKAGES

The major process packages expected in this LSTK tender are:

- Ammonia compressor
- Instrument air compressor
- Flare

The requirements for process packages are mentioned below:

5.3.2.1. The ammonia compressors shall be operated with individual PLC for each compressor, which shall be located inside the Control room. These PLCs shall be non-redundant in configuration. The operation of compressors shall be possible from flame proof local panel with necessary pushbuttons and lamps. All parameters of the compressors shall be available at control room through serial communication. However, the critical signals (Which are part of an interlock) shall be hardwired. Vibration monitoring panels if applicable shall be mounted in the control room, and interfaced with PLC through serial communication or direct hardwiring of Vibration monitors to compressor PLCs also accepted.

5.3.2.2. The instrument air compressor shall be provided with PLC/ OEM Microcontroller separately for each compressor. All the interlocks and monitoring for safe operation, start-up and shutdown in case of emergencies for compressor shall be possible by the PLC/controller. Repeat indications shall be made available to the main control room for monitoring. If instrument air compressor control is with PLC, non-redundant configuration shall be used. Flameproof/ Purged panel need to be considered if area classification is demanding for the same.

5.3.2.3. Flare shall be operated from a local panel, protected from rain and sun light adjacent to the fuel trains. However, the flame ignition provision shall be provided from both local and Control room. One hydrocarbon detector shall be provided in LPG manifold area to detect leakage, with signal to control room.

5.3.2.4. Calibration kit shall be provided for all the gas detectors (Ammonia/ Hydrocarbon, Chlorine etc) used in the plant.

5.3.3. AMMONIA TANK INSTRUMENTATION

Tank Instrumentation shall be provided as per clause 2.3.2 "Tank Instruments" of Design philosophy- process document, 32686-11-PS-002-PH. The basic requirements are detailed as below:

a. TANK LEVEL MEASUREMENT

The tank shall be provided with 2 number of independent level measurement systems as following:

I. Top mounted servo gauge with calibration chamber and SS isolation valve- 2 No.(same make & model) both with 2 Nos each alarm contacts in addition to 4-20mA output, SIL 2 Certified, +/1mm accuracy. Vendor shall include 1 number of common handheld device for servo communication/ calibration in the supply. Tank side indicator shall be supplied with each gauge. Each gauge shall be provided with flameproof power isolation switch.

II. The servo gauges shall be provided with still well.

b. TANK TEMPERATURE MEASUREMENT

Two numbers independent multipoint type temperature measurement system shall be provided for the tank. Each multipoint temperature probe/ multiple RTD assembly shall be installed in fabricated thermo-wells mounted from top of the tank. The well shall be filled with anti-freezing thermal conducting liquids. Minimum 6 no. of temperature measurements shall be possible at equal heights. This shall include at least one temperature measurement at lowest tank level and at least one vapor temperature measurement at tank full level condition. All these RTDs shall be duplex type.

c. TANK ANNULAR SPACE LEVEL MEASUREMENT

Two numbers level measurement, DP type shall be provided to detect liquid ammonia formation in the tank annular space.

d. TANK SHELL TEMPERATURE MEASUREMENT

The LSTK Contractor shall provide skin temperature type measurement for tank cooling down to detect the skin temperature of the inner tank shell at varying heights.

e. TANK PRESSURE MEAUREMENT

The pressure inside the tank shall be measured with minimum 2 no. of pressure/ differential pressure transmitter. All these instruments shall be certified SIL-2.

f. GAS DETECTORS

Necessary gas detectors shall be provided in the new installation to detect the ammonia leakage to atmosphere. Spot type gas detectors are to be provided at the inlet / outlet of the tank, Tank top, compressor house area, ammonia pump area etc. Line of sight type and aspirating (Sampling and centralized detector) type gas detectors shall not be used. Minimum number of gas detectors to be considered is 10 (Excluding spares). Chlorine detectors are to be used at cooling tower area (1 No.) if chlorine is used in cooling water dosing.

g. VIBRATION MONITORING

Vibration monitoring as applicable as per 32686–01–PS–002 PH1 shall be provided for all heavy machineries.

5.4. SCOPE OF INTEGRATION

5.4.1. The LSTK contractor is responsible for integrating the existing Ammonia storage and handling system also into the new control system offered by the LSTK contractor.

5.4.2. All logic, graphics etc shall be collected from client for the existing system and minor modifications if required may be done by the LSTK contractor similar to the new ammonia storage system logics in consultation with owner/ PMC.

5.4.3. The tentative IO count of existing facilities is given below. However, the LSTK contractor is requested to visit the site if required to assess additional details if any. All the RTD/ T/C IO in existing system will be converted by client to 4-20mA by installing transmitters. Accordingly, LSTK shall consider 4-20mA IO (Not RTD IO) only for the same.

From / IO Type	AI	AO	DI	DO
Field	104	15	87	37

From / IO Type	AI	AO	DI	DO
Flare	**3**	**4**	9	**5**
MCC	20	**6**	20	12
Control room	1	**7**	46	7
Total	125	15	162	56

5.4.4. The client shall lay all the cables till new control room which is to be constructed as part of the new tank. Sufficient spare MCT blocks are to be considered by the LSTK contractor for accommodating the cables of existing facility. Details will be shared after award of work to successful bidder.

5.4.5. No new instrument need to be supplied by the LSTK Contractor for the existing system integration unless specifically demanded in specifications. Informative and minimum detail of the IO count which are to be integrated to the new control system is included in this document, for tender purpose. Note that this is a preliminary data only and subject to change due to modification already going on at site. The complete details of the existing IO which are to be integrated to the new control system will be provided during detailed engineering. If the LSTK Contractor requires further information on the details of integration, bidder is requested to visit the installation before submitting the techno commercial bid.

5.4.6. Bidder to provide 3 nos of serial communication interface for integrating the PLCs of the existing ammonia compressor as part of the compressor interlock modification by owner. Note that the Physical IO count as per the above table need to be provided in addition to the serial interface.

5.4.7. The LSTK contractor shall schedule the integration of existing ammonia storage to the control system without disturbing the existing plant operations in any manner. It is proposed to carry out the integration of existing ammonia storage control system to new control system in a phased manner (section/ equipment-wise).

6.0. STATUTORY APPROVALS

The vendor shall be responsible for furnishing all statutory approvals as the case may be even if not explicitly mentioned in the specifications. For flame proof instruments, the following are required:

- For Imported items FM/UL/BASEEFA/UL/CSA/Equivalent and PESO/CCOE
- For indigenous items CIMFR/ ERTL and PESO/CCOE

7.0. APPLICABLE CODES AND STANDARDS

7.1. All local (State)/ National/ International/ statutory or regulatory bodies' (KSPCB and CPCB) rules, acts, standards and codes shall be followed by the bidder.

7.2. Relevant standards and codes are mentioned in this document and its attachments. The latest version of all standards shall be followed by the LSTK Contractor.

7.3. Where no code / standard / guidelines are specified in the documents/ attachments, the Vendor shall propose applicable codes and /or standards on which the Vendor's design and manufacturing is based, for review and approval by Client/ PMC.

API (AMERICAN PETROLEUM INSTITUTE)

RP 505	Classification of locations for electrical installations at Petroleum facilities classified as Class 1, Zone 0, 1, 2
RP 521	Guides for Pressure Relieving and De-pressurizing Systems
RP 551, Part 1	Process Measurement Instrumentation, Process Control and Instrumentation
RP 552	Transmission Systems
RP 554	Process Instrumentation and Control
API 608	Metal Ball Valves- Flanged, threaded and welding ends

ASME (AMERICAN SOCIETY FOR MECHANICAL ENGINEERS)

B 1.20.1	Pipe Threads
B16.5	Pipe Flanges and Flanged Fittings
B16.20	Ring Joint Gaskets and Grooves for Steel Pipe Flanges
B16.36	Orifice flanges
PTC 19.3	Temperature measurement instruments and apparatus
MFC-3M	Measurement of Fluid Flow in Pipes using Orifice, Nozzle and Venturi
MFC-14M	Measurement of Fluid Flow in Pipes using Small Bore Precision Orifice Meters

ASTM (AMERICAN SOCIETY FOR TESTING MATERIALS)

A269	Standard specification for seamless and welded Austenitic steel tubing for general service

ANSI (AMERCAN NATIONAL STANDARDS INSTITUTE)

ANSI/ FCI 70.2	Control valve seat leakage classification
ANSI B16.36	Orifice flanges
ANSI B 40.1	Indicating pressure and vacuum gauges
ANSI MC 96.1	Temperature Measurements- Thermocouple

IS (INDIAN STANDARDS)

1239- part 1, 2	Steel Tubes, tubulars and other wrought steel fittings specification Part 1-Steel tubes, Part 2-Steel pipe fittings
IS 5	Colours for ready mixed paints.
IS 1239	Mild steel tubes, tubulars and other wrought steel fittings
IS 1271	Specification of thermal evaluation and classification of Electrical Insulation
IS 1554	PVC insulated (heavy duty) electric cables-working Part I voltage upto and including 1100V
IS 2074	Ready mixed paints, air drying, red oxide- zinc chrome.
IS 2147	Degrees of protection provided by enclosures for Low Voltage Switchgear And Control-gear
IS 2148	Electrical Apparatus for Explosive Gas Atmospheres - Flameproof Enclosures
IS 2629	Recommended practice for Hot-Dip galvanizing of Iron and steel
IS 2806	Thermometry Electrical resistance –Guide
IS 2848	Specification for industrial platinum resistance thermometer sensors
IS 3043	Code of practice for Earthing
IS 3624	Specification for pressure and vacuum gauges
IS 3975	Mild Steel Wires, formed wires And tapes for armouring Of Cables
IS 5831	Specification for PVC insulation and sheath of electric cables
IS 7358	Specifications for Thermocouples

IS 8130	Specification for conductors for insulated cables and flexible cords
IS 8784	Specification for thermocouple compensating cables
IS 8784	Thermocouple compensating cables
IS 8935	Specification for Solenoid operated actuators
IS 10189-1	Specification for Industrial process control valves- General requirements and tests
IS 12579	Specification for base metal mineral insulated thermocouple cables and thermocouples

IEC (INTERNATIONAL ELECTROTECHNICAL INSTITUTE)

IEC 60079	Electrical Apparatus for Explosive Gas atmosphere. (All parts)
IEC 60079-29-1	Gas detectors
IEC 60085	Electrical Insulation — Thermal Evaluation and Designation
IEC 60332	Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus Parts and Sections
IEC 60529	Classification of degree of protection provided by enclosures.
IEC 60534-2	Industrial process Control Valves-Flow capacity.
IEC 60584-2	Thermocouples — Tolerances
IEC 60751	Industrial Platinum Resistance Thermometer and Platinum Resistance Sensors
IEC 61000-4	Electromagnetic compatibility for Industrial Process measurement and Control equipment

DIN (Deutsches Institut)

DIN 43760	Temperature vs Resistance Curves for RTD’s

BS (BRITISH STANDARD)

BS/EN 50288-7	Multi Element Metallic Cables used in Analogue and Digital Communication and Control — Part-7 : Sectional specification for Instrumentation and Control cables

BS 6121	Mechanical cable glands

ISO (INTERNATIONAL ORGANISTAION FOR STANDARDISATION)

ISO 5167-2	Measurement of fluid flow by means of orifice plates, nozzles and venture tubes inserted in circular cross-section conduits

ISA (INTERNATIONAL SOCIETY OF AUTOMATION)

ISA 5.1	Instrumentation symbols and identification
ISA 5.2	Binary logic diagrams for process operations
ISA 5.3	Graphic symbols for Distributed control/ Shared display instrumentation, Logic and computer systems
ISA 5.4	Instrument loop diagrams
ISA 18.1	Annunciator sequences and specifications
ISA 75.01.01	Flow Equations for sizing control valves
ISA S-5.2	Binary logic diagrams for process operations.
ISA S 7.0.01	Quality standard for Instrument Air
ISA S-75.01.01	Control valve sizing equations

8.0. BATTERY LIMITS OF INSTRUMENTATION

UPS shall be in LSTK Electrical scope. The power supply to each UPS shall be from separate feeder of LSTK electrical panel. The UPS shall cater to the needs of both existing and new instrumentation systems for minimum half an hour time period. For existing instrument systems, approximately 3 KVA UPS load shall be considered by the bidder. During the UPS backup time verification, the actual load (both new and existing, after integration) only shall be considered.

Note:-At UPS end, the cable shall be terminated such that one UPS can be completely isolated without disturbing the other UPS. (looping of incoming cable is not permitted). Similarly, the battery shall be connected to the UPS through separate cables and looping is not permitted.

Instrument air compressors are included in the scope of LSTK for instrument air. Instrument air distribution is in the scope of LSTK vendor

9.0. GENERAL INSTRUCTIONS TO THE VENDOR

9.1. Specifications of items not covered in this document or its attachments shall be submitted by vendor for review by Owner/ PMC.

9.2. Any information beyond what is specified in the document/ attachment if required shall be sought by the vendor before going to select / assume the same at vendor's end.

9.3. The compliance to this specification and its attachments does not absolve the vendor of the responsibility towards contractual obligations with regards to completeness, compliance to relevant codes as applicable, proper selection, satisfactory operation, safety and reliability, easy maintenance and accessibility of the unit.

9.4. PURCHASER's/ PMC's REVIEW

Vendor shall be responsible for any discrepancies, errors or omissions in the drawings/ documents prepared by vendor or sub vendor, even if these have been approved / reviewed by the owner/ PMC. Review of vendor's documents by owner/ PMC does not relieve Vendor of his responsibility for correctness of design and supply. If any such errors or omissions are discovered later, that shall be made good, by Vendor, without any cost implications to Owner/PMC.

9.5. VENDOR DATA/ DRAWING REQUIREMENT

The list of drawings and documents required to be furnished by the LSTK contactor is indicated in the vendor data requirements attached to this specification. The list of documents and drawings included is typical in nature. If any additional documents and drawings are necessitated during the course of the project, the same have to be furnished by the contractor as required. All comments from PMC/ Owner shall be incorporated or justification for not doing the same shall be furnished within reasonable time. For all instruments, the data sheet / specification shall be approved before ordering the same from sub vendors.

9.6. SITE VISIT

The LSTK contractor is requested to visit the site for assessing the extent of integration of existing facilities and to collect additional data if required.

9.7. USE OF STANDARD SOFTWARE

Vendor shall use Standard Office tools for drawings and data preparation (MS Office, Excel, Power point, Autocad, Adobe PDF – Latest version of all software). When asked for, editable copies shall be submitted. For sizing calculations of control valves, orifice, thermowell etc, OEM calculation sheet shall be supplied. The editable copies of all drawings and documents shall be supplied to client/ PMC during closeout of the project in CDs/ DVDs.

9.8. COMMUNICATION LANGUAGE , COMMUNICATION PROTOCOL AND SYMBOLS USED

All vendor data shall be in the English language. Metric System units shall be used, unless otherwise specified. All the communication shall be addressed to the assigned project manager of Owner and PMC and through E-mails.

All symbols and tag numbers used in P&IDs shall be as per ISA standard.

9.9. EXECUTION PLAN AND PROGRESS

During the execution, the LSTK contractor is required to provide a site execution plan and a format for monitoring the progress individually for each unit. The LSTK contractor shall daily update the same and submit to Client and PMC during the course of execution.

The LSTK contactor shall regularly update and inform completion of an activity stage wise for inspection of the client/ PMC (Instrument mounting, cable laying, termination etc). Any punch points noted by EIC / owner/ PMC shall be rectified. Further, all such formats shall be kept recorded and compiled before completion of the instrumentation activities.

9.10. OWNER/PMC's INSPECTION

Owner/ PMC/ assigned TPI agencies will be supervising LSTK contractor's job at site and shall be permitted to access the LSTK vendor's storage, fabrication and work site. All assistance shall be extended by the LSTK vendor for facilitating such inspection.

Additionally, the owner/ PMC shall have access to sub-vendor shops for monitoring progress of manufacturing items. All such visits shall be accompanied by LSTK representatives if insisted for.

9.11. CORRECTION OF DEFECTIVE WORK

If at any point during erection it is found that the work is not going on as per approved documents/ drawings or defective material is found being used, the

client/ PMC shall instruct to stop / rectify the work done. In such a case, the LSTK contractor is bound to rectify the same before proceeding further.

9.12. CLIENT/ PURCHASER's RESOLUTION

In the event of any conflict between this specifications, data sheets, related standards, codes etc, the vendor shall refer the matter to the client/ PMC for clarification and only after obtaining the same should proceed with the manufacturing/ engineering of the item in question. In the absence of above, any item manufactured/ transported and the cost of any such items/ services will have to be borne by the contractor and client/ PMC shall not be responsible for the same. If any deficiency/ discrepancy is found at site during the guarantee period, the same have to be replaced by the vendor at his own cost and risk.

9.13. OWNER'S RESPONSIBILITY

The Owner shall assist LSTK in integration of the existing ammonia tank and associated facilities to the new control system (Glanding and termination, by client, Loop checking in association with LSTK). The assistance is limited to providing necessary data, loop checking, functional checking, FAT, SAT etc. It must be noted that, data which can not be provided by owner shall be collected by LSTK contractor from site in discussion with operating personnel/ from control room.

9.14. DOCUMENT SECRECY

The LSTK shall maintain tight control on its document distribution and shall maintain secrecy in documents/ drawings generated/ given to LSTK by Owner/ PMC. No such documents or drawings shall be submitted to other clients or contractors (except with permission of PMC/ Owner) nor shall the same be made publicly available through internet.

9.15. SUB VENDOR LIST & BOUGHT OUT ITEMS

9.15.1. All the instruments and control system supplied shall be of high quality and shall be from manufacturer of good repute.

9.15.2. Vendor shall supply all instruments and erection material from vendor list attached. Supply of material from any other vendor is subject to PMC/ Owner approval.

9.15.3. In case any item is found supplied other than from approved make, same needs to be replaced by contractor at his own cost and risk.

9.15.4. If for an item, the list of vendors are not available in the tender document, the same shall be brought to the attention of Owner/ PMC with a proposed list of

vendors. The credentials of such vendors need to be provided for review and only after written approval from client/ PMC, material shall be ordered from a party not included in the original vendor list. Post delivery vendor approval shall not be entertained in any case and such materials will be rejected at PMC/ Owner discretion.

9.15.5. All similar instruments (except for instruments in equipment packages) shall be supplied from the same vendor and to the extent possible the number of sub-vendors shall be kept to a minimum.

9.15.6. EXPERIMENTAL INSTRUMENTS

Instruments which are of development stage/ experimental in nature or are not yet proven in similar industrial service shall not be supplied. Instruments which are near to their end of life in its technology/ obsolete also shall be avoided in the project.

9.16. HAZOP/ AUDITS

Any additional instrument arising out of HAZOP/ AUDIT studies also need to be included in the scope of vendor without any additional claim.

9.17. SPECIAL TOOLS AND TACKLES

Vendor shall offer special tools and tackles if any required for the operation, startup/ shutdown/ maintenance of the instrument/ unit. This may include special type of spanners/ screw drivers, interfacing connectors, software/ laptop/ calibrators/ communicators etc.

9.18. QUALITY ASSURANCE

The LSTK contractor shall provide QAP for each item being supplied / bought out. Only after approval from PMC/ Owner, the LSTK vendor shall advise the OEM to start manufacturing of the item.

For field installation work, the LSTK contractor shall provide suitable formats for inspection and checklist for assuring quality and workmanship of every activity such as installation, cable laying, tray work, hydro test, pneumatic test, interlock test/ alarm/ trip verification, loop checking etc. Such checklist shall be finalized at site in consultation with PMC/ Owner representative.

9.19. USE OF MODERN TECHNOLOGY

Any system / instrument proposed / required in this tender document can be replaced by new technology system/ instrument as per opinion of the LSTK vendor provided that,

1. Such system/ instrument is already proven in the experience of LSTK contractor and based on his expertise in terms of trouble free operation, long term availability etc
2. It is convinced to client/ PMC with proper supportive documents and evidences and approval for the same is availed in writing and all such proposals are made clear in the offer stage itself. Post award of work, acceptance of such proposals shall be at the discretion of OWNER/ PMC only.

Specifications contained in this tender document are not limiting the vendor in choosing better technology/ system than that specified in the document.

9.20. ENGINEER IN-CHARGE

The work at site shall be supervised by PMC/ Owner's dedicated engineer in charge (EIC) and his/her decision shall be final as far as erection and documentation activities are concerned

9.21. SAFETY AND CLEANLINESS AT SITE

The LSTK contractor shall maintain safe working place for its workers by providing proper tools and safety awareness and maintain cleanliness at site/ control room during erection. The waste/ un used material shall be removed to dedicated place as per instruction of EIC.

9.22. OEM ASSISTANCE

As and when required, the EIC/ Owner/ PMC shall demand demonstration of special system/ testing and for which OEM assistance shall be provided by LSTK.

9.23. DOCUMENT PRECEDENCE

The document precedence shall be as follows:

1. Applicable statutory rules and regulations- National and international
2. Special requirements (This document)
3. Attached Engineering specifications
4. Licensor's recommendations

However, if there is any conflict in following the priority mentioned above and is found later on, same shall be reported to client/ PMC for resolution.

9.24. TRANSIT DAMAGE

The LSTK Vendor shall instruct sub- vendors on pre-shipment protection and preservation of equipments/materials bought out as per vendor's standard. Immediately on receipt of material at site, the same shall be inspected for any transit damage by vendor representative and corrective actions shall be taken if replacements are required.

10.0. INSTRUMENT DESIGN PHILOSOPHY

10.1. GENERAL

10.1.1. All electronic field instruments shall be smart, HART compatible, 4-20 mA, 2 wire type with integral LCD local indication.

10.1.2. Drain/ vent connections shall be ensured in all instrument hookups. Condensate/ seal pot shall be considered for steam/ congealing liquids. The hookup templates shall be submitted by the contractor during detailed engineering for review and approval by PMC/ Owner.

10.1.3. The control room shall be provided with false flooring and air conditioning (LSTK CIVIL SCOPE)

10.1.4. Mercury filled temperature gauges or switching contacts shall not be used in the project.

10.1.5. Freewheeling diodes shall be considered across all relays.

10.2. TEMPERATURE TRANSMITTERS

All temperature sensors (RTD/ Thermocouples) shall be connected to PLC through field mounted temperature transmitters.
Head mounted temperature transmitters shall not be used. Only temperature instrument with remote transmitter is allowed.

10.3. HAZARDOUS AREA INSTRUMENT SELECTION

All instruments shall be specified Flame proof (Exd). Non-flame proof instruments shall be housed in purged panel / flameproof panel (Preferred) as necessitated.

Ingress protection shall be minimum IP65 for all field instruments and field panels.

Junction boxes and cable glands also shall be certified Flame proof and weather proof matching to the associated instrument.

10.4. FLOW METER SELECTION

The following table shall be the guideline for flow meter selection of the project. For any other flow measurement necessitated by the process, suitable measurement method shall be selected by the LSTK vendor, subject to the approval of Owner/ PMC

Service	**Type of Flow meter**
Steam, Vapour ammonia	Orifice/ Vortex/ Ultrasonic
Raw water, Effluent water	Magnetic Flow meter (PTFE Lined internals)
Liquid Ammonia	Coriolis Mass flow meter
Instrument air	Vortex/ Thermal mass flow meter

10.5. PROCESS SWITCHES

Process Switches are not preferred, instead transmitters with either inbuilt contact (In addition to the 4-20mA HART signal) or with external trip amplifier or with soft switch in control system is preferred because of advanced diagnostic possibilities.

10.6. MATERIAL SLECTION

Being ammonia installation, copper and copper bearing alloys shall be avoided in wetted parts or exposed parts of instruments. For all other instruments, the wetted parts shall be as per Piping material specification.

10.7. TRIP PHILOSOPHY

All instrumentation shall be based on de-energise (ie, normally energized during operation- i.e Relays and Solenoid valves) to trip concept and fail safe instruments shall be considered.

All alarm contacts shall ‘break’ incase of alarm and shall ‘make’ under normal situation.

For temperature instruments, burnout shall be upscale for low temperature trip circuits and downscale for high temperature trip circuits to avoid spurious trips.

10.8. CABLE ENTRY

All cable entries to instruments and junction boxes shall be from Bottom/ side only and top entry is prohibited.

One spare cable entry shall be provided in all instruments. At junction boxes, 20% of each type cable entry is to be spare and plugged.

Control room Cable entry shall be below the false floor and through MCT.

Cable entry to marshalling panels shall be through bottom mounted gland plate.(Preferably split type gland plate)

10.9. REDUNDANCY & VOTING LOGIC

A deviation alarm shall be triggered in control system if any deviation noted among different transmitters used for same process variable measurement.

Instruments used for control and interlock or for redundancy purposes, shall be separate and shall be from different process tappings.

One tapping shall not be shared between local gauge and associated transmitter.

10.10. INSTRUMENT RANGES

Instrument Ranges shall be selected as per the following guidelines:

- All gauges shall be show normal values at 2/3rd of their range.
- Control valves shall be sized with maximum flow at 80% of stem position
- RTDs shall be selected till 200Deg.C and beyond that range; thermocouples shall be used suitable for the temperature.

10.11. UNITS OF MEASUREMENT

- Pressure Kg/Cm2, Kg/Cm2a
- Differential Pressure mmH2O
- Flow
  - o Liquids Kg/hr, M3 / Hr
  - o Gas Nm3/hr
  - o Steam Kg/Hr
- Temperature Deg C
- Level % or mm
- Analysis results % or ppm
- Combustibles % LEL

10.12. INSTRUMENT ACCURACIES

The following accuracy shall be applied by default for the instruments:

Instrument	Accuracy Required
Pressure gauges	+/- 1% FSD
Temperature gauges	+/-1.5% FSD
Pressure/ Differential pressure transmitter	+/- 0.05% of Reading
Coriolis Mass Flow meter	+/-0.2% of Reading
Magnetic Flow meter	+/-0.5% of Reading
PH/ Conductivity Analysers	+/-0.5% of Reading
Servo Gauge	+/-2mm
Displacement type Level transmitter	+/-0.5% of reading

10.13. INSTRUMENT CONNECTIONS

Instrument	Process Connection	Instrument Connection
Pressure Gauge (Threaded)	20NB	15NB (1/2" NPTM) With 2Valve manifold ½" NPTF
Pressure gauges - Flanged	80NB (3")	80NB (3")

Instrument	Process Connection	Instrument Connection
Pressure/ differential pressure transmitter	20NB (3/4”)	15NB (1/2” NPTF)
Pressure/ Differential pressure transmitter-Flanged	50NB (2”)/ 80NB (3”)	50NB (2”)/ 80NB (3”)
Temperature gauges-Threaded	Well ½” NPTF	15NB (1/2” NPTM)
Orifice Tapping	20NB (3/4” NPTF)	-
Level gauges- Reflex/ Magnetic- Flanged	20NB (3/4”)	20NB (3/4”)/ 25NB(1”)
Displacement Type Level transmitter-Flanged	50NB (2”)	50NB (2”)
Guided wave Radar-Flanged	50NB (2”)	50NB (2”)
Servo Gauge	200NB (8”)	Servo end-50/100NB (2/4”) Cal. Chamber-200NB (8”)
Thermowells- Flanged*	40NB (1 1/2”)	1/2” NPTF+ NUN Connection to Head
Solenoid valves	-	¼” NPTF/ ½” NPTF

*For multipoint temperature measurement on tank, 3” fabricated well shall be considered.

10.14. IO SEGREGATION

Different junction boxes shall be used for the following types of inputs/ outputs.

- AI/AO
- DI/DO
- Power for instruments (110 VAC)

10.15. POWER SUPPLY

The following power supply/ rating shall be used for various instruments in the system:

Pressure/ DP transmitters	24 VDC loop powered
Solenoid valves	24 VDC
Valve limit switches	NAMUR with barrier of 24VDC
Servo Level gauge	110VAC
Cabinet Utilities (Lighting, Fan, utility socket etc)	230V non UPS
Relays	Coil-24V DC Contact-2A Rated general, For Solenoids, 5A Rating
Operator stations	110VAC UPS
Packages	110VAC UPS for control and Monitoring, 230VAC Non UPS for Utilities
Alarm contacts Interrogation voltage for instruments	24VDC (Contact rating shall be 2A.)
INSTRUMENT ELECTRICAL INTERFACE	
Inputs from MCC (Feedbacks)-Potential free contact for instrumentation	Interrogation Voltage 24V DC from Instrument panel Contact rating 5A Relay located at Instrument panel in control room*
Relay contact interrogation voltage from MCC (Commands to MCC)-Potential free contact for Electrical	110VAC (Interrogation From MCC) Contact rating 5A to be considered Relay located in Instrument panel in control room*

*Separate instrument relay cabinet is not envisaged since the number of signals in between Electrical and Instrumentation is less.

10.16. ISOLATION & BYPASS

Inline control Valves & Flow meters shall have block and bypass facility to facilitate the removal and maintenance of the instrument without disturbing the process. Necessary piping arrangements shall be ensured during design. For instrument air service, one isolation valve shall be provided near the Air header and secondary isolation valve shall be provided if the consumer is more than 15 mtr from air header.

10.17. INSTRUMENT LOCATION AND PROTECTION (TROPICALISATION)

All instruments offered shall be suitable for the hazardous area determined for the installation. Additionally, such instruments shall be suitable for the tropical atmosphere with hot humid conditions and vibration prone atmosphere which are typically expected in industries.

If the instrument alone is incapable of resisting these ambient effects, additional protection shall be provided for the instrument. (Rain hood, Cooling/ heating arrangements, jacketing, insulation, screening, pressure/ temperature compensation, enclosure material of construction, Painting, steam/ electrical tracing etc)

All instruments located outdoor shall be provided with rain hood/ canopy irrespective of ingress protection certification. This includes Instruments and junction boxes, local panel etc.

Canopy for instruments and junction boxes shall be of FRP material with one or two standard size suitable for different instruments from different manufacturers. The canopy shall be fully enclosed type (Openable) with viewing glass for transmitters.

10.18. ELECTRO MAGNETIC COMPLANCE

All instruments shall meet the technical requirements as defined in the following
Specifications to be suitable for use in the Radio frequency/ Electro magnetic interference prone areas typically expected in industrial area:

IEC 61000 Sections 4.1 thru 4.5 - Electromagnetic Compatibility.

IEC 61326 section 1	Electrical Equipment for Measurement, Control and Laboratory use -EMC requirements
IEEE C37.90.1	Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

10.19. ACCESSIBILITY

All the instruments/Junction boxes/ local panel shall be installed/ located such that the instrument/JB/ local panel is easily accessible in terms of installation height for maintenance/ removal and operation visibility. Fixed platform shall be provided for instruments/ valves installed at heights more than 2 meter.

10.20. INSTRUMENT IDENTIFICATION

Every instrument shall be identified with manufacturer's name plate with essential information such as make, model number, serial number etc.

Every instrument shall be provided with a project specific tag plate indicated in the P&ID attached to the instrument by SS wire.

Additionally, instrument tag number shall be painted on a stanchion/ pipe/ column/ wall etc for location identification of the instrument when under maintenance/ removal.

The local panels shall have acrylic/ SS name plate. Every accessory inside and outside the panel shall be identified with a tag number painted or with name plate including terminal block terminals, earthing bars, power supply units etc.

Every cable shall be identified at instrument end, Junction box end, Control room end, at both sides of every crossings, turns, and at regular intervals on Aluminium/ SS Tag plates.

All wires shall be identified with Tubular ferrules (Pre-printed) with cross ferruling.

Main cable trays shall be identified with suitable marking (Painting) at its side to distinguish power and signal cable trays as per instruction of EIC.

All lettering on metallic plates shall be of minimum 4mm size.

11.0. ERECTION MATERIALS

11.1. CABLES

All the cables shall be Annealed Tinned Copper conductor with min 1sqmm. The insulation shall be PVC Type C. The inner and outer sheath as applicable shall be extruded PVC ST2 type with FRLS properties. All cables used shall be armored except special cables used if any inside control room, which shall be suitably protected to avoid rodent attack. For power cables, min 2.5sqmm conductor size shall be selected. Screening shall be considered for all analog input and output signal cables. All cables shall meet the relevant IS standards listed in this document.

11.2. JUNCTION BOXES

All junction boxes shall be Flame proof made of Die case Aluminium LM6. Cable entries shall be provided as per detailed engineering ensuring spares philosophy. The Junction box shall be provided with terminals suitable for 4mm2 conductor.

11.3. CABLE GLANDS

All cable glands shall be NPT, SS316 double compression type suitable for armoured cables. PVC shroud shall be provided with each cable gland.

11.4. CABLE TRAY

Perforated type Cable tray shall be FRP/ GRP type with cover.

12.0. INSTRUMENT ERECTION

12.1. GENERAL

The following requirements shall be followed in instrument erection:

12.1.1. No instrument shall be mounted in handrails. Each instrument/ local panel shall have its own support except pressure/ temperature gauges.

12.1.2. The instrument installation shall not restrict the available spaces and access ways.

12.1.3. The mounting of gas detectors shall be close to the leak sources and at an elevation based on gas density.

12.1.4. Instrument / impulse lines shall be protected from cold and freezing conditions of process fluids.

12.1.5. Where cable crossing the footpath is unavoidable, conduits/ pipes shall be provided.

12.1.6. The tube fittings shall be installed by trained fitters.

12.1.7. Generally the instrument installation shall be as per 14ES008 section 4 to 16.

12.2. CABLE LAYING/ WIRING

- Flying leads are not acceptable. All wires in panel/ instrument / junction box shall be terminated in terminal blocks with suitable ferrule in proper sized terminals.
- All terminals shall be installed on DIN rails for easy removal. Crimping Lugs shall be used for stranded wires only.
- The terminals shall be mechanical screw type/ spring loaded type. All terminations of voltage above 110VAC shall be suitably protected for accidental contact. Terminals shall be generally suitable for 4mm2 solid/ stranded conductor and for power cables, higher size shall be used as per situation demands.
- No joints shall be used in cabling. (ie the cable shall be of single section from instrument to Junction box)
- If more than one terminal block is considered in a junction box, adequate space shall be ensured for ferrule installation and readability on both side if the terminal block.
- Fiber optic cables shall be laid through HDPE conduits only.
- Further reference shall be made to 14ES008 section 17 & 18 for further requirements.

12.3. CALIBRATION & TESTING

All instruments shall be calibrated at site using suitable calibration equipments to test and verify its output prior to installation. This includes gauges, transmitters, control valves, on-off valves etc. Any adjustment required to attain the performance shall be made during calibration. The performance of the instrument shall be recorded at site in suitable formats to be agreed between site engineer in charge and LSTK contractor and the process shall be witnessed by client/ PMC if demanded.

12.3.1. Necessary calibration equipments shall be brought to site. The calibration of all these equipments shall be traceable to international standards and shall have valid calibration certificate as on date of calibration.

12.3.2. All pneumatic lines/ pipes, Cables, loops etc shall be tested as per 14ES008 in coordination with the client.

12.3.3. Further reference shall be made to 14ES008 section 20& 27 for calibration & testing requirements.

12.4. EARTHING

- Double Earthing of all field instruments and junction boxes/local panel, trays etc is in the LSTK scope. For this adequate earthing cables shall be considered. Earth cables shall be connected to earth pits.
- Earth pit as per IS-3043 shall be provided separately for instrument earthing and safety earthing of panels at control room end. Necessary earth pit construction is also included in the scope of LSTK Contractor. The earth pit resistance shall be as per limits advised by the OEM of the control system vendor. The LSTK Contractor is liable to provide as many earth pits as may be required to achieve the resistance recommended by the OEM. If additional and separate earth-pit is advised for local PLCs by OEMs, same also shall be considered in scope.
- Further reference shall be made to 14ES008 section 17 for earthing and grounding requirements.

12.5. PAINTING

- All accessories/ structural used for mounting the Junction boxes, local panels and instruments shall be painted.
- Further reference shall be made to 14ES008 section 26 for painting requirements.

12.6. ERECTION/ CALIBRATION TOOLS AND CONSUMABLES

LSTK contractor shall ensure that the workers are provided with correct tools for erection and calibration equipments intended for the purpose. All consumables such as insulation tapes, Teflon tape, welding eletcrodes etc shall be provided to workers as required.

13.0. SPARES

13.1. GENERAL

13.1.1. LSTK vendor is advised to minimise the make/ model for a particular type of instrument so as to reduce the inventory spares.

13.1.2. LSTK vendor is to ensure availability of spares for all instruments and control system for at least 15 years.

13.1.3. For any item for which spares are not listed in the list, OEM recommendations/ FEDO decision will be final and binding to LSTK Contractor.

13.1.4. Vendor to offer the following type of spares as a minimum:

13.2. MANDATORY SPARES

13.2.1. The spares indicated in the document 32686-14-PS-0002 SPR INST is the loose spares (mandatory spares) to be supplied which are in addition to the installed spares in panels/ field.

13.2.2. The List is minimum and indicative. The LSTK vendor shall ensure that spares are offered for all items supplied. Functionality of any or part of the plant shall not be compromised due to lack of spares.

13.2.3. Vendor may add additional spares as required if absolutely essential for plant maintenance/ consult with owner/ PMC before quoting in price bid. All spares as per OEM recommendation shall be included for any instrument or system.

13.2.4. Vendor may strikeout spares which are not applicable in the list. Vendor to submit compliance to list of spares during bidding stage.

13.3. COMMISSIONING SPARES

These spares shall be included for replacements if any due to damage/ maintenance requirements arising out of pre-commissioning/ commissioning stage. The cost of the same shall be considered by vendor in his scope. The list of proposed commissioning spares and quantity shall be submitted along with offer.

13.4. 2 YEAR OPERATIONAL SPARES

13.4.1. LSTK vendor shall offer a list of recommended spares from Instrument/ valve sub vendors, to be retained by the client for normal operation of the unit. The list shall be reviewed for correctness only and shall not be considered for offer evaluation. A separate order shall be placed if required. Indicative list of

operational spares is listed in 32686-14-PS-002 SPR INST A. In addition to the items in the list, vendor shall include spares recommended by OEM for the safe operation of the plant for 2 years from date of completion of warranty.

13.4.2. Detailed spare list shall be submitted after commitment based on ordered items make/ model numbers and shall be submitted for FEDO approval listed against each instrument or package.

13.4.3. The price quoted against this item shall be valid for a period of 2 years.

13.5. INSTALLED SPARES PHILOSOPHY

The installed spare philosophy to be followed is noted below:

Instrument/ System	*Spare Philosophy*
Cables	20% spare in multi core cables
Cable entries	1 no. per instrument, plugged 20% on Junction boxes (Both inlet and outlet) plugged (Min 2 in individual cables entry, Min 1 in Multi Cable entry)
Terminals	20% installed spare
Air distribution header	Min. 2 number on each header with isolation valve-Plugged
Cable trays	30% spare space
Panel Lamps, Pushbuttons, relays etc	20% installed spare
PLC	25% (Existing+ New IO) spare in each IO module (AI, AO, DI and DO) Spare Serial communication Modules/ Channels (20%) Isolators -Installed for all Spare channels
Muti Cable transit	20% Spare for each size of MCT Blocks (Existing +New)

14.0. FACTORY ACCEPTANCE TEST

14.1. The purpose of FAT is to test the control system at one place and in a totally integrated manner so as to ensure that the system is expected to work smoothly at site.

14.2. Vendor shall intimate commencement of FAT at least two weeks in advance to owner/ PMC.

14.3. The following are the minimum pre-requisites for conducting FAT.

- The FAT procedure approved from PMC/ Owner
- Approved P&ID Graphics – For both new system as well as for existing installation
- Interlock Scheme and write-ups
- Hard wired console layout
- Submission of successful In-house test report from OEM
- Approved vendor drawings- GA drawings, Power supply distribution drawings, Bill of material etc.

14.4. FAT shall be conducted at OEM work place as per the approved procedure. Necessary Technical personnel shall be available for the test and FAT shall be planned for minimum 2 days. Simulators for AI/AO/DI/DO/Serial communication etc shall be made available/ readily wired for FAT. Any minor observations shall be rectified before site erection only. Any major observations need to be rectified before closure of FAT. Otherwise, the FAT shall be repeated at a later date. The decision of classification of observation as major/ minor will be the PMC's/ Owner's inspector decision.

14.5. On successful completion of FAT, the activities are recorded in suitable formats and mutually signed. The successful FAT report is the minimum requirement for dispatch of the control system to site.

15.0. SITE ACCEPTANCE TEST

15.1. The site acceptance test is intended to verify the successful erection and commissioning of the system as per approved documents and specifications after completion of all activities at site.

15.2. Prior to SAT, vendor shall intimate the Owner/ PMC about completion of erection activities and fix a mutually acceptable date for SAT.

15.3. PRE-REQUISITE FOR SAT

- All approved documents at site related to control system and wiring, interlock, control scheme etc
- Site in-charge report on completion of erection including necessary test report for loops
- Approved SAT Procedure

15.4. The OEM of PLC shall be available at site for SAT. During SAT, all loops shall be verified and hardware, communications, interlocks/ function checks etc shall be verified 100%.

15.5. Any observations are to be immediately addressed irrespective of major/ minor in nature. If the observation/ fault is of major in nature, the SAT shall be repeated as per instruction of Owner/ PMC. Successful completion of SAT starts the warrantee period for one year.

16.0. PRE-COMMISSIONING

The vendor shall check and ensure all instruments and control system are installed as per sound engineering practice during pre-commissioning stage.
The following pre-commissioning activities shall be conducted as minimum and PMC/ Purchaser shall be updated by witnessing/ through suitable formats:

- Ensuring of all instrument mounting and tubing/ glanding etc
- Functional checks of all instruments and valves
- Hydrotest and pneumatic test on tubes and piping
- Calibration of all instruments
- Loop check
- Stroke checking of valves
- Interlock checking
- Alarm and trip simulation
- Availability of sufficient documentation for startup, maintenance, operation etc
- Ensuring availability of spares for commissioning

Each of the checking/ testing shall be witnessed by FEDO/ Site in-charge and vendor shall maintain records to be kept signed by FEDO representative/ Site in-charge.

17.0. COMMISSIONING AND STARTUP

The detailed procedure for commissioning shall be provided for review and approval of owner/ PMC. Vendor's commissioning team shall be professional, conversant with the system and shall be present round the clock. Control system OEM shall be present for the commissioning and startup activities.

The commissioning activity shall be considered complete after the successful completion of system integration of both existing and new ammonia storages.

18.0. TRAINING

The LSTK vendor shall provide training services to owner's personnel on operation and maintenance of the system supplied.

18.1. Training shall be provided for owner's personnel by the PLC/ SCADA OEM at factory and details of training shall be included in the technical proposal. This training is intended for PLC/ SCADA system maintenance and engineering, Programming etc

18.2. Training shall be offered by the licensor at factory for the operating personnel of the client.

18.3. Further training shall be provided on site for both PLC/ SCADA/ Operation during commissioning and startup

18.4. Each of the training shall be handled by experienced personnel of OEM/ Licensor in the relevant field.

18.5. Additional training shall be provided on request (Without any extra cost to client) if there are any special analysers/ instruments used in the plant and to handle special tools etc (Servo gauge calibration etc)

18.6. Training material (Both soft and Hard copy) shall be provided to each personnel attending the training.

18.7. Details of training shall be included in the technical bid. (Course duration, number of people, venue etc). Minimum the following types of training shall be provided:

Location	Purpose	Duration
At Factory/ OEM Training center	Operation	2 Days/ 2 Batch / 2 Person in each Batch
At Factory/ OEM Training center	Maintenance	2 Days / 2 Batch/ 2 Person
At site	Operation	5 person 2 day

Location	Purpose	Duration
At Site	Maintenance	5 person 2 day

18.8. The training personnel shall be experienced in their relevant field and shall be fluent in English language.

19.0. DATA SHEETS AND ENGINEERING SPECIFICATIONS

The following engineering specifications are attached as guidelines for design/ erection of respective items/ system:

19.1. Data sheet for Programmable logic controller (32686-14-DA-0002)

19.2. Field instrument erection specification (14ES008)

- Clause 3.0.0- Owner's obligations shall be limited to that mentioned in project Special conditions of contract and in this document.
- Clause 8.1.0- Not applicable
- Clause 22.1.0, 22.2.0, 24.0.0 to 24.2.2- Not applicable
- Part E- Not Applicable

19.3. DCS /PLC/SCADA/System Erection Specifications (14ES009)

19.4. General Specification for Field instrumentation (14ES010)

The following supersedes the requirements mentioned in the document 14ES010:

1. Cable glands shall be of SS304 (Section 11.2)
2. Cable trays shall be of FRP (Section 11.10)
3. Process Switches mentioned in the document shall be ignored
4. Servo Level transmitter shall be ignored (Section 8.3)

19.5. Instrumentation Panel (14ES013)- Shall be followed for Marshalling/ system panels inside control room.

- Clause No. 8.6 Regular Mechanical key to be provided for access control of all local panels.

19.6. Tank farm management system –Chapter 3 and 4 (14ES011)

20.0. ANNUAL MAINTENANCE CONTRACT

20.1. ANNUAL MAINTENANCE CONTRACT (AMC) - Non Comprehensive for Control System (PLC)

19.2.1 General

19.2.1.1 The control system (Central PLC only) supplied shall be covered under post warranty AMC for 5 years.

19.2.1.2 The AMC order shall be executed by OWNER and the Control system vendor (OEM) before expiry of defect liability period. For this, OWNER may enter into separate contract with OEM at the rates agreed by LSTK and OEM. The price, terms and conditions shall be as agreed by the LSTK contractor in his offer. Placement of AMC order on LSTK contractor is kept optional.

19.2.1.3 The AMC charges quoted shall be inclusive of all charges for Transportation, Lodging, Boarding, all Taxes/ Duties/ Cess/ Levies/ Fees and all other incidental charges excluding GST. The payment towards the AMC shall be quarterly and shall be based on OWNER's prevailing commercial terms and conditions at the time of placing the AMC order on OEM.

19.2.1.4 All the hardware and software supplied by control system vendor including third party devices shall be covered under AMC excluding furniture and consumables.

19.2.1.5 AMC rates shall be considered for price bid evaluation.

19.2.1.6 The AMC proposal shall include: (3 periodic visits and 1 shutdown visit per year is proposed, each visit shall be delivered on quarterly basis)

- Periodic maintenance (At least 2 man days quarterly)
- Shut down maintenance (Not limited to, but minimum 3 consecutive Man days /year)
- Breakdown maintenance (As per requirement)

19.2.1.7 The activities to be carried out during AMC period is detailed below. As per control system OEM maintenance practices, any change to following points can be considered only after taking prior permission from Owner.

19.2.2 **Scope of work for Periodic maintenance service**

19.2.2.1 The periodic maintenance shall be carried out three times each year. The periodic maintenance visit shall be for atleast two days on mutually agreed schedule. The activities to be carried out are detailed below:

19.2.2.2 **Checking of operating conditions-**OEM's engineer shall have an open discussion with OWNER's EIC to ascertain the existing operating conditions of the system. If required, the images of control stations shall be saved.

19.2.2.3 **Checking General Healthiness of system-** Test programs shall be run on operator/engineering stations to detect any functional problems. Battery voltage, output voltage at power supply unit etc shall be checked.

19.2.2.4 **Investigation of Problems/ Troubleshooting-** If any problems are identified during the test run or pointed out during the discussion with OWNER/EIC, OEM's Engineer shall investigate the problems and necessary modifications/changes shall be carried out to resolve the problem.

19.2.2.5 **Replacement of parts/Spares& identification and reporting of Spares in Stock-**If any item is to be replaced, same shall be carried out with spares available at site. Low stock levels of any item shall be reported to EIC.

19.2.2.6 **Report-** A detailed report on the jobs carried out and observations found shall be submitted to EIC at the end of each visit. Necessary back up of all data shall be taken in CD/DVD and the same shall be handed over to EIC.

19.2.2.7 Minor system configuration, changes in graphic pages, addition/ deletion of tags/ loops shall also be performed during the visit as per owner's requirement.

19.2.3 **Scope of work for Shutdown maintenance service**

19.2.3.1 Shut down maintenance shall be carried out once in every year during plant shut down to ensure smooth and trouble free operation. Date for such visit shall be intimated 7 days in advance. The activities to be carried out are detailed below:

19.2.3.2 **Dismantling of system**

The control system shall be completely taken out (Controller/ CPU, cards, Power supply modules, Communication cards etc) for overhauling and cleaning if required to ensure normal system operation.

19.2.3.3 **Checking of operating conditions-** Suggestion on operating conditions (Dust, temperature, Moisture etc)if any, shall be submitted to EIC.

19.2.3.4 **Inspection of power sources-** Voltage of all power sources for each device shall be measured and adjustments shall be made if necessary.

19.2.3.5 **Cleaning and inspection of hardware-** All Control system components (Controller/ CPU, cards, Power supply, communication cards, Operating station, Engineering station and all console hardware etc) shall be cleaned thoroughly. Printed circuit board and cables shall be checked for loose connections.

19.2.3.6 **Functional Test & Calibration Check-** Functionality of each component of control system shall be checked using diagnostic software wherever applicable. Accuracy shall be checked by giving inputs from standard instruments and adjustments/calibration shall be done wherever required. Redundancy check of various subsystems shall be performed during this visit.

19.2.3.7 **Resolving Problem-** The problems identified during the functional check and problems highlighted by EIC shall be rectified.

19.2.3.8 After the overhauling and cleaning activities the system components shall be re-assembled and all system functionality in terms of operation & performance shall be reinstated

19.2.3.9 **Reports & Suggestions-**After the shutdown maintenance works, a detailed report shall be submitted with details of works carried out and suggestions which comprise of the activities to be carried out on routine basis.
Necessary backup of all data shall be taken in CD/DVD and handed over to EIC.

19.2.4 **Scope of work for Break down maintenance service**

19.2.4.1 Break down visits shall be provided 'on demand' during the contract period.

19.2.4.2 Necessary advice over telephonic/mail communications shall be provided to overcome the emergency situations arose due to control system fault. If still the problem cannot be rectified by OWNER Group, the OEM's engineer shall report to site at the earliest but not later than12 hours from the time of first intimation to attend the problem.

19.2.4.3 Duration of each break down visit shall be controlled only by the time taken by OEM engineer to resolve the failure/issue.

19.2.4.4 Emergency situations are defined as the failure of any components related to control system which may lead to plant shut down or any problem related to control system causing inconsistency in operation.

19.2.4.5 The number of breakdown visits is not limited and shall be as per requirement arising in the plant.

21.0. GUARANTEE/ WARRANTY

All the instruments and control system supplied shall be offered with guarantee/ warrantee for minimum period of 12 months from the date of commissioning/ hand over or 18 months from the date of supply whichever is later. During this period, the vendor is responsible to replace / rectify the damage immediately without any time/ cost implication to owner. Should the LSTK contractor fail to rectify/ replace such damage within reasonable time, the same will be attended by the client with recovery of assessed amount from the LSTK contractor.

22.0. LIST OF SPECIAL TOOLS AND TACKLES REQUIRED

1. INDUSTRIAL GRADE MULTI METERS-2 No.

(5½digit, measure/display Current (AC/DC), Voltage (AC/DC), Resistance, Temperature, Diode, Capacitance etc. shall have backlit display, shall be

provided with traceable NIST / Other acceptable test and Calibration certificates. Over voltage, over current protection should be considered.)

The list is only indicative and all necessary special tools and tackles shall be offered for smooth operation and maintenance of the system. If any such item is not mentioned above, the same can be indicated in the technical proposal by the bidder.

2. LAPTOP

One laptop shall be provided with engineering software installed for all package PLCs with necessary Physical connector with cable /adaptor (USB/ other) with driver software with the following specifications:

Size-15”
HDD-1TB
RAM-4GB

Intel Processor with Latest Windows OS, Antivirus, MS Office package pre-installed

External Optical Mouse, DVD Drive, Carrying case etc shall be provided.

1.0. GENERAL

1.1. The PLC system shall function as overall control and monitoring of the unit during start-up, operation and shutdown conditions.

1.2. Electronic cards shall be conformance coated to level G3 as per ISA 71.4.

1.3. Any single point failure within the system shall cause a warning alarm without executive actions. Any such alarm should be available to SCADA through a pop up window along with an indication of remaining hours to repair the fault before automatic shutdown.

1.4. It shall be possible to replace, test or implement configuration changes to PLC without disrupting to their functionality or operational capability.

1.5. Applicable standards are the following:

IS 14254 Part 1	- Programmable controllers Part 1 General information
IS 14254 Part 2	-Programmable controllers Part 2 Equipment requirements and test
IEC-61000- parts 1 -6	- Electromagnetic compatibility (EMC): General - Guide to the assessment of measurement uncertainty

1.6. PLC system shall be designed for fail safe i.e de-energize to trip.

1.7. Trip resets shall be implemented in SCADA which shall communicate to PLC through soft. All other resets from field or package units shall be hardwired to PLC. Automatic trip resets shall be avoided.

1.8. The system shall comply with the European Union EMC directives specified above.

1.9. The system shall be installed in air conditioned non hazardous area in control room (25 deg C and 95% RH). The cabinet equipments shall work satisfactorily upto 50degC cabinet temperature in case of loss of control room air conditioning.

2.0. ENGINEERING PARAMETERS

- Availability 99.99% or better
- MTTR 8 hrs
- Mean time to spurious alarm/ trip >10 years

3.0. REDUNDANCY

Redundancy shall be provided at the following levels for the central control room PLC:

- Processor and Power supply to processor
- IO cards/ modules (Only for critical IOs) and Power supply to IO cards
- Communication bus and All Serial links
- All redundant modules shall be installed as hot standby.

4.0. POWER SUPPLY

4.1. Two separate 110VAC 50Hz distribution boards fed from parallel redundant UPS shall be available to power the PLC system. Redundant 110VAC UPS feeders shall be provided to engineering stations.

4.2. Each marshalling cabinet and system cabinet shall be provided with redundant 24VDC PSU each installed such that failure of one PSU shall initiate an alarm and shall not initiate a shutdown.

4.3. Transfer of main power source to redundant one shall be automatic and bumpless. Also manual switching facility shall be provided. All switching shall be alarmed and logged.

4.4. The operation of the PLC system shall be completely unaffected by momentary power failure for 20mS, which shall be demonstrated during FAT.

4.5. Power supply for two wire instruments shall be through the IO modules. If separate power is required for instruments, necessary provision (bulk power supply) shall be provided.

4.6. BPS shall be redundant floating and within +/-0.5V tolerance. Each BPS shall be sized to 150% load. The failure of one BPS shall not cause the other BPS to load more than 80% of its rated capacity.

4.7. PLC&SCADA system shall be capable of retaining memory contents after complete power failure for a minimum 30 days.

4.8. System shall be provided with proper earthling and the responsibility for the same shall be in vendor's scope.

5.0. MARSHALLING/ SYSTEM CABINETS

5.1. Refer the document *14ES013 Marshalling cabinet* for detailed specification.

5.2. System cabinets shall have transparent windows to view status of various signals without opening the cabinet.

6.0. SPARE CAPACITY

- IO modules -installed, wired and fully functional IO for all types as per document 32645-14-PS-002INST.
- IO rack -10% fully wired spare rack space
- Cable trunk -40% free space
- Power supply -system power supply units shall have 25% spare capacity over and above peak load (When all racks including spare is operational)
- Ethernet loading -15%
- Processor/ memory utilised <60% after commissioning
- Communication networks <60% after commissioning

7.0. CONFIGURATION

The basic PLC system shall consist of the following major sub-systems.

7.1. INPUT / OUTPUT SYSTEM

7.1.1. The maximum number of input /output per I/O module shall be limited to 16 for DI/DO and 16 for AI/AO.

7.1.2. Each input shall be provided with filters to avoid noise and contact bouncing. Filters shall be with a time delay for detecting transition of states.

7.1.3. Analog input modules shall be designed to accept 4-20mA. LED indicators are to be provided showing the status of field input/ output circuits in each channel.

7.1.4. Relays shall be provided with LED, which shall provide input status of each digital input/ output.

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7.1.5. The input cards shall incorporate open, short, out of range faults and give alarm.

7.1.6. Hot swapping shall be possible for the I/O modules

7.1.7. Auto testing for I/O modules shall be provided with alarm for faulty I/O points.

7.1.8. On-line (without de-energising) addition/ replacement of any module shall be possible.

7.1.9. IO ISOLATION -Each external signal must be optically/ galvanically isolated from the internal bus system, from the power supplies, and from other I/O signals. The I/O boards must be protected against transients and surges.

7.1.10. The minimum isolation level between I/O and logic circuit shall be 500 volts DC.

7.1.11. Where non-galvanically isolated modules have been used, a system of ground leakage detection shall be employed. It shall alarm in that particular cabinet by means of a lamp and to SCADA.

7.1.12. Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

7.1.13. End of line monitoring shall be provided for energise to trip systems/ IOs.

7.1.14. The PLC inputs shall be provided with only dry contacts (Potential free) unless otherwise specified. Two nos. terminal blocks are to be provided for each input and the supply for the input shall be routed through one of these terminal blocks.

7.1.15. Powering to the relays and other units shall be in bus form, looping through wires shall not be done and is not permitted. Input/output cables of the PLC shall be suitably terminated using plug in connectors.

7.1.16. All outputs of PLC shall be interfaced with interposing relays

7.1.17. Each I/O shall be short-circuit proof and protected by fuses. Fuse blown indication shall be available.

7.1.18. All the spare channels shall be wired up to terminal block.

7.1.19. IOs from same process area shall be in the same IO card for maximum availability and ease of maintenance. However, redundant/ voted IO shall reside on different IO card in different rack where possible. However, it must be ensured that no IO card is shared between existing facility as well as new facility.

7.2. PROCESSOR SYSTEM

7.2.1. The processor shall have capability to implement all the control functions required to implement the logic and analog control scheme.

7.2.2. Memory shall be non volatile EEPROM and shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements.

7.2.3. Redundant processors shall be provided as “Hot standby” modules. Failure of a single processor shall not affect the system. The changeover shall be bumpless and the system shall be fail proof. The switch over shall be alarmed.

7.2.4. In case of failure of complete processor system outputs shall take fail-safe state.

7.2.5. First out facility shall be provided for pre-defined group of alarms.

7.2.6. The system shall monitor its own hardware for faults and annunciate alarm in SCADA. Watch dog timers shall be used for PLC through software to monitor the healthiness of processors. Any hardware or software problem in the processor system, shall cause the watch dog timer to report processor failure.

7.3. SYSTEM SOFTWARE

7.3.1. The system software shall include all programs which are required to perform all PLC functions including communication and self-diagnostics. Diagnostic message up to card level shall be provided

7.3.2. The system software shall be the latest commercially released version at the time of FAT. All necessary licenses shall be provided enabling the right to exercise the use of relevant applicable software.

7.3.3. Supplied software licenses should not be time bound. Validity of license shall be unlimited. It includes licenses for operating system software, MS office, Anti-virus software, HMI software, engineering software etc for all systems supplied.

7.3.4. Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be furnished.

7.3.5. The report generated shall be in EXCEL format. It is mandatory to keep the data for 90 days before overwriting

7.3.6. Vendor shall offer free software upgrades for one year from the date of commissioning. Vendor shall supply the updates in CD, till the expiry of warranty period.

7.3.7. SCADA system shall allow Sequence of event recording facility with record, display, report, archive, filter, interrogation of events etc.

7.3.8. The software shall allow;

a. Logic testing and logic diagram generation using graphical language or cause and effect tables- PLC shall have simulation mode for logic, so that the logic can be tested without affecting the plant operation. On line modification of the program shall also be possible. The PLC programming language for implementation of logic/ control operations shall be any of following:
   1. Functional Logic diagrams
   2. Ladder Diagram
   3. Structured text
   4. Sequential Functional chart

b. Proportional, integral, derivative or any of its combinational control programming

c. Perform online diagnostics- The system shall be able to identify the failure of any module viz. I/O modules, communication Link and processors.

d. Provide standard library of logic functions

e. Real time application diagnostics online

f. Include passwords or similar access protection

g. IO forcing - For dual CPU any forcing operation performed in one CPU shall be automatically effective in the other. Similarly, while removing the forcing, a single operation to remove the forcing from one CPU shall affect other also.

7.4. COMMUNICATION LINKS

7.4.1. The PLC system shall communicate with SCADA through redundant network switches via redundant communication bus.

7.4.2. PLC shall have Serial as well as Ethernet communication provision.

7.4.3. Critical signals shall be connected through hardwiring only. Communication links shall maintain systems electrically separate either through galvanically/ optically.

7.4.4. Loss of data communication shall not cause trip, instead it shall be alarmed.

7.5. SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

7.5.1. SCADA shall provide all necessary interface for operator such as graphics, trends, alarm status etc.

7.5.2. All graphics shall be provided in SCADA for monitoring, controlling, alarm status, sequence of events, reset, cause and effect logic diagram, interlocks, start-up and shutdown logic, PLC system health status etc

7.6. OPERATOR STATION

7.6.1. VDU shall be 21" colour screen with high resolution graphics

7.6.2. The PCs shall be with the minimum specification

- Desktop PC with Windows based latest operating system software
- Pentium Dual core processor
- 4GB RAM
- 1TB Hard disk
- 21" LCD/LED VDU, Touch screen
- CD/DVD drive
- Keyboard
- Optical mouse etc

7.7. ENGINEERING STATION

7.7.1. The PC shall be of the same specification as of operator station. The engineering mode shall have separate password protection. This PC shall be used for programming, changing of set points, fault diagnosis, alarm monitoring etc. The PLC programming software shall be installed in Engineering station.

7.7.2. It shall be possible to modify add or delete the application program on line without affecting the outputs. Diagnostic capability including the diagnosis of hidden failures with display is required in engineering station which shall be able to locate the faulty IO card and define the cause.

7.7.3. The Engineering station shall be capable of producing logic diagrams, IO list, soft copy of data or program etc.

7.8. OPERATOR KEY BOARD

Operator keyboard shall be Spill proof membrane type.

7.9. PRINTERS

Requirement of printer is specified in Special requirements of Project.

7.10. HARDWIRED CONSOLE WITH ANNUNCIATOR

Hardwired console for housing the key switches, lamps and push button shall be supplied.

7.11. OVERRIDE SWITCHES

Manual overrides shall be implemented as required in soft/ hard form. Start-up overrides (both manual and automatic), operational overrides, maintenance override etc shall be implemented wherever required as found during detailed engineering phase. Automatic start-up overrides shall be reset by timer or when process variable become normal.

8.0. PLC I/O LIST

The vendor shall submit the detailed IO list for the installation for client/ PMC approval. In addition to field IOs Spares and others IOs (Cabinet status, UPS status, HWC IOs etc) etc shall be considered separately by the vendor.
The existing IO list shall be provided by client, which shall be combined into the vendors IO list document so as to have single IO list for the project.

9.0. FURNITURE

The requirement is specified in special requirements of the project.

10.0. SPARES

Spares shall be provided as specified in special requirements of the project.

11.0. TRAINING

Training shall be provided as specified in special requirements of the project.

12.0. INSPECTION/ FAT/ SAT

Inspection/ FAT/ SAT shall be specified in special requirements of the project.

13.0. ERECTION & COMMISSIONING

As specified in *14ES009 PLC Erection*

14.0. WARRANTY

Warranty shall be specified in special requirements of the project.

15.0. SITE SUPPORT DURING INSTALLATION AND COMMISSIONING

As specified in special requirements of the project.

16.0. SITE SUPPORT AFTER WARRANTY PERIOD (AMC)

Five year AMC shall be quoted by the vendor. This shall include:-

1. Quarterly visit at site by qualified engineer
2. Complete overhaul of the system during shutdown periods for major repair/ replacement.

Details of AMC services are elaborated in the special requirements of the project. (32686-14-PS-0002)

Sl. No.	Description	Quantity	Unit price	Total price
1.	**SPARES FOR FIELD INSTRUMENTS**			
a.	Pressure Gauges (Of each range and type)	10% or Min 1 No. whichever is higher		
b.	Pressure Gauges for special services (Of each range and type) **	10% or Min 1 No. whichever is higher		
c.	Pressure switches (Of each type, range etc) (If used)	Min 1 of each type		
d.	2 Way and 3 Way manifold valves	10% of Quantity used		
e.	Temperature gauges (Of each range and type)	10% or Min 1 No. whichever is higher		
f.	Temperature elements (RTD- Of each length)(For Tank multi point temperature sensor, if all the RTDs are enclosed in a common sheath (ie individually not replaceable, 1 no spare shall be offered)	10% or Min 1 No. whichever is higher		
g.	Flare thermocouple	3 No.		
h.	Thermo well (Each length, connection and Material)	10% or Min 1 No. whichever is higher		

Sl. No.	Description	Quantity	Unit	Total
i.	Pressure/ Differential pressure transmitter (Of each range)	10%		
j.	Temperature Transmitter	10%		
k.	Differential pressure type flow transmitter (Of each range)	10%		
2.	**CONTROL VALVE SPARES**			
a.	Air filter regulator (Of each type)	10% or Min 1 No. whichever is higher		
b.	Actuator Diaphragm (For each valve)	1 No.		
c.	Trim set (Plug, Cage, stem, Seat Ring)- For each valve	1 Set		
d.	Gland packing, Stem seal, Bonnet Gasket, 'O' Rings etc for each valve	1 Set		
3.	**ON-OFF VALVE SPARES**			
a.	Air filter regulator	10% or Min 1 No. whichever is higher		
b.	Limit switch (On and Off)	10% or Min 1 No. whichever is higher		
c.	Barriers for limit switch (If applicable)	10%		
d.	Piston O ring, Packing etc (For each actuator)	1 Set		
4.	Span gas 150Ltr at atmospheric pressure (Ammonia)	1 No.		
5.	Span gas 10 Liter at atmospheric Condition	1 No.		

Sl. No.	Description	Quantity	Unit	Total
	(Chlorine)			
6.	Calibration gas 10 Liter at atmospheric condition (Hydrocarbon)	1 no.		
7.	**ANALYSER SPARES**			
a.	PH Analyser Electrodes (Of each type)	10%		
8.	**RPM SENSOR**	10% or Min 2 No. whichever is higher		
9.	**CONTROL ROOM SPARES (APPLICABLE FOR PLC)**			
a.	PLC IO Modules (of each type- AI, AO, DI, DO)	10%		
b.	PLC Processor module	1 No.		
c.	PLC Communication modules	Min 1 No.		
d.	PLC Power supply modules	Min 1 No.		
e.	Terminals	10% of each type and colour		
f.	Fuses	10% of each type and rating		
g.	Barriers/ isolators	10%		
h.	Relay/ relay board of each type and rating	10%		
i.	Bulk Power supply	Min 1 No.		
j.	Diode O Ring Module	Min 1 No.		
k.	MCBs of each type and rating	Min 10%		
l.	System cables	Min 1 No. of each type		
m.	Ethernet switches (If applicable)	Min 1 No.		

Sl. No.	Description	Quantity	Unit	Total
n.	Hard disk for ES/OS,	1 No.		
o.	Display (LCD/ LED)			
p.	Regular keyboard, mouse, Engineering keyboard etc	Min 2 Set		
q.	Printer spare cartridges	Min 2 No.		

**Special services: Ammonia, Chlorine and steam.

NOTES:

1.0 The above indicated spares are loose items to be handed over to client at the end of project.

2.0 Note that the list of spares is indicative and same philosophy shall be followed for every package in the plant. The spare supplied for one package shall not count as spare of the same instrument in any other package.

3.0 Next rounded figure to be considered wherever % is specified (Example: For total 11 nos. instruments with 10% spares basis, 2 Nos. spares shall be provided)

4.0 Wherever complete instrument/set is considered as spare, spare quantity shall never exceed ordered/ purchased quantity (for example, if ordered quantity is 1 and mandatory spare philosophy is 20% or min 2, in such cases mandatory spares quantity shall be 1 and not 2)

5.0 Above-mentioned mandatory spares list defines the minimum requirement. Additional items as recommended by manufacturer if any, shall also be considered

Sl. No.	Description	Quantity	Unit price	Total price
1.	**AMMONIA TANK SERVO LEVEL TRANSMITTER**			
a.	Complete assembly of Servo Level transmitter including displacer/ float and tape (Except calibration chamber)	1 No.		
2.	**CONTROL VALVE SPARES**			
a.	Solenoid Valve (of each type)	10% or Min 1 No. whichever is higher		
3.	**ON-OFF VALVE SPARES**			
a.	Solenoid valve (of each type)	10% or Min 1 No. whichever is higher		
4.	**AMMONIA GAS DETECTORS**	**2 No.**		
5.	**CHLORINE GAS DETECTOR**	**1 No.**		
6.	**HYDROCARBON DETECTOR**	**1 No.**		
7.	**LOCAL PANEL SPARES***			
a.	Pushbuttons (Of each type and colour)	10% or Min 2 No. whichever is higher		
b.	Lamps/ indicators (of each type and colour)	10% or Min 2 No. whichever is higher		
c.	Selector switches	10% or Min		

Sl. No.	Description	Quantity	Unit	Total
		2 No. whichever is higher		
d.	Relays (Of each type and rating)	10% or Min 2 No. whichever is higher		
e.	Fuses (each type and rating)	10% or Min 2 No. whichever is higher		
f.	Timers (If used)	10% or Min 2 No. whichever is higher		
g.	Annunciator cards	10%		
h.	*If Local panel include any PLC, applicable items in PLC spares mentioned in this spare list is applicable for local PLC also.			
8.	**FLOW TRANSMITTER (CORIOLIS)**			
a.	Transmitter head	1 no of each type		
9.	**ANALYSER SPARES**			
a.	Conductivity Analyser (Of each range- One complete assembly)	1 No.		
b.	PH analyzer Transmitter	1 No.		
c.	Any other analyser spares	LS		
10.	**VIBRATION MONITORING SYSTEM SPARES**			

Sl. No.	Description	Quantity	Unit	Total
a.	Vibration probes and cable	Min 1 No of each type		
b.	Any other spare as per recommendation of OEM	To be quoted in 2 years operational spares		
11.	**BEARING RTDS**	10% or Min 2 No. whichever is higher		
12.	**SYSTEM / MARSHALLING CABINET SPARES**			
a.	Door switch	Min 1 No.		
b.	Fans	Min 1 No.		
c.	Dust filters	Min 10%		
d.	Fan Failure Units	Min 1No.		
e.	Thermostat Units- Complete assembly	Min 1 No.		
13.	**HARD WIRED CONSOLE SPARES**			
a.	Pushbuttons and selector switches of each type, size and colour	10%		
b.	Lamps and indicators each type, size and colour	10%		
14.	**CABLE SHROUD OF EACH TYPE**	10%		

The make of Instrumentation items shall be as per the following list.

1.	**GAS ANALYSERS (IR, THERMAL CONDUCTIVITY, PARAMAGNETIC)**	
a.	ABB LTD (BU – ANALYTICAL &ADV)	INDIA
b.	CHEMTROLS INDUSTRIES LIMITED (MAIHAK MAKE)	INDIA
c.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD	INDIA
d.	ENDRESS+ HAUSER (INDIA) PVT. LTD.	INDIA
e.	MAIHAKAKTIENGESELLSCHRAFT	GERMANY
f.	SIEMENS AG	GERMANY
g.	EMERSON PROCESS MANAGEMENT SINGAPORE LTD	SINGAPORE
h.	AMETEKINC	U.S.A
i.	M.S.A INTERNATIONAL	U.S.A
2.	**PH, CONDUCTIVITY & ORP ANALYSER**	
a.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD	INDIA
b.	ENDRESS+ HAUSER (INDIA) PVT. LTD. (LIQUID ANALYSER)	INDIA
c.	ABB INDIA LIMITED	INDIA
d.	FORBES POLYMETRON PVT. LTD.	INDIA
e.	ZELLWEGER SA	FRANCE
f.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
g.	EMERSON PROCESS MANAGEMENT SINGAPORE LTD	SINGAPORE
h.	FOXBARO FAR EAST PTE LTD	SINGAPORE
i.	ABB PROCESS ANALYTICS	U.K
j.	HACH COMPANY	U.S.A
3.	**TRACE ANALYSER/ ION SELECTIVE**	
a.	FORBES POLYMETRONPVT. LTD	INDIA
b.	ABB INDIA LIMITED	INDIA
c.	ZELLWEGER SA	FRANCE
d.	BRAN &LUEBBE LTD	U.K

					PROJECT	New 10000 MT Double wall double integrity Ammonia storage tank and Associated facilities for FACT-CD, Ambalamedu on LSTK Basis.
3						
2					CLIENT	M/s FACT-CD
1					P.O. NO	
0	16/04/21	DCK	MKZ	MS	VENDOR	
REV	DATE	PRPD	CHKD	APRD		

FACT ENGINEERING AND ORGANISATION

FEDO

14FT703/15

e.	HACH COMPANY	U.S.A
4.	**SO_X/ NO_X ANALYSER**	
a.	ABB INDIA LTD.	INDIA
b.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD	INDIA
c.	SICK AG	GERMANY
d.	SIEMENS AG	GERMANY
e.	HORIBA LTD.	JAPAN
f.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
g.	EMERSON PROCESS MANAGEMENT SINGAPORE LTD	SINGAPORE
h.	LEAR SIEGLER MEAS. CONTROLS CORP.	U.S.A
i.	M.S.A INTERNATIONAL	U.S.A
j.	THERMO ENVIRONMENT INSTRUMENTS INC	U.S.A
5.	**MASS SPECTROMETER**	
a.	VG GAS ANALYSIS SYSTEMS	U.K
b.	ORBITAL SCIENCE CORPORATION	U.S.A
c.	ABB INDIA LIMITED	INDIA
6.	**GAS CHROMATOGRAPH**	
a.	APPLIED AUTOMATION INC	SINGAPORE
b.	FOXBARO FAR EAST PTE LTD	SINGAPORE
c.	ABB INDIA LIMITED	INDIA
d.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
e.	ABB PROCESS ANALYTICS	U.K
7.	**FLUE GAS ANALYSER (ZRO_2 TYPE)**	
a.	ABB LTD (BU – ANALYTICAL &ADV)	INDIA
b.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD	INDIA
c.	AMETEK INC	U.S.A
d.	GE PANAMETRICS	IRELAND
8.	**H_2S/ TOTAL SULPHUR ANALYSERS**	
a.	BARTON INSTRUMENT SYSTEMS LIMITED	U.K
b.	ABB INDIA LTD.	INDIA
9.	**DENSITY ANALYSERS**	
a.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD (CORIOLIS TYPE)	INDIA
b.	BOPP & REUTHER MESSTECHNIKGMBH (CORIOLIS TYPE)	GERMANY

c.	SOLARTRON MOBREY	U.K
10.	**MOISTURE ANALYSERS**	
a.	GE PANAMETRICS	ITALY
b.	AMETEKINC	U.S.A
11.	**GAS & FIRE DETECTION SYSTEM**	
a.	ANDREW YULE & COMPANY LTD. (FIRE)	INDIA
b.	HONEYWELL AUTOMATION INDIA LIMITED (GAS)	INDIA
c.	J B BODA AND BROTHERS PVT. LTD. (GAS MAKE-INTERNATIONAL SENSOR TECHNOLOGY)	INDIA
d.	POLLUTION PROTECTION SYSTEM MUMBAI PVT LTD (GAS)	INDIA
e.	TELEDYNE FLUID SYSTEMS (GAS)	THAILAND
f.	GENERAL MONITORS (GAS)	U.K
12.	**FLOW ELEMENT: ORIFICE/ VENTURI/ FLOW NOZZLE**	
a.	BALIGA LIGHTING EQUIPMENTS LIMITED (ONLY ORIFICE)	INDIA
b.	GENERAL INSTRUMENTS CONSORTIUM (ONLY ORIFICE)	INDIA
c.	INSTRUMENTATION LTD, PALAKKAD	INDIA
d.	MICRO PRECISION PRODUCTS PRIVATE LTD.	INDIA
e.	EURECA INDUSTRIAL EQIPMENTS PVT LTD.	INDIA
f.	UNICONTROLS INSTRUMENTS PVT. LTD.	INDIA
g.	BOPP & REUTHER MESSTECHNIKGMBH	GERMANY
h.	TECHNOMATIC SPA	ITALY
i.	ISA CONTROLS LIMITED	U.K
j.	DANIEL MEASUREMENT & CONTROL	U.S.A
k.	FLOWTECH INSTRUMENTS SERVICES (ORIFICE/VENTURI)	INDIA
l.	CHEMTROL INDUSTRIES LTD	INDIA
13.	**PITOT TUBE/ ANNUBAR**	
a.	CONTROL ENGINEERS	INDIA
b.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
c.	MICRO PRECISION PRODUCTS PRIVATE LTD.	INDIA
d.	ABB INDIA LIMITED	INDIA
e.	UNICONTROLS INSTRUMENTS PVT. LTD.	INDIA
f.	TECHNOMATIC SPA	ITALY
g.	ISA CONTROLS LIMITED	U.K
h.	DANIEL MEASUREMENT & CONTROL	U.S.A

14.	**ROTAMETERS**	
a.	INSTRUMENTATION ENGINEERS PVT. LTD.	INDIA
b.	KROHNE MARSHALL PVT. LTD.	INDIA
c.	PLACKA INSTRUMENTS & CONTROLS PVT. LTD. (PURGE ROTAMETER ONLY)	INDIA
d.	ROTA INSTRUMENTATION	INDIA
e.	EURECA INDUSTRIAL EQIPMENTS PVT LTD.	INDIA
f.	ABB INDIA LTD.	INDIA
g.	KROHNE	GERMANY
h.	ROTA YOKOGAWA GMBH& CO. KG	GERMANY
i.	TOKYO KEISO CO. LTD.	JAPAN
j.	YAMATAKE CORPORATION	JAPAN
k.	EMERSON PROCESS MGT	U.S.A
l.	FLOWTECH INSTRUMENTS SERVICES	INDIA
m.	CHEMTROL INDUSTRIES LTD	INDIA
15.	**MASS FLOW METER (CORIOLIS TYPE)**	
a.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
b.	SIEMENS LTD.	INDIA
c.	ABB INDIA LIMITED	INDIA
d.	BOPP & REUTHER MESSTECHNIKGMBH	GERMANY
e.	ENDRESS + HAUSER GMBH& CO.	GERMANY
f.	KROHNE	GERMANY
g.	SCHLUMBERGER RESOURCE MANAGEMENT LTD.	U.S.A
h.	CHEMTROL INDUSTRIES LTD	INDIA
16.	**TURBINE FLOWMETER**	
a.	FMCSANMAR LTD.	INDIA
b.	ABB INDIA LTD.	INDIA
c.	BOPP & REUTHER MESSTECHNIKGMBH	GERMANY
d.	INSTROMET INTERNATIONAL N.V	HOLLAND
e.	ITOCHU CORPORATION (REP.KUBOTACORPN.)	JAPAN
f.	YAMATAKE CORPORATION	JAPAN
g.	OVAL ASEA PACIFIC PTE LTD	SINGAPORE
h.	BARTON INSTRUMENT SYSTEMS LIMITED	U.K
i.	EMERSON PROCESS MGT	U.K
j.	EMERSON PROCESS MGT	U.S.A

k.	ROCKWELL INTERNATIONAL CORPN.	U.S.A
l.	CHEMTROL INDUSTRIES LTD	INDIA
17.	**VORTEX METER**	
a.	KROHNE MARSHALL PVT. LTD.	INDIA
b.	YOKOGAWA LIMITED	INDIA
c.	SIEMENS LTD.	INDIA
d.	ABB INDIA LTD.	INDIA
e.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
f.	BOPP & REUTHER MESSTECHNIKGMBH	GERMANY
g.	ENDRESS + HAUSER GMBH& CO.,	GERMANY
h.	KROHNE	GERMANY
i.	ITOCHU CORPORATION (REP.KUBOTACORPN.)	JAPAN
j.	SCHLUMBERGER RESOURCE MANAGEMENT LTD.	U.S.A
18.	**PD METER**	
a.	ROCKWIN FLOW METERS (I) PVT. LTD.	INDIA
b.	BOPP & REUTHER MESSTECHNIKGMBH	GERMANY
c.	OVAL ASEA PACIFIC PTE LTD	SINGAPORE
d.	EMERSON PROCESS MGT	U.S.A
e.	SCHLUMBERGER RESOURCE MANAGEMENT LTD.	U.S.A
f.	CHEMTROL INDUSTRIES LTD	INDIA
19.	**MAGNETIC FLOW METER**	
a.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
b.	ABB INDIA LTD.	INDIA
c.	ENDRESS + HAUSER (INDIA) PVT. LTD.	INDIA
d.	KROHNE MARSHALL PVT. LTD.	INDIA
e.	SIEMENS LTD.	INDIA
f.	BOPP & REUTHER MESSTECHNIKGMBH	GERMANY
g.	KROHNE	GERMANY
h.	YAMATAKE CORPORATION	JAPAN
i.	CHEMTROL INDUSTRIES LTD	INDIA
20.	**INSERTION TYPE FLOW METER**	
a.	SIEMENS LTD.	INDIA

21.	**ULTRASONIC FLOW METER**	
a.	ENDRESS + HAUSER (INDIA) PVT. LTD.	INDIA
b.	SIEMENS LTD.	INDIA
c.	CHEMTROL INDUSTRIES LTD	INDIA
22.	**PRESSURE GAUGES**	
a.	A N INSTRUMENTS PVT. LTD.	INDIA
b.	GENERAL INSTRUMENTS CONSORTIUM,	INDIA
c.	H.GURU INDUSTRIES	INDIA
d.	MANOMETER (INDIA) PVT. LTD	INDIA
e.	PEEJEEENGG. WORKS	INDIA
f.	PRECISION INDUSTRIES LTD. (STANDARD NORMAL TYPE)	INDIA
g.	PREMIUM INST. & CONTROLS LTD.	INDIA
h.	WALCHANDNAGAR INDUSTRIES LTD.	INDIA
i.	ASHCROFT INDIA(P) LTD. (STANDARD NORMAL TYPE)	INDIA
j.	DRESSER EUROPE S.A	GERMANY
k.	WIKAALEXENDERWIEGARDGMBH& CO.	GERMANY
l.	SPRIANO SPA	ITALY
m.	NAGANO KEIKI SEISAKUSHO	JAPAN
n.	RUEGER SA	SWITZERLAND
o.	BUDENBERG GAUGE CO. LTD	U.K
23.	**VOL. SEAL PR. GAUGES**	
a.	A N INSTRUMENTS PVT. LTD. (=<600# EXCEPT UREA SERVICE)	INDIA
b.	DRESSER EUROPE S.A.	GERMANY
c.	WIKAALEXENDERWIEGANDGMBH& CO.	GERMANY
d.	SPRIANO SPA	ITALY
e.	NAGANO KEIKI SEISAKUSHO	JAPAN
f.	RUEGER SA	SWITZERLAND
g.	BUDENBERG GAUGE CO. LTD.	U.K
24.	**LOCAL D/P INDICATORS**	
a.	SWITZER INSTRUMENT CO.	INDIA
b.	BARTON INSTRUMENT SYSTEMS LIMITED	U.K
c.	DELTA CONTROLS LTD.	U.K
25.	**PRESSURE & D/P TRANSMITTERS**	
a.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA

b.	HONEYWELL AUTOMATION INDIA LIMITED	INDIA
c.	YOKOGAWA LIMITED	INDIA
d.	SIEMENS LTD.	INDIA
e.	ENDRESS + HAUSER (INDIA) PVT.LTD.	INDIA
f.	SIEMENS AG, GERMANY	GERMANY
g.	YAMATAKE CORPORATION	JAPAN
h.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
i.	EMERSON PROCESS MGT SINGAPORE LTD	SINGAPORE
j.	SMARSINGAPOREPTE. LTD.	SINGAPORE
k.	HONEYWELL INC.	U.S.A
l.	MOORE PRODUCTS COMPANY	U.S.A
26.	**VOL. SEAL PR./DP TRANSMITTER**	
a.	HONEYWELL AUTOMATION INDIA LIMITED	INDIA
b.	YOKOGAWA LIMITED	INDIA
c.	SIEMENS LTD.	INDIA
d.	ABB INDIA LIMITED	INDIA
e.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
f.	ENDRESS+ HAUSER (INDIA) PVT. LTD.	INDIA
g.	FUJI ELECTRIC SYSTEMS CO., LTD. (EXCEPT UREA SERVICE)	JAPAN
h.	YAMATAKE CORPORATION	JAPAN
i.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
j.	EMERSON PROCESS MGT SINGAPORE LTD	SINGAPORE
k.	MOORE PRODUCTS COMPANY	U.S.A
27.	**PRESSURE & D/P SWITCHES INCLUDING VOL. SEAL**	
a.	INDFOS INDUSTRIES LTD. (EXCEPT VOL.SEAL)	INDIA
b.	SWITZER INSTRUMENT CO., (EXCEPT VOL.SEAL)	INDIA
c.	KAUSTUBHA UDYOG (PRESSURE SWITCH & D/P SWITCHES EXCEPT VOLUMETRIC SEAL)	INDIA
d.	ENDRESS + HAUSER(INDIA) PVT. LTD.	INDIA
e.	NAGANO KEIKI SEISAKUSHO	JAPAN
f.	YAMATAKE CORPORATION	JAPAN
g.	DELTA CONTROLS LTD.	U.K
h.	SOR INC.	U.S.A
i.	UNITED ELECTRIC CONTROLS CO.	U.S.A
28.	**TRANSPARENT/ REFLEX / BICOLOR MAG.LEVEL GAUGES**	

a.	CHEMTROLS SAMIL(INDIA) PVT LTD.	INDIA
b.	PUNE TECHTROLPVT.LTD. (<=300# RATING ONLY)	INDIA
c.	TECNOMATIC (INDIA) PVT. LTD.	INDIA
d.	V-AUTOMAT & INST. (P) LTD., (UPTO 300#)	INDIA
e.	NISAN SCIENTIFIC PROCESS EQUIPMENTS PVT. LTD.	INDIA
f.	ABB INDIA LTD.	INDIA
g.	BLISS ANAND PRIVATE LTD.	INDIA
h.	RICHARD KLINGER AG	AUSTRIA
i.	CESAREBONETTI	ITALY
j.	TECHNOMATIC SPA	ITALY
k.	NIHON KLINGAGE CO. LTD.	JAPAN
l.	CLARK-RELIANCE CORP.	U.S.A
m.	JERGUSON GAUGE & VALVE CO.	U.S.A
n.	TYCO INTERNATIONAL INC.	U.S.A
o.	FLOWTECH INSTRUMENTS SERVICES	INDIA
29.	**LEVEL SWITCHES (FLOAT & DISPLACER TYPE)**	
a.	CHEMTROLS ENGINEERING LIMITED	INDIA
b.	V-AUTOMAT & INST. (P) LTD., (UPTO 300# , NON-CRITICAL SERVICE)	INDIA
c.	ABB INDIA LTD.	INDIA
d.	BLISS ANAND PRIVATE LTD.	INDIA
e.	SIEMENS LTD. (ULTRASONIC, VIBRATING, CAPACITANCE,PADDLE)	INDIA
f.	MAGNETROL INTERNATIONAL N.V.	BELGIUM
g.	ISA CONTROLS LIMITED	U.K
h.	KDGMOBREY LTD.	U.K
i.	SOR INC.	U.S.A
30.	**CAPACITANCE LEVEL SWITCH**	
a.	VEGA GRIESHABER KG	GERMANY
31.	**RADARLEVEL SWITCH**	
a.	VEGA GRIESHABER KG	GERMANY
32.	**DISPLACER TYPE LEVEL TRANSMITTERS**	
a.	CHEMTROLS INDUSTRIES LIMITED (ECKDART MAKE ELECTRONICS)	INDIA
b.	DRESSER VALVE INDIA PVT LTD (RATING <= 600#)	INDIA
c.	MAGNETROL INTERNATIONAL N.V. (LVDT)	BELGIUM

d.	DRESSER MASONEILAN	FRANCE
e.	FOXBORO ECKARDTGMBH	GERMANY
f.	PARCOL SPA (PNEUMATIC TRANSMISSION ONLY)	ITALY
33.	**NUCLEONIC LEVEL TRANSMITTER**	
a.	BERTHOLD TECHNOLOGIES GMBH&CO.KG	GERMANY
b.	ENDRESS + HAUSER GMBH& CO.	GERMANY
c.	KAY RAY	U.S.A
d.	VEGA GRIESHABER KG	GERMANY
34.	**CAPACITANCE TYPE LEVEL TRANSMITTER**	
a.	MAGNETROL INTERNATIONAL N.V	BELGIUM
b.	ENDRESS + HAUSER (INDIA) PVT. LTD.	INDIA
c.	SIEMENS LTD.	INDIA
d.	ENDRESS + HAUSER GMBH& CO.	GERMANY
e.	KROHNE	GERMANY
f.	KDGMOBREY LTD	U.K
g.	VEGA GRIESHABER KG	GERMANY
35.	**TANK LEVEL INSTRUMENTS**	
a.	ENDRESS + HAUSER GMBH& CO., (NON-CONTACT & SERVO)	GERMANY
b.	KROHNE (NON-CONTACT TYPE)	GERMANY
c.	ABB INDIA LIMITED	INDIA
d.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
e.	SIEMENS LTD. (RADAR LEVEL TRANSMITTER, GUIDED WAVE RADAR)	INDIA
f.	TOKYO KEISO CO. LTD.	JAPAN
g.	ENRAFSINGAPOREPTE. LTD.	SINGAPORE
h.	L & J TECHNOLOGIES	U.S.A
36.	**SPECIAL LEVEL SWITCHES (VIBRATION FORK/RF ADMITTANCE)**	
a.	ENDRESS + HAUSER GMBH& CO.	GERMANY
b.	ABB INDIA LIMITED	INDIA
c.	PROTOCONTROL INSTRUMENTS (I) PVT. LTD. (FOR NON CRITICAL APPLICATIONS)	INDIA
d.	SOR INC.	U.S.A
e.	VEGA GRIESHABER KG	GERMANY
37.	**ULTRASONIC LEVEL TRANSMITTER**	

a.	SIEMENS LTD.	INDIA
b.	VEGA GRIESHABER KG	GERMANY
38.	**GUIDED WAVE RDAR**	
a.	ENDRESS + HAUSER (INDIA) PVT. LTD	INDIA
39.	**TEMPERATURE ELEMENTS (THERMOCOUPLE, RTD)**	
a.	ALTOP INDUSTRIES LTD. (ONLY NORMAL TYPE (MI))	INDIA
b.	ABB INDIA LIMITED	INDIA
c.	DETRIV INSTRUMENTATION & ELECTRONICS LTD (ONLY NORMAL TYPE)	INDIA
d.	PYRO ELECTRIC INSTRUMENTS GOA PVT. LTD. (A. THERMOCOUPLE ASSEMBLIES WITH/WITHOUT THERMOWELSS; B.RTD ASSEMBLIES WITH/WITHOUT THERMOWELLS)	INDIA
e.	TEMPSENS INSTRUMENTS (I) PVT. LTD.	INDIA
f.	UNICONTROLS INSTRUMENTS PVT. LTD.	INDIA
g.	ELECTRICAL & ELECTRONICS LTD. (ONLY NORMAL TYPE)	INDIA
h.	ELIEND ENGINEERING PVT. LTD. (ONLY NORMAL TYPE)	INDIA
i.	GENERAL INSTRUMENTS CONSORTIUM	INDIA
j.	INDUSTRIAL INSTRUMENTATION, (ONLY NORMAL TYPE)	INDIA
k.	ENDRESS + HAUSER (INDIA) PVT. LTD.	INDIA
l.	SENSYCON (M/S DEGUSSA AG)	GERMANY
m.	W.C. HERAEUSGMBH	GERMANY
n.	THERMO ELECTRIC CO. LTD.	HOLLAND
o.	OKAZAKI MANUFACTURING CO.	JAPAN
p.	YAMATAKE CORPORATION	JAPAN
q.	GOA INSTRUMENTS INDUSTRIES LTD	INDIA
40.	**BIMETALLIC THERMOMETER**	
a.	A N INSTRUMENTS PVT. LTD.	INDIA
b.	GENERAL INSTRUMENTS CONSORTIUM	INDIA
c.	H.GURU INDUSTRIES	INDIA
d.	KROHNE MARSHALL PVT. LTD.	INDIA
e.	WAAREE INSTRUMENTS LTD	INDIA
f.	ASHCROFT INDIA(P) LTD.	INDIA
g.	TECHNOMATIC SPA	ITALY
h.	NAGANO KEIKI SEISAKUSHO	JAPAN
i.	RUEGER SA	SWITZERLAND

j.	TREND INSTRUMENT INC.	U.S.A
k.	GOA INSTRUMENTS INDUSTRIES LTD	INDIA
41.	**RADIATION PYROMETER**	
a.	SIEMENS AG, GERMANY	GERMANY
b.	TEMPSENS INSTRUMENTS (I) PVT. LTD.	INDIA
c.	C.C.R. TECHNICO	ITALY
d.	CHINO CORPN.	JAPAN
e.	LAND INFRARED	U.K
f.	WAHL INSTRUMENTS	U.S.A
42.	**TEMPERATURE TRANSMITTERS**	
a.	ABB INDIA LIMITED	INDIA
b.	ENDRESS+ HAUSER (INDIA) PVT. LTD.	INDIA
c.	SIEMENS LTD.	INDIA
d.	SIEMENS AG, GERMANY	GERMANY
e.	M-SYSTEM	JAPAN
43.	**TEMPERATURE SWITCHES**	
a.	GOA INSTRUMENTS INDUSTRIES LTD	INDIA
44.	**GATE/PLUG VALVES**	
a.	AUDCO INDIA LIMITED(L&T VALVES DIVN.)	INDIA
b.	BHEL(VALVES DIVISION)	INDIA
c.	CHEMTROLS ENGINEERING LIMITED (PLUG VALVES)	INDIA
d.	KSB PUMPS LIMITED (VALVES DIVN)	INDIA
e.	FLOWSERVE INDIA CONTROL PVT. LTD.(PLUG VALVE UPTO 12”300# UPTO 6” 600#)	INDIA
f.	VELAN INC.	CANADA
g.	MALBRANQUES.A.	FRANCE
h.	CESAREBONETTI	ITALY
i.	FASANI S.P.A.	ITALY
j.	PETROL VALVES S.R.L	ITALY
k.	MATSURA H. P MACHINE WORKS CO.LTD.	JAPAN
l.	BEL VALVES	U.K
45.	**GLOBE / ANGLE VALVES**	
a.	DRESSER VALVE INDIA PVT LTD (RATING <= 600# , SIZE 3/4 TO 6”)	INDIA
b.	EMERSON PROCESS MANAGEMENT INDIA LTD	INDIA
c.	INSTRUMENTATION LTD. (PALAKKAD)	INDIA

	(=<2500#,EXCEPT SLURRY,NOISE,CAVITATATION)	
d.	MIL CONTROLS LIMITED (=<600#,EXCEPT SLURRY,NOISE,CAVITATION)	INDIA
e.	R K CONTROLS INSTRUMENTS PVT LTD(=<600#,EXCEPT SLURRY,NOISE,CAVITATION)	INDIA
f.	SAMSON CONTROL PVT LTD(UPTO 6'' &=<600#)	INDIA
g.	CIRCOR FLOW TECHNOLOGIES INDIA PVT. LTD. (GLOBE 2" TO 16" 300# ANGLE 12" 2500#)	INDIA
h.	FLOWSERVE INDIA CONTROL PVT. LTD. (GLOBE VALVE UPTO 30" 600# UPTO 24" 900#, UPTO 16" 2500# UPTO 4" 4500#)	INDIA
i.	KOSO FLUIDS CONTROLS PVT. LTD. (GLOBE VALVES: UPTO 8" 2500# 10 TO 18" 300# ANGLE VALVES UPTO 8" 300#)	INDIA
j.	SEVERN GLOCON (I) PVT. LTD. (1 TO 8 " RATING 2500# (EXCEPT SLURRY ,NOISE , CAVITATION); 1 TO 12 " RATING 600# (EXCEPT SLURRY ,NOISE CAVITATION)	INDIA
k.	TECNIK VALVES PVT. LTD. (GLOBE VALVE (UPTO 4"-150# ,AIR & WATE SERVICE))	INDIA
l.	DRESSER MASONEILAN (=<2500#,UREA SERVICE ALSO)	FRANCE
m.	ARCA-REGLERGMBH (=< 2500#)	GERMANY
n.	PARCOL SPA (=<2500#,UREA SERVICE ALSO)	ITALY
o.	NIPPON FISHER CO. LTD. (=<2500#)	JAPAN
p.	YAMATAKE CORPORATION (=<2500#)	JAPAN
q.	FISHER XOMOX (=< 2500#)	SINGAPORE
r.	FLOWSERVE (=<2500#)	U.S.A
s.	EMET CONTROL PVT LTD (GLOBE UPTO 4" 300#, ANGLE UPTO 11/2" 2500#)	INDIA
t.	CHEMTROL INDUSTRIES LTD. (FOR WATER & STEAM)	INDIA
46.	**BALL VALVES**	
a.	TYCO VALVES & CONTROLS (I) LTD (=< 150 #)	INDIA
b.	VIRGO ENGINEERS LTD. (=<600# WITH MACCAIR ACTUATORS)	INDIA
c.	ANAND TEKNOW AIDS ENGINEERING INDIA LIMITED (UPTO 6", 600# (ON-OFF))	INDIA
d.	FLOWSERVE INDIA CONTROLS PVT. LTD. (UPTO 16" 600#)	INDIA
e.	KOSO FLUID CONTROLS PVT. LTD. (UPTO 8 " ,2500# ,10" TO 18" 900#)	INDIA
f.	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED (SHUTDOWN VALVES PDIL APPROVED MAKE , UPTO 6" 600#, 6" TO 10" 150#)	INDIA
g.	VELAN INC. (BALL VALVES ON/OFF SIZE: ¼" TO 6" (RATING UPTO 2500#) SIZE 8"TO 16" (RATING UPTO 900#) SIZE 18" TO 30 " (RATING UPTO 300#)	CANADA

h.	PERRIN GMBH (SIZE ½" TO 12 " & RATING 150# TO 2500# , SIZE 14" TO 18" & RATING 150# TO 1500# SIZE 20" TO 24 " , RATING 150 # & 300#)	GERMANY
i.	METSO AUTOMATION (=<2500#)	ITALY
j.	PETROL VALVES S.R.L	ITALY
k.	PIBIVIESSE S.P.A. (RATING UPTO 2500 #)	ITALY
l.	GTC ITALIA	ITALY
m.	METSO AUTOMATION (=<2500#)	SINGAPORE
n.	ORBIT VALVES (=<2500#)	SINGAPORE
o.	M/S BRAY CONTROL PVT LTD (UPTO 4" 300#)	INDIA
p.	EMET CONTROL PVT LTD (UPTO 8" 150#, FOR AIR SERVICE)	INDIA
47.	**BUTTERFLY VALVES**	
a.	INSTRUMENTATION LTD. (PALAKKAD) (=< 300#)	INDIA
b.	TYCO VALVES & CONTROLS (I) LTD (=< 150 #)	INDIA
c.	VIRGO ENGINEERS LTD. (=<300#)	INDIA
d.	FLOWSERVE INDIA CONTROL PVT. LTD. (UPTO 30",300# UPTO 12" 600#)	INDIA
e.	KOSO FLUID CONTROLS (PVT.) LTD. (=< 150#)	INDIA
f.	KOREA UNICOM VALVES CO. LTD.(FOR RATING =< 300#)	KOREA
g.	PARCOL SPA (=< 2500# UREA SERVICE ALSO)	ITALY
h.	ORTON S.R.L (UPTO 2500#)	ITALY
i.	BRAY CONTROLS(=< 300#)	U.S.A
j.	KEYSTONE (UPTO 2500#)	SINGAPORE
k.	METSO AUTOMATION (UPTO 2500#)	SINGAPORE
l.	LEEDS VALVE LTD	U.K
m.	EMET CONTROL PVT LTD (UPTO 4" 900#, 6" 150# TO 16" 150#, DOUBLE ECCENTRIC)	INDIA
48.	**SAUNDERS (PINCH) VALVES**	
a.	WEIR BDK VALVES(A UNIT OF WEIR INDIA PVT. LTD.) UPTO 1500#	INDIA
49.	**SOLENOID VALVES**	
a.	ASCO (INDIA) LIMITED	INDIA
b.	ROTEX AUTOMATION LIMITED	INDIA
c.	IMI NORGREN-HERIONFLUIDTRONICGMBH&CO.	GERMANY
d.	ALEXENDER CONTROLS LTD.	U.K
e.	ASCO JOUCOMATIC LTD.	U.K
50.	**PRDS& SPRAY NOZZLE,VENT VALVES UPTO 2500#**	

a.	CCI VALVE TECHNOLOGY AB	SWEDEN
b.	ABB	U.K
c.	CONTROL COMPONENTS INC.	INDIA
d.	SPX VALVES & CONTROLS (COPES-VULCAN LTD)	U.S.A
e.	ARCA(FORBES MARSHAL)(MECH SPRAY NOZZLE TYPE DESUPERHEATER)	INDIA
f.	CONTROL COMPONENTS INC.	INDIA
g.	CIRCOR FLOW TECHNOLOGIES INDIA PVT. LTD. (1" TO 20 " UPTO 150#, 1"TO 10" UPTO 1500#, 1" TO 8 " UPTO 2500#)	INDIA
h.	CHEMTROL INDUSTRIES LTD (PRDS COMBINE & SPLIT)	INDIA
51.	**ELECTRIC ACTUATOR**	
a.	ROTORK CONTROL (DEUTSCHLAND) GMBH	GERMANY
b.	BIFFI ITALIA S.R.L	ITALY
c.	LIMITORQUE, U.S.A	U.S.A
d.	MARSH AUTOMATION (FOR SAFE AREA)	INDIA
52.	**AIR FILTER REGULATOR**	
a.	ASEA BROWN BOVERI LTD.	INDIA
b.	DIVYA CONTROL ELEMENTS PVT. LTD.	INDIA
c.	MIL CONTROLS LIMITED	INDIA
d.	PLACKA INSTRUMENTS & CONTROLS PVT. LTD.	INDIA
e.	SHAVO NORGREN(INDIA) PVT LTD.	INDIA
f.	ABB INDIA LIMITED	INDIA
53.	**PRESSURE REGULATOR**	
a.	CHEMTROL INDUSTRIES LTD	INDIA
54.	**LIMIT/PROXIMITY SWITCHES**	
a.	OSNA ELECTRONICS PVT. LTD. (INTRINSICALLY SAFE PROXIMITY SWITCHES)	INDIA
b.	PEPPERL + FUCH	INDIA
c.	EL-O MATIC INDIA PVT LTD(FOR NON CRITICAL APPS)	INDIA
d.	ROTEX MANUFACTURERS & ENGINEERS PVT LTD(FOR NON CRITICAL APPS)	INDIA
e.	PROTOCONTROL INSTRUMENTS (I) PVT. LTD. (FOR NON CRITICAL APPLICATIONS)	INDIA
f.	PEPPERL + FUCH	GERMANY
g.	PEPPERL + FUCHS PTE LTD.	SINGAPORE
h.	HONEYWELL INC.	U.S.A
55.	**VALVE ACTUATOR (PNEUMATIC/ ROTARY)**	

a.	EL-O-MATIC INDIA PRIVATE LIMITED (FOR NON-CRITICAL APPLICATIONS)	INDIA
b.	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED	INDIA
c.	BRAY CONTROL PVT LTD.	INDIA
56.	**SELF ACTUATED PRESSURE CONTROL VALVE**	
a.	NIRMAL INDUSTRIAL CONTROLS PRIVATE LIMITED (SIZE ½" TO 6 " & RATING : < =300#)	INDIA
57.	**ELECTRONEUMATIC POSITIONER**	
a.	SIEMENS LIMITED	INDIA
58.	**DESUPERHEATER**	
a.	CICOR FLOW TECHNOLOGIES INDIA PVT. LTD (UPTO 24" 300# UPTO 28" 1500 # MULTI NOZZLE 3" TO 4 " UPTO 2500#)	INDIA
b.	EMET CONTROL PVT LTD (1 ½" 600# X 3" 2500#)	INDIA
59.	**PRESSURE REDUCING STATION**	
a.	CICOR FLOW TECHNOLOGIES INDIA PVT. LTD. (1 TO 20" UPTO 1500#, 1 TO 10" UPTO 1500 # 1"TO 8" UPTO 2500#)	INDIA
60.	**CONTROL PANEL**	
a.	ASEA BROWN BOVERI LTD.	INDIA
b.	ELECTRONICS CORPORATION OF INDIA LTD	INDIA
c.	INDUSTRIAL CONTROL APPLIANCES (P) LTD.,	INDIA
d.	JAISUN&HUTCHISUN CONTROLS LTD.,	INDIA
e.	PYROTECH ELECTRONICS PVT.LTD.	INDIA
f.	UNITED ELECTRIC CO. (DELHI) PVT. LTD. (UPTO 10 MTRS.)	INDIA
g.	YOKOGAWA LIMITED	INDIA
h.	INSTROMET INTERNATIONAL N.V	HOLLAND
i.	PRIMA AUTOMATION (INDIA) PVT. LTD. (FOR PACKAGE EQUIPMENTS)	INDIA
j.	TAN SWA TECHNOLOGIES INC	INDIA
61.	**PANEL ACCESS. (RELAY, SWITCH, LAMP, TERMINAL, PUSH BUTTON)**	
a.	LARSEN & TOUBRO LTD.(CONTROL& AUTOMATION (LAMP, PUSH BUTTON)	INDIA
b.	ROCKWELL AUTOMATION INDIA LTD. (RELAYS)	INDIA
c.	ECONIX HI-TECH COMPONENTS PVT. LTD. (FOR TERMINAL BLOCKS & ACCESSORIES ONLY)	INDIA
d.	ELMEX CONTROS PVT. LTD.	INDIA
e.	JYOTI LIMITED (RELAY)	INDIA
f.	DIGITABLETHIELENGMBH& CO	GERMANY

g.	PHOENIX CONTACT GMBH& CO.	GERMANY
h.	SIEMENS AG, GERMANY (LAMP,PUSHBUTTON,CONTACTORS)	GERMANY
i.	STAHL-UND APPARATEBAU HANS LEFFERGMBH (LAMP,PUSHBUTTON)	GERMANY
j.	WAGOKONTAKLTECHNIKGMBH	GERMANY
k.	WEIDMULLER LTD.	GERMANY
l.	OMRON CORPORATION (RELAY)	JAPAN
m.	PEPPERL + FUCHS PTE LTD. (SWITCH)	SINGAPORE
n.	PHOENIX CONTACT (INDIA) PVT. LTD. (FOR TERMINAL BLOCKS)	INDIA
o.	M/S POWERCAM ELECTRICALS PVT LTD (PILOT LAMP, PUSH BUTTON)	INDIA
62.	**PROGRAMABLE LOGIC CONTROLLER**	
a.	GE FANUC SYSTEMS PRVITATE LIMITED	INDIA
b.	HONEYWELL AUTOMATION INDIA LIMITED (SAFETY SYSTEM)	INDIA
c.	LARSEN & TOUBRO LTD.(CONTROL& AUTOMATION (NON FAILSAFE)	INDIA
d.	MOORE CONTROLS LTD. (FAILSAFE)	INDIA
e.	ROCKWELL AUTOMATION INDIA LTD. (NON FAILSAFE)	INDIA
f.	SIEMENS LTD., (NON FAILSAFE)	INDIA
g.	ABB INDIA LIMITED	INDIA
h.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD. (DELTA V SIS ESID SYSTEM)	INDIA
i.	ROCKWELL AUTOMATION INDIA PVT. LTD. (NON FAILSAFE & FAILSAFE (ICS TRIPLEX TMR, DMR)	INDIA
j.	SIEMENS LTD. (ESD- SIEMATIC S7-400FH/PLC-SIMATIC S-300,S7-400 (FMR/DMR)	INDIA
k.	HIMA PAUL HILDEBRANDT GMBH + CO KG (FAILSAFE)	GERMANY
l.	MARCONI ITALIANA (NON FAILSAFE)	ITALY
m.	OMRON CORPORATION (NON FAILSAFE)	JAPAN
n.	TRICONEX (FAULT TOLERANT TMR)	SINGAPORE
o.	GE FANUC AUTOMATION NORTH AMERICA, INC. (FAULT TOLERANT TMR)	U.S.A
63.	**DISTRIBUTED CONTROL SYSTEM**	
a.	HONEYWELL AUTOMATION INDIA LIMITED	INDIA
b.	YOKOGAWA LIMITED	INDIA
c.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
d.	ABB INDIA LIMITED	INDIA
e.	SIEMENS LTD. (SIMATIC –PCS7)	INDIA

f.	SIEMENS AG, GERMANY	GERMANY
g.	INVENSYS	HOLLAND
h.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
i.	EMERSON PROCESS MGT SINGAPORE LTD	SINGAPORE
j.	BAILEY CONTROLS COMPANY	U.S.A
k.	HONEYWELL INC.	U.S.A
64.	**RECEIVER INSTRUMENTS (INDICATOR, CONTROLLER, RECORDER)**	
a.	CHINO-LAXSONS (INDIA) LIMITED (ONLY RECORDER)	INDIA
b.	EUROTHERM DEL INDIA LIMITED	INDIA
c.	HONEYWELL AUTOMATION INDIA LIMITED	INDIA
d.	MOORE CONTROLS LTD.	INDIA
e.	YOKOGAWA LIMITED	INDIA
f.	MASIBUS AUTOMATION & INSTRUMENATION PVT.LTD. (RECEIVER INSTRUMENTS EXCEPT RECORDER)	INDIA
g.	ABB INDIA LIMITED	INDIA
h.	SIEMENS AG, GERMANY	GERMANY
i.	CHINOCORPN.	JAPAN
j.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
k.	HERAEUS ELECTRO-NITE INTERNATIONAL N.V.	JAPAN
l.	HONEYWELL INC.	U.S.A
65.	**ALARM ANNUNCIATOR**	
a.	INDUSTRIAL INSTRUMENTS & CONTROLS	INDIA
b.	SHREE ELECTRONICS	INDIA
c.	M.T.L., U.K.	U.K
d.	ROCHESTER INSTRUMENT SYSTEMS LTD.	U.K
e.	RILEY PANALARM	U.S.A
f.	RONAN ENGG. CO.	U.S.A
66.	**BARRIER/ISOLATOR/TRIP AMPLIFIER**	
a.	MTL INSTRUMENT LIMITED	INDIA
b.	PEPPERL + FUCH	INDIA
c.	DIGITABLETHIELENGMBH& CO	GERMANY
d.	FOXBORO ECKARDTGMBH	GERMANY
e.	PEPPERL + FUCH	GERMANY
f.	STAHL-UND APPARATEBAU HANS LEFFERGMBH	GERMANY
g.	YOKOGAWA ELECTRIC CORPORATION	JAPAN

h.	M. SYSTEM CO. LTD. (SIGNAL ISOLATORS FITTINGS:MODEL NOS. M2VS;M5VS;W2VS;W5VS)	JAPAN
i.	PEPPERL + FUCHS PTE LTD.	SINGAPORE
j.	CAMILLE BAUER AG	SWITZERLAND
k.	M.T.L., U.K.	U.K
l.	HONEYWELL INC.	U.S.A
67.	**CCTV / ACCESS SYSTEM**	
a.	HONEYWELL AUTOMATION INDIA LIMITED	INDIA
b.	YOKOGAWA LIMITED	INDIA
68.	**MISCELLENOUS ITEMS (RTU / SCADA ETC)**	
a.	ABB INDIA LIMITED	INDIA
b.	ROCKWELL AUTOMATION INDIA PVT. LTD.	INDIA
c.	SIEMENS LTD. (SIMATIC WINCC)	INDIA
69.	**ENERGY METER**	
a.	M.SYSTEM CO. LTD.(MODEL NO. 53U)	INDIA
70.	**SURGE PROTECTION DEVICES**	
a.	PHOENIX CONTACT (INDIA) PVT. LTD.	INDIA
71.	**WIRING DUCTS**	
a.	TRINITY TOUCH PVT.LTD.	INDIA
72.	**DIN RAIL**	
a.	TRINITY TOUCH PVT.LTD.	INDIA
73.	**INTERFACE MODULE**	
a.	TRINITY TOUCH PVT.LTD.	INDIA
74.	**CABLE CONNECTOR**	
a.	PHOENIX CONTACT (INDIA) PVT. LTD.	INDIA
75.	**MACHINE MONITORING SYSTEM**	
a.	BRUEL&KJAERGMBH	GERMANY
b.	SKF CONDITION MONITORING INC.	SINGAPORE
c.	BENTLEY NEVEDALLC	U.S.A
76.	**SPEED INDICATOR**	
a.	PEPPERL + FUCH	GERMANY
b.	SHINKAWA ELECTRIC CO.	JAPAN
c.	PEPPERL + FUCHS PTE LTD.	SINGAPORE
d.	JACQUET	SWITZERLAND
e.	BENTLEY NEVEDALLC	U.S.A

77.	**ANTI SURGE CONTROLLER**	
a.	COMPRESSOR CONTROL CORPORATION	SINGAPORE
b.	INVENSYS TRICONEX	SINGAPORE
c.	DRESSER – RAND CO.	SINGAPORE
78.	**BURNER MANAGEMENT SYSTEM**	
a.	DURAGINDUSTRIEELEKTRONIKGMBH& CO KG	INDIA
b.	SIEMENS AG, GERMANY	GERMANY
c.	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
d.	OMRON CORPORATION	JAPAN
e.	YAMATAKE CORPORATION	JAPAN
f.	HONEYWELL INC.	U.S.A
79.	**FURNACE CAMERA, HEATER, THERMAL IMAGER**	
a.	TEMPSENS INSTRUMENTS (I) PVT. LTD.	INDIA
80.	**I/P CONVERTER**	
a.	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.	INDIA
b.	INVENSYS (FOXBORO)	INDIA
c.	YOKOGAWA LIMITED	INDIA
d.	YOKOGAWA ELECTRIC CORPORATION	JAPAN
e.	EMERSON PROCESS MANAGEMENT LTD	U.S.A.
f.	MOORE PRODUCTS COMPANY	U.S.A.
81.	**INSTRUMENT POWER & CONTROL CABLES**	
a.	ASSOCIATED CABLES LTD.	INDIA
b.	ASSOCIATED FLEXIBLES & WIRES PVT. LTD.	INDIA
c.	CORDS CABLE INDUSTRIES LTD.	INDIA
d.	DELTON CABLES LTD	INDIA
e.	INSUCON CABLES & CONDUCTORS (P) LTD. (FOR SMALLER NON-CRITICAL PROJECTS)	INDIA
f.	J K CABLES LIMITED	INDIA
g.	KEI INDUSTRIES LIMITED	INDIA
h.	PARAMOUNT CABLE CORPORATION	INDIA
i.	T C COMMUNICATIONS PVT LTD	INDIA
j.	THERMO CABLES LIMITED	INDIA
k.	TOSHNIWAL CABLES	INDIA
l.	UDEY PYRO CABLES PVT LTD	INDIA
82.	**EXTENSION & COMPENSATING CABLES**	

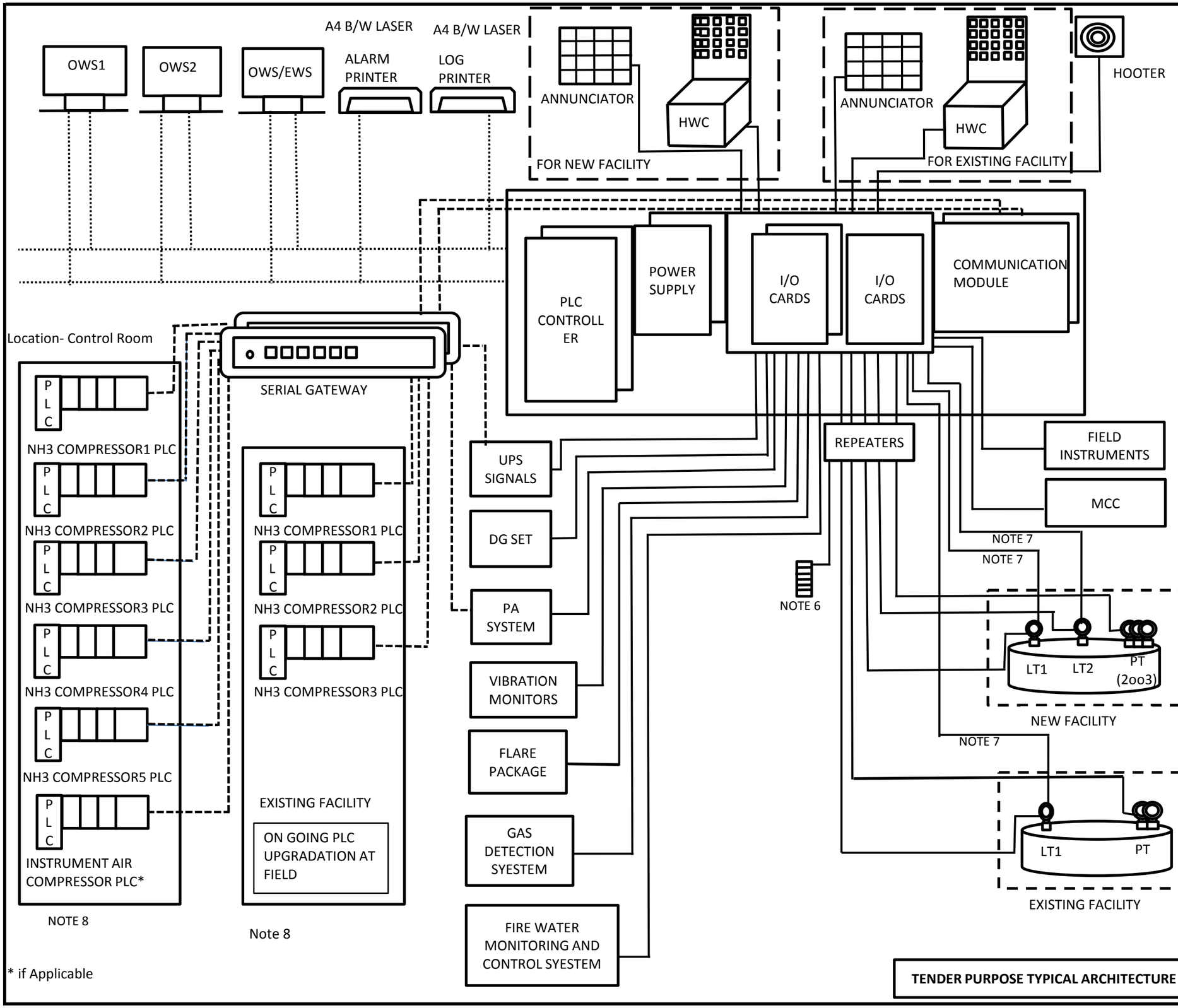
a.	ASSOCIATED CABLES LTD.	INDIA
b.	ASSOCIATED FLEXIBLES & WIRES PVT. LTD.	INDIA
c.	CORDS CABLE INDUSTRIES LTD.	INDIA
d.	DELTON CABLES LTD	INDIA
e.	GENERAL INSTRUMENTS CONSORTIUM,	INDIA
f.	J K CABLES LIMITED	INDIA
g.	KEI INDUSTRIES LIMITED	INDIA
h.	PARAMOUNT CABLE CORPORATION	INDIA
i.	THERMOPADSPVT. LTD.	INDIA
j.	TOSHNIWAL CABLES	INDIA
83.	**CABLE TRAYS & ACCESSORIES (AL./GI)**	
a.	GLOBE ELECTRICAL INDUSTRIES	INDIA
b.	INDIANA ENGG WORKS PVT LTD	INDIA
c.	METALITE INDUSTRIES,	INDIA
d.	PAREKH ENGINEERING COMPANY	INDIA
e.	SADHANA ENGINEERING CORPORATION	INDIA
f.	STEELITE ENGINEERING LIMITED	INDIA
84.	**MULTI TRANSIT INLET SYSTEM**	
a.	MCTBRATTBERGAKTIEBOLAG	SWEDEN
b.	ROXTECAB	SWEDEN
c.	HAWKE INTERNATIONAL	U.K
85.	**JUNCTION BOX & CABLE GLAND**	
a.	BALIGA LIGHTING EQUIPMENTS LIMITED	INDIA
b.	CEAG FLAMEPROOF CONTROL GEARS PVT.LTD.	INDIA
c.	FLAMEPROOF EQUIPMENTSPVT. LTD.	INDIA
d.	FLEXPRO ELECTICALS PVT. LTD.	INDIA
e.	TRINITY TOUCH PVT. LTD. (ONLY CABLE GLANDS UPTO SIZE 25M)	INDIA
f.	STAHL-UND APPARATEBAU HANS LEFFERGMBH	GERMANY
g.	TAN SWA TECHNOLOGIES INC (JUNCTION BOX)	INDIA
86.	**CS SEAMLESS PIPES**	
a.	INDIAN TUBE CO(TATA DIV. OF TUBES &PIPES)	INDIA
b.	ISMT LIMITED	INDIA
c.	MAHARASHTRA SEAMLESS LTD.	INDIA
d.	ETSTROUVAY&CAUVIN	FRANCE

e.	PHOCEENNE	FRANCE
f.	HORST KURVERSGMBH	GERMANY
g.	MANNESMANN HANDEL AG	GERMANY
h.	DALMINE SPA	ITALY
i.	IBF SEAMLESS PIPES SPA	ITALY
j.	MARUBENI ITOCHU STEEL	JAPAN
k.	NIPPON STEEL CORPORATION	JAPAN
l.	NISSHO IWAI CORPORATION	JAPAN
m.	OKURA & CO. LTD.	JAPAN
n.	SOJITZ CORPORATION CS SEAMLESS PIPES	JAPAN
o.	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
p.	HYUNDAI CORPORATION	KOREA
q.	VOMAL INTERNATIONAL LIMITED	U.K
87.	**SS SEAMLESS PIPES**	
a.	CHOKSI TUBE COMPANY LTD.	INDIA
b.	NUCLEAR FUEL COMPLEX	INDIA
c.	RAJENDRA MECHANICAL INDUSTRIES LTD.	INDIA
d.	RATNAMANI METALS & TUBES LIMITED	INDIA
e.	MATIX TUBES COMPANY PVT. LTD.	INDIA
f.	PHOCEENNE	FRANCE
g.	TPS-TECHNITUBEROHRENWERKEGMBH	GERMANY
h.	DALMINE SPA	ITALY
i.	T.T.I- TUBACEX TUBOS INOXIDABLES,SA(1/2'' NB SS PIPE)	SPAIN
88.	**SS TUBES**	
a.	CHOKSI TUBE COMPANY LTD.	INDIA
b.	NUCLEAR FUEL COMPLEX	INDIA
c.	RATNAMANI METALS & TUBES LIMITED	INDIA
d.	MATIX TUBES COMPANY PVT. LTD.	INDIA
e.	ITOCHU CORPORATION (REP.KUBOTACORPN.)	JAPAN
f.	NISHITANI& CO. LTD.	JAPAN
g.	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
89.	**PIPE FITTINGS**	
a.	EBY INDUSTRIES	INDIA

b.	EXCEL HYDRO-PNEUMATICS PVT LTD,	INDIA
c.	MICRO PRECISION PRODUCTS PRIVATE LTD.	INDIA
d.	PRECISION ENGINEERING INDUSTRIES	INDIA
e.	TECNOMATIC (INDIA) PVT. LTD.	INDIA
f.	WESMEC ENGINEERS PVT. LTD.	INDIA
g.	CELLIERS.A.	FRANCE
h.	SIEMENS AG PGI	GERMANY
i.	THYSSEN-KRUPP STAHLUNIONGMBH	GERMANY
j.	CESAREBONETTI	ITALY
k.	TECHNOMATIC SPA	ITALY
l.	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
m.	DEWRANCE& CO. LTD.	U.K
n.	HOPKINSONS LIMITED	U.K
o.	THOMPSON VALVES LTD.	U.K
p.	VELAN ENGINEERING CO. LIMITED	U.K
q.	ANDERSON GREENWOOD & CO.	U.S.A
r.	CRANE COMPANY INTL. SALES	U.S.A
90.	**COMPRESSION FITTINGS**	
a.	AURA INC	INDIA
b.	BALDOTA VALVE & FITTING CO.PVT.LTD.	INDIA
c.	EXCEL HYDRO-PNEUMATICS PVT LTD,	INDIA
d.	EXCELSIOR ENGG WORKS	INDIA
e.	PANAM ENGINEERS	INDIA
f.	PRECISION ENGINEERING INDUSTRIES	INDIA
g.	RELIANCE ENGG. & ELECTRICAL CORPN.	INDIA
h.	VIKAS INDUSTRIAL PRODUCTS	INDIA
i.	ARYA CRAFTS & ENGINEERING PVT LTD.	INDIA
j.	FLUID CONTROLS PVT LTD	INDIA
k.	WESMEC ENGINEERS PVT. LTD.	INDIA
l.	PARKER HANNIFIN SINGAPOREPTE. LTD.	SINGAPORE
m.	SWAGELOCK COMPANY/CREXIMCO	U.S.A
91.	**INSTRUMENT MINIATURE VALVES**	
a.	AUDCO INDIA LIMITED(L&T VALVES DIVN.)	INDIA

b.	AURA INC	INDIA
c.	BHEL (VALVES DIVISION)	INDIA
d.	CHEMTROL INDUSTRIES LTD	INDIA
e.	EXCEL HYDRO-PNEUMATICS PVT LTD,	INDIA
f.	CHEMTROLS SAMIL(INDIA) PVT LTD	INDIA
g.	HYD- AIR ENGINEERING WORKS LONAVLA	INDIA
h.	EXCELSIOR ENGG WORKS	INDIA
i.	KSB PUMPS LIMITED (VALVES DIVN)	INDIA
j.	PANAM ENGINEERS	INDIA
k.	TECNOMATIC (INDIA) PVT. LTD.	INDIA
l.	WESMEC ENGINEERS PVT. LTD	INDIA
m.	CELLIERS.A.	FRANCE
n.	BFEBONNEY FORGE VALVE LICENSEE	ITALY
o.	EUROMISURE CREMONA	ITALY
p.	TECHNOMATIC SPA	ITALY
q.	KOSEI SANGYO LTD	JAPAN
r.	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
s.	DEWRANCE& CO. LTD.	U.K
t.	HOPKINSONS LIMITED	U.K
u.	VELAN ENGINEERING CO. LIMITED	U.K
v.	ANDERSON GREENWOOD & CO.	U.S.A
w.	CRANE COMPANY INTL. SALES	U.S.A
x.	SWAGELOCK COMPANY/CREXIMCO	U.S.A
92.	**PURGE ROTAMETER**	
a.	INSTRUMENTATION ENGINEERS PVT. LTD.	INDIA
b.	PLACKA INSTRUMENTS & CONTROLS PVT. LTD.	INDIA
c.	EURECA INDUSTRIAL EQUIPMENTS PVT LTD	INDIA
93.	**AIR HEADER/ADPOT**	
a.	WESMEC ENGINEERING PVT. LTD.	INDIA
94.	**CONDENSATE POT**	
a.	WESMEC ENGINEERING PVT. LTD.	INDIA
95.	**VALVE MANIFOLDS**	
a.	WESMEC ENGINEERING PVT. LTD.	INDIA

96.	**CALIBRATION EQUIPMENT & SERVICES**	
a.	TEMPSENS INSTRUMENTS (I) PVT. LTD.	INDIA
97.	**ENCLOSURES**	
a.	TRINITY TOUCH PVT. LTD. (WEATHERPROOF SIZE 80 * 80 MM)	INDIA
98.	**THIRD PARTY INSPECTION AGENCIES (TPI)**	
a.	LRIS (LLOYDS)	
99.	**DEW POINT METER**	
a.	GE	INDIA
b.	AMETEK INC	INDIA
c.	TESTO	INDIA
100.	**WORKSTATIONS**	
a.	DELL	INDIA
101.	**NETWORK SWITCHES**	
a.	CISCO	INDIA
102.	**CHLORINATOR SYSTEM**	
a.	FISHER & PORTER	INDIA
b.	THOMAS DASON	INDIA



NOTES

1. The architecture is for reference purpose only. Actual Control system architecture shall be prepared by the Contractor after awarding the Job.
2. All Package system shall be interfaced to Plant PLC through serial and/or hardwired communication as per specifications. The indicated Package/PLCs may not be complete and this drawing is intended for Bidder's preliminary understanding only.
3. Only important instruments on the tank are indicated.
4. Separate Marshalling panels shall be considered for New and existing facilities.
5. Redundancy of Package PLCs are as per Tender document.
6. Repeated signals shall be kept terminated in a Terminal block for future use.
7. 4-20 mA current output from Servo level transmitter shall be hardwired directly to Central PLC (one relay contact of Servo level transmitter shall be wired through repeater to Central PLC which is shown seperately).
8. All critical signals from compressors shall be repeated/ hardwired to Central PLC.

LEGENDS

- HARDWIRED
- SERIAL COMMUNICATION LINK
- NETWORK COMMUNICATION LINK

PROJECT	**Construction of Additional Ammonia Storage and Handling**		
CLIENT	**M/S FACT CD**		
REVISION	**0**		
DOC NO	**32686-14-MD-002**		
TITLE	**CONTROL SYSTEM ARCHITECTURE**		
16.4.21	**AB**	**MKZ**	**MS**
DATE	**DRAWN**	**CHECKED**	**APPROVED**

FACT ENGINEERING AND DESIGN ORGANISATION

CONTENTS

NOTE:

The description under scope of supply will be general in nature and covers most of the prevalent types of instruments, some of which may not be required for this particular project. Hence only the applicable items shall be referred to. For actual list of instruments, refer schedule of work.

PART A- GENERAL

1.0.0 SCOPE OF WORK

The scope of work shall include but not be limited to: -

1.1.0 Unpacking, checking, cleaning and withdrawal of instruments, instrument accessories and erection materials at owner's stores and /or from places of storage anywhere within the boundary wall of project and existing factory. Return of leftover materials to owner's stores.

1.2.0 Transportation and handling of instruments, instrument accessories and erection materials at owner's stores and /or from places of storage anywhere within the boundary wall of project to work site and /or contractors stores.

1.3.0 Installation of field mounted instruments such as pressure/vacuum gauges, dial thermometers, pressure switches, blind switches, manometers, differential pressure indicators, local flow indicators/ recorders, local indicating controllers, flow transmitters, pressure transmitters differential pressure transmitters, temperature transmitters, rotameters etc.

1.4.0 Installation of vessel mounted instruments such as level gauge glass, magnetic level gauges, bi-colour level gauges, torque tube level instruments, level switches, dial thermometers, pressure gauges etc.

1.5.0 Installation of instruments on vendor's equipment such as Speed Indicators, Speed Controllers, Vibration/Axial Displacement/ axial Thrust Monitoring Systems, Ammeters, Anti surge Controls etc.

1.6.0 Supervision of installation of on-line instrument (by other contractors) such as Orifice Flow Element, Control Valves, PD/ Turbine Meters, Rotameters etc.

1.7.0 Installation of analytical instruments such as Infrared Analysers, Paramagnetic Analysers, Thermal conductivity Analysers, NOX analyser, H2S analysers, silica analysers, Density Analysers, PH

analysers, Electrical Conductivity Analysers, Dissolved Oxygen analysers, Online gas Chromatographs, oxygen analysers etc

1.8.0 Installation of miscellaneous instruments such as Belt weighers, flame safe guard instruments, pneumatic change over switches, air sets, thermocouple assemblies, thermo resistance assemblies, purge type liquid level measuring systems, volume tanks for double acting piston actuators etc.

1.9.0 Installation of local panel mounted instruments such as receiver indicators, indicating controllers, pneumatic/ electronic receiver recorders, manual loaders, ratio control stations, computing/ selector relays, temperature indicators/ recorders, receiver switches, alarm annuciators, timers, analyser recorders, etc.

1.10.0 Interconnecting field & panel mounted instruments.

1.11.0 Cutting gasket of various materials to suitable sizes and fixing the same along with the fitting or flanged connections.

1.12.0 Any modifications jobs during installation of instruments.

1.13.0 Erection and interconnection of control panels, cubicle boards, control desks etc. locally and in the control rooms.

1.14.0 Fabrication and installation of frames, supports, mounting stands, clamps, brackets, cable racks, cable tray and bends, tees and crossings etc. for the racks and trays.

1.15.0 Fabrication and installation of instrument protective boxes (Canopy).

1.16.0 Laying and supporting of cable tray and ducts.

1.17.0 Laying and supporting of instrument air headers and distribution lines.

1.18.0 Laying and support of multi run tubing and single run tubing on racks and their termination.

1.19.0 Laying and support of multicore and single pair electrical cables, multicore and single pair compensating cable and any other special cables on racks/ trays and their terminations.

1.20.0 Fabrication, laying and supporting of impulse piping and sample lines for analyzer and for laboratory.

1.21.0 Fixing in position electrical junction boxes, distribution boxes and relay boxes- in the field and behind the control panel-, conduit pipes, fittings and flameproof boxes.

1.22.0 Any civil job involved in the installation of supports, mounting stands, control panels, junction boxes, relay boxes, air piping, tubes etc.

1.23.0 Cleaning and blowing of main air header and distribution lines, pneumatic tubing, impulse piping and sample lines for analysers etc.

1.24.0 Testing of main air header distribution lines, pneumatic tubing etc, for any leakage and proper connections.

1.25.0 Hydraulic/ pneumatic testing of impulse piping and sample lines.

1.26.0 Testing of electrical cables, compensating cables, and special cables for proper connections, continuity and insulation, together with other contractors as required.

1.27.0 Testing of complete instrument loops for proper connections and functioning, together with automation contractor.

1.28.0 Steam tracing of impulse lines wherever necessary and final connections to steam jacketed instruments. Piping connections for internal washing of instruments and purging of instrument casing.

1.29.0 Cleaning and painting of frames, supports, clamps, mounting stands and racks etc, as per painting specifications.

1.30.0 Testing, calibration and functional checking of all the instruments and accessories.

1.31.0 TIG welding, stress relieving and dye penetrant tests wherever required. Welding of IBR impulse pipes (CS), SS316 and 316L impulse pipes.

1.32.0 Sealing of cable entries into control panels /room after laying of all cables and tubes.

2.0.0. CONTRACTOR'S OBLIGATIONS

The contractor's obligations shall include:

2.1.0 Arrangement and supply of required tools and tackles such as electric welding sets, gas welding sets, gas cutting sets, hydro testing pumps, trailer, forklifts, crane, jumbo trucks, pipe and tube benders, drilling equipments, multi-meters, ferrule printers etc and all other tool necessary for the installation of instrument according to good international practice.

2.2.0 Arrangement and supply of consumables like welding electrodes, industrial gases, cleaning fluids such as kerosene, insulation tapes, sealing compounds, all clamping materials for cable/tube trays

and racks, impulse piping and air header such as bolts, nuts, M.S. clamps (straight pin type)/ U type lugs of 1.5 mm Sq./ 2.5mm Sq. size in required quantity, SS/ aluminium tag plates, PVC cable marking ferrules etc. and all other consumables necessary for execution of the job.

2.3.0 Arrangement and supply of testing equipments and other instruments such as dead weight tester (weight in kg/cm .Sq) manometer, portable pneumatic /electronic calibrator, standard test gauge, thermocouple test kit, D.C potentiometer, whetstone bridge, decade resistance box, temperature bath with thermostatic control, oscilloscope, telephone sets, signal generator, megger, vacuum pump, hydraulic pump avometer, digital multimeter, testing /calibrating facilities for panel mounted indicators, recorders, controllers, computing relays, counters, turbine flow meters, transmitters , electro pneumatic converters etc.

2.4.0 Planning and maintaining of all activities of the contract as per PERT chart approved by owner. Arranging staff like supervisory staff, skilled and unskilled labour forces etc as required for timely completion of the entire job.

2.5.0 Maintaining records on daily basis of all the works as per approved schedule, calibration and inspection reports as per the advice of OWNER.

2.6.0 Making arrangements for distribution of electricity and water from supply point to work spots.

2.7.0 Co-ordination with other contractors' works as required by OWNER to complete the instrument erection work.

2.8.0 Security arrangement for contractor's office and stores to ensure safety of all equipments and all free issue materials supplied by the OWNER.

2.9.0 Clearing of site after completion of work.

2.10.0 Return of OWNER'S surplus and free supply materials and other excess materials included in work order to OWNER after accounting.

3.0.0 OWNER'S SUPPLY

Owner's obligations shall include: -

3.1.0 Supply of all pipes, pipe fittings, cable trays and ducts, valves, flanges, junction boxes, control panels, gauge boards two core and multi-core control/ power/ shielded cables, three core and multicore resistance thermometer cables, single pair and multipair compensating cables two core and multi-core electrical/ electronic cables etc (except those included in contractor's scope.)

3.2.0 Supply of all pneumatic, electrical, electronic and analytical instruments, special sampling systems, resistance thermometers, dial thermometers, thermocouples, bi- metallic thermometers, thermo wells, all the switches for alarm and shutdown, pressure and vacuum gauges, air filter regulators, solenoid valves, output gauges, analyzer cabinets etc except those included in the contractor's scope.

3.3.0 Supply of water free of cost and electricity on chargeable basis.

3.4.0 Cranes, jumbo trucks, forklifts etc will be spared by the owner on chargeable basis (only if available) otherwise contractor has to make his own arrangements.

PART B- TECHNICAL REQUIREMENTS

4.0.0 INSTRUMENT INSTALLATION

4.1.0 The instrument contractor shall ensure that the instruments are received in good condition and shall report defect if any to the engineer in charge. The contractor will be responsible for safety of all instruments thereafter till the commissioning of the plant. Any loss or damage of instruments while in his custody shall be chargeable to the contractor. Contractor shall be responsible for supply and cost of all replacement material and labour necessary to rectify faults which occur during instrument installation or testing period due to reasons such as falls or due to faulty work man ship or faulty material in the contractor's supply.

4.2.0 All the instruments are to be checked for their calibration prior to installation in the field and shall be corrected for any calibration misalignments that would have occurred during transportation or subsequent handling.

4.3.0 All the installation works shall be done as per released construction drawings, instrument installation drawings and manufacturer's instruction manuals that will be supplied after the contract is finalized.

4.4.0 If the area in which the installation are to be carried out are partially hazardous [as per area of classification] and partially

general purpose then the instrument erection contractor shall execute all the electrical works in accordance with applicable codes of Indian standards for electrical installation and owners safety regulations.

4.5.0 Contractor shall handover/ report all faulty instruments or any defects found, which may arise due to design omission or discrepancies, which would impede the proper functioning of instruments/ system must be brought to the notice of engineer in charge without undue delay.

5.0.0 ONLINE INSTRUMENTS

Instrument contractor shall supervise and ensure correct installation of on-line instruments, by piping contractor. It will be the responsibility of the instrument contractor to see that the following are accomplished as per specifications and drawings.

5.1.0 FLOW TUBES (Venturi, nozzle etc)

5.1.1. The flow tube shall be installed in pipeline with arrow aligned in the direction of flow.

5.1.2. The straight pipe lengths adjacent to flow tube shall conform to vendor drawings /standards.

5.1.3. Tapping & fittings shall be as specified in the instrument process piping drawings.

5.1.4. Measurements of I.D, length shall be done in order to ensure that correct unit is installed for each line. Change in I.D if any, shall be reported to site Engineer.

5.1.5. Ensure that no weld deposit is projecting inside the pipeline.

5.1.6. Gasket used shall be that specified for duty and shall not project inside the pipe beyond the limits specified by standards.

5.2.0 ORIFICE PLATE

5.2.1. Orientation of tapping & necessary straight length upstream and down stream of orifice.

5.2.2. Proper gasket (gasket shall not project inside the pipe and shall be within the limit specified in orifice plate specification.)

5.2.3. Proper direction of orifice plate.

5.2.4. No weld materials shall project inside the pipeline near the orifice.

5.2.5. Location of tapping shall be at proper distance from orifice plate.

5.2.6. Correct orifice plate /unit is installed for each line.

5.2.7. The drain/ vent hole in the orifice plate shall be located as per specification.

5.2.8. Concentricity of orifice bore with pipe I.D. shall be ensured.

5.3.0 INTEGRAL ORIFICE TRANISMITTERS

5.3.1. Transmitters shall be installed in co-ordination with piping contractor with correct flow direction along with the straight pipe pieces adjacent to flow transmitter.

5.3.2. In the case of pneumatic transmitter, connect receiver gauge and air set with proper air and signal tubing. Tubing wherever required shall be done with necessary slopes as stipulated in the installation standards.

5.3.3. In the case of electronic transmitters, twisted pair screened armored cable /cables as specified shall be glanded and terminated as per termination details.

5.4.0 ROTAMETER, PURGE ROTAMETER & ROTAMETER TRANISMITTER

Contractor shall supervise &ensure the following while piping is in progress.

5.4.1 Verticality of meter

5.4.2 The float which is removed for the purpose of transportation shall be kept in position before installation.

5.4.3 Proper gaskets are used.

5.4.4 Rotameter scale clearly visible from the operation platform. Reducer pairs supplied with meter to be installed by piping contractor shall be supervised by instrument contractor.

5.4.5 After installation, proper air & signal connections shall be made through junction box & to control room. [tubing &tube connections are covered separately in section 16.0.0]

5.4.6 Air set if supplied loose shall be installed as per instrument pneumatic diagram.

5.5.0 TURBINE /MAGNETIC /VORTEX/ POSITIVE DISPLACEMENT/ ULTRASONIC/ MASS FLOW METER

The flow meter is to be mounted, wired and tubed as mentioned below: -

5.5.1 Flow meter shall be installed, in co-ordination with the piping contractor, on pipeline with arrow aligned in the direction of flow.

5.5.2 The straight pipe lengths adjacent to flow meter shall be 10xD upstream 5xD downstream or as recommended by the manufacturer.

5.5.3 Care shall be taken to ensure correct alignment of flow meter with in mating pipe work.

5.5.4 Electrical connection from the flow meter to the secondary instruments shall be

made. Do not run the signal leads in the same conduit/ tray as that for power supply. [Cable wiring & conduit work are covered separately]

5.5.5 The complete installation shall be carried out in accordance with the instruction manual supplied by vendor.

5.5.6 The flow meter shall not have any strain on its body from adjacent pipes.

5.6.0 CONTROL VALVES, DAMPERS, PRESSURE REDUCING VALVES, DESUPERHEATERS

The instrument contractor shall ensure the following while the control valve is being installed by the piping contractor.

5.6.1 Control valve is installed in the correct direction.

5.6.2 The control valve is not under mechanical strain after erection.

5.6.3 Proper gaskets are used for the purpose.

5.6.4 In the case of butterfly valve the vane shall not be obstructed by any piping parts and shall be free to rotate.

5.6.5 The air supply to the control valve and the signal line from the respective controller to the valve positioners /valve shall be made by the instrument contractor.

5.6.6 Signal tubing, instrument piping etc are covered separately.

5.6.7 For valves with air filter set and positioner, contractor shall ensure that the valve positioner & the associated linkages are physically and functionally in good condition.

5.6.8 When solenoid valve is mounted on the valve, the air connections would be provided by the valve supplier. Contractor shall give all electrical connections through required fittings.

5.6.9 Instrument contractor shall ensure the proper installation of the pressure control valve by piping contractor with respect to direction and other aspects for control valves. The backpressure tappings from the downstream/ upstream piping shall be properly connected by the instrument contractor.

5.6.10 Calibration of control valve shall include all testing and calibration of all the accessories such as limit switches, continuous position feedback etc.

5.7.0 MOTOR OPERATED VALVES

The instrument contractor shall ensure proper installation of motor operated valve while it is being erected by piping contractor. The electrical connections will be provided by the electrical contractor. Instrument contractor shall ensure that proper earthing of the valve body is made by the electrical contractor before commencing any work on the valve. Also instrument contractor shall ensure proper functioning of limit switches, open, close commands, continuous position feedbacks, other contacts if any.

5.8.0 SOLENOID VALVES

Work involves installation of solenoid valve on pneumatic signal lines to control valve/ damper actuator, and termination of electrical cables. All necessary electric & pneumatic connections shall be done by instrument contractor, [tubing & wiring conduit work etc are covered separately under sec. 16.0.0& 17.0.0].

6.0.0. **FIELD MOUNTED PRIMARY MEASURING ELEMENTS**

6.1.0. ANNUBAR FLOW ELEMENTS/ PITOT TUBE

6.1.1. Elements shall be so installed that it can be inserted or withdrawn from the pressurized pipe lines under flow conditions without interruption of service.

6.1.2. Annubar installation shall be as per instrument process piping drawings and instruction manual supplied by the vendor.

6.1.3. All the process piping connections shall be given by the contractor [piping covered under 16.0.0].

6.2.0. TEMPRATURE ELEMENTS [T/C & RTD]

6.2.1. T/C shall be installed at proper locations along with specified thermo well.

6.2.2. T/W shall be screwed or flanged type and shall be adequately tightened with use of proper gasket, nuts & bolts, which will be supplied by the owner.

6.2.3. Each T/C shall be connected by proper signal /extension cable using proper glands from individual temperature element to junction boxes.[cables are included separately under 18.0.0]

6.3.0. MULTIPLE T/C ASSEMBLIES

Work involved is same as above.

6.4.0. RTD ELEMENTS [FOR BEARING TEMPRATURE]

R.T.D elements are already wired up to local junction boxes by the equipment vendors. Contractor shall connect these from junction boxes through the multicore leads with the corresponding instrument point. [The cabling is included separately

under 18.0.0]. The RTD elements are already installed on machinery / equipment. In case these instruments are not installed by the vendor in the field, instrument contractor shall arrange to install these instruments as per 6.0.0.

6.5.0. VIBRATION PROBES, AXIAL DISPLACEMENT PROBES & DRIVE SPEED PROBES

All the probes are already mounted on the machinery /equipment by the vendor and wired up to junction box and terminated. Instrument contractor shall provide the electrical connection from the junction box to control panel. In case these were not installed by the vendor in the field, instrument contractor shall arrange to install these probes as per drawings.

7.0.0. FIELD MOUNTED TRANISMITTERS PNEUMATIC

7.1.0. D/P TRANISMITTER FOR FLOW, LEVEL, DENSITY ETC

Mounting of differential pressure transmitters, air filter regulator, locally fabricated suitable stands /supports, tubing them from the first isolation valves with the 3 valve manifold, giving necessary slopes as stipulated in the installation diagrams. Provide air supply using 6mm OD SS tubes; connect ¼" OD copper tube [output], to a receiver gauge or to the secondary local instrument or to junction box as the case may be. Install air filter set. [Tubing, process piping supports etc are covered separately under sec 16.0.0].

7.2.0. LEVEL TRANISMITTER- FLANGE MOUNTED

7.2.1. FLUSH /EXTENDED DIAPHRAM TYPE

Mounting of the transmitter on the vessel nozzle /isolation valve using proper nuts, bolts, gaskets, receiver gauge, air set and pneumatic tubing shall be installed as per 7.1.0.

7.2.2. FLUSH /EXTENDED DIAPHRAM TYPE WITH REMOTE SEAL–FOR LEVEL AND DENSITY

Work involved is identical to item 7.1.0 except that instead of impulse tubing, capillary tubing with flanged diaphragm to be mounted on to the vessel nozzle/ isolation valves the capillary tube shall be supported properly.

7.3.0. GAUGE/ ABSOLUTE PRESSURE TRANISMITTERS

The work involved is identical to item 7.1.0 except that there will be only one impulse tapping.

7.4.0. DISPLACEMENT TYPE LEVEL TRANISMITTERS WITH AIR SET

7.4.1. The displacement type level transmitters with air set shall be fitted in such a way that it is subjected to minimum vibration

7.4.2. The installation shall be carried out using necessary pipes, isolation valves & other fittings as specified in the instrument process piping drawings.

7.4.3. Connections of air supply lines- free of oil, water &dust -at constant pressure of 1.4 kg/cm.sq.

7.4.4. Calibration &checking should be carried out in co-ordination with piping group. [Installation of valves, pipes& tube are covered in section 16.0.0].

7.4.5. The air filter set shall be installed as specified in instrument pneumatic tubing diagram.

ELECTRONIC TRANISMITTERS

The details in item 7.1.0 to 7.4.0 under pneumatic transmitters will be applicable to electronic transmitters except that cabling is involved instead of tubing.

7.5.0. ELECTRO MECHANICAL LEVEL TRANISMITTERS

Mounting the instrument on the vessel nozzle/ flange using proper gaskets, nuts, bolts and connecting the power /signal cables.

7.6.0. RADIO ACTIVE LEVEL TRANISMITTERS

Installation of the radioactive source, line detector and point detectors as per the details provided by the manufacturer and strictly following the government regulations.

7.7.0. TANK LEVEL TRANISMITTERS (FLOAT AND TAPE TYPE)

Installation of float and tape, guide wires, protector pipe with V– seal and mounting the transmitter on suitable supports. The protector pipe shall be properly supported and signal cable shall be terminated.

7.8.0. TEMPRATURE TRANISMITTERS

7.8.1. The installation shall be carried out as per instruction manuals of vendors.

7.8.2. The thermo well with bulb shall be fixed [screwed or flanged] on the pipeline using proper thread sealant or nut, bolt, gaskets as the case may be as per 6.2.2.

7.8.3. Integral type temperature transmitters shall be mounted on the thermo well

head. Signal Cable shall be glanded and terminated.

7.8.4. Remote mounted transmitter shall be separately mounted on a pedestal with proper accessibility and the cable to temperature element and signal cable to control room shall be glanded and terminated to the transmitter.

8.0.0. FIELD MOUNTED CONTROLLERS

8.1.0. INDICATING CONTROLLERS-PNEUMATIC
The work involves mounting the transmitter/ controller on proper support Suitable piping connections, air supply connections, and signal lines shall be provided as specified to correct final control element. The piping & tubing shall be as specified in the process piping diagrams. [The details for supports tubing's &piping are covered under 16.0.0].

8.2.0. DISPLACEMENT TYPE LEVEL TRANISMITTER + CONTROLLER WITH AIR SET
Work involved is a combination of 7.4.0 and 8.1.0.

8.3.0. ELECTRONIC CONTROLLERS
Field mounted electronic controllers are either mounted inside local control rooms or in local control panel. The installation of the controller inside the room shall be in a panel with suitable size cut out. The panel cutting and complete installation and wiring of the controller shall be as per manufacturer's instruction manuals and shall be done by the contractor. Wherever local panel mounted controllers are used, mounting of the panel on its foundation, purging connections, all wring and termination, canopy for the local panel etc will be in contractor's scope.

9.0.0 FIELD MOUNTED GAUGES

9.1.0 PRESSURE GAUGES
Installing pressure gauge using suitable connecting tubes /vent/ drain/valves /etc from the first isolation valve provided on ducts/ pipes/ vessels/ pumps etc.

9.2.0 MANOMETER
Scope includes: -

9.2.1. The installation of instruments with proper supports.

9.2.2. Filling with proper manometer fluid.

9.2.3. Connecting all the piping and valves as per the drawings.

9.2.4. Providing final connections using a flexible hose.
(The details for piping fittings and valves are covered separately.).

9.3.0 LEVEL GAUGE [REFLEX TYPE]
Each level gauge shall be fitted with a pair of gauge cocks, the piping connections & fittings shall be carried out as per the instruction given by the supplier and as per the instrument installation diagram.

9.4.0 MAGNETIC LEVEL GAUGES
Work involved is same as item 9.3.0 except that care shall be taken to handle it properly so that the magnetic float is not damaged.

9.5.0 BOILER LEVEL GAUGES

9.5.1 The high pressure level gauge shall be fitted with proper gaskets & weather proof one end open hood and suitable illuminator.

9.5.2 Process piping connections & complete installation shall be in accordance with instruction manual supplied by vendor. Supply using cables shall be connected to the illuminator from the near by switch provided by the electrical contractor. [The details for piping and fixing valves conduit &wiring etc. shall be covered separately.]

9.6.0 BOILER LEVEL GAUGE WITH REMOTE INDICATION

9.6.1 This shall include the erection of condensate chamber.

9.6.2 Process connections &complete installation should be carried out in accordance with instruction manual supplied by the vendor, while piping work is in progress.

9.7.0 TANKAGE SYSTEMS

9.7.1. ELECTRONIC TANK GAUGING SYSTEM

9.7.1.1. The tankage system, including servo and radar type level instruments with associated instruments such as pressure /single element temperature transmitter/ multiple temperature element transmitters, tank side indicators, junction boxes etc shall be mounted and wired as per vendor's installation manual and wiring drawings.

9.7.1.2. Connection to control room and commissioning of the system shall be under the supervision of the tank gauging vendor.

9.7.1.3. The control room panel erection, necessary inter-panel wiring, cold loop checking of field cables etc of the system is also under the scope of the vendor.

9.7.2. FLOAT AND TAPE METHOD

9.7.2.1. Contractor shall ensure that the instrument is located in an easily accessible place. Location shall also be such that ambient temperature is within the specified limits as given by the vendor.

9.7.2.2. For float and tape measurement, contractor shall install measuring tape, float, protector pipe, local indicator and supports as per hookup drawings or vendor drawings.

9.7.2.3. Contractor shall fix the channel steel or pipe vertically, which does not bend due to its weight, under the sidewall of tank, for accurate measurements.

9.7.2.4. The float and tape shall not be subjected to sudden, abnormal vibrations, due to a violent stream of feed fluid or while erecting the same.

9.8.0 DIAL TYPE INDICATING THERMOMETERS

The work involves installing of thermometers and thermo-wells (threaded or flanged) on pipes/ vessels using proper nuts, bolts &gaskets provided by piping group. The threaded thermo well shall be fitted using Teflon tapes or pipe 'dopes' as the case may be.

9.9.0 TEST THERMOWELLS

Mounting of thermo well on the pipes/ vessels using proper nuts, bolts and gaskets

9.10.0 DIFFRENTIAL PRESSURE INDICATOR

Work involved is same as per 9.1.0 except that there are two tapping.

9.11.0 THERMOMETER –CAPILARY TYPE

Work involved is same as per 9.7.0, except that the capillary tube shall be supported by tray / structural.

10.0.0. **FIELD MOUNTED SWITCHES**

10.1.0. RECIEVER PRESSURE SWITCH (PNEUMATIC)

The pressure switches shall be mounted on suitable supports. Necessary pneumatic tubing and electrical connections shall be made. The pneumatic signal shall come from corresponding transmitter. [Pneumatic tubing and electrical wiring are covered separately under 16.0.0 & 17.0.0]

10.2.0. DIRECT CONNECTED PRESSURE SWITCH

10.2.1. Work involved is same as 10.1.0 but impulse tubing shall be connected from pipelines /vessels using proper isolation valves instead of pneumatic copper tubing from transmitters.

10.2.2. Pressure switches shall be installed rigidly to avoid vibration.

10.3.0. DIRECT CONNECTED DIFFRENTIAL PRESSURE SWITCH

Work involved is same, as 10.2.0 except that impulse tubing shall be provided.

10.4.0. DIRECT CONNECTED LEVEL SWITCH [INTERNAL/ EXTERNAL/ FLOAT TYPE]

Scope includes the installation of level switches on vessel, making necessary electrical connections using armored cable [scope for wiring is covered separately under 16.0.0& 17.0.0].

10.5.0. LEVEL SWITCH

TUNING FORK TYPE, PADDLE TYPE, CAPACITANCE TYPE [WITH OR WITHOUT EXTERNAL CHAMBER]

Scope of work is same as item 10.4.0

10.6.0. TANK LEVEL SWITCHES [FLOAT AND TAPE TYPE]

Installation of float, tape and guide wires, mounting the switch on the vessel flange, connecting the cable and termination.

10.7.0. TEMPRATURE SWITCH

The scope of work includes mounting temperature switch with thermo well on the vessel/ pipe line, cabling and termination etc.

10.8.0. DIRECT CONNECTED FLOW SWITCH

Scope of work includes, mounting the flow switch on the pipe line, cabling and termination.

10.9.0. LIMIT SWITCH

Electrical connection to be made to the limit switches mounted on control valves, actuators etc.

11.0.0. **ANALYSERS**

Manufacturer's instruction manuals shall be strictly followed for proper installation and functioning of analyser.

11.1.0. PH ANALYSERS

11.1.1. IMMERSION TYPE

Mounting the electrode with holder using the mounting hardware provided, installing the analyser transmitter and JB on 2" pipe pedestal and termination.

11.1.2. FLOW THROUGH TYPE

Contractor shall supervise and ensure the proper installation of the electrode chamber on the pipe line by piping group. Analyser transmitter and JB shall be mounted on 2" pipe pedestal and the air supply tubing, cabling and termination shall be done.

11.1.3. PH- ANALYSER, CABINET MOUNTED

Installation of the analyser cabinet, air supply tubing, interconnecting cabling and termination.

11.2.0. CONDUCTIVITY ANALYSERS
Contractor shall supervise and ensure the proper installation of the electrode chamber on the pipe line by piping group. Analyser transmitter and JB shall be mounted on 2" pipe pedestal and the interconnecting cabling and termination shall be done.

11.2.1. CONDUCTIVITY ANALYSER WITH SAMPLING RACK
Installation of the analyser sampling rack, impulse tubing for sample inlet and outlet/ drain, cooling water inlet and outlet, interconnecting cabling and termination etc shall be done.

11.3.0. DISSOLVED O2 ANALYSERS
Mounting the electrode with holder using proper support, installing the analyser amplifier and JB on 2" pipe pedestal, mounting the power supply converter and inter connecting cabling and termination etc.

11.4.0. PROCESS TITRATORS
Installation of the process titrators inside the local control room and the connected cabling and tubing/ piping, as per installation details provided by the manufacturer shall be done.

11.5.0. DENSITY ANALYSER (VIBRATION TYPE)
Mounting the analyser sampling rack and cabling and termination etc shall be done.

11.6.0. DENSITY ANALYSER (FLOAT TYPE)
Contractor shall supervise and ensure the proper installation of the density analyser on the pipe-line by piping group. Pneumatic to electronic converter shall be mounted on 2" pipe pedestal, air supply /signal tubing, cabling and termination etc to be done.

11.7.0. MOISTURE ANALYSERS
The analyser probe shall be mounted on the flange provided on the pipe line using proper gasket, nuts and bolts which will be supplied by the owner. The signal cable shall be connected to the probe and terminated.

11.8.0. OLEUM ANALYSER
Work involved is same as item 11.7.0. In addition to the above, contractor shall mount the analyser transmitter and junction box on suitable support in the field, and inter-connecting cable to be terminated.

11.9.0 TERMAL CONDUCTIVITY ANALYSER
Installation of the sampling cabinet, analyser cabinet at locations shown in the layout drawings, connecting the sample tubing as per the drawings, and terminating the cables etc shall be done. Manufacturer's instruction manuals shall be strictly followed for the installation and functioning of the analyser.

11.10.0 INFRARED ANALYSERS.
Work involved is same as item 11.9.0

11.11.0 PARA MAGNETIC O2 ANALYSERS
Work involved is same as item 11.9.0

11.12.0 NOX ANALYSERS
Work involved is same as item 11.9.0

11.13.0 SO2 ANALYSER
Work involved is same as item 11.9.0

11.14.0 ZIRCONIA PROBE FOR O2 ANALYSER
Work involved is same as item 11.8.0

11.15.0 ONLINE GAS CHROMATOGRAPHY
Work involved is same as item 11.9.0

12.0.0 **MISCELLANEOUS INSTRUMENTS**

12.1.0 HYDROCARBON DETECTOR

12.1.1. The scope includes fixing of the detector on a pedestal downstream of local wind direction such that the gases to be detected are facing to the element. The installation of canopy shall not keep the wind away from the detecting assembly. The associated cabling and termination shall be as per the drawings released by FEDO.

12.1.2. The elevation of the detector shall be such that for detection of heavier gases (Compared to air) the instrument shall be located above the point of leak source. Similarly, for detection of lighter gases, the instrument shall be mounted below the point of leak source.

12.1.3. Where line of sight gas detectors are specified, their installation, alignment etc shall be strictly as per vendor's instruction manual. For transmitter-receiver type or transmitter-reflector type instrument, the line of view shall be free of obstructions and frequent passage ways of man/ machinery. The cabling of both the transmitter and receiver will be in the scope of the contractor.

12.1.4. For detection of toxic gases, the instrument shall be located as near to the point of source as possible for faster detection of leaks.

12.2.0 HEAT/ SMOKE DETECTOR

12.2.1. These types of instruments are normally located inside buildings. The installation of these instruments shall be as per relevant NFPA standards. The scope shall be generally same as in 12.1.0 except that these instruments are either ceiling/ wall mounted.

12.3.0 FLAME DETECTORS

12.1.1. Fixing the detecting element in such a way that direct flame and heat will not damage the instrument.

12.1.2. Mounting the preamplifier/ relay units inside a dust tight metal enclosure or local panel supplied by others.

12.1.3. Interconnecting cabling between the detecting element and the relay.

12.4.0 VANE ACTUATORS

12.2.1. Supervision of installation of the vane actuator carried out by mechanical contractor and to ensure that the same installed as per manufacturer's recommendations.

12.2.2. Termination of tubing and wiring on to the positioners, air set, I/P converter etc of the actuator.

12.5.0 SUCTION PYROMETERS

12.3.1. To install the suction pyrometer assembly on to the flange nozzle of the furnace using proper gaskets, bolts and nuts, supplied by the owner.

12.3.2. This is to be connected by proper compensation/ extension cable up to the junction box.

12.3.3. Provide necessary tubing with required fittings for air connection to the ejector of the suction pyrometer.

12.3.4. Cabling for suction pyrometer will be similar to thermocouple.

12.6.0 ACTUACTOR OF CONTROLLED VOLUME PUMPS

12.4.1. The control volume pump will be installed by machinery contractor. Instrument contractor shall supervise the installation work and ensure that the same is installed as per manufacturer's instructions/ recommendations.

12.4.2. Provide the termination of signal cable (4-20 mA signals) and also tubing for all connection to the positioners unit and the actuator.

12.4.3. Generally the scope of work will be similar to control valve.

12.7.0 OPERATION BOX

12.5.1. This is required for the local operation of bagging machines etc. This houses the push buttons and lamps required for the operation of bagging machine.

12.5.2. Instrument erection contractor shall install the operation box properly on a suitable structure nearby using brackets if required. Provide termination of all incoming and out going cables to the operation box as per the wiring scheme of bagging machine supplier.

12.8.0 MOTION DETECTOR

This is Small electronic instrument provided with mounting socket, similar to a relay. Contractor shall mount the motion detector inside a housing provided by purchaser and terminate all incoming and outgoing cables as per manufacturer's wiring scheme.

12.9.0 I/P CONVERTERS + POSITIONERS & E/P POSITIONERS

Mounting I/P converters on separate supports wherever necessary, making the electrical and pneumatic connections.

13.0.0 JUNCTION BOXEs, PDBs, MBs

13.1.0. ELECTRICAL JUNCTION BOXES, PDB'S, MB'S AND TERMINATION BOXES

13.1.1. Fabrication of necessary supports and welding it on the available structures or grouting on to the floor including the civil work connected with it. Mounting the junction box, connecting the individual cables and multicore cable using cable glands and terminating the wires. All the electrical wires shall be identified using the cable marking ferrules. For termination boxes, only one cable entry and outlet is required. All other holes shall be blinded with suitable plugs.

13.1.2. Where cable runs are underground, junction boxes, marshalling boxes etc shall be mounted above grade at convenient height for easy access.

13.1.3. If the wiring is over-head, JBs/ PDBs/ marshalling boxes shall be mounted a few feet above grade for easy access. Care shall be taken to ensure safe working conditions.

13.1.4. Where wiring must enter the top of JBs/ PDBs/ marshalling boxes, it shall be brought near the bottom of the box and then back up to terminals. Forming a drip loop near the bottom of the JBs/ PDBs/ marshalling boxes.

13.1.5. JBs/ PDBs/ Marshalling boxes shall be mounted suitably such that they do not hinder works like movement of personal around the plant, removal of equipments like heat exchanger shell tubes .etc.

13.2.0. RTD JUNCTION BOXES

Work involved is same as item 13.1.0

13.3.0. TERMOCOUPLE JUNCTION BOXES
Work involved is same as item 13.1.0, except that compensating cables are used instead of electrical cables.

13.4.0. A.C. POWER DISTRIBUTION BOXES
Work involved is same as item 13.1.0, except that the distribution box houses isolation switches and fuse units for distributing 110VAC power to field instrument.

13.5.0. ENCLOSURE FOR INTRINSIC SAFE BARRIERS
Work involved is same as 13.1.0, except that the contractor shall mount I.S barriers inside the enclosure and the incoming and outgoing cables are to be glanded and terminated.

14.0.0 CONTROL PANELS

14.1.0. The control panel is pre-wired, and pre-tubed, all the wire and tubes being terminated to the respective terminal blocks, and bulkheads respectively. Instrument contractor shall undertake the installation of panels, mounting the instruments on the panel and execute all the termination of wiring & tubing at the back of the panel.

14.2.0. Instrument erection contractor's scope shall include but not be limited to the transportation, calibration / testing, loop-checking etc, of all the panel mounted instruments. However, if the contractor has to under take some of wiring and tubing which are found necessary at a later stage for which they have to indicate the cost of the wiring / tubing per meter basis the materials will be supplied by the purchaser.

14.3.0. The local control panels shall be mounted as per instrument location and cable routing diagrams, IADs/ GADs. All the wires and tubes shall be terminated as per instruction manual from manufacturer. Foundation for panels and racks shall meet the requirements of the equipment vendor's specifications.

14.4.0. Panel shall be located to allow easy access and operation and to permit operator to survey the maximum panel area, panels shall be arranged and located for easy reading, servicing and maintenance of equipments and panels/ cubicles. Air purging shall be used whenever necessary for environment reason as well as electrical safety. Panels shall be removed from racks only when ready for installation. Hooks shall be used while lifting and moving the panel. Welding shall not be done on the panel at site for supports etc. Panels shall not be used as earth as it may damage the electronic instrument. Proper earthing for the panel shall be provided separately; otherwise it shall be connected to the main earth of the plant.

15.0.0 **FABRICATION WORK AND MOUNTING OF INSTRUMENTS**

15.1.0 FABRICATION WORK.

15.1.1. Instrument contractor shall fabricate different steel structures supplied to him as per drawings. Unit rates shall be applicable as shown in bid item. Minor civil works like chipping, grouting, etc, shall form part of fabrication job. Consumables like welding rods and gas shall be included in the fabrication cost.

15.2.0 INSTRUMENT AIR LINES

15.2.1. Piping contractor will terminate main instrument air header lines on the pipe bridge with first isolation valve for branch lines for instrument air distribution.
The fittings will be welded type and pipes will be galvanized carbon steel type. Contractor's scope includes installing, testing and commissioning of these lines.

15.2.2. 316L PIPES /316SS PIPES, CARBON STEEL PIPES
Welding of instruments' impulse lines using pipes shall be done by qualified welders as per the standard welding procedure.
NOTES ON MOUNTING OF INSTRUMENTS

(a) Mounting of all accessories of field-mounted instruments such as manifolds, air sets, condensate pots etc wherever applicable, are included in the installation of the instruments and no extra shall be paid for their accessories.

(b) No field mounted instrument shall be installed with support from impulse piping/ signal lines.

(c) Hand rails shall never be used for mounting or supporting instruments.

(d) Instruments shall be mounted on pedestal fabricated using base plate and 2" pipe of about 1.5meter height.

(e) All field mounted instruments shall be mounted at grade or on platform.

(f) If pedestal is installed at paved area, it shall be fixed to the concrete paving with anchor bolts

(g) If ground is unpaved, a concrete base shall be provided for the pedestal. Pedestals mounted on the top of platforms or process piping shall be removable.

(h) The instruments shall be mounted on pedestals using "U" clamps, nuts and bolts or as per installation drawings given by engineering department or vendor.

(i) Pedestal shall be painted to protect from corrosive atmosphere and weather conditions.

16.0.0. **GENERAL NOTES FOR INSTRUMENT PIPING AND TUBINGS**

16.1.0. The sizes of the piping /tubing and also their materials of construction are decided by the designer of the instrumentation and control system.

16.2.0. Instrument tubing (mainly SS) shall be cut using only the standard cutter. Use only fine sand–paper for polishing the outer edge of the tubes after cutting. Never use a file or grinder. Any burr or scratch will not make a good tight–fit when joining the tube with compression type couplings. After tightening, softly remove the joint and inspect for the uniform closure of the ferrule on the fitting.

16.3.0. Where tubing is adjacent, clearance between them near the coupling portion shall be at least 10cm for easy maintenance.

16.4.0. The pipes shall be supported on angles using proper U-clamps.

16.5.0. Pipe lines (for impulse lines) shall be bent only after sand filling and heating and using a bending tool, otherwise, it will kink and become weak.

16.6.0. Always avoid sharp bends. Use only smooth bends wherever necessary.

16.7.0. Give proper support for the piping for drawing out purpose.

16.8.0. When using pipe connector or couplings, adequate space for spanner head shall be provided.

16.9.0. When brazing or welding two pipe ends, care shall be taken to see that the adjacent pipes/ vessels are not affected by this heating.

16.10.0. For 'reference drawings' list refer to document control index.

16.11.0. All instruments on instrument piping details and other instrument drawings are shown symbolically. For true picture and location of connection refer to vendor's drawings.

16.12.0. Instrument connection block valves on lines, orifice flanges, vessels and equipment are to be in accordance with the specification of the line, vessels or equipment to which they connect and that are furnished by the piping division.

16.13.0. Field contractor shall relieve strain from all connections by properly supporting all pots, leads and instruments. Refer to "typical instrument support details" and standard drawings attached.

16.14.0. Instrument pressure leads and flow meter leads are to be sloped 1 in 12 minimum in horizontal runs, except that long pressure instrument leads carried on racks through the yard may be run horizontally, but without pockets, together with pneumatic leads.

16.15.0. When a pressure lead rises above the pressure connection and the instrument it serves a minimum slope of approximately 1 in 12 from high point of the lead toward the pressure connection and the instrument must be maintained.

16.16.0. 'Field' contractor shall provide sufficient flexibility for pressure leads and pneumatic leads to allow for thermal expansion of vessels, lines or equipment to which they connect.

16.17.0. Use bends in all pressure leads and keep threaded joints to a minimum.

16.18.0. Bends in tubing for pneumatic leads are to be kept to the absolute minimum required.

16.19.0. All pressure leads and pneumatic leads to and from instruments are to be thoroughly cleaned of burrs and foreign matter before being put into operation.

16.20.0. All pressure/ level instruments in wet service are to be corrected for liquid head pressure.

16.21.0. Instruments, instrument pressure leads, flow meter leads and pneumatic leads shall not be mounted on, nor supported from platforms, railings, steel supports, equipment and process or utility lines that are subject to abnormal vibrations, particularly vibrations caused by reciprocating machines, unless absolutely necessary. Additional bracing and / or supports shall be provided for instrument and instrument leads to assure rigidity under such abnormal conditions.

16.22.0. Where rack is not provided, pneumatic leads [generally 3 or less] shall, be strapped to air headers or branches.

16.23.0. Elevation shown in instrument locations and air supply header drawings are to bottom of piping unless otherwise noted.

16.24.0. The quantities given in the bill of materials for pipes and tubes are for straight pieces only. Installation of fittings like elbows, tees, valves condensate pots etc. shall be included in the cost of erection and no separate charges will be applicable for these items.

16.25.0. Locations and facing of instruments shall be adhered to as closely as possible.

16.26.0. Air supply piping will be supported on existing steel. 'Field' contractor shall provide additional steel wherever required.

16.27.0. 'Field' contractor shall provide all materials required for mounting and supporting instruments, Instrument pots, piping etc. Refer to "typical instrument support details" drawings.

16.28.0. Unless otherwise noted, pedestal type mounted transmitters, indicators, recorders and controllers shall be located with the center line of the instrument 1.3M above grade or platform.

16.29.0. All elevations given are based on the grade elevation indicated on the lay out drawings.

16.30.0. All tube fitting shall be used as specified in instrument hook up &layout drawings. The contractor shall ensure material, dimension and physical condition of all items before putting them into service.

16.31.0. For D/P transmitters with capillary extension, the capillary tube shall be insulated using glass wool with aluminum cladding as indicated in the instrument application diagrams.

16.32.0. Welding as per the standard procedure /specifications shall be followed. Any pre heating/ post-weld heat treatment shall be done wherever required as per standards.

16.33.0. All pipe lines shall be thoroughly checked for cleanliness and moisture before and after installation.

16.34.0. After testing, all C.S pipes shall be epoxy painted.

16.35.0. The take off points shall be from top of the header.

16.36.0. While brazing or welding two pipe ends, care shall be taken to see that adjacent pipes /vessels do not get affected due to heating.

16.37.0. Even when dryers are supplied to keep the air dry, a drain shall be installed at low point(s) in the system to provide drainage.

16.38.0. No bends, scratches or cuts shall be made on any of the enclosed tubes, as these will be points of potential failure.

17.0.0 **GENERAL NOTES ON TERMINATION, ELECTRICAL INSTALLATION AND GROUNDING**

17.1.0 TERMINATION

17.1.1 Wires of cable shall be cut as it comes off the reel at location free from sharp objects.

17.1.2 Jacket shield material shall be terminated without cutting insulation underneath. If no pair jackets is used and pair are individually shielded then insulating tape or sleeving shall be applied to exposed shielded in order to protect accidental grounds.

17.1.3 All cable ends shall be protected against moisture entry prior to connecting the cables to its permanent terminations.

17.1.4 Stripping of insulations from wire shall be done without cutting the conductor. Standard stripping tools of proper design shall be used.

17.1.5 Screws shall be torqued adequately to get good contact with wires inserted under the screw.

17.1.6 Proper compression of terminal screws shall be done to prevent corrosion which may later cause poor continuity, galvanic, or rectification action .High quality-terminal strips and insulating materials shall be used.

17.1.7 All wires or leads terminated at connection shall have sufficient slack to reduce the effect of vibrations.

17.1.8 Necessary cable supports shall be provided to avoid having cable weight support from wire terminations.

17.2.0 ELECTRICAL INSTALLATION

17.2.1 The equipment erection and their installation shall confirm to the latest Indian electricity rules and Indian Factories Act, as regards safety, earthing and other essentials provisions specified therein form installation and operation of the electrical part of the instrumentation loop.

17.2.2 Fittings switches, distribution boards, junction boxes etc for electrical lines shall be installed at places indicated in drawings.

17.2.3 The cable termination shall be done using solderless crimping type closed eyelet connectors [contractor's supply].

17.2.4 Cables carrying 110 volts or above shall not run in same conduit, metal or PVC ducting, trunking or trays as cables carry lower voltage.

17.2.5 Cables carrying alternative current shall not be run in the same conduit, metal or PVC ducting trunking or trays, as cables carrying direct current unless agreed to the owner in writing. There shall be a minimum separation of 200mm between trays carrying these signals.

17.2.6 Laying of earth, conductors fixing on cable duct /tray structural, clamping/ jointing by brazing wherever necessary, testing and commissioning including supply of earth conductors, crimping lugs, bolts, nuts, washers etc and supply and installation of earth pits as per drawings.

17.2.7 Where cables are run through pipes, the entry to and exit from pipes shall be smooth and free from burrs. Cables shall be pulled into such pipes in such a way that there is no damage to the cable.

17.2.8 Where space is left in pipes for cables to be pulled in at a later date, a galvanized draw wire of adequate size shall be left in the pipes.

17.2.9 There shall be no intermediate joints in any cable. Joints shall be made only at terminals in instruments or approved equipment.

17.2.10 Temperature compensation cables, alarm and trip system wires shall be run in conduit or on cable tray as specified on drawings.

17.2.11 Elevations shown for horizontal conduit /tray runs are the elevations of the platforms, steel or piping from which these are to be supported. Contractor shall provide any additional supports if required.

17.2.12 Vertical conduit /tray runs at structures shall be supported from ladders unless otherwise noted.

17.2.13 Location and elevation of conduit /cable tray run may be changed when necessary to avoid interference.

17.2.14 Cables shall be located at minimum distance of 300 mm from hot piping or equipment.

17.2.15 Vents and drains shall be furnished at high and low points in conduit runs. Conduit shall be sloped towards drain fittings.

17.2.16 All sealing fittings shall be dammed with fiber and filled with sealing compound after wiring is completed.

17.2.17 The 24V/ 110V alarm, control and instrument power wiring shall be run in conduit/ cable trays from local instruments to centrally located terminal boxes. Wires shall be copper single conductor, PVC insulated rated 600 V.

17.2.18 Conduits/ cable trays in main runs shall be supported on a suitable steel rack.

17.2.19 Minimum size of conduit shall be 20 mm and that of cable tray shall be 50mm.

17.2.20 All the spares wire shall be tagged and placed in convenient place or terminated suitably.

17.2.21 All cables shall be tagged with Aluminium laminating plates at every 30m, at every crossings (Pipe bridges/ walls) etc.

17.3.0 GROUNDING

17.3.1 All exposed metallic parts that could become energized with hazardous potentials shall be reliably connected to the equipment grounding circuits.

17.3.2 On complex inter-connected instrumentation networks caution shall be exercised when grounding the circuit to ensure that multiple grounds are not established.

17.3.3 Cable screen shall be earthed at only one point near the control room.

17.3.4 All instrument grounds shall be checked for same potential if tying between instrument circuit grounds to the same earth electrode beds that are used for power grounding is done.

17.3.5 All the spares conductors in a multicore cable shall be grounded to avoid induction of large voltage surges on signal circuits when near by lightning strikes occur.

17.3.6 Shields or signal wires shall never be left unconnected, grounded indiscriminately, connected to their signal pair at two more points or tied to other signal leads.

17.3.7 Instruments, junction boxes, cable gland plates shall be properly earthed whenever applicable.

18.0.0 **GENERAL NOTES ON CABLES ON TRAYS, DUCTS AND CONDUIT INSTALLATION**

18.1.0 Changes in direction of cable trays/ cable ducts shall be achieved by use of cable tray bends and tee pieces or by efficient clampings. For cable trays, generally available supports will be used for routing. But whenever it is not available.

Contractor shall make necessary supports for routing the cable trays/ cables ducts

18.2.0 Main cables shall be laid through cable ducts. Contractor shall provide proper covers after installation of all the cables inside the duct. In case of new cables are laid in existing ducts, contractor shall uncover and re-fix the covers as necessary.

18.3.0 All pneumatic tubing and electrical cables shall be clamped on the cable tray at intervals of not more than 500mm.

18.4.0 Grease shall be applied to all machine bolts before tightening. Necessary grease shall be supplied by contractor. Cable tray &cable ducts shall be fixed on structural supports fabricated at site by contractor.

18.5.0 Contractor shall fabricate at site, suitable bends, tees, crossings etc and shall supply/ fabricate required clamps from sheets/ strips for the trays and ducts wherever required according to the routing requirement. The cables taken along trays /angles alone will have to be clamped. The cable inside the duct shall be neatly arranged. This shall also include laying under ground cables through the trench wherever required.

18.6.0 The quantity given in the bill of materials for cable trays, cable conduits and cable ducts are for straight pieces only. Installation of fittings like bends, tees, reducers etc shall be included in the cost of erection and no separate charges will be applicable for these fittings. Fire resistant materials/ coatings as specified shall be applied on the cable trays/ ducts at locations where fire proofing is required.

18.7.0 Trays are not designed as walkways or hoisting beams and persons shall be advised not to use them as such.

18.8.0 All runs of ducting and conduits shall be mechanically and electrically continuous. Running threads shall be secured by lock nuts.

18.9.0 Underground conduit banks which cross beneath roadways, railways or other areas subject to heavy loading or having poor soil conditions shall be adequately supported or the envelope reinforced using concrete cover slabs to prevent shearing, crushing or damage from uneven settlement.

18.10.0 All underground runs in process plants shall be clearly marked for run location and identified using pointer marks and service identification signs as per the installation standards.

18.11.0 Cable conduit shall be supported from at least every 1.5 meters. Supports shall be tack welded to conduits.

18.12.0 Conduits shall not be supported from piping -that may have to be replaced or removed for inspection-, or from high temperature piping.

18.13.0 Conduit runs shall be solidly connected to assure continuity in their entire length. Ground jumbers shall be installed where physical condition cast any doubt as to the required electrical continuity.

18.14.0 All underground conduits shall be arranged in banks and should have protection and identifying concrete envelop.

18.15.0 Conduit banks shall be installed about 2 feet below grade, 12” below drainage ditches in process areas, or below the frost line, whichever is deeper.

18.16.0 The ends of cables shall be properly sealed before pulling, to prevent moisture and damaging substances from entering.

18.17.0 Cables normally shall be pulled directly from a shipping reel placed on a cable puller into position in the tray. Cables shall be taken out from drums using cable puller only, to avoid twisting and subsequent damage of outer sheath of cable. The cable puller shall be either fabricated or supplied by the contractor. Small, cables (2’and smaller in diameter), can be laid with a basket grip. The pulling tension shall not exceed the cable manufacturer’s recommendations. Pulley, rollers, etc shall be used to guide the cables into positions in the tray.

18.18.0 Specific care shall be taken while installing special cables like co-axial cables as electrical characteristics may change due to improper handling.

18.19.0 Care shall be taken to see that there are no kinks or loops that may scrape the edges of conduit fittings, cover plate surfaces and edges etc and result in damaged insulation and even broken wire.

18.20.0 Covers on tray shall be used to prevent accumulation of dirt, debris, snow, ice, etc.

18.21.0 A minimum of 5 feet clearance shall be present between noise generating

equipments and cable tray on which signal cables will be laid.

18.22.0 Cable trays shall be run with the breadth of the tray in a vertical plane. Where FEDO's site engineer agrees that a vertical run is not possible, a short horizontal section shall be used, but the run shall revert to the vertical plane at the nearest point.

18.23.0 The contractor's scope shall include cable laying harnessing/ dressings, clamping on trays, making Aluminium tags with cable numbers punched on the cable before entering the instruments, junction boxes or control room. The tags may be tied to the cable using PVC insulated GI/ SS wires. PVC marking ferrules [contractor's scope of supply], shall be used at the termination end of the cables. All single /multi-core tubing/ cables connecting the field instruments /junction boxes with bulk heads/ junction boxes of control panel are to be laid on cable trays and properly clamped at intervals not exceeding 1000mm on horizontal runs and 300mm on vertical runs.

19.0.0 CIVIL WORKS

All civil works such as grouting, chipping of the wall /concrete floor as required for some fixtures of instrument, cable racks, instrument pedestal etc will have to be undertaken by the contractor. All the chipped areas shall be re-plastered to attain the same finish as before. For opening up walls at any place, prior permission shall be obtained & the same shall be closed neatly after completion of said work to the same specification & finish as before such a work was undertaken.

20.0.0 CALIBRATION AND FUNCTIONAL CHECK

Instrument contractor shall possess all relevant test instruments and shall test the installation in the following manner in the presence of site engineer.

20.1.0 All pneumatic signal lines shall be disconnected and blown through with instrument air.

20.2.0 The signal lines shall be blanked off and pressurized pneumatically using bubble bottle to 1.5Kg/cm2. The bubble rate after pressurizing shall be less than 1 bubble in ten minutes.

20.3.0 All instrument air mains shall be isolated from the instrument and pressure pneumatically 1.5 times maximum working pressure and isolated from the source of pressure. The pressure shall not fall by more than 0.1Kg/cm2 in ten minutes.

20.4.0 All the impulse lines shall be isolated from the instrument, and hydraulically tested to 1.5 times the working pressure and isolated from the source of pressure. The pressure shall not fall by more than 0.1kg/cm2 in ten minutes.

20.5.0 All the installation will have to be checked and tested by the method of simulation for working of entire Instrumentation loop and its circuits to include the relevant, primary, secondary and control elements.

20.6.0 All RTD electric and electronic instrument wiring shall be tested for resistance between conductors and earth for 500V DC. These tests shall be carried out with all conductors disconnected except from the test instruments. The insulation resistance shall not be less than 10 mega ohms.

20.7.0 Transmitter's connections to the correct receiver and polarity shall be checked.

20.8.0 Controller connections to their correct control devices shall be checked.

20.9.0 Correct connection of pneumatic and electric switches shall be checked.

20.10.0 Correct operation of alarms and functioning of interlocks shall be checked. This testing shall be in co-ordinate with site engineer.

20.11.0 The written results /certificates of all tests [loop tests and group tests] shall be approved by site engineer in writing.

20.12.0 Reasonable evidence of the satisfactory conditions of the test equipment shall be provided, if required.

20.13.0 All errors of faulty workmanship regarding the installation discovered during the testing shall be corrected.

20.14.0 All pneumatic, electro-pneumatic and electronic transmitters, indicators and recorders shall be calibrated, taking eight check points throughout the instrument range. Four each shall be taken on the upscale run and downscale run.

20.15.0 Contractor shall have signal sources and other precision calibration equipments for all pneumatic and electronic instruments as per the instrument list given. The ranges of the instrument shall be set as per the specifications. The instrument shall have required characteristics throughout their range as per

specifications within the tolerance. Any deviations shall be brought to the notice of engineer in-charge. Contractor shall undertake any minor repairs of instruments found necessary, as part of calibration work. However such work may be under taken only with consent of the engineer in –charge.

20.16.0 Precaution shall be taken to see that no instrument is subjected to overloading or unwanted signal is supplied to the instrument.

20.17.0 Calibration work shall be undertaken only after studying the instruction manuals and other special instructions from manufacturer's regarding each instrument.

NOTE:

a. All hydraulic test fluid shall be drained off from the impulse line when hydraulic test is over.

b. All impulse line shall be blown off using instrument air before testing.

c. For float type level instrument the test pressure shall be the rated pressure.

20.18.0 Procedure for testing and checking of instruments is provided in Annexure-B.

20.19.0 To identify the stage of inspection done, small label with different colour shall be attached on the field instrument as follows:-

a. Bench calibration
b. Pressure test flushing of impulse line
c. Electrical test (megger continuity etc.)
d. Blowing in air supply.
e. Loop checking.

20.20.0 SMART transmitters shall be configured using HART calibrator. All functionality to be simulated and verified, prior to taking up installation/ put up with plant.

21.0.0. **TESTING AND LOOP CHECKING**

21.1.0. TESTING

21.1.1. For analog instruments testing of wires shall be done after installation to verify freedom from grounds.

21.1.2. After all connections are given the complete loop shall be checked for satisfactory performance.

21.1.3. Where meggers are used, care shall be taken not to use a voltage in excess of the insulations rated voltage.

21.1.4. While testing the wires, all the instruments shall be disconnected to avoid damage to the instruments.

21.1.5. Wire to wire and wire to ground resistance shall normally not exceed 10Mohms in most applications.

21.1.6. The shield drain shall also be tested for accidental shorts or grounds as just another conductor requiring high resistance to ground.

21.1.7. Grounding circuits shall be tested for resistance low enough to operate over-current devices incase a ground fault occur within the instrument.

21.1.8. Instrument erection shall be considered 100% complete only after all the checks as indicated below are complete.

21.1.9. All instrument loops are to be checked for compliance of the installation drawings. Wherever possible signals are to be simulated at the transmitter end and shall be followed at the indicator / controller/ alarm/ interlock components up to the final control element. Loop check shall be carried out by simulation of signals from transmitter end at minimum four points, 25%, 50%, 75% and 100%, all defects such as leaks at the instrument process piping / tubing, instrument air lines/ fittings etc insulation/ connection faults at electrical wirings shall be rectified to the satisfaction of the owner. All the calibration variations, misalignment of linkages of final control element are to be rectified.

21.1.10. All the joints in the air lines and pneumatic signal lines are to be tested for leaks using soap solution. All checking shall be done as per the general notes on wiring & tubing.

PART C- JOB COMPLETION REQUIREMENTS

22.0.0. COMPLETION OF ERECTION JOB

The completion of the entire job on instrumentation will be considered in following three major stages and the payment will be accordingly made subject to the other commercial terms.

a. 60% of the job will be considered completed when erection of the instrument material is mechanically completed.

b. 20% of the job will be considered completed on completion of checking and calibration of individual instruments.

c. 20% of the job will be considered completed after loop checking of instruments.

22.1.0. MATERIAL RECONCILATION/ WASTE ALLOWANCE

The contractor shall plan and execute the work in such a manner that wastage of materials shall be limited to minimum. The contractor should take precaution to ascertain the actual route and lengths required before laying of cables and tubes so that the lengths of cut pieces are kept to the minimum possible and not exceed 0.5% of total Qty, for cables and SS tubes. As far as possible, total wastage /scrap which cannot be accounted for in receipt, consumption return statement should not exceed following % allowances item wise. Items supplied by the owner as free issue shall be returned to store with proper return notes. He shall also furnish reconciliation statement for their material supplied to him. The Work will be deemed incomplete without submission of proper material reconciliation report. The responsibility of submitting 'material reconciliation report' without any delay towards the end of the job lies solely with the contractor. The statement prepared by the contractor with proper references of receipts, dates etc should be submitted which will be verified for the total quantum of job carried out and materials / items installed. After checking the three statements with due allowances for wastage /scrap, material statements can be accepted by FEDO/ OWNER/ CLIENT. This marks the completion of the job and final payment will be made only after this activity is completed. Allowances for unaccountable wastage for various categories of material will be as given below

Item	% allowances
Length of S.S. pipes, tubes alloy steel pipes.	0.5%
Electrical cables (3 meter per length of cables or which ever is less)	2%
C.S pipes, Aluminium trays	1%
Structural material	2%
Valves, pipe fittings compression fittings glands etc.	nil
Nut, bolt, gasket material	2%

Note: for wastage over and above the figures indicated, contractor will be charged at the cost of price +overheads + taxes.

22.2.0. QUANTITY VARIATION

Quantities indicated in the bill of quantities are tentative and are likely to vary subsequently. The unit rates shall remain firm for any variations in the scope of work to an extent of +/–25% of total contract value.

23.0.0. **COMMISSIONING AND START UP**

For commissioning and start up contractor shall deploy qualified skilled, semi skilled and unskilled personal at the rates quoted under schedule of labour rates.

The approximate number of personal that would be required is also indicated in the schedule of labour rates. The owner will have option to engage partially, fully or additional personals as required by him and the contractor shall provide the personal at the rate indicated. Actual requirement will be intimated to the contractor at least 15 days in advance. These rates shall be applicable for any additional work done on "labour supply basis" for the entire period of erection.

24.0.0. **BILL OF QUANTITIES AND MATERIALS**

24.1.0. RATES

The rates for installation of instrumentation shall be included for:

24.1.1. Handling, Transportation, care and protection of owner issued equipment and materials from owner's stores to contractor's stores or point of installation.

24.1.2. All installation works, fixing and testing.

24.1.3. Maintaining proper inventory of owner supplied equipments and materials and returning all surplus equipment and materials to stores of owner, after completion of work.

24.1.4. Provision of adequate and proper storage for owner's equipment and materials.

24.1.5. Provision of complete instrument workshop with testing and calibration equipments.

24.1.6. Provision of all installation equipments, tools, scaffolding, workshop, offices and any other equipments and /or appliances necessary to complete the installation, in accordance with the specifications.

24.1.7. All consumable materials other than those separately enumerated in the bid items.

24.1.8. Removal, re-calibration and re-installation of instrument as required during pre commissioning.

24.2.0. MEASUREMENT

24.2.1. As far as possible, all measurement for payment shall be taken from" good for construction drawings 'released for construction and schedules provided by owner.

24.2.2. Only the items listed in the schedule shall be measured for payment. All other labors and activities necessary to complete the installation shall be deemed included in the items in the schedule.
Note. For measurement & billing refer formats 25FT407& 25FT408.

PART D-PROCEDURES AND STANDARDS

25.0.0. GENERAL REQUIREMENTS AND RECOMMENDATIONS FOR PIPE WELDING

25.1.0. SCOPE

25.1.1. This specification covers the requirements and recommendations for welding procedure qualification test and welder's performance qualification test of piping/ instrumentation structural work.

25.2.0. REFERENCES

25.2.1. The following codes, standards and specification in the latest editions as of now shall form a part of this specification unless otherwise mentioned.

a) ANSI/ASME B31.3
b) ASME CODE SECTION IX
c) "SPECIFICATION FOR FABRICATION AND INSTALLATION OF STEEL PIPING".
d) "PIPING MATERIAL CLASSIFICATION"

25.3.0 WELDING PROCEDURE

25.3.1 GENERAL

a) TABLE-1 includes the several kinds of welding procedure.
The contractor or sub contractor who will do the actual welding work for piping shall select the applicable welding procedure for each kind of pipe welding from table-1.
After that the contractor or sub contractor shall prepare the detailed WPS and procedure Qualification record (PQR) in accordance with ASME CODE SECTION IX and obtain the written approval from Owner prior to the commencement of any welding work.

b) If the contractor or sub contractor wants to use other welding procedures not listed in the table-1 the contractor or sub contractor shall submit the detailed WPS and PQR to owner and get the approval before use.

25.3.2 WELDING PROCEDURE FOR CARBON STEEL

a) All pressure retaining welds and attachment welds to the pressure retaining part shall be made by SHIELDED METAL ARC WELDING (SMAW) using low hydrogen type electrode AWSE 7018 except root pass.

b) Root pass of girth butt weld and branch connection weld, where the complete penetration is required shall be made by GAS TUNGESTON ARC WELDING (GTAW) process or SMAW process. For GTAW, filler metal shall comply with AWS ER70S-2, 3, 6 or ER70S-G (TGS-50, KOBE STEEL LTD.). For SMAW, electrodes shall comply with ASW E6010.

c) For small diameter piping (2" & smaller), all GTAW process may be used for all passes.

d) End preparation and root gap shall be in accordance with Fig.327.3.1 of ANSI/ASME B31.3.

e) In case of ASW E 6010 for root pass, minimum 80 degC pre-heating is required for the thickness 1/2" and over.

f) Weld progression for vertical position shall be uphill.

g) When post weld treatment (PWHT) is necessary from the fluid service requirement PWHT conditions shall be as follows.
MATERIAL : Carbon steel.
HOLDING TEMPRATURE : 625+/-25 degC
HOLDING TIME : Min 1 Hr.

25.3.3 Welding procedure for C-1/2Mo Steel (piping material service class).

a) Root pass of girth butt weld and branch connection weld where the complete penetration is required shall be, made by GTAW process.

b) Filter pass and cover pass shall be made by GTAW or SMAW.

c) GTAW filler metal shall comply with ASW ER80S-D2 or ER80S-G (TGS-M, KOBE STEEL LTD.). For SMAW, electrode shall comply with AWS E7016-AI, low

hydrogen type electrode. E7010-AI type (high cellulose type)) shall not be used.

d) For small diameter piping (2"&under), all GTAW process is preferable.

e) End preparation and root gap shall be in accordance with FIG 327.3.1 of ANSI/ ASME B31.3.

f) Weld progression for vertical position shall be uphill.

25.3.4 Welding procedure for austenitic stainless steel, SS TP–304, 304L, 316L, 316SS.

a) Root pass of girth butt weld and branch connection weld where the complete penetration is required shall be made by GTAW process. Root pass by SMAW process shall be prohibited.

b) Filler pass and cover pass shall be made by GTAW or SMAW. For small diameter piping (2" &under), all GTAW process is preferable.

c) Accepted filler metal and electrode shall be as follows:

Piping material	Filler metal (GTAW)	Electrode (SMAW)
TP304	AWSER 308	AWSE 308-16
TP304L	AWSER 308L	AWSE 308L-16
TP316L	AWSER 316L	AWSE 316L-16
316SS	AWS ER 316	AWSE 316L-10

Notes: -

1. For welding electrodes AWSE 308L-16, the maximum carbon content shall be 0.03% (extra low carbon type). At the time of purchasing these welding materials, maximum carbon content shall be specified, because maximum carbon content of normal AWS E308L-16 and AWS E316L-16 is 0.04%.
2. The following are the acceptable materials which comply with the above requirement.

AWS class	Trade name & Manufacturer
E308L-16	NC38EL(K.S.L),WEL 308 ELC(N.W.R)(K.S.L—KOBE STEEL LTD)
E316L-16	NC36EL (K.S.L), WEL 316 ELC (NWR) (NWR—NIPPON WELDING ROD CO., LTD.).

d) End preparation and root gap shall be in accordance with FIG.327.3.1 of ANSI/ ASME B31.3.

e) Weld progression for vertical position shall be uphill.

f) Internal back shielding with pure argon gas (min 99.9%) shall be required during the welding. Back shielding with nitrogen gas shall not be permitted.

g) Maximum inter-pass temperature during welding shall be 150 degC.

25.3.5 Welding procedure for dissimilar metals.

a) Root pass of girth butt weld and branch connections weld where the complete penetration is required shall be made by GTAW process. Root pass by SMAW process shall be prohibited.

b) Filler pass and cover pass shall be made by GTAW or SMAW. For small diameter piping (2" & under), all GTAW process is preferable.

c) Acceptable filler metals and electrodes for various combinations of base metals shall be as follows.

Piping material	C/S	S.S 304	S.S 304L	SS 316L
C/S	-----	ER 309 E309-16		
S.S 304	----------		ER308 E308-16	
SS.304L	----------			ER308 L E308L -16
S.S 316L	----------			

NOTE: for E308L-16 max. Carbon Content shall be 0.03 % (extra low carbon). See note 1 of 25.3.4.

d) End preparation and root gap shall be in accordance FIG 327.3.1 of ANSI/ ASME B31.3.

e) Weld progression for vertical position shall uphill.

f) Internal back shielding with pure argon gas (min.99.9%) shall be required during the welding. Back shielding with nitrogen gas shall not be permitted.

g) Maximum interpass temperature during welding shall be 150 degC.

h) Welding between galvanized carbon steel or zinc rich primer coated carbon steel and stainless steel shall be prohibited to avoid the zinc embitterment crack on the weld and heat affected zone (HAZ).

25.4.0 WELDING PROCEDURE QUALIFICATION TEST

25.4.1. All welding procedure used for the instrument piping construction works shall be qualified or shall have been qualified by the contractor or subcontractor as his responsibility in accordance with ASME CODE SECTION IX and the requirements herein before the commencement of any welding work. If the contractor or sub contractor does not have the procedure qualification records (PQRs) for the applicable welding procedure specifications (WPSs) according to these specification requirements, he shall carry out the welding procedure qualifications tests and shall submit the complete documents as "WPSs & PQRs to owner for approval.

25.4.2. TABLE –2 " STANDARD PROCEDURE FOR WELDING PROCEDURE QUALIFICATION TEST" are the sample of procedure qualification test for each welding procedure listed in TABLE -1
The contractor or sub contractor may modify the test procedure as far as the requirements of ASME CODE SECTION IX and this specification are kept.

25.5.0 WELDER PERFORMANCE QUALIFICATION TESTS

25.5.1 All welders and welding operators engaged in this job are required to pass the performance qualification test in accordance with ASME CODE SECTION IX. The contractor or sub contractor shall be wholly responsible for qualifying each welder and welding operator has enough skill to make the sound welds by using the welding procedure to be used for this job.

25.5.2 TABLE-3: STANDARD PROCEDURE FOR WELDER PERFORMANCE QUALIFICATION TEST" are the sample of performance qualification test for each welding procedure listed in TABLE –1.

25.5.3 The contractor or subcontractor may modify the test procedure as far as the requirements of ASME CODE SETCTION IX and the specification are kept.

25.5.4 Visual inspection during welding and after welding is very important. Therefore the competent welding inspector or welding supervisor who has enough experience for visual inspection of weld shall witness the weld test and judge his capability before guided bend test or radiographic examination.

25.5.5 GTAW welder who passed the carbon steel weld shall not be qualified for stainless TIG welding, even if the No. of ASME CODE SECTION IX is same, but not vise versa.

26.0.0 SPECIFICATION FOR PAINTING WORK

26.1.0 SCOPE
This specification covers the general requirements for painting of instruments /accessories; steel structure's and instrument piping.

26.2.0 REFERENCE

26.2.1. The requirement given in the following specification in the manner and to thee extend indicated therein.

26.2.2. I.S for surface preparation.

26.3.0 SURFACES TO BE PAINTED AND SURFACES NOT TO BE PAINTED

26.3.1 The following surfaces shall be painted in accordance with the painting classes of this specification; -
carbon steel instrument accessories.

26.3.2 Steel supporting structures.

26.3.3 Carbon steel instrument impulse piping.

26.3.4 Other surfaces which are required to be painted for any specified reason.

26.3.5 However the following shall not be painted:-

a. Nonferrous metal, stainless steel or other high alloy steel.
b. Name plates or identification tags.
c. Valve stems or other machined contact surfaces.
d. Galvanized surfaces.
e. Insulation covers.
f. Plastic.

26.4.0 PAINTING CLASSES
The materials or paints specified in the CLASSES A to E are selected on the basis of service conditions. Refer to Annexure-1 for details.

26.5.0 PREPRATION OF SURFACES

26.5.1 General requirements.

a) The surface shall be prepared to dry metal after removing rust ,oil, grease, dust , stain, or other extraneous matter by manual or mechanical cleaning such

as wire brushing grinding ,power brushing ,etc.

b) Wet surfaces due to rain fall, dew-drop and frost etc shall be thoroughly wiped with rags and dried before each painting.

c) Cleaning of wet or soiled surfaces shall be done immediately before application of paint in such a manner that adjacent wet paint surfaces are not damaged by the cleaning operation.

d) Drying of wet surfaces may be expedited by blowing warm air.

e) The painted /primed surfaces shall be dry and clean before application of subsequent coats. Deposits on the primed /painted surface must be cleaned before the application of the next coat.

f) If the painted surfaces are exposed to rain while painting is in progress, the effected paint shall be entirely removed and be repainted after making the surface clean.

26.5.2 Cleaning of surfaces.

a) Cleaning of rolled steel surfaces shall be carried out in the manner that all crevices, corners and edges of sharp steel, joints of steel plates ,especially around bolt heads ,welds beads etc. may be cleaned.

b) Cleaned surfaces shall not be damaged by unnecessary tapings, etc.

c) Where sand blasting is required, the same shall be carried out to SA21/2 grade the sand blasted surfaces shall be painted with in 6 hours after sand blasting.

26.6.0 STORAGE OF PAINTING MATERIALS

26.6.1 Paints, varnishes, thinners or other volatile and inflammable painting materials shall be stored on a 150mm thick layer of sand in well ventilated and detached storage sheds.

26.6.2 Fire extinguishers or sufficient amount of sand shall be placed where readily accessible in case of fire.

26.6.3 'No Smoking " And Other Suitable Warnings Signs , Such as "No Open Flames"," Danger", "Storage Of Inflammable Materials " etc shall be posted , around storage sheds.

26.7.0 MIXING AND THINNING

Mixing and thinning shall be done only at well ventilated places where there are no open flames.

26.7.1. MIXING

Whenever mixing of base paint and additives are involved, such mixing shall be done strictly as per manufacturer's specification/ recommendations.

As far as practical, quantity of mixing shall be sufficient to cover the given section or entire surface of the specific colour.

26.7.2. Thinning whenever required shall be strictly as per recommended ratio.

26.8.0 PAINTING

26.8.1 General requirements.

a) Painting on instrument equipment /accessories and piping shall be done at plant site or at shop as required.

b) Painting shall be performed only in favorable weather conditions. Paintings shall not be performed in rainy, damp, windy, dusty, weather or on the day of such unfavorable weather is predicted.

c) During painting, adjacent surface shall be properly protected from paint splashes. If blemishes or damages occur by accident, they shall be thoroughly cleaned, repaired or replaced.

d) Upon completions of paintings work, all staging, scaffolding, paint containers, etc, shall be removed from the job site and the, premise shall be left clean.

e) Caution signs of "wet paint" shall be posted around the areas where readily visible, until the paint has completely dried.

26.8.2 Methods of application.

a) Painting shall be generally performed by hand brush method. Spray method may be adopted for surfaces likes that of control panels for specified reasons.

b) Whenever hand brush method is employed for painting, painting shall be done in alternate directions from vertical to horizontal or from horizontal to vertical and shall be applied to all edges, corners, crevices, joints, intersections etc.

c) If brush marks, drags, adhesions of brushes bristles, dust or blemishes occur, the surfaces shall be lightly sand papered before further coats are applied.

d) All surfaces that are inaccessible after installation and assembly except for contact surfaces, shall be painted twice that is after first coat, the same is repeated again. The second and final coats are also repeated in same manner.

26.9.0 PRECAUTIONS

26.9.1 Open flames, smoking exposed elements or sources of ignition of any and shall be

strictly prohibited in area where painting is being performed

26.9.2 During painting operation and for a sufficient time thereafter, welding or open flame work shall be prohibited in the adjacent area.

26.9.3 "No Smoking" and other warning panels to read "Caution" "No open flames" etc shall be posted in all areas where and while painting is performed. The sign shall remain posted for a sufficient time after painting has been completed.

26.9.4 Hand lamps, flash lights etc which will cause a fire shall be handled carefully.

26.9.5 Inflammable liquids with a flash point below 40 deg C shall not be used for cleaning purpose.

26.9.6 Where it is practicable, adequate ventilation shall be provided to reduce the concentration of harmful vapours in the atmosphere. Otherwise workmen shall wear vapor-proof mass, rubber gloves etc for protection when he has to work in a badly ventilated place.

26.10.0 INSPECTION

26.10.1. Finished surfaces shall be uniform and smooth, free from mass of drops, ridges, waves, laps, wrinkles, brush marks, and other defects.

26.10.2. Finished surfaces shall be of uniform colour that presents good appearance, without spots, stains, and discolorations.

26.10.3. Inconspicuous parts, such as the corner of build up members, around bolts, undersides and backsides of pipelines, pipe bends and valves etc shall be closely checked so that they may not be left unpainted.

26.10.4. Paint colours for identification purposes of piping shall be checked for correct colour application, if required.

26.10.5. Defective surfaces, if any, shall be cleaned and repainted.

26.10.6. Additional requirements.

a) Any imperfect or damaged layer shall be repainted before the next layer is applied.

b) The field welding for damaged layer shall be repaired before the next layer is applied.

c) Bolts and nuts shall be provided with the relevant priming coat immediately after mounting.

d) Places where field welds are to be provided a section of 50 to 500 mm shall remain unpainted on both sides

26.11.0 TABLES

The tables for class-A to E are given in annexure-A.

27.0.0 INSPECTION AND TEST PROCEDURE FOR INSTRUMENT INSTALLATION WORK

27.1.0 SCOPE

27.1.1. This specification covers the procedure for inspection and test of instruments installation work.

27.2.0 REFERENCE

27.3.0 GENERAL

27.3.1. Inspection and tests shall be performed for the following work items:

a) Instrument pressure piping

b) Instrument electrical wiring and temperature wiring.

c) Instrument signal air tubing.

d) Instrument supply air piping

27.3.2. Test reports shall be prepared for all tests and be submitted to CONSULTANT/ OWNER immediately after tests are completed

Typical report forms will be furnished along with the erection tender or the same may be requested by the contractor to FEDO site in-charge.

27.4.0 INSPECTION AND TEST – INSTRUMENT PRESSURE PIPING

27.4.1 Instrument pressure lead lines between the process isolating valves and the instruments to which they are connected shall be tested. Prior to the test, the following items shall be inspected visually:

a) Whether instruments are correctly installed according to the P&ID.

b) Whether the upstream and downstream connections of the instruments pressure leads line for differential pressure type instrument is correct.

c) Whether adequate slope is provided to instrument pressure lead line.

d) Whether sufficient supports are provided to instrument pressure lead line.

e) Whether correct materials of the correct rating are used for instrument pressure lead lines.

27.4.2 TESTING DESCRIPTION

Instruments with an operating pressure less than 40kgf/cm2g shall be pneumatically tested. Instruments with an operating pressure equal to or more than 40kgf/cm2g shall be hydrostatically and pneumatically tested.

Unless otherwise specified, test shall be performed with instrument connected to the line.

1. Hydrostatic test

a. Test fluid: water.

b. Test pressure.
Normally operating pressure x1.5 or 90% of the maximum allowable pressure of instrument (in the case of pressure instrument, its measuring range), which ever lower.

c. Test procedure (see Annexure C)
After closing the process isolation valves and opening the equalizing valve, if installed, fresh water shall be fed into the pressure lead line. Details are as follows:

Step 1-
Close valves 1, 2, and 8
Open valves 3, 4, 5, 6, and 7
Pump enough water and pressurize system up to test pressure.

Step 2-
Close valves 6, 7
Open valve 8
Confirm that pressure gauge indication does not decrease during 3 minutes.

Step 3-
Close valves 8
Open valves 1, 6 and 7
Then pump enough water to confirm that valve 1 is not blocked.

Step 4-
Close valve 1 &Open valve 2.
Then pump enough water to confirm that valve 2 is not blocked

Step 5
Close valves 1, 2, 3, and 5
Open valves 4

2. Pneumatic test

a.) Test fluid: Air, N2 gas or inert gas.

b.) Test pressure
7 kgf/cm2g or 90% of the maximum allowable pressure of the instrument (in the case of pressure instruments its measuring range), which ever lower, with a minimum test pressure of 1kgf/cm2g. If instrument is not durable to1 kgf/cm2g, test shall be performed with instrument disconnected from the line.

c.) Test procedure (see Annexure D)
After closing the process isolating valves and opening the equalizing valve, if installed, test fluid shall be fed into the pressure lead line. Details are as follows:

Step 1-
Close valves 1 .2
Open valves 3, 4, 5, and 6
Pressurize system up to the test pressure.

Step 2
Close valve 6
Confirm that there is no leak by pouring soap water on each connection.

Step 3
Open valves 1
Confirm that valve 1 is not blocked

Step 4
Close valve 1
Pressurize system again and open valve 2 to confirm that valve 2 is not blocked

Step 5
Close valves 1, 2, 3, and 5
Open valve 4

Notes:-

a) The analyser pipeline shall be tested by disconnecting the lead line from instrument. The test procedure shall be the same as that with process pipeline.

b) Test may be performed separately or together with the test for process piping or equipment.

c) All instrument piping systems shall be cleaned by blowing air or flushing water before and or after the test, all joints which are defective shall be repaired immediately and shall be re-tested by the original test method.

27.5.0 INSTRUMENT ELECTRICAL WIRING AND PENETRATING WIRING

27.5.1. GENERAL
Continuity, identification and cable insulation resistance test shall be performed. Prior to the test, the following shall be inspected visually:

a) Whether instruments are correctly installed according to the P&ID.

b) Whether wire marking and/ or colour coding at terminals are correct.

c) Whether sealing compound or packing is provided as specified at entry of each instrument.

27.5.2. TEST PROCEDURE
STEP.1. Continuity and identification of each wire and continuity of shield wire shall be inspected between the field instrument terminals and the control

panel board terminals by using a telephone, a buzzer, or other suitable means.

STEP.2. Insulation resistance test shall be performed by using a 500 V or 1000V Megger. In this case, the wire shall be disconnected from the terminal both at the field and the control panel.

The minimum resistance value shall be as follows

a) Line to line
b) Line to ground All min 10Mohm
c) Line to shield.

STEP.3. the electricity charged in the wire by the insulation resistance shall be discharged by grounding the wire and then the wire shall be connected firmly to its terminal.

27.6.0 INSTRUMENT SIGNAL TUBING

Continuity, identification and leak test shall be performed as per the instruction of FDEO site-in-charge. Prior to test, a visual inspection shall be made as to whether instruments are correctly installed according to the P&ID.

27.7.0 INSTRUMENT SUPPLY AIR PIPING

27.7.1. GENERAL

Pneumatic test and air blowing of the supply air piping system shall be performed between the first take off valve on the main air header and instruments. Prior to the test, visual inspection shall be made as to whether instruments are correctly installed according to the P&ID.

27.7.2. TEST FLUID AND PRESSURE

Test fluid shall be free of oil, dry air or N2 gas.

Test pressure for air supply pipe from main header first take–off valve to individual instrument air regulators shall be equal to main air header operating pressure.

Short length of air tubes between instrument and its air regulator shall be tested by the set pressure of the air regulator.

27.7.3 TEST PROCEDURE

STEP 1. Air blowing of the system shall be performed by disconnecting air tube at the inlet of the air regulator and opening the shutoff valve. Air blowing shall be done by opening and closing the shut off valve for a minimum of five times until the air system is confirmed to be clean.

STEP 2 the air tube shall be connected again and the shutoff valve shall be opened to pressurize the system. All joints and connections shall be tested with soap solution to facilitate the detection of leaks.

Note:

a) Test may be performed separately or together with the test main air header.
b) All joints & connections found to be defective shall be repaired immediately and shall be re-tested by the original test method.

27.8.0 CONFIGURATION OF SMART FIELD INSTRUMENTS

Normally HART/ FOUNDATION FIELD BUS/ PROFIBUS –DP based SMART field instruments are used. The HART configuration shall be used for verifying / configuration/ calibration checks for tag no, range, engineering units, LRV, URV, alarm settings ,functional blocks, configuration output function, trouble shooting etc. This is applicable with respect to all SMART field instruments, communicating with DCS/ PLC/ SCADA system. Re-ranging, download/ upload from DCS/ SCADA, point data base verification etc shall be carried out for each tag/ transmitter. Cold loop check and hot loop check shall be carried out. Diagnostic functions and communication shall be verified. Also any other functionality required /specified shall be configured.

28.0.0 APPLICABLE STANDARDS

API-RP-550- Installation of refinery instruments & control system

ISA Standard- Standard & practices for installation

28.1.0 OTHER STANDARDS

Inspection & test procedure for instrument installation work

General requirement and recommendation for pipe welding

Installation standards for instrumentation

PART E - ATTACHMENTS

29.0.0 DRAWINGS - ANNEXURE I

The drawings issued for Instrument erection are attached in Annexure I. The drawings provided are only typical and covers almost all type of instruments. All the required drawing will be issued before start of work or progressively during erection. Modification/ deviation (If any) in the drawings shall be informed to engineering department for approval.

30.0.0 SCHEDULE OF WORK - ANNEXURE II

The schedule of work is attached in Annexure - II. The instrument contractor shall follow standard erection procedure and maintain good quality of work. The wastage of material shall be limited to minimum as possible.

31.0.0 ITEMS TO BE SUPPLIED BY CONTRACTOR - ANNEXURE III

The list of items to be supplied by the contractor is attached in Annexure-III. The instrument contractor shall supply the specified items purchased from standard suppliers/ sub-vendors approved by FEDO / OWNER. The items supplied shall be inspected for damages and compliance with specifications given by the engineering department. Any damage and unacceptable variation shall be recorded (Refer 25 FT 403) and brought to the notice of concerned Engineer- in- charge.

ANNEXURE-A

PAINTING SPECIFICATION-SELECTION OF CLASS

Table 1-Painting classes

SERVICE CONDITION	SCOPE OF APPLICATION	SURFACE PREPARATION	CLASS
Ambient. Temp up to 65 deg C.	Instrument accessories such as condensate pots, air headers, instrument pedestals, impulse piping, steel structures etc.	Mechanical power tool cleaning /wire brushing	**A**
Chemical splashing area, mild acid/ alkaline atmosphere. Saline atmosphere			**B**
General use for surfaces 65 deg C to 120 deg C Chemical splashing area particularly Urea, acid/ alkaline atmosphere. Highly corrosive area particularly urea and abrasive environment subject to wind /dripping etc			C
General use for epoxy coatings Highly corrosive and abrasive areas Chemical splashing areas including fluorine Surface at sub zero temperatures			D
120 to 400 deg C			E

1. DETAILED SPECIFICATION OF PAINTING CLASSES

CLASS	Painting	Process	Paint	No. of Coats	Film thick/coat
A	Before shipment at shop	Primer	Red oxide zinc chromate primer to IS -2074	1	20
	At field	Primer	-Do-	1*/2	20
		First finish coat	Synthetic enamel to IS-2932 or Aluminium paint to IS-2339	1	15
		Second finish coat	-Do-	1	15
B	Before shipment at shop	Primer	Red oxide zinc chromate primer chlorinated rubber based	1	25
	At field	Primer	-Do-	1*/2	25
		First finish coat	Chlorinated rubber finished-un modified	1	25
		Second finish coat	-Do-	1	25
C	Before shipment at shop	Primer	Epoxy red oxide zinc phosphate primer	1	25
	At field	Primer	-Do-	1*/2	25
		First finish coat	Epoxy finish paint	1	40
		Second finish coat	-Do-	1	40
D	Before shipment at shop	Primer	2 pack polyurethane primer	1	25
	At field	Primer	-Do-	1*/2	25
		First finish coat	2 pack polyurethane finish	1	40
E	Before shipment at shop	Primer	Heat resistant silicone / aluminium paint	1	25
	At field	Primer	-Do-	1*/2	25
		First finish coat	-Do-	1	20
		Second finish coat	-Do-	1	20

(*) Where primer is applied before shipment, one coat instead of two coats shall be applied.

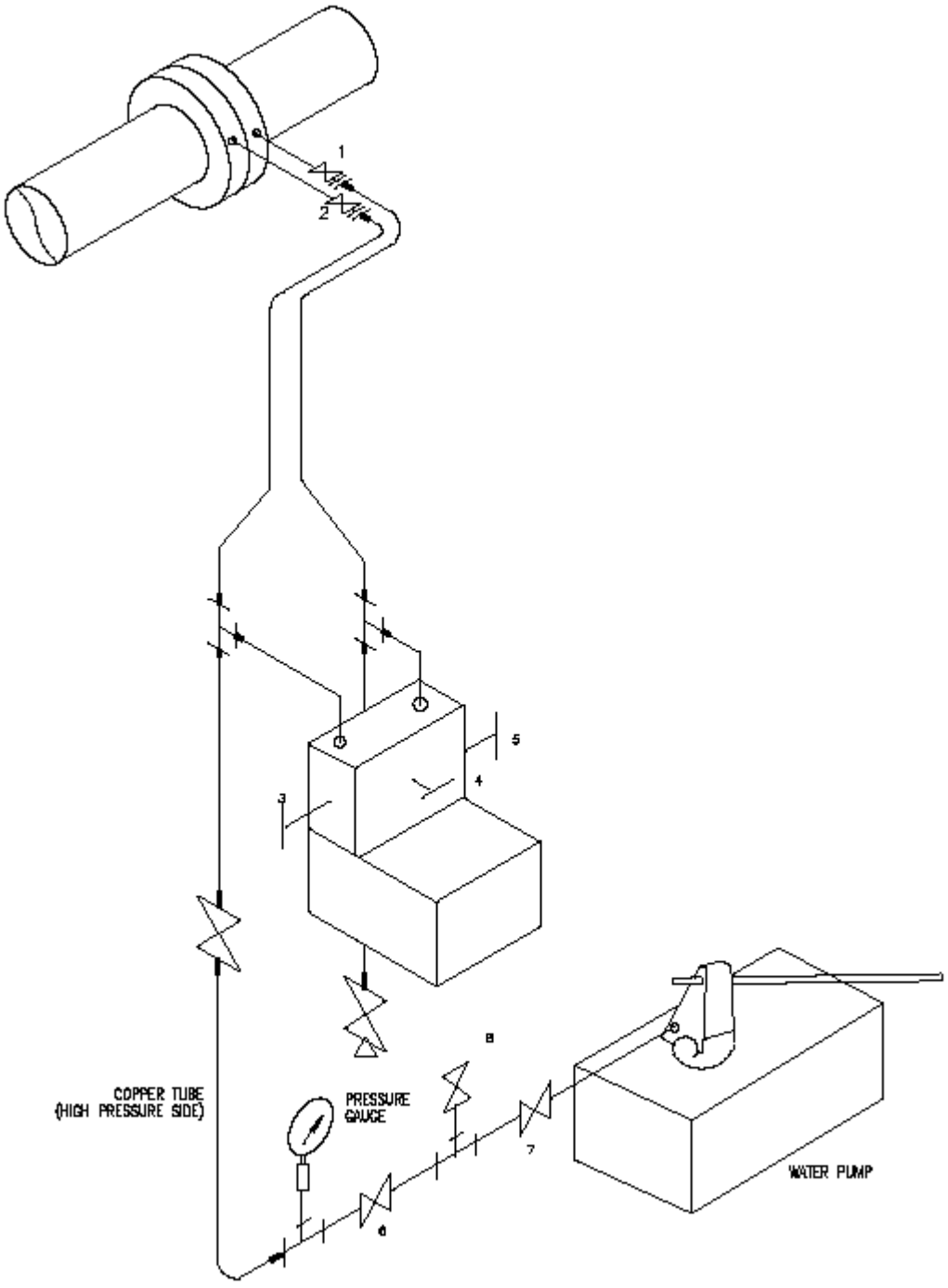
ANNEXURE-B
CALIBRATION METHODS

Pressure vacuum gauge	Dead weigh tester and vacuum gauge test	By comparing with master gauge
Pressure gauge	Pneumatic rig	By comparing with Hg manometer
Receiving instrument (pneumatic)	Using test rigs with accurate gauge	-Do-
Receiving instrument (electronic.)	Using electronic calibrator &test rig	-Do-
Receiving pressure switch	Hydraulic/ pneumatic tester	Check the operation using Multi-meter
Receiver switches	Pneumatic test rig	-Do-
Electronic switch.	Signal generator	-Do-
Dial thermometer & temperature transmitter	Temperature bath with standard thermometer	Checked at various temperature
Temperature switches	Multivolt source or resistance source	Checked increasing and decreasing the value
Vibration /axial displacement system	Bently Nevada testing equipment	This to be calibrated as per manufacturer's instruction. If contractor does not have the instrument, he shall do this on sub contractor under his responsibility by BN Indian agent.
Control valve	Pneumatic /electric test rig	Lubricated stored &checked for smooth operation & hysteresis I/P SOV, limit switch, valve opening &closing time etc to be checked.
Controller	Electronic& pneumatic rigs	Manufacturer's instruction manuals
Temperature indicator	Potentiometer/ decade resistance box	Calibration to be checked giving known input of T/C or resistance and comparing output standard curves.
Differential pressure transmitters Hg manometer	Hydraulic or pneumatic rig output meter (elect or pneumatic)	Output shall be measured using master output gauge.
E/P transducer	Field calibrator standard gauge for Hg manometer.	Checking shall be done by feeding input from field calibrator & noting the output reading.

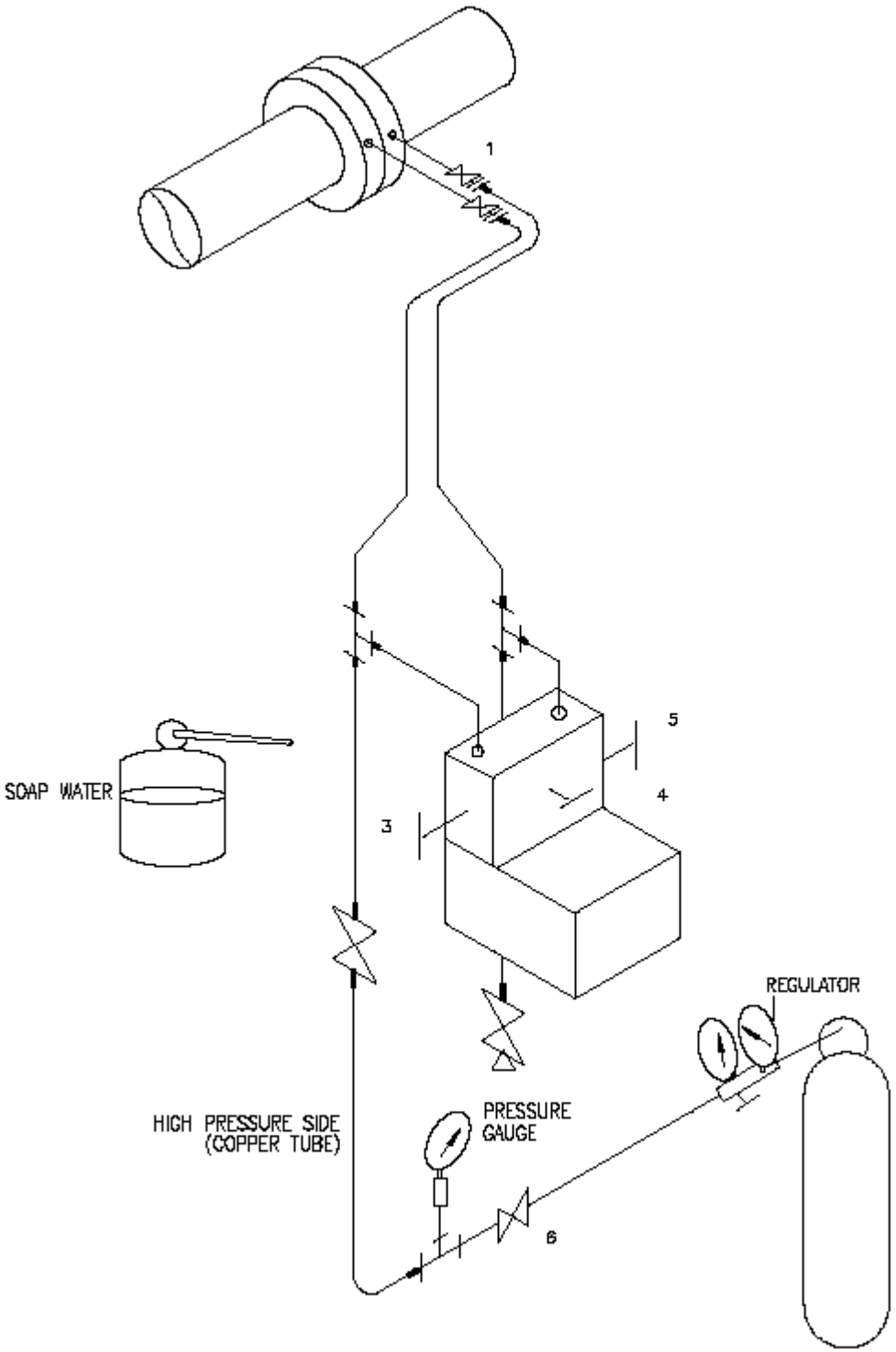
ANALYSERs

O2, H2, CO2 etc.	Zero /span gas &output meter	Calibration shall be checked using zero &span gases &noting the output meter.
PH, conductivity dissolved O2	Solution & output meter	Using these std. solution & output meter, calibration to be checked.

ANNEXURE-C
HYDROSTATIC TEST ARRANGEMENT



ANNEXURE-D
PNEUMATIC TEST ARRANGEMENT



CONTENTS

1.0. INTRODUCTION

This document deals with the requirement of erection of the distributed control systems (DCS)/ Programmable Logic Controller (PLC) or SCADA system. Contractor shall execute the installation work based on the requirements of the purchaser.

2.0. INSTRUCTIONS TO CONTRACTOR.

2.1. Contractor shall handle equipments like computer, monitors, printer, hard copier, disk drives, other electronic devices etc in such a way that they are not subjected to any vibration. The pulley blocks, cranes, trolleys etc shall be designed properly for easy and careful transportation of the equipments from site store to control room. All cases shall be protected from rain, heat and vibrations while transporting. The materials shall not be allowed to remain in open space at site. Before transportation, get the clearance for transportation routes, up to the building in which the devices are going to be installed.

2.2. Contractor shall lay plywood sheets inside the control room floor, to avoid any damage of the false flooring inside the control room until whole installation is done.

2.3. Vacuum cleaners shall be used to clean the control room which shall be provided by the contractor. At least on alternate days control room shall be cleaned. No welding shall be undertaken inside the control room after any of the equipments are taken inside the control room.

2.4. Application of wireless radio sets/ walki-talkies etc operating with a wattage of 3 or more are not allowed within 1 meter of any of the equipments used in DCS/PLC. No equipments /tools that give out magnetic field strengths of more than 50 Gauss shall be permitted inside the control room.

2.5. Contractor shall not bring any toxic or inflammable materials inside the control room.

2.6. Only qualified personal shall be deputed by contractor for the erection of job. All technical personnel assigned by contractor for installation, testing and commissioning of the systems shall have thorough knowledge of the system supplied and in the area of their specialization, with minimum interference to activities being done at site by other departments.

2.7. The contractor shall make his own arrangements for necessary floodlights and other facilities for work on round –the –clock basis.

2.8. The contractor shall be responsible for protection of instruments and instrument accessories during handling /storage/installation.

2.9. Continuity test shall be carried out in all cables before wiring.

2.10. Contractor shall carryout re-touching of painted surface of racks /cubicles, wherever required. Repainting of racks /cubicles shall be carried out by the contractor at his own cost in case of damage to painted surfaces due to bad handling by the contractor during installation. The paint for the purpose shall be provided by the contractor. The contractor must get the paint approved by the engineer in charge before using the same.

2.11. During painting of the racks/consoles see that the instruments /cards inside them are perfectly clean. Daily cleaning of the equipment front as well as interior shall be the responsibility of the contractor till its equipment are handed over to the owner. Nothing extra shall be paid to the contractor for this.

2.12. Keys for various panel doors must be properly tagged and bunched. The contractor shall be responsible for safe custody of panel keys.

2.13. Contractor shall not store any materials inside control room or panel.

2.14. It is assumed that all the sub- components in the various cabinets and the consoles come to the site in assembled (on /inside cabinets) condition. However those components /electronic boards which are supplied loose shall be installed at a site in proper places by the contractor.

2.15. Contractor shall reinforce the site with additional manpower and machinery if found necessary to meet the schedule.

2.16. Contractor shall offer the services for the installation of DCS systems in the control room, laying inter-connecting cables inside the control room, checkout, and test and commissioning the entire system.

2.17. The contractor shall, submit a weekly report in the format to be supplied by FEDO/Owner and details shall consist of the following:-
- Weekly progress, planning and retrieve of activities during the week
- Activities planned and could not be achieved during the week
- Reason for short fall
- Activities planned for the next week
- Required input data/ outstanding data restraining work
- Manpower problems: - manpower reports shall be submitted every Monday or on any other day fixed by purchaser

2.18. Contactor shall depute a senior level planning engineer for the control of the above activities.

3.0. SCOPE OF WORK

3.1. Supply of all materials for fabrication, welding, drilling etc as required.

3.2. Transportation of DCS equipment to the control room from manufactures work site. All the equipments shall be stored in AC room. Room shall be kept clean and dust free.

3.3. Unpacking the different equipments at site and inspection for any damages.

3.4. Transferring the equipments to the respective control rooms.

3.5. Arranging the control rooms suitably (which includes checking the structural, leveling the false flooring area etc.) to mount the equipments.

3.6. Doing the steel structural work for the supporting structure of the cabinets etc.

3.7. Mounting of all equipment in control room under the supervision of purchaser/DCS contractor.

3.8. Mounting of instruments /signal converter, as specified by the purchaser, on the instrument panel.

3.9. Supervision of field cable terminations in the marshalling box.

3.10. Cabling between UPS system to the power supply distribution box.

3.11. Power supply distribution to various racks.

3.12. Cabling between the marshalling box and the DCS-racks /instrument racks/manipulation desk etc, as required.

3.13. Wiring /cabling inside the control room between DCS-racks and operator station.

3.14. Preparation of earth pit and connection of the common earth strip to the pit.

3.15. Earthing of all cubicles, signal shielding and power supply.

3.16. Checking of equipment installation.

3.17. Checking of all interconnections, hardware and software configuration, overall system functioning etc.

3.18. Testing/calibration of control room instruments.

3.19. Testing /calibration of the DCS equipments.

3.20. Field tests

3.21. Loop checking (in coordination with field contractor).

3.22. Commissioning and online debugging of the DCS system till acceptance of the system.

4.0. GUIDELINES FOR SCOPE OF WORK

4.1. Transportation

Before transporting DCS related items, prepare a program /procedure for transportation.

4.2. Loading and unloading.

Contractor/Manufacturer shall carefully load/unload the DCS equipments. Use ropes /wires which meet the standard requirements and which can withstand the weight of the equipment being loaded or unloaded.

4.3. Carrying in

4.3.1. While equipments are being carried inside the control room from out side, make sure that sufficient space is available in the routes.

4.3.2. While transferring the equipments inside the control room, use pipe rollers or trolleys and protect the floor surface by laying plywood or similar type boards on it.

4.3.3. When using a lever, place a strip of wood between the devices to avoid damaging the surface.

4.3.4. For other devices such as operator console, racks etc, their gravity centers shall be considered.

4.3.5. Make the temperature difference between inside and outside of the room into which the devices are carried as minimum as possible, to prevent condensation on the internal and external surfaces of the cabinets.

4.3.6. The gap between the floor or the base and the device channel base is to be properly filled.

4.3.7. Contractor shall clean the control room for all the dust and waste materials before and the after the installation of the DCS. No food or drinks shall be allowed inside the control room. After the equipments are unpacked and kept in position the usage of foot wear inside the control room shall be avoided, to protect the flooring and to keep the room clean.

4.4. Supporting structure for panels

4.4.1. Proper supporting channels shall be used based on the control room equipment layout, dimension and weight of equipment.

4.4.2. Supports for false flooring, channel work for the cubicle shall be done by the DCS erection contractor in co- ordination with civil contractor. Before setting up the devices, check the installation, locations, anchor bolts. Pitting for wiring etc and position them properly. Arrange the equipments properly as per drawings.

4.4.3. The equipments shall be vertical or horizontal as per the drawings given by vendor /engineering department.

4.4.4. No anchor or lock bolt shall be missing, and all these shall be adequately tightened.

4.4.5. No tools shall be left inside the panels.

4.5. Power supply distribution

4.5.1. Power supply distribution to various equipments shall be indicated in the drawings.

4.5.2. Power cable shall be routed separately from other process input/output signal wiring.

4.5.3. While connecting a power cable to the terminal block of a device, use a suitable crimping type terminal lug. Voltage drop shall be less than 2%.

4.6. Laying and wiring of signal cables.

4.6.1. When laying cables, separate them from power cables or use a separate route for each of the two cable groups. Avoid mixing them as much as possible. When cables of these two groups have to be crossed, it shall be at right angle and use an earthed steel plate on which to make one bridge the other.

4.6.2. Signal lines shall be located away from the main lines.

4.6.3. The cables have a specified length and connectors at both ends, make sure that cable length is sufficient for wiring, space is sufficient through which the connectors is passed and has the residual cable part can be properly tied.

4.6.4. When straining the cable during wiring, cover the connections with vinyl or thick cloth to avoid damaging them or to prevent dust from adhering to them. After the connector has been plugged in the specified device, lock it with a screw lock. Do not pass analog and digital signals through one multicore cable; also avoid mixing an analog input low level signal with signals of other levels.

4.6.5. Terminate all the field cables up to the marshalling boxes.

4.7. Cable routing details

All the cables inside the control room shall run under the false flooring. All the cable entries to the cubicles/racks shall be from the bottom. After completing the wiring, following points shall be checked:-

a. Cable number and connector number are as per drawings.
b. Shielded cables are properly handled.
c. Connectors and terminals screws are properly handled.
d. Cables are tied up and set unmovable.
e. No loose pieces of cables, screws etc are caught in terminal blocks or in cables.
f. The holes for cables from ducts are sealed and protected against dust.
g. Sharp bends and twists shall be avoided when cables are laid in cavity floorings.
h. The connectors at both ends shall be carefully tightened to avoid excess strain at the connection terminal.
i. All the field inputs and outputs shall be brought and terminated at marshalling box in the control room and then to the system by multi-core, screened and unarmored cables.
j. Isolating type of terminals shall be used for field instruments inputs and system outputs to the field.
k. The cables for different type of inputs like 4-20 mA, T/C etc shall be segregated and run to the system from the marshalling box/room.
l. All cables shall be tagged for easy identification. The size of cable entry points in the cavity floorings shall be sized properly for future expansion and subsequent easy cable routing.
m. Continuity of cables shall be checked.

4.8. Grounding

4.8.1. Standard grounding procedure /practices or the recommendations of the manufacture shall be followed strictly while DCS system and other control room instruments are being installed.

4.8.2. Sufficient number and type of earth pits shall be provided to get required earth resistance. All equipments inside the control room shall be grounded to inhibit noise and protect the operator or maintenance personnel against electrical shock.

4.8.3. Contractor shall provide earthing as per latest edition of IS 3043.

4.8.4. Provision for wetting the earth pit shall be provided so that ground resistance shall be with in the acceptable limits.

4.8.5. Supply of required conductors such as PVC insulated copper flats and PVC insulated copper grounding wire /insulated materials for earthing, fixing bolts/nuts (Ni plated Brass), crimping type lugs shall be included under the scope of the contractor.

4.8.6. The installation shall fully comply with the requirements of the Indian electricity rules &regulations and also to be the regulation /standard s that are in force at the place of installation.

4.8.7. Duplicate earthing connection shall be provided. Whenever bare conductors to come in contact with the ground walls etc they shall be taken through PVC pipes.

4.8.8. Earthing conductors shall be neatly taken along suitable structural below the false flooring and they shall be neatly clamped at every two meter interval.

4.8.9. At all termination of earth conductors on equipment, sufficient length shall be left for easy movement of the equipment from its position for alignment purposes.

4.8.10. Whenever not detailed, the route of the conductor and location of the earths pit shall be arranged, so as to avoid obstructions, crossings etc and shall be got approved by the owner's representative/ in-charge of the work.

4.9. Earth pits

4.9.1. All accessories required for the earth pits such as electrodes clamps, clips, bolts/nuts/washers, GI pipes, funnel and also the masonry works of the pits including supply of necessary materials like cement and excavation of earth for providing earth pit shall be in the scope of the contractor.

4.9.2. The electrode shall be well packed with earth and charcoal up to the level of connections.

4.10. Joints /terminations

4.10.1. The joints of bare earth strip shall be bolted.

4.10.2. In the case of PVC insulated earth conductors proper joints shall be made using suitable connectors and the entire joint shall be fully sealed by suitable compound so that no metallic part is exposed.

4.10.3. Crimping type of lugs shall be used for termination of earth conductors.

4.10.4. The contractor shall make his own arrangement for necessary crimping tools soldering equipments, drilling machines and other tools and tackles which are necessary for the completion of installation.

4.10.5. Testing Of Earth Conductors/Electrodes

4.10.6. All earthen conductors shall be tested before and after jointing /termination as per relevant Indian standards. Jointing /termination shall be redone, if found unsatisfactory without any extra cost to owner.

4.10.7. Earth pits shall be checked &tested for proper connections /terminations.

4.10.8. Each earth electrode shall be tested as per relevant standards and result tabulated.

4.10.9. Effective resistance of the earthing system shall be tested and tabulated.

4.10.10. All tests shall be carried out in the presence of owner's representative and tabulations furnished.

4.10.11. The contractor shall make his own arrangements for necessary testing meters and equipments.

5.0. CALIBRATION /LOOP CHECKING

5.1. Loop checking shall be carried out by contractor to check the functional performance of all the elements comprising the loop and thereby ensuring proper configuration, functioning and interconnection.

5.2. Contractor shall co-ordinate with the field contractor for smooth and proper loop checking. Any discrepancy found during checking shall be brought to the notice of engineer in charge. All loop checking shall be recorded in a suitable format approved by site engineer in charge.

5.3. All components of the loop shall be checked for proper functioning. All field instruments connected to the control room shall be loop checked for values of 0%, 25%, 50%, 75%, and 100% for both increasing and decreasing signals.

5.4. Receiver alarm cards shall be checked for different settings on both increasing and decreasing signals.

5.5. Shutdown systems shall be checked for proper functioning, configuration and actuation.

5.6. Signal from controller/shutdown systems control valves/shutdown valves shall be checked at respective valves.

5.7. The stroke checking of time of operation of control valves /shutdown valves also forms a part of loop checking.

5.8. After loop checking is completed, contractor shall connect back any terminals and connectors removed for loop checking.

6.0. LIST OF DRAWINGS

a. 14DS 305: - cable routing, cable tray laying and equipment supports under false flooring
b. 14DS 306: - laying/joining of grounding bus.
c. 14DS 307: - laying of power and signal cables.
d. 14DS 308: - mounting structure.
e. 14DS 177: - installation of instrument panel on false floor.
f. 14DS 178: - typical arrangement of instrument wiring in control building.
g. 14DS 179: - installation of auxiliary equipment on false floor.
h. 14DS 180:- typical instrument cabling below false floor.
i. 14DS 559:- typical arrangement of pipe electrode.
j. 14DS 560:- typical earthing connection details.
k. 14DS 561:- grounding system.

CONTENTS

1.0 STANDARDS

Design and terminology shall comply, as minimum, with the latest editions of the following codes and design standard practices and publications.

ANSI B 16.5	Steel Pipe Flanges and Flanged Fittings
ANSI B 1.20.1	Pipe Threads
ANSI B 40.1	Indicating pressure and vacuum gauges
ANSI MC 96.1	Temperature Measurements-Thermocouple
API 608	Metal Ball Valves- Flanged, threaded and welding ends
API 609	Butterfly Valves-Flanged, Lug and Wafer type
API 2534	Measurement of liquid hydrocarbons by turbine meter systems
API MPMS 5.8	Measurement of liquid hydrocarbons by Ultrasonic flow meters using transit time technology
API RP 505	Classification of locations for electrical installations at Petroleum facilities classified as Class 1, Zone 0, 1, 2
API RP 520	Recommended Practices For Design And Installation Of Pressure Relieving System In Refineries Part-1 – Design. Part2- Installation
API RP 521	Guides for Pressure Relief and Depressurizing Systems
API RP 526	Flanged Steel Safety Valves
API RP 527	Commercial Seat Tightness Of Safety Relief Valves With Metal To Metal Seat
API RP550	Manual on Installation Of Refinery Instruments And Control System
API RP 551	Process Measurement Instrumentation
API RP 554	Process instruments and control
ASTM A269	Standard specification for seamless and welded Austenitic steel tubing for general service
ASME B16.36	Orifice flanges
ASME PTC 19.3	Temperature measurement instruments and apparatus
BS 5308-1	Specification for Poly ethylene insulated cables
BS 5839	Fire detection and Alarm system for buildings
BS 6121	Mechanical cable glands
DIN 43760	Temperature VS Resistance Curves for RTD's
FCI-70-2	Control Valve Seat Leakage Classification
IEC 60079-1	Equipment protection by flameproof enclosure "d"
IEC 60079-2	Equipment protection by purged enclosure "p"
IEC 60079-10	Classification of hazardous areas
IEC 60079-16	Artificial ventilation for the protection for analyser houses
IEC 60079-25	intrinsically safe systems
IEC 60079-27	Fieldbus Intrinsically safe concept and fieldbus non-incendive concept
IEC 60079-29-1	Gas detectors
IEC 60529	Degrees of protection provided by enclosures
IEC 60331	Fire resisting characteristics of electric cables
IS 2806	Thermometry Electrical resistance –Guide
IS 2848	Specification for industrial platinum resistance thermometer sensors
IS 694	PVC insulated unsheathed and sheathed cabls/ cods with rigid and flexible conductor for rated voltages upto and including 450/750V
IS 1239- part 1, 2	Steel Tubes, Tubulars and Other wrought steel fittings specification Part 1-Steel tubes, Part 2-Steel pipe

	fittings
IS 1554-1	Specification for PVC insulated (Heavy duty) Electric cables for working voltages upto and including 1100V
IS 1868	Anodic coatings on Aluminium and its alloys-specification
IS 2629	Recommended Practice for Hot-Dip galvanizing of Iron and steel
IS 2801	Accuracy requirements for bulk meters used in petroleum trade
IS 3043	Code of Practice for Earthing
IS: 3624	Specifications for Pressure and Vacuum Gauges
IS 5831	Specification for PVC insulation and sheath of electric cables
IS 8130	Specification for conductors for insulated cables and flexible cords
IS 8784	Specifictaion for thermocouple compensating cables
IS 8935	Specification for Solenoid operated actuators
IS 10189-1	Specification for Industrial process control valves-General requirements and tests.
IS 12579	Specification for base metal mineral insulated thermocouple cables and thermocouples
IS 13673	Expression of performance of electrochemical analysers Part-1 General, Part-2 Ph Value, Part-3 Electrolytic conductivity, Part-4 Standard for measuring Oxygen dissolved in water, Part-5 Oxidation reduction potential or redox potential
IS 15672	Flow measurement of natural gas and other fluids by coriolis metering
IS 15674	Flow measurement of natural gas by Ultrasonic meter
IS 15675	Flow measurement of natural gas other fluids by orifice plate meters
IS 15676	Flow measurement of natural gas by Turbine meters
ISA 5.1	Instrumentation symbols and identification
ISA 5.2	Binary logic diagrams for process operations
ISA 5.3	Graphic symbols for Distributed control/ Shared display instrumentation, Logic and computer systems
ISA 5.4	Instrument loop diagrams
ISA S7.0.01	Quality standard for instrument air
ISA 18.1	Annunciator sequences and specifications
ISA 75.01.01	Flow Equations for sizing control valves
ISO 5167	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full
NACE MR 0175	Petroleum Industries-Sulphide stress cracking resistant metallic material
NFPA 85	Boiler and combustion systems hazards code
OISD 152	Safety Instrumentation for Process system in Hydro Carbon Industry
OISD 163	Safety of Control rooms
UL 217	Single and multiple station smoke detectors
UL 521	Standard for heat detectors for fire protective signaling systems

2.0 GENERAL REQUIREMENTS

2.1. The instruments in hazardous area shall be explosion certified as follows:

Zone		Certification	
Gas/ Vapour	Dust	For gases/ vapour	For dust
0	20	Exia	ExiaD
1	21	Exib	EXibD
2	22	Exic	EXicD
MOVs in Zone 1	MOVs in zone 20	Exd	ExtD

2.2. Where intrinsic safety is not available for a particular type of instrument, 'Exd' – flameproof/ or 'Exp'-purged enclosure shall be provided.

2.3. Gas group shall meet the gas group specified in the Hazardous area classification drawings.

2.4. The above certifications shall be from CCOE Nagpur and an internationally accepted agency.

3.0 INSTRUMENT SELECTION

Unless specified, the following apply for instruments:

3.1. Standard transmitters
Static pressure- 100Kg/Cm2
Overall rangeability 1:100
Accuracy +/-0.075% of span within a turndown ratio of 1:10

3.2. Transmitters with diaphragm seals
Static pressure- 100Kg/cm2
Overall rangeability- 1:100
Accuracy- +/-0.2% of span within a turndown ratio of 1:10

3.3. Draft range transmitters-
Static pressure as required
Overall rangeability- 1:30
Accuracy- +/-0.15% of span within a turndown ratio of 1:10

3.4. Pressure gauge +/-1%FS

3.5. Temperature gauge +/-1.5%FS

3.6. Accessibility:-All local instruments shall be readable from grade or platforms. For instruments located above 4 meter, a permanent platform shall be provided. Instruments located less than or equal to 0.5meter are considered to be accessible from that platform.

4.0 FLOW INSTRUMENTS

Selection of type: - Normally square edged concentric orifice plates are used. Conical entrance or quarter circle orifice plates may be considered for viscous liquids or slurries. Segmental orifice plates shall be considered to measure liquids containing large amount of solids and for flow in large conduits. Venturi tubes, flow nozzles, low loss tubes may be considered where good pressure recovery is essential or high flow rates are to be measured/ solids are suspended in liquids. Averaging pitot tube may be considered for special clean services in large lines. Their wake frequency shall be checked as per PTC19.3, unless supported at both ends.

4.1. ORIFICE PLATES

4.1.1. These are mounted between a pair of weld neck flanges of minimum 300#ANSI rating with flanges taps for line sizes 2" to 8" and with D and D/2 for higher sizes of lines.

4.1.2. The material of the orifice plate shall be normally SS316. Metering orifices shall not be installed on lines less than 40mm nominal diameter.

4.1.3. Integral orifice meter/prefabricated meter runs shall be installed in lines less than 50mm diameter. The associated orifice shall be installed in a carrier ring utilizing corner taps. The meter run, plate and carrier ring all shall be fabricated from SS 316 minimum. For extremely small flows, integral orifice transmitters shall be used.

4.1.4. Sizing of orifice plate shall be carried our in accordance with ISO-5167-2. The normal sizing D/P be 2500 mm H2O. Other preferred ranges are 62.5, 125, 250, 500, 1250, 5000 mm of H2O. However the selected value shall be less than the allowable pressure drop mentioned in the process data sheet.

4.1.5. Orifice diameter shall be selected so that d/D ratio is between 0.3 & 0.7. For high accuracy applications (0 additional uncertainty), 0.56 shall be used. The straight length shall be as per ISO 5167 tables for a beta of .75. (0.5% uncertainty)

4.1.6. Tappings shall be in the upper quadrant for gases/vapors and in the lower quadrant for liquid.

4.1.7. Orifice flanges shall be as per ASI/ASME B16.36. They shall be supplied with two pair of flange taps complete with plugs. The tap design shall be as per ISO 5167. For pressure class greater than or equal to 900lb, flange facing shall be RTJ and the orifice plate shall be installed in an API carrier ring.

4.1.8. Where multiple ranges are required from one orifice for turn down reasons, single transmitter shall be used with range changes performed in DCS. Where shutdown signal is required from an orifice in addition to flow measurement, a separate transmitter shall be used.

4.1.9. The orifice flange assemblies shall consist of ½" welded nipples for pressure taps, gaskets, metric size bolts and nuts, jacking bolts etc. Gasket bolts and nuts shall be designed according to the line specification.

4.1.10. The tab handles shall be marked with tag number, flange rating, pipe size in inches, bore size, plate thickness, materials, "UPSTRAEM" etc.

4.1.11. Restriction orifices shall be sized in accordance with RW Miller Flow measurement engineering Hand book. Where high noise is expected, multi stage reduction shall be used and the noise level shall be calculated.

4.2. VARIABLE AREA FLOWMETERS

4.2.1. Rotameters are used when

a. Fluid is highly viscous or solids in suspension or cloggy and easily

freezes or congeals at ambient temperature etc
b. Where rangeability in excess of 3:1 is required
c. As a field indicator which is economically justifiable than a DP type instrument
d. Linearity of measurement is essential

4.2.2. For process fluids or rotameters with transmitters, the tube shall be metal.

4.2.3. Glass tube is used when all these conditions are satisfied
a. Temperature less than 100 deg C
b. Pressure less than 5 Kg/Cm2
c. Not toxic/ poisonous
d. Fluid is transparent
e. Size less than 4”
For detailed specification see 14ES001

4.2.4. A bypass shall always be provided for rotameters. Clearance for float removal shall be ensured.

4.3. VORTEX METERS
Vortex meters can be installed on steam or other services which require extremely low loss.

4.4. POSITIVE DISPLACEMENT AND TURBINE TYPE

4.4.1. These instruments are used when high degree of accuracy is required than that obtainable from orifice. Positive displacement type is preferred; however, turbine type may be used under the following conditions:
a. For high rangeability for low viscosity fluids such as naphtha and lighter hydrocarbon services.
b. High pressure services

4.4.2. All PD and turbine instruments shall be equipped with strainers, with material same as that of flow meter. Over speeding device where required shall be included. Air eliminators shall be included where vapor is expected to affect the accuracy such as in custody transfer applications or where it is statutory.

4.4.3. Temperature compensation shall be provided as required.

4.4.4. The necessary straight run with or without straightening vanes for the turbine meter shall be ensured as per manufacturer’s recommendations.

4.4.5. The installation shall ensure flooding of the meters while in operation. Except for metering purposes, a bypass and isolation shall be provided bridging both the strainer and meter.

4.5. MAGNETIC FLOW METER

4.5.1. These instruments are used when:
a. The fluid has required electrical conductivity
b. Other types are not suitable due to corrossivity, solids in suspension, low loss requirement etc
c. Ideal for metering of dirty fluids and slurries

4.5.2. These instruments may be used for lines as small as 0.1” to 100” or more diameter.

4.5.3. The wetted parts may be Teflon or fiber glass

4.6. ANNUBAR AND PITOT TUBE

4.6.1. This type of flow instruments are used for measurement of clean fluids in large pipes.

5.0 PRESSURE INSTRUMENTS

5.1. PRESSURE GAUGES

5.1.1. Applicable standards are ANSI B.40.1 and IS-3624.

5.1.2. Element: - Pressure gauges shall be of C type bourdon tube elements. For low pressure ranges or for differential pressure application, bellows or diaphragms can be used as pressure elements. Diaphragm type shall be used for slurries/ congealing/ crystallizing type services.

5.1.3. Dial: - Standard dial size shall be 150 mm. Boiler services shall use 200 or higher dial sizes. Dial shall be white, non-rusting with black figures. For special services such as Oxygen, ammonia, chlorine etc, the service shall also be marked on the dial as per ANSI B40.1. Pointer shall have micrometer for zero adjustments. Draft gauges may employ a quadrant edgewise indicator of suitable size.

5.1.4. Accuracy: -Pressure gauges have an accuracy of +/-1% FSD.

5.1.5. Type: - Flanged diaphragm seal type pressure gauges without capillary shall be used for corrosive service.

5.1.6. Connection: - Gauge connections shall normally be ½” NPT (M), receiver gauges shall have1/4” NPT (M) connection.

5.1.7. Range:- Range shall be specified so that normally the gauge indication is 35% to 75% of its range. For fluctuating pressures, it shall not exceed 60%. The ranges shall be selected from standard ranges available as per IS-3624.

5.1.8. Gauge window shall be shatter resistant safety glasses.

5.1.9. Protection: - Gauges shall be solid front for pressure above 25Kg/cm2. Over

range protection shall be provided for at least 130% of the full range. Gauges subjected to vibration or process pulsations shall be fitted with pulsation dampers, which shall be of the material same as the element. Gauge savers shall be provided wherever required. Gauges used in vacuum service shall be capable of with standing full vacuum regardless of the range. Pigtail siphons shall be provided on steam, condensing vapours and high temperature services beyond 80deg C . Oil seal type siphon shall be provided in corrosive services. Blow out device shall be provided at rear side for gauges in gases working beyond 25Kg/cm2 and liquids beyond 60Kg/cm2.

5.1.10. PRESSURE SWITCHES

5.1.11. Element: - Direct mounted switches shall normally have a diaphragm or bellow element of SS316 material as a minimum. The pressure sensing elements shall be designed to meet a service life of one million switching cycles.

5.1.12. Type: - Pressure switches shall be provided with hermetically sealed snap acting SPDT type micron switches.

5.1.13. Connection: -connection shall be ½" NPT (F) according to ANSI B1.20.1. Flanged connection shall be as per ANSI B16.5.

5.1.14. Enclosure: - The switch enclosure shall be weather proof and explosion proof suitable for area classification specified in the design philosophy.

5.1.15. Range:- In general, vendor shall ensure that the set point falls in the middle 3rd of the full adjustable range i.e., set point shall between 35% and 65% of the adjustable range. The switching set point shall be adjustable over the entire range with an internally calibrated scale, vendor shall provide a locking mechanism for locking the set point adjuster, and an indicating scale shall be provided for set point adjustment. The set point change with time due to work hardening or wear of moving parts shall be minimized.

5.1.16. Protection: -Unless otherwise mentioned, the pressure switch shall have an over–range protection of at least 130% of range.

6.0 ELECTRONIC TRANISMITTERS

6.1. Electronic transmitters shall be SMART type with 4 -20mA with HART protocol and an accuracy of +/-0.075%.

6.2. Ranges for transmitters shall be selected in general, such that in normal process operation the indication is between 40% and 60% of span for linear and 60% to 80% of span for square root inputs. SMART transmitters shall also meet the requirements:

6.3. The transmitter shall incorporate a temperature sensor to compensate for temperature effect.

6.4. The transmitter shall preferably be intrinsically safe or flame proof suitable for hazardous area as specified in the design philosophy. The transmitters shall also incorporate a memory unit, which stores complete characteristics of the sensor.

6.5. The data from the sensor is converted into digital form and transmitted to the electronic unit for processing.

6.6. All necessary signal conversion to produce output with required protocol shall also be carried out by the transmitter electronics.

6.7. Transmitters shall also run complete diagnostic routine in the event of detection of failure; the output shall be driven to a pre-defined value.

6.8. All field transmitters shall have an integral, output meter for local display.

6.9. These meters shall have square root scale for flow measurement and linear scale for other measurement. Square root function shall be done in transmitter itself.

6.10. Body material shall be die-cast aluminium/ carbon steel/ 316 SS as noted in the data sheet.

6.11. Transmitter's internals in contact with the process fluid (wetted parts) shall be 316LSS unless other wise noted.

6.12. Transmitters with remote seal diaphragms can be used when the liquid has a tendency to crystallize/ congeal/ for viscous/ corrosive fluids. Transmitters used for the vacuum service shall be able to withstand full vacuum. Transmitters shall have an accuracy of +/-0.2% of calibrated span.

6.13. The accuracy includes the combined effect of linearity; hysteresis and repeatability. Rangeability shall be 100:1 for flow transmitters and 200:1 for pressure transmitter. Temperature transmitter shall be SMART integral head mounted or remote mounted.

7.0 TEMPERATURE INSTRUMENTS

7.1. TEMPRATURE GAUGES

7.1.1. Temperature gauges shall be mounted in thermo-wells, unless specified otherwise

in the data sheet. Local temperature indicators shall be bi-metallic dial thermometers calibrated in deg.C.

7.1.2. Dials shall be 150 mm size and shall have black numerals /white background as standard. Negative temperatures shall be red numerals on white background.

7.1.3. Connection between the head and thermo well shall be by 1/2" NPT adjustable union. Bi-metallic dial thermometers shall be hermetically sealed, every angle, with external pointer adjustment.

7.2. THERMOCOUPLE

7.2.1. For measurement up to 1300deg C, Ni-Cr/Ni-Al (Type K) shall be used as per IEC60584. Above 1300 deg C or for Hydrogen service above 750 deg C, Pt-13%Rh/Pt (Type R) shall be used.

7.2.2. All thermocouples shall be mineral insulated SS sheathed to 6mm diameter with hot junction insulated from the sheath. Bare wire thermocouple elements shall be insulated with double bore ceramic insulators.

7.2.3. Thermocouple heads shall be weather proof IP65 with terminals marked for –ve and +ve. The head shall have spring loaded Ni-plated brass terminals.

7.2.4. Transmitters if required shall be head or remote mounted type. Output shall be linear 4-20mA with HART. Upscale and downscale burnout protection shall be provided.

7.3. FURNACE TUBE SKIN THERMOCOUPL

The installation of these instruments shall be such that the replacement of the element can be done without re-welding.

7.4. RESISTANCE TEMPERATURE DETECTOR (RTD)

7.4.1. RTDs shall be used for -200 degC to 400 deg C range. RTD element shall be industrial platinum type (PT100) as per IS-2848. 3 wire type RTD shall be normally used. The grade of accuracy depends on the process application.

7.4.2. The element shall be of highly refined material as per IS-2848 and shall be stress relieved. The wire shall be wound on a ceramic core. The element shall be within a metal sheath, in a manner, which provides good thermal transfer and protection against moisture.

7.4.3. For narrow ranges, differential resistance type may be used.

7.4.4. The sheath material shall be 316SS unless otherwise specified.

7.4.5. The RTD assemblies shall be furnished with threaded heads. The threaded head shall generally be weather proof IP65. In case of explosion –proof construction, heads shall be constructed to IS 2148 and weather proof IP65 as per IS-2147. The head shall consist of a case, screwed on cover with chain and a terminal block.

7.4.6. The RTD shall be screwed to the terminal block. A heat resistant and moisture proof gasket shall be fitted between the case and cover.

7.4.7. The connecting terminals shall be properly numbered. The leads shall be copper up to the terminal block. The terminals shall be spring-loaded. `

7.4.8. Transmitters if used shall be head or remote mounted type, 4-20mA HART type. Upscale and down scale burnout protection shall be provided.

7.5. THERMO WELLS

7.5.1. Thermo wells shall normally be fabricated out of SS 316. If process conditions demands, alternate material superior to SS316 shall be used.

7.5.2. All thermo wells shall be drilled out of solid bar stock. Flanges shall be attached by full penetration welds.

7.5.3. The wake frequency of the thermo well shall be checked as per ASME PTC 19.3, and shall be within acceptable limits. Else, suitable engineering resolution shall be applied to bring it to the acceptable limits.

7.5.4. The thermo well bore shall be suitably sized to closely fit the thermometer bulb/ thermo element. insertion length of thermo wells for thermocouples and temperature gauges shall be as follows:

Line size	insertion length-mm
Upto 4"	200mm (On line) 250mm (At elbow or inclined)
6" to 10"	250mm
10 to 18"	320mm
20" and above or vessels	400mm

7.5.5. The above dimensions are inclusive of a piping neck extension of 150mm. For insulated lines, the insertion length shall be selected from the standardized lengths as indicated, but considering thickness of insulation and penetration into the pipe within 35 to 70%.

7.5.6. Any pipe lines less than 4" nominal bore shall be swaged to 4" size for installation of thermo well. If thermo well is required

to be installed at pipe elbows, the minimum pipe size shall be 80NB. The thermo well flange shall be 40NB.

7.5.7. Unless otherwise mentioned, end connections details shall be as below:

a) Thread end connections shall be NPT according to ANSI B1.20.1.

b) Flanged end connections shall be according to ANSI B16.5.

c) Flange face finish shall be serrated concentric according to ANSI B 16.5.

d) Groove for ring type joint flanges shall be according to ANSI B 16.20.

7.5.8. Normally the thermo well shall be 40NB flanged. However for non-toxic services, ¾" NPTM screwed thermo well may be used.

7.6. Local thermometers

7.6.1. Rigid stem Hg in steel or bimetallic type may be used for -50 to 500 deg C range. Capillary type is to be used when vibration is expected, with 5m cable. Capillary shall be SS armoured type. For corrosive applications. The capillary shall be PVC coated.

7.6.2. The connection size shall be ½" NPTM.

7.7. Pyrometers

7.7.1. Where the temperature is above 1500degC, infrared type pyrometers may be sued.

8.0 LEVEL INSTRUMENTS

8.1. LEVEL GAUGES

8.1.1. Transparent- Non toxic applications such as acids, caustic, dirty/ dark coloured liquids etc

8.1.2. Reflex:-Non toxic, clean and colourless services, not for interface level

8.1.3. Magnetic follower type:- Toxic/ Congealing/ fouling/ high pressure/ high temperature services

8.1.4. All gauges body and cover material shall be of forged carbon steel as a minimum and shall have tempered borosilicate glass with non-asbestos gaskets.

8.1.5. Gauge illuminators shall be provided integrally, operating at 230V AC, 50Hz supply and suitable for electrical area classification specified.

8.1.6. All gauge glasses must have a rating equal to or more than the vessel design pressure and temperature.

8.1.7. Transparent type with mica or Kel-F, shield shall be used for treated water, boiler and condensate service high temperature use and corrosive liquids. All gauges shall have top and bottom chamber, unless otherwise specified. In addition each gauge shall be provided with ball check valve and pipe union. The visible range of level gauge shall be selected to cover the complete operating level as well as measuring range of the other level instruments provided for the same purpose.

8.1.8. The visible range of level gauge shall be limited to 1500 mm. For higher requirement of visible length, multiple gauges with min.100mm overlap shall be used.

8.1.9. Where heat tracing is required, manufacturer shall be asked to supply integral steam jacketing.

8.1.10. The gasket material and type shall be suitable for process fluid and its operating conditions

8.1.11. Vent and drain connections shall be fitted with plugs. Gauge cocks shall be forged, offset type, with an integral ball check and back sealing stem.

8.2. RADAR TYPE LEVEL TRANSMITTER

8.2.1. Radar type level transmitters are preferred because of its high reliability and SIL-2 certification which is imposed by MB Lal committee recommendation for level instruments in oil tanks. Radar type level instruments are good for continuous level monitoring of liquids, liquefied gases, slurries, molten sulphur, corrosive fluids, and underground tanks except for ammonia. Temperature and density compensation is mandatory for automatic level gauging systems employed for tankage systems and custody transfer applications.

8.2.2. Radar type level instruments employed for tank farms for automatic tank gauging (ATG) are custom made by each manufacturer and not interoperable and hence, the radar gauges along with all accessories such as field indicators, water level sensors, multipoint temperature sensors, field communication units, associated software etc up to control room shall be ordered as a package from a single vendor. Serial link to DCS shall be provided in all such cases.

8.2.3. However, radar gauges except for ATG application shall be 4-20mA HART with 2 wire or 4-wire configurations.

8.3. SERVO TYPE LEVEL TRANSMITTER

8.3.1. Servo level transmitter is preferred for tanks which may be requiring a range greater than 10m and where radar type is not practical. Servo type shall be the best option for ATG applications as the

secondary level transmitter in-connection with the tank farm management system. Temperature and density correction shall be necessary for ATG type servo level transmitters. All necessary accessories such as tank side indicators, field communication systems, tank farm management system with necessary software etc shall be ordered as a single package from vendor.

8.3.2. The installation of the instrument shall be supervised by the vendor if it is to be for ATG applications.

8.3.3. Servo gauges other than those used for ATG applications, shall utilize 4-20mA with HART protocol with 110VAC power supply.

8.4. DIFFERENTIAL PRESSURE TYPE

8.4.1. This type of level measurement with pressure lead piping may be used for level control or monitoring of clear liquids. Flange mounted diaphragm seal type shall be used for highly viscous/ cloggy/ solid suspending fluids/ corrosive fluids.

8.5. DISPLACER LEVEL TRANSMITTERS

8.5.1. This type of instrument is used for liquid interface measurement or local control and where other type of measurement is unsuitable. Displacer type is not preferred for corrosive applications.

8.5.2. For level range measurements of up to 1.2 meters, displacer type transmitters shall be used. Where specified as an external mounting type, the level instrument shall be furnished with external cage.

8.5.3. Displacer chamber and mechanism chamber shall be separable with flange connection. The float shall be a “Ball” type with float cum shaft and lever arms with adjustable balancing weight. Transmitters shall be two wire 24V DC and transmitter head shall be rotatable type. The top of the chamber shall be full flanged to allow removal of the displacer for maintenance.

8.5.4. The standard M.O.C shall be: -

Displacer	: 316 SS
Torque tube	: Inconel
Chamber	: 316SS

Finned torque tube extensions shall be used on non–corrosive, non-toxic, atmospheric services where an external arrangement is not mechanically possible.

8.6. LEVEL SWITCHES

8.6.1. Guided or unguided radar type level transmitter directly connected to vessel or with external cage shall be the first choice. All such instruments shall be analog 4-20mA with HART and switching shall be preferably in DCS.

8.6.2. Direct acting level switch can be external cage or internal float type with magnetically operated (glandless) transmission of float movement to the switching element.

8.6.3. The coupling shall be shielded against accumulation of magnetic particles and provide high integrity partitioning between process and electronics.

8.6.4. The float material shall be of 316SS as a minimum.

8.6.5. Cages shall be carbon steel as standard unless service conditions demand a higher specification. The switch enclosure shall be weather proof and explosion proof suitable for area classification specified in the design philosophy. Switch contacts shall be rated at 24 VDC, 3 A. Switches shall be single pole, double throw (SPDT), and hermetically sealed.

8.6.6. For high availability systems such as in petroleum sector, radar type level switches with internal relay contacts shall be used.

8.6.7. Rotating paddle type/ capacitance type/ tuning fork type may be used for solid level measurement.

9.0 CONTROL VALVE

9.1. Type:-Usually single seated globe valves with top guiding shall be used. For high pressures, the guiding shall be from top and bottom. Cage type will be used in case of higher pressure drop or high fluid velocity or in order to reduce noise. Where low DP is required with high capacity, butterfly type may be considered with a minimum size of 4” (API-609). Angle valves may be used in slurries/ flashing or high DP services. Butterfly valves shall not be used were cavitations is expected. Plug valves may be used in throttling of slurries. Self acting regulator valves shall be used for local control in systems such as fuel control etc where lower precision is acceptable. Shutdown valves shall be ball/ plug/ butterfly type except where the same control valve with SOV is used for shutdown as permitted by system.

9.2. Body sizes: The minimum body size shall be 1” with reduced trim as necessary. The following valve sizes shall not be used: - 1 ¼, 2 ½, 3 ½, 5”. The body size

shall not be less than half of the pipe size where it is installed. Rating shall be as per piping specification.

9.3. Sizing:-The control valve sizing shall be as per ISA-S75.01.01 at 1.3 times the maximum flow. The minimum flow rate shall be at minimum 20% of full stroke. The maximum flow shall be between 60 to 80% of stroke for equal percentage trims and 50 to 80% for linear trims. Butterfly valve sizing shall be on maximum opening at 60 Degrees. The effect of reduced inlet and outlet shall be accounted for while sizing the valve. Valve maximum exit velocity shall be less than 5m/s for liquids and 0.33 (Mach) for gases. The valve noise either aerodynamic or hydrodynamic as applicable shall be calculated as per ISA 75.17 or IEC 534. The noise at 1m radius from discharge flange shall not exceed 85dBA

9.4. Material selection:- Body materials shall generally conform to the piping specification. Except for saunder valve, trim shall be normally SS316. Stellite faced SS316/ 17-4PH/ Tungsten carbide etc shall be considered for :-Flashing/ cavitations services, erosive/ slurry services with more than 100psi differential, wet gases, steam services with differential above 150 psi, pressure drop in excess of 10Kg/cm2, solid suspension type liquids, process temperature above 300 deg C etc. Metal seated fire safe design shall be considered for emergency valves as required. (ISO 10497)

9.5. Construction:- All valves shall have removable seat rings and plugs. For ease of maintenance, valve trim shall be quick change type with no internal components screwed or welded into the valve body or bonnet. Threaded bonnet is not acceptable. All valves in hydrogen services shall have bonnet flange and lower blind flange fitted with retained metallic gaskets suitable for the service with a bellow seal. Where noise abatement cannot be achieved by trim design alone, path treatment such as heavy wall pipe/ external insulation/ silencers may be considered. Ball valves shall be floating for low pressure applications and trunnion mounted for high pressure and higher sizes. Plug valves shall be pressure balanced. Butterfly valves can be of wafer type suitable for mounting in between a pair of flanges or flanged type.

9.6. Bonnet:-Bonnet shall be of standard or extended with or without cooling/ radiation fins as required. The material of bonnet shall be same as that of the valve body. Extension bonnets shall be considered for below 0 and above 230 deg C.

9.7. Stem seals:- Normally control valves shall have bolted packing box assembly. Asbestos in any form is prohibited. Where for toxic services, low emission packing such as bellows shall be specified with a monitor such as a pressure gauge.

Temperature range	Packing material
-40 to 230 eg C	PTFE V rings
Above 230 deg C	Graphite in preformed rings

9.8. Leakage:- Normally control valves shall be class IV as per FCI 70.2. Where Tight shut off is specified, class shall be VI. Leakage for emergency services- soft seated valves shall be of ISO 5208 rate A and metal seated valves shall be ISO 5208 rate D.

9.9. End connections:- All control valves shall be flanged and shall be as per B16.5 and B16.10. Butterfly valves shall be double flanged.

9.10. Actuator:- Actuator shall be designed for the shutoff pressure indicated in data sheet. Actuator travel shall be readable locally in a scale calibrated from 0 to 100% with 10% increments. Spring return diaphragm actuators are preferred for control valves. The springs shall be Cd-Ni plated. The compression on the spring shall be adjustable. The normal operating range shall be 0.2 to 1 Kg/cm2. Actuator casing and diaphragm shall be designed for at least twice the minimum pneumatic pressure of the valve. Piston actuators shall be used for emergency services. These may be used for modulating control where high thrust and longer stroke is required. They shall be single acting spring return type valves operating at 3.5 Kg/Cm2. All control shall operate in fail-safe mode. Motor actuators shall be used where the location is accessible and the service is non-critical, large lines where long stroke is required etc. Actuator housing shall be in steel. Actuator stroking speed shall be as per the table below: When spring less

type is considered, all accessories like pilot valves, directional control valve, booster relay and volume tank etc as required shall be provided to ensure desired action on air failure. Suitable scheme shall be provided wherever fail lock action is desired based on vendor recommendations.

15-65mm	2 sec
80-150mm	3-6sec
200-600m	8-24sec

9.11. All accessories shall be pre-tubed and wired. Tubing shall be of SS316. Compression fittings shall be of double ferrule type. Cable glands/ plugs shall be of Cd-Ni plated brass. Tube sizes shall be 6mm and higher for achieving the stroking time. All brackets, fixings and fittings shall be S316.

9.12. Air receiver: Local air receiver shall be supplied where necessary, sized for minimum three full strokes.

9.13. Positioner:- All positioner shall be electro-pneumatic, SMART with 4-20mA and HART protocol. They shall have air filter regulator with 5 micron filter. Positioner shall have gauges for supply and output pressure indication. Partial stroking shall be required for SIL 2 and above services for shut down valves. These shall have an accuracy of 0.25% of full scale.

9.14. Limit switches shall be of proximity type.

9.15. Continuous position indication:- To be specified for all motor operated actuators. These shall be passive (Powered from control room) 2 –wire 4-20mA type.

9.16. Solenoid valves (IS-8935): SOV coil shall be epoxy encapsulated type class 'H' rated for continuous duty. These shall have integral terminal blocks. Flying leads are not acceptable. Valve body shall be SS316 with a 3/2 universal design and vent port bug proofed. Quick exhaust shall be considered if required to achieve the closure time. Local manual trip and reset buttons are required for ESD SOVs where specified. An external earthing pin shall be provided for all SOVs.

9.17. Volume booster:- TO be chosen as per vendor recommendation to achieve desired stroke speed.

9.18. Hand wheels:- Hand wheel shall not be fitted for valves which are fitted with SOV and valve is designed for fail close. Hand wheels shall be side mounted wherever specified. These shall facilitate operation of valve independently of the spring action.

9.19. Marking:- The direction of flow shall be punched on the valve body. Tag number, manufacturer name, model no, specification number if any, trim size, material of body, trim, packing, Cv value, failure mode, input signal etc shall be marked on a corrosion proof tag plate attached to the actuator.

10.0 INSTRUMENT AIR SUPPLY REQUIREMENTS

10.1. The air supply for individual instruments shall be taken off the top of the main header or an auxiliary manifold supplied from the top of the main header. Each take off shall have an isolation valve tagged with the instrument number. 10% spare valves shall be provided on the header or manifold, with a minimum of two.

10.2. Instrument air tubing shall be normally 6mm stainless steel as a standard. Fittings shall be double compression ferrule made from stainless steel.

10.3. Any bending of header manifolds of tubings etc shall be carried out using equipments designed for the purpose. Hammered, flattened or otherwise distorted bends are not acceptable.

10.4. Cutting of pipes and tubing shall be executed using approved cutters, saw cuts shall not be used.

10.5. Headers, manifolds and tubing shall be internally cleansed, degreased and dried prior to installation.

11.0 ERECTION MATERIALS

The following are the minimum acceptable salient features of some of the erection materials.

11.1. CABLES

11.1.1. All cables shall be resistant to oil, water and UV radiation. Minimum oxygen index shall be 30 as per ISO 4589.

11.1.2. The insulation grade shall be 600V/1100 V minimum.

11.1.3. All signal cables shall be in twisted pair, screened and armored. Number of twists shall be 18 per meter. All power cables shall be armored. All cables for frequency signal shall be twisted, individually and overall screened and armored.

11.1.4. Primary insulation shall be as per IS-5831; type C PVC (85 degC). For emergency services, silicone insulated cables shall be used. All cables shall be fire-retardant (FR) as per standard

IEEE383. However, fire resistant low smoke zero halogen (FR-LSZH) cables as per IEC-60331 shall be used on ESD/ PA/ F&G and cables for power to these systems.

11.1.5. The conductor shall be electrolytic grade copper as per IS-8130. Stranded and tinned annealed copper conductor shall be specified for field application. Thermocouple extension cables shall be as per IS-8784.

11.1.6. Inner and outer jacket shall be made of PVC applied by extrusion and shall be type ST2 (90 degC) as per IS 5831.

11.1.7. Pair identification shall be with numbers and suitable colour code as per vendor's standard

11.1.8. The signal cables shall have 1.3mm2 stranded conductors with each strand of 0.53 mm diameter for single pair and 0.5mm2, conductors for multipair cables. Colour of core insulation shall be black and blue in pair. Where individual pair shielding is required (BS-5308-1), each pair shall have an aluminium bonded polyester tape applied with the metallic side down, in electrical contact with one or more tinned annealed copper wire (drain wire) of 0.5mm2 cross section. Minimum overlap shall be 25%. The aluminium shall have a minimum thickness of.008mm and a minimum thickness of polyester shall be 0.010mm. Drain wire shall be provided for individual pair and overall shields

11.1.9. Collective screen and drain wire shall also be as per the same specification as for individual screening.

11.1.10. A pair of communication wire shall be provided for multipair cables. Each wire shall be stranded, plain annealed copper conductor of 0.54mm diameter and with 0.4 mm thick, PVC insulated. The insulation shall be red and green color coded.

11.1.11. Tolerance in overall diameter cable shall be within +0.5 mm and –2mm.

11.1.12. Binder tape: For cables without a collective screen, a non hygroscopic tape of minimum 0.023mm shall be applied with a minimum overlap of 25%.

	Type	Thickness mm	Overlap
1	Cables without collective screen	0.023	25%
2	Collectively screened cables other than one pair	0.023	50%/ 25% two layer
3	Collectively screened cables one pair	optional -As per sr no.2	

11.2. CABLE GLANDS

11.2.1. All cable glands shall be double compression, Nickel–Cadmium plated brass and they shall be suitable for armored cables.

11.2.2. Weather- proof (IP-65) and explosion proof (as per area class) Cable glands shall be used for field applications. Cable glands used inside control room need to be weatherproof only.

11.3. JUNCTION BOX

11.3.1. Instrument junction boxes shall be made from die cast Aluminium/ Cast iron/ 2.5mm thick SS Sheet.

11.3.2. The junction box shall be weather protected to IP-65 for use in safe areas and shall be Ex proof as per area classification for hazardous locations.

11.3.3. These boxes shall have terminals for min 4 mm2 cable termination (klip on) mounted on rails. 20% spare terminals shall be supplied in each junction box.

11.3.4. Each junction box shall have 10% or minimum 2 nos. cable entries duly provided with plugs.

11.3.5. The junction box shall be supplied with bottom and side entry gland plates/ NPT cable entries.

11.3.6. Cables on IS service shall have all spare cores terminated. For IS service, junction box shall be Exe certified.

11.3.7. Different signal types shall not be mixed in the same junction box.

11.3.8. The junction box number shall be permanently and clearly indicated by a black on white SS nameplate.

11.3.9. Separate junction boxes shall be used for process control and shutdown service and intrinsic safe or non intrinsic safe applications.

11.4. INSTRUMENT VALVES AND MANIFOLDS

11.4.1. Body material and rating shall be as per piping class or minimum SS -whichever is better -and shall be forged type.

11.4.2. Valve trim materials shall be 316SS minimum or superior as required by process conditions.

11.5. IMPULSE PIPING/ TUBING

11.5.1. In general 12mmOD 1.5mm thick ASTM A269 stainless tubes for impulse lines shall be used.

11.5.2. Where the operating pressure exceeds 100kg/cm2g seamless pipes of size ½"

NB of required thickness shall be supplied with material as per piping class.

11.6. PIPES AND TUBE FITTINGS

11.6.1. In general compression fittings shall be used for tubes.

11.6.2. The ferrule hardness shall be greater than 90RC and of the stainless steel tube used in general.

11.6.3. Socket–weld type forged pipe fitting of suitable material and rating shall be supplied for pipefitting. The minimum rating shall be 3000ibs.

11.7. PNEUMATIC SIGNAL TUBES

11.7.1. In general 6mmOD 1mm thick SS tubes shall be used. Where, 6mm tube is not recommended for higher size valves, 12mm tube or ½" pipe shall be used.

11.8. INSTRUMENT GAS LINES FITTINGS AND VALVES

11.8.1. Seamless galvanized (inside and outside) heavy duty carbon steel pipes used for instrument gas distribution, shall be as per IS 1239.

11.8.2. Galvanized forged screwed carbon steel fittings shall be used.

11.8.3. Isolation valves on instrument gas service shall be packless gland type full-bore ball /globe valves.

11.9. AIR FILTER REGULATOR

11.9.1. Instrument air filter regulator of suitable sizes shall be used for each pneumatic instrument. The filter shall have 5 micron sintered bronze filter element and shall be provided with manual drain and 2" nominal size pressure gauge with SS dial.

11.10. CABLE TRAYS

11.10.1. All cable /tubes shall run on cable trays. These cable trays shall be made out of galvanized MS with red oxide primer and shall be of 2.5 mm thick SS sheet/ Aluminium / FRP/ GRP as the application needs considering the environment. Same tray shall not be used for both Cable and tubes. Suitable protective coatings such as Galvanising/ anodizing may be specified as required.

12.0. EARTHING

12.1.1. All instruments, cable trays, supports, junction boxes etc shall be earthed to locally available earth grid for personal safety using 8SWG solid GI wire. While the instrument screen shall be earthed only at one point near the control room. IS and NIS instrument earthing shall be separate. The earthing pits shall be provided as per IS 3043.

CONTENTS

CHAPTER 1
GENERAL

1.0 SCOPE AND APPLICABILITY OF THIS DOCUMENT

1.1 This engineering specification covers the minimum requirements/ features for the design and development, testing and supply of Tank Farm Management System hardware and software. The specification shall be read in conjunction with special requirements of the project and data sheets attached.

1.2 This specification is intended for tank farms which store oil and gas products in raw form or in product form. The same specification may be used for chemical storage tank farm with special care in hardware design changes and referred national/ international standards.

2.0 CONFLICTING REQUIREMENTS

2.1 In the event of any conflict between these specifications, data sheet and standards mentioned, the following priority should be adopted:

a. Statutory rules/ standards and regulations
b. Special requirements
c. Data sheet
d. Engineering specification (This document)

2.2 The vendor should also refer the matter to the purchaser for clarifications and only after obtaining the same should proceed with the manufacture/ ordering of the item.

3.0 SITE VISIT/ PRE-BID MEETING

3.1 Before submitting the Techno commercial bids, vendors are advised to visit the site (except for a Greenfield project)/ attend the pre-bid meeting (if conducted) and obtain necessary details on the scope and familiarize with the actual site conditions; and to assess requirement of any additional hardware not envisaged in the tender for achieving functionality stipulated in the tender.

3.2 Vendors to specifically mention in their offer about any hardware (Like ports of existing switches, spares in cables etc) planned to be used for their offered system. In case such a visit is organized, only one visit shall be made for all the parties and the discussed topics shall be signed off by all parties and shall form part of the original tender.

3.3 By submitting the technical and commercial bid by the vendor, it is presumed that the vendor has read all the terms and conditions - both technical and commercial and understood the same. However FEDO's assistance if any required at site after the work order finalization, for the purpose of clarifications of facility detail or technical specifications of tender etc shall be chargeable/payable to the FEDO at stipulated rates.

4.0 LEGENDS

TFMS	Tank farm management system
ATG	Auto Tank Gauging (Total system)
TGS	Tank gauging system
OEM	Original Equipment Manufacturer
DCS	Distributed Control system
PLC	Programmable Logic Controller
TAS	Terminal Automation System
SCADA	Supervisory control and data acquisition
OPC	OLE for Process Control
OLE	Object Linked Embedding
OIC	Operator interface console
MST	Multi spot temperature probe
MSTW	MST with integrated water bottom sensor
CIU	Communication interface unit
FIU	Field Interface unit
FCU	Filed communication unit
MTTR	Mean time to repair

MTBF	Mean time between failures
CCOE/PESO	Chief Controller of explosives/ Petroleum and explosives safety Organization
FAT	Factory Acceptance test
SAT	Site acceptance test
RTG	Radar tank gauge
SIL	Safety integrity level
GWR	Guided wave radar
TPI	Third Party Inspector

5.0 DEFINITIONS

Client/ Owner: The Company that purchases the TFMS system / the end user of the TFMS system

PMC The Owner/ client authorized company to issue this document to the supplier of TFMS system

Vendor/ Contractor:- The OEM/ TFMS supplier

TGS/ TFMS- These terms are used interchangeably

Engineer in-charge: The Authorized PMC/ Owner representative supervising the vendor's site work

CIU/FCU/FIU- These terms are used interchangeably.

6.0 RESPONSIBILITY DEMARCATION

6.1. **PURCHASER'S RESPONSIBILITY**

6.1.1. The details of the instruments, tanks, product etc will be provided to successful vendor after award of contract.

6.1.2. The purchaser shall handover the nozzles of all tanks ready for instrument erection.

6.1.3. The purchaser shall be responsible for providing the following to the successful vendor during detailed engineering/ execution phase:

a. Air conditioned room for installation of the TFMS hardware (See hardware specification for details) in control room.

b. Raw power/ UPS power supplied at one point of installation premises for the control room hardware.

c. The tank strapping table with at least 1000 points shall be provided by customer to TFMS vendor for each tank in MS- Excel format.

d. P&ID/ PFD, site plan, Details of tanks, basic process data etc of the tank farm for graphic design and configuration of the software.

6.2. **TFMS VENDOR's RESPONSIBILITY**

6.2.1. If the whole TFMS system is reckoned as a single package, all necessary trays/ trench, structural steel, junction boxes and other erection hardware like cables, Multi cable transit blocks etc, and the erection of the same including earthing and necessary civil works shall be covered in TFMS vendor's scope.

6.2.2. Vendor to specify any other utility requirements other than those mentioned in Purchaser's responsibility.

6.2.3. The specified technical details are for guidelines only. Vendor to study each application and operating conditions and provide suitable solution on a case to case basis.

6.2.4. In case of remote communication is required (Data from geographically different location to be integrated to central TFMS), the necessary communication structure shall be proposed for purchaser's approval (Wireless/ OFC or other)

6.2.5. Depending on the type, number of tanks, instrument and system configuration, requirement of multiple client stations at different geographical locations etc, TFMS vendor to propose/design the detailed architecture of the TFMS system.

6.2.6. Installation of the TFMS software on all systems supplied is essential part of TFMS package.

6.2.7. The power requirement for the TFMS system shall be derived from the TFMS hardware (Power distribution box or UPS supplied or client UPS) locally as required. Necessary wiring and accessories shall be in vendor's scope.

6.2.8. The schedule of supply (BOM) and erection shall be indicative only. However any item which is technically required for achieving the functionalities as per the requirements of this specification shall be included in scope of supply/ erection, for which no additional claim is admissible from the vendor.

7.0 SCOPE OF DESIGN, SUPPLY AND ERECTION- GENERAL

An indicative scope of supply and services is given below and in subsequent chapters. Vendor to refer the data sheets and special requirements for details :

7.1. DESIGN

The scope of vendor includes detailed design of the TGS for each tank/ site as per the specifications outlined here. The detailed design includes the selection of

proper instruments with configuration and compatibility, developing of the SCADA graphics and developing the logics/ interlocks, reports, alarms etc. as required.

7.2. SUPPLY OF FIELD LEVEL ATG SYSTEM HARDWARE

This includes the major hardware like gauging instruments- Radar, servo gauges, and accessories like MST/ MSTW and pressure transmitter etc ; and spares for each equipment supplied. The detailed technical specifications of each items are given in subsequent chapters.

7.3. SUPPLY OF FIELD LEVEL ERECTION HARDWARE

When the complete package is offered as a single responsibility for the supply and erection, the field erection hardware like cables, cable trays, junction boxes, structural steel, and all other hardware required for proper completion of work as per sound engineering practices are deemed included in the scope of supply. The details of these materials are not covered under this document, which shall be referred from the attached data sheets/ special requirements of the project.

7.4. SUPPLY OF CONTROL LEVEL ATG SYSTEM HARDWARE

The control level ATG system includes the field communication units, TFMS PC/ Server, Panels, associated furniture, other electronic gadgets like Ethernet switch, GSM modem etc and spares for the equipments. The specification for control level ATG system is covered under relevant chapters in this document. For the scope of supply for a specific item, vendor shall refer to the schedule of items/ special requirements of the project.

7.5. SUPPLY OF CONTROL LEVEL ATGS SYSTEM SOFTWARE

This includes the software for the operation of all hardware supplied as part of the TFMS package and for networking as detailed in special requirements. The details are mentioned in the appropriate chapters.

7.6. SERVICES

7.6.1. This include the erection services like mechanical and electrical erection portion of all hardware and software supplied, interfacing to third party equipments/ systems, quality assurances, FAT, SAT, AMC, Resident engineer support, training, documentation, Guarantee and performance warrantee etc, the details of which are mentioned in 14ES0012.

7.6.2. Configuring the offsets so as to compensate for the deviations from ideal installation (Dead volume, temperature probe length mismatches, pressure transmitter elevation based correction in density, deviations in nozzle elevations etc)

7.6.3. Net working of the printer (In case network printer is used) and configuring of the reports in local/ network printers

7.6.4. Installation of all other software as detailed/required.

8.0 PROVEN TRACK RECORD

The TGS system offered shall have minimum 4000 hours of trouble free operation in India. Necessary testimonial in proof has to be submitted along with the bid.

9.0 SUB - VENDOR LIST

Refer to the sub-vendor list attached with the TPS for supply items. For any item for which the list of vendors are not provided, TFMS vendor shall bring it to the attention of the Owner/ PMC for specific approval of the sub-vendors, before ordering the material from non- approved vendors to avoid subsequent rejection of the material by the Owner/ PMC at OEM shop/site.

10.0 HAZARDOUS AREA CLASSIFICATION

10.1. Refer to the special requirements/ data sheets for the electrical hazardous area classification details.

10.2. Equipments in the hazardous area shall be connected to the non hazardous area equipment only through approved interfacing equipments.

11.0 SUB-SYSTEMS OF TFMS

11.1. The TFMS system shall have the following sub Systems:

A. Field level ATG system

B. Control level ATG system

11.2. The components and technical requirements of each of the above systems are discussed in the subsequent chapters of this specification.

12.0 STANDARDS

12.1. The system offered shall meet the requirement of applicable standards like OISD, BIS, PESO, W&M, API, IEC and all other statutory rules and regulations like the Indian electricity rules, Factories act, Hazardous area regulations and others if any prevailing at the date of issue of work order for the area of installation.

12.2. The latest version of the following national / international standards shall be adhered to for the system design/

development and installation. The list is not exhaustive and any standards not mentioned below, which is otherwise mandatory shall also be adhered to/followed:

API STANDARDS

API RP 500 Recommended Practices for Classification of Locations for Electrical Installations at Petroleum facilities Classified as Class I, Division I and Division 2

API/ ASTM tables 5/6, 23/24, 53/54A-B

API MPMS Ch 3.1A,B, Ch 3.3, 3.6, 7.0, 7.1

OIML STANDARDS

OIML R-125

OIML R-85/2008 Automatic level gauges for measuring the level of liquid in stationary storage tanks Part 1 and 2

IEC STANDARDS

IEC 61511- Functional safety- Safety Instrumented systems for process industry sector

IEC 61508- Functional safety of Electrical/ Electronic/ Programmable electronic safety-Related systems

IEC 61000 All parts- Electromagnetic Compatibility for industrial process measurement and control equipments

IEC 600529- Degrees of Protection Provided by Enclosures

IEC 60079- Explosive Atmospheres

IEC 62591- Industrial communication networks- Wireless communication network and communication profiles- Wireless HART

IEC 60529- Degrees of protection provided by enclosures

ASTM STANDARDS

ASTM D 1250 Standard guide for petroleum measurement tables

ISO STANDARDS

ISO 4266 Petroleum and liquid petroleum products, measurement of level and temperature in storage tanks by automatic methods

ISO 91-2 Petroleum Measurement Tables based on a reference temperature of 20 Deg C

ISO 9001/2015 Quality Management System- Requirements

ISO 140001/2015 Environmental management System- Requirements

OISD STANDARDS

OISD RP 158 Recommended Practices on Storage and Handling of Bulk Liquified Petroleum Gas (LPG), 2000

OISD RP 108 Recommended practices on oil storage handling

OISD RP 158 Recommended practice on storage and handling of bulk liquefied petroleum gas (LPG)

OISD RP 108 Recommended Practices on Oil Storage and Handling

OISD 244 Storage and handling of Petroleum products at depots and terminals

INDIAN STANDARDS

IS 2148- Electrical Apparatus For Explosive Gas Atmospheres

IS 3043 Code of practice of earthing

ASME STANDARDS

ASME B1.20.1 Pipe threads

ASME B16.5 Steel pipe flanges and flanged fittings

ASME B16.20 Ring Joint gaskets and grooves for steel pipe flanges

BRITISH STANDARD

BS.5345 Code of practice in Selection and Maintenance of Electrical Apparatus for use in Potentially Explosive Atmosphere (other Than Mining Applications for explosive Processing and Manufacture) Part 1-9

ISA STANDARDS:

ISA 100.11a Wireless networking

ISA 71.04 Functional safety- safety instrumented systems for the process industry sector

ISA S84.00 Functional safety

OTHER STANDARDS

MIL-HDBK217 Reliability Prediction of Electronic Equipment

DIN 43760

EMC Directive (89/336/EEC),

Low Voltage Directive (73/23/EC),

Atmosphere explosive Directive (94/9/EC) and Telecommunication Directive R&TTE (99/5/EC)

CHAPTER 2
RADAR LEVEL GAUGE

1.0. GENERAL

1.1. The gauge shall use FMCW technology.

1.2. The gauge shall be of antistatic construction for flammable liquids and liquefied gases.

1.3. The instrument shall be operating at the rated operating conditions as per OIML R 85-Parts 1&2.

1.4. The enclosure of the instrument shall be of die cast aluminium with epoxy painting.

1.5. The minimum ingress protection shall be IP65. The instrument enclosure shall withstand the harsh environment conditions near to sea as well and shall not require any additional protection for protection against sun light/ rain etc.

1.6. Intrinsic safe explosion protection method is preferred. However, when the supply voltage is higher, flameproof enclosure shall be provided to suit the hazardous area classification. However the connections to the loop powered indicator shall be intrinsically safe.

1.7. The instrument electronics shall be of microprocessor based solid state design.

1.8. The instrument shall be 4 wire SMART type / OEM digital protocol. The power supply shall be 110/ 230V AC.

1.9. The accuracy shall be as per OIML R 85 (1mm at standard conditions and 4mm after installation).

1.10. The instrument shall have separate zero and span adjustment locally.

1.11. Hysteresis error shall be max.+/-1 mm

1.12. Resolution shall be min. 1 mm

1.13. The gauge shall be designed to be immune to radio frequency and electro-magnetic interference with field strength of up to 15V/meter over 50Hz to 450MHz range.

1.14. The gauge shall not emit microwaves to a level dangerous to human beings. (as per API MPMS 3.1B, Max. 2mw) Necessary certificate proof of shall be provided.

1.15. The radar gauge MTBF shall be minimum 20 years

1.16. After power failure, the gauge shall generate a new level measurement within 30Sec

1.17. There shall not be any discrepancy between the level indicated in control room and that in the tank side indicator. The level update shall be simultaneous at control room and in respective TSI.

1.18. The instrument shall have an integral LCD display which is configurable in both mm and percentage units.

1.19. The gauge shall have the capability to automatically asses the submerged temperature spots and calculate the true average and temperature profile. In case of non cylindrical tanks, weighing factors shall be provided to calculate the true average temperature.

1.20. The calibration shall be possible from local (Gauge head) or from control room. If any separate hand held terminal is required for calibration purpose, the vendor shall clearly indicate the same in their offer.

1.21. The radar gauge shall have inputs for pressure, temperature and water bottom sensor. The same shall be selected unless specifically excluded from scope in the data sheet.

1.22. The pressure transmitter used for pressurized tanks shall be used to compensate for the level reading due to vapor density.

1.23. The gauge shall have Hi-Hi overfill protection alarm hardwired to the control system.

1.24. The blocking distance of the radar gauge shall be such that the gauge can measure the maximum level without any performance degradation.

1.25. The instrument shall be protected against lightning and over voltage both in its power supply and communication lines through diversion circuits (galvanic methods). The isolation voltage shall be higher than 1500VDC. All the applicable peripherals also shall have electrical circuitry to protect against surge and lightning.

1.26. In case, the same still well is used for manual dipping and radar gauging, the radar gauge shall have the inbuilt option for this and all accessories for this purpose shall be included in the scope of supply and installation.

1.27. The total system shall be of a modular design to permit ease of exchange/ replacement of individual components like antenna, electronic cards etc without the need of recalibration at site.

1.28. Whenever SIL certification is specified for use of the gauge for a safety instrumented system (SIS), it shall be assessed by an approved third party agency and a certificate for the same shall be produced as per requirements of IEC 61508.

2.0. ANTENNA

2.1. The antenna design shall ensure that product condensation/ vapor shall not affect the performance of the gauge.

2.2. The antenna type and material selection for the radar gauge shall be by vendor for the optimum performance of the gauge based on their expertise. (Horn/ Planar/ Rod/ Parabolic/ Cone/ Array etc). PTFE or other encapsulated type antenna shall be used if service conditions demands its use.

2.3. Wherever free space antenna is considered, no degradation is allowed in performance due to multipath effect when installation is nearer to tank shell.

3.0. PROCESS CONNECTION

3.1. Flanged instrument shall be used with a minimum rating of 150#.

3.2. For details of process connection size and mounting, refer to the data sheet. The following are the methods of mounting commonly followed:

a. Mounting directly on roof nozzle with/ without still well

b. Mounting on roof manhole without still well

4.0. ALARM CONTACT

4.1. The Radar gauge or the associated Field hardware (like Hub) shall have alarm contacts for the purpose of hardwired alarm directly from gauge to be transmitted to DCS/ PLC. For details of the quantity of alarm contacts and the contact rating, and the required number of cable entries and size, refer to the data sheets attached.

4.2. All the cable shall be terminated into the terminal blocks. Flying leads shall not be permitted in the main instrument or any accessories.

4.3. The instrument shall have pre-defined fail position, that can be configured.

4.4. All spare/open cable entries shall have metallic plugs.

5.0. STILL PIPE

5.1. The recommended still pipe details shall be reviewed/ provided by radar gauge vendor before fabrication and erection. If necessary, OEM assistance shall be sought during fabrication and erection of the still well.

6.0. **COMMUNICATION**

6.1. For process control applications the instrument shall communicate in 4-20mA HART protocol.

6.2. For inventory control/ custody transfer applications, specifications vide following clauses take precedence over specifications above:

6.3. The gauge shall support field bus communication protocols such as Profibus, Modbus/ Foundation Field bus or other as per vendor's standard. Using built in communication adapters/ protocol drivers, the gauge shall be able to communicate with other types of tank gauging systems.

6.4. The baud rate of the instrument shall be selected to meet the response time requirements. The same shall be demonstrated during the SAT.

6.5. The radar gauges shall communicate in multi-drop mode. Minimum 20% spare shall be kept spare in each loop to connect additional instruments in future.

7.0. WIRELESS COMMUNICATION

7.1. If specified in special requirements or data sheets, the field instruments shall communicate in wireless HART protocol as per IEC 62591 or ISA 100.11a. The wireless protocols should comply with IEEE 802.15.4 for wireless HART or IEEE 802.11 for ISA 100.11a.

7.2. The gauges shall have redundant communication paths in a self organizing mesh network so as to have alternate communication through nearby gauge or repeater ensuring reliable communication in case of any primary communication path failure due to any static or dynamic obstructions.

7.3. In case of distance limitations, intrinsic safe repeater shall be placed at convenient location, designed by vendor to cover all gauges.

7.4. The wireless data security and reliability shall be ensured using 128bit encryption with 16 channel frequency hopping.

7.5. The antenna shall not be directional and shall not require direct line of sight with other instruments for communication. Minimum 200 meters direct radial communication shall be possible without repeaters.

7.6. The gauge shall have interoperability feature with the same wireless protocol instruments.

7.7. The gauge shall transmit level, pressure, water level, average temperature etc to control room at an update rate of 8sec.

7.8. The gateway used to collect field device information and interfaces to the host shall communicate over OPC or Modbus TCP/IP. The TFMS OEM shall specify the maximum number of tanks that can communicate with a single gateway.

Gateways shall be organized in hot standby redundant manner.

7.9. The gauge shall be able to provide the battery diagnostic alarm through the communication network.

8.0. CONFIGURATION

8.1. The instrument shall be configurable from handheld communicator or through remote host.

8.2. Necessary software installed in laptop with necessary interface cards shall be provided for testing, configuration and diagnosis of the instrument.

9.0. EARTHING

9.1. The gauge shall have provision for external grounding pins for the safety earth connection.

10.0. TANK SIDE INDICATOR

10.1. The tank side indicator shall be min IP65 and certified intrinsically safe. Flameproof protection shall be considered as an alternative only, if intrinsically safe instrument is not available.

10.2. The tank side indicator shall be capable to display level, pressure, temperature (Spot and average), water level etc through digital communication with the gauge.

10.3. The tank side indicator operation shall be completely independent of the remote communication healthiness and the control level hardware.

10.4. The display shall be LCD with backlit option for visibility even under low ambient light conditions.

11.0. ACCESSORIES

11.1. The accessories shall include items like cable glands; loop powered indicator, power isolation switch, instrument mounting plate, mounting brackets for the loop powered indicator, reflector kit and reference pin or other field devices, insulation sleeve for catholically protected vessels, isolation valves etc. See the data sheet for the details on the accessories.

12.0. NAME PLATE

12.1. Tag plate shall be provided in SS tied to the instrument with SS wire/ chain.

12.2. The OEM nameplate shall be firmly attached to instrument by way of SS Screws not affecting the explosion proof properties of the enclosure, detailing the make, model no, serial no, basic technical details and statutory marking/ license no. etc.

13.0. SPARES & SPECIAL TOOLS

13.1. The instrument manufacturer shall list down all the spares available for the instrument and requirement of any special tools in hardware/ software for maintenance/ diagnosis of the instrument to facilitate ordering of the same by owner/ PMC.

13.2. The spares shall include

a. Commissioning spares
b. Two years operation spares
c. Mandatory spares

13.3. The list of spares attached along with the TPS to be referred for typical list of spares. Manufacturer to quote all the recommended spares even if not listed in spares document.

14.0. CERTIFICATIONS

- SIL2 certification shall be available certified from TUV, Exida or other equivalent agencies.
- The alarm relays shall be approved for overfill protection.
- OIML type certification shall be available
- Other certificates like Calibration, material test, CCOE/PESO etc shall be available.
- W&M (India)
- CE Mark / ATEX certified
- Material test certificate from Manufacturer
- Routine certificates

Note: SIL rating is required only if specified in data sheet and is based on the SIL requirement/ risk assessment.

CHAPTER 3
SERVO LEVEL GAUGE

1.0. GENERAL

1.1. The gauge shall be based on the principle of digitally driven high precision stepper motor and displacer mechanism to sense the Tank ullage.

1.2. The gauge shall be of antistatic construction for flammable liquids and liquefied gases.

1.3. The instrument shall be operating at the rated operating conditions in OIML R 85.

1.4. The gauge shall use displacer method to measure the Tank ullage.

1.5. The enclosure of the instrument shall be of die cast aluminium with epoxy painting. The drum compartment shall be of a material suitable to the wetted process liquid/ vapor, minimum Stainless steel 316 grades.

1.6. The minimum ingress protection shall be IP65. The instrument enclosure shall withstand the harsh environment conditions near to sea as well and shall not require any additional protection for protection against sun light/ rain.

1.7. Incase flameproof protection is provided/ permitted; all accessories shall be conforming to this requirement.

1.8. The instrument shall be 4 wire SMART type / OEM digital protocol. The power supply shall be 110/ 230V AC.

1.9. The accuracy shall be as per OIML R 85 (1mm at standard conditions and 4mm after installation).

1.10. The instrument shall have separate zero and span adjustment.

1.11. Hysteresis error to be max.+/-1 mm
Resolution to be min. 1 mm
Spot and profile density accuracy to be 0.003g/cc

1.12. The gauge shall be designed to be immune to radio frequency and electro-magnetic interference with field strength of up to 15V/meter over 50Hz to 450MHz range.

1.13. The servo gauge MTBF shall be minimum 10 years

1.14. After power failure, the gauge shall generate a new level measurement within 30Sec

1.15. There shall not be any discrepancy between the level indicated in control room and that in the tank side indicator. The level update shall be simultaneous at control room and respective TSI.

1.16. The instrument shall have an integral LCD display which is configurable in both mm and percentage units.

1.17. The gauge shall have the capability to automatically asses the submerged temperature spots and calculate the true average and temperature profile. In case of non cylindrical tanks, weighing factors shall be provided to calculate the true average temperature.

1.18. The calibration shall be possible from local (Gauge head) or from control room. If any separate hand held terminal is required for calibration purpose, the vendor shall clearly indicate the same in their offer.

1.19. The gauge shall have inputs for pressure, temperature and water bottom sensor. The same shall be selected unless specifically excluded from scope in data sheet.

1.20. The gauge shall have Hi-Hi overfill protection alarm hardwired to the control system.

1.21. The horizontal movement of the displacer shall be clearly mentioned in the data sheet for optimum still well design/ the displacer shall be selected properly to suit the already mentioned still well size.

1.22. The instrument shall be protected against lightning and over voltage both in its power supply and communication lines through diversion circuits (galvanic methods). The isolation voltage shall be higher than 1500VDC. All the applicable peripherals also shall have electrical circuitry to protect against surge and lightning.

1.23. The density measurement shall be initiated by a Switch or through TFMS software.

1.24. The total system shall be of modular design to permit ease of exchange/ replacement of individual components like motor, electronic cards etc without the need of recalibration.

1.25. The gauge's self diagnostics feature shall include wire jamming, break, etc and any damages to the gauge shall be prevented due to such problems.

2.0. WETTED PARTS

2.1. All the wetted parts like the displacer and the wire shall be SS316 minimum and PTFE coated if application demands it. The manufacturer shall advise for better material based on process conditions.

2.2. The displacer shall be firmly attached to the wire so that the displacer is not normally detached from the wire during operation.

3.0. PROCESS CONNECTION

3.1. Flanged instrument shall be used with a minimum rating of 300#. For the exact detail of the flange size and rating, the data sheet shall be referred to.

4.0. ALARM CONTACTS

4.1. The servo gauge shall have alarm contacts for the purpose of hardwired alarm directly from servo to be transmitted to DCS/ PLC. For details of the quantity of alarm contacts and the contact rating, and the required number of cable entries and size, refer to the data sheets attached.

4.2. All the cable shall be terminated into the terminal blocks. Flying leads shall not be permitted in the main instrument or any accessories.

4.3. The instrument shall be protected against lightning and over voltage

4.4. The local display shall be configurable in metric/ percentage units

4.5. The calibration shall be possible from local (Gauge head) or from control room. If any separate hand held terminal is required for calibration purpose, the vendor shall clearly indicate the same in the offer.

4.6. The gauge shall support field bus communication protocols such as Profibus, Modbus/ Foundation Field bus or other as per vendor's standard.

4.7. Whenever SIL certification is specified for use of the gauge for a safety instrumented system, it shall be assessed by a third party and a certificate for the same shall be produced as per requirements of IEC 61508.

4.8. All spare/open cable entries shall have metallic plugs.

5.0. STILL PIPE

5.1. The recommended still pipe details shall be reviewed by servo gauge vendor before fabrication and erection. If necessary, OEM assistance shall be sought during fabrication and erection of the still well.

6.0. **COMMUNICATION**

6.1. For process control applications the instrument shall communicate in 4-20mA HART protocol.

6.2. For inventory/ custody transfer applications, the following specifications listed below take precedence over the above specifications:

6.3. The gauge shall support field bus communication protocols such as Profibus, Modbus/ Foundation Field bus or other as per vendor's standard. Using built in communication adapters/ protocol drivers, the gauge shall be able to communicate with other types/ makes of tank gauging systems.

6.4. The standard baud rate shall be 2400. The same shall be demonstrated during SAT.

6.5. The Servo gauges shall communicate in multi-drop mode. Minimum 20% spare shall be kept spare in each loop to connect additional instruments in future.

7.0. WIRELESS COMMUNICATION

7.1. If specified in special requirements or data sheets, the field instruments shall communicate in wireless HART protocol as per IEC 62591 or ISA 100.11a. The wireless protocols should comply with IEEE 802.15.4 for wireless HART or IEEE 802.11 for ISA 100.11a.

7.2. The gauges shall have redundant communication paths in a self organizing mesh network so as to have alternate communication through nearby gauge or repeater ensuring reliable communication in case of a primary communication path failure due to any static or dynamic obstructions.

7.3. In case of distance limitations, intrinsic safe repeater shall be placed at convenient location designed by vendor to cover all gauges.

7.4. The wireless data security and reliability shall be ensured using 128bit encryption with 16 channel frequency hopping.

7.5. The antenna shall not be directional and shall not require direct line of sight with other instruments for communication. Minimum 200mtr direct radial communication shall be possible without repeaters.

7.6. The gauge shall have inter-operability feature with the same wireless protocol instruments.

7.7. The gauge shall transmit level, pressure, water level, average temperature etc to control room at an update rate of 8sec.

7.8. The gateway used to collect field device information and interfaces to the host shall communicate over OPC or Modbus TCP/IP. The TFMS OEM shall specify the maximum number of tanks that can communicate with a single gateway. Gateways shall be organized in hot standby redundant manner.

7.9. The gauge shall be able to provide the battery diagnostic alarm through the communication network.

8.0. CONFIGURATION

8.1. The instrument shall be configurable from handheld communicator or through remote host.

8.2. Necessary software installed in laptop with associated interface cards shall be provided for testing and diagnosis of the instrument.

9.0. **EARTHING**

9.1. The gauge shall have provision for external grounding pins for the safety earth connection.

10.0. TANK SIDE INDICATOR

10.1. The tank side indicator shall be min IP65 and certified intrinsically safe.

10.2. The tank side indicator shall be capable to display level, pressure, temperature (Spot and average), water level etc through digital communication with the gauge.

10.3. The tank side indicator operation shall be completely independent of the remote communication healthiness and the control level hardware.

10.4. The display shall be LCD with backlit option for better visibility even under low ambient conditions.

11.0. ACCESSORIES

11.1. The accessories shall include cable glands, loop powered indicator, power isolation switch (Only for 110 or 230V operated device), mounting brackets for loop powered indicator, insulation gaskets and sleeve for installation on cathodically protected vessels, calibration chamber, isolation valves etc. See the data sheet for the details of the accessories.

12.0. NAME PLATE

12.1. Tag plate shall be provided in SS tied to the instrument with SS wire/ chain.

12.2. The OEM nameplate shall be firmly attached to instrument by way of SS Screws not affecting the explosion proof properties of the enclosure, detailing the make, model no, serial no, basic technical details and statutory marking/ license no. etc.

13.0. SPARES & SPECIAL TOOLS

13.1. The instrument manufacturer shall list down all the spares available for the instrument and requirement of any special tools in hardware/ software for maintenance/ diagnosis of the instrument to facilitate ordering of the same by owner/ PMC.

13.2. The spares shall include

a. Commissioning spares
b. Two years operation spares
c. Mandatory spares

13.3. The list of spares attached along with the TPS to be referred for typical list of spares. Manufacturer to quote all the recommended spares even if not listed in spares document.

14.0. CERTIFICATIONS

- SIL2 certification shall be available certified from TUV, Exida or other equivalent agencies.
- The alarm relays shall be approved for overfill protection.
- OIML type certification shall be available
- Other certificates like Calibration, material test, CCOE/PESO etc shall be available.
- W&M (India)
- CE Mark / ATEX certified
- Material test certificate from Manufacturer
- Routine certificates
- Wherever IBR certification is specified in data sheets (Normally for guided wave), vendor to provide certificate as a proof for the same.

Note: SIL rating is required only if specified in data sheet and is based on the SIL requirement/ risk assessment.

CHAPTER 4
GUIDED WAVE RADAR GUAGE

1.0. GENERAL

1.1. The instrument shall be based on transit time technology. (TDR- Time Domain Reflectometry)

1.2. The gauge shall be of antistatic construction for flammable liquids and liquefied gases.

1.3. The instrument shall be operating at the rated operating conditions in OIML R 85.

1.4. The enclosure of the instrument shall be of die cast aluminium with epoxy painting.

1.5. The instrument Ingress protection shall be min IP65. The instrument enclosure shall withstand the harsh environment conditions near to sea as well and shall not require any additional protection for protection against sun light/ rain.

1.6. Intrinsic safe explosion protection shall be the preferred method. See the data sheet for the details of area classification.

1.7. Incase flameproof protection is provided/ permitted; all accessories shall be conforming to this requirement.

1.8. The instrument electronics shall be of microprocessor based solid state design.

1.9. All the GWR instruments shall be HART/FF compatible and Smart with 2 wire (i.e, 24VDC, without need of separate power) technology. In case separate power (4 wire) required, it is mentioned in data sheet. Refer to the data sheet for the output protocol for a particular application.

1.10. The accuracy shall be +/-3mm or better

1.11. The instrument shall have a moving average function to average signals to reduce noise.

1.12. The instrument shall have separate zero and span adjustment.

1.13. The gauge shall be designed to be immune to radio frequency and electro-magnetic interference with field strength of up to 15V/meter over 50Hz to 450MHz range.

1.14. The radar gauge MTBF shall be minimum 20 years

1.15. After power failure, the gauge shall generate a new level measurement within 30Sec

1.16. There shall not be any discrepancy between the level indicated in control room and that in the tank side indicator (used if any). The level update shall be simultaneous at control room and respective TSI.

1.17. The instrument shall have an integral LCD display which is configurable in both mm and percentage units.

1.18. The instrument calibration shall be possible from gauge head/ from control room/ handheld communicator. Any special HH communicator (Other than HART) required shall be supplied along with instrument.

1.19. The instrument shall have separate zero and span adjustment.

1.20. For inventory control, the GWR gauge shall have inputs for pressure, temperature and water bottom sensor (If specified). The same shall be selected unless specifically excluded from scope in data sheet. The gauge shall have the capability to automatically asses the submerged temperature spots and calculate the true average and temperature profile. In case of non cylindrical tanks, weighing factors shall be provided to calculate the true average temperature.

1.21. The pressure transmitter used for pressurized tanks shall be used to compensate the level reading due to vapor density.

1.22. The gauge shall have Hi-Hi overfill protection alarm hardwired to the control system.

1.23. The blocking distance of the radar gauge shall be such that the gauge can measure the maximum level without any performance degradation.

1.24. The instrument shall be protected against lightning and over voltage both in its power supply and communication lines through diversion circuits (galvanic methods). The isolation voltage shall be higher than 1500VDC. All the applicable peripherals also shall have electrical circuitry to protect against surge and lightning.

1.25. The total system shall be of a modular design to permit ease of exchange/ replacement of individual components like probe, electronic cards etc without the need of recalibration.

2.0. WAVE GUIDE

2.1. Wetted parts like wave guide and flange shall be SS316 minimum. The manufacturer shall advise better material based on process conditions and expertise in this field.

2.2. The probe diameter shall be chosen carefully to avoid the requirement of any

still well. Any accessories to align the probe properly shall be supplied by the vendor.

2.3. The instrument shall be easily removable without the need to remove the probe from the tank/ vessel.

3.0. PROCESS CONNECTION

3.1. Flanged instrument shall be used with a minimum rating of 300#.

3.2. For details of process connection size and mounting, refer to the data sheet. The following are the methods of mounting commonly followed:

3.3. Mounting directly on roof nozzle with/ without still well

3.4. Mounting on external cage

4.0. ALARM CONTACT

4.1. The GWR gauge or the associated Field hardware (Like Hub) shall have alarm contacts for the purpose of hardwired alarm directly from gauge to be transmitted to DCS/ PLC. For details of the quantity of alarm contacts and the contact rating, and the required number of cable entries and size, refer to the data sheets attached.

4.2. All the cable shall be terminated into the terminal blocks. Flying leads shall not be permitted in main instrument or any accessories.

4.3. The instrument shall have pre-defined fail position, that can be configured.

4.4. Whenever SIL certification is specified for use of the gauge for a safety instrumented system, it shall be assessed by a third party and a certificate for the same shall be produced as per requirements of IEC 61508.

4.5. All spare/open cable entries shall have metallic plugs.

5.0. STILL PIPE

5.1. If still pipe is used/ recommended by the OEM (Or required because of turbulence), the still pipe details shall be reviewed/ provided by GWR vendor before issued for fabrication and erection. If necessary, OEM assistance shall be provided to mechanical contractor during fabrication and erection of the still well.

6.0. **COMMUNICATION**

6.1. When specified for inventory control, the following shall take precedence over the specification above regarding the communication protocols:

6.2. The gauge shall support field bus communication protocols such as Profibus, Modbus/ Foundation Field bus or other as per vendor's standard. Using built in communication adapters/ protocol drivers, the gauge shall be able to communicate with other types of tank gauging systems.

6.3. The standard baud rate shall be 2400. The same shall be demonstrated during SAT.

6.4. The GWR shall communicate in multi-drop mode. The number of gauges to be multi-dropped in a single loop shall not exceed manufacturer's specified maximum per loop-20%.

7.0. WIRELESS COMMUNICATION

7.1. When specified for inventory control with wireless communication, the following shall take precedence over the specification above:

7.2. The field instruments shall communicate in wireless HART protocol as per IEC 62591 or ISA 100.11a. The wireless protocols should comply with IEEE 802.15.4 for wireless HART or IEEE 802.11 for ISA 100.11a.

7.3. The gauges shall have redundant communication paths in a self organizing mesh network so as to have alternate communication through nearby gauge or repeater ensuring reliable communication in case of a primary communication path failure due to any static or dynamic obstructions.

7.4. In case of distance limitations, intrinsic safe repeater shall be placed at convenient location designed by vendor to cover all gauges.

7.5. The wireless data security and reliability shall be ensured using 128bit encryption with 16 channel frequency hopping.

7.6. The antenna shall not be directional and shall not require direct line of sight with other instruments for communication. Minimum 200 meters direct radial communication shall be possible without repeaters.

7.7. The gauge shall have interoperability feature with the instruments of same wireless protocol.

7.8. The gauge shall transmit level, pressure, water level, average temperature etc to control room at an update rate of 8sec.

7.9. The gateway used to collect field device information and interfaces to the host shall communicate over OPC or Modbus TCP/IP. The TFMS OEM shall specify the maximum number of tanks that can communicate with a single gateway. Gateways shall be organized in hot standby redundant manner.

7.10. The gauge shall be able to provide the battery low alarm through the communication network.

8.0. CONFIGURATION

8.1. The instrument shall be configurable from handheld communicator or through remote host.

8.2. Necessary software installed in laptop with necessary interface cards shall be provided for testing and diagnosis of the instrument.

9.0. EARTHING

9.1. The gauge shall have provision for external grounding pins for the safety earth connection.

10.0. TANK SIDE INDICATOR

10.1. The tank side indicator shall be min IP65 and certified intrinsic safe.

10.2. The tank side indicator shall be capable to display level, pressure, temperature (Spot and average), water level etc through digital communication with the gauge.

10.3. The tank side indicator operation shall be completely independent of the remote communication healthiness and the control level hardware.

10.4. The display shall be LCD with backlit option for better visibility even under low ambient conditions.

11.0. ACCESSORIES

11.1. The accessories include the cable glands, loop powered indicator (Either 4-20mA based or Digital protocol based depending on type and application in data sheet), power isolation switch (Of 110 or 230V power), insulation sleeve, insulation gasket etc for cathodically protected vessel installation. See the data sheet for required accessories.

12.0. NAME PLATE

12.1. Tag plate shall be provided in SS, tied to the instrument with SS wire/ chain.

12.2. The OEM nameplate shall be firmly attached to instrument by way of SS Screws not affecting the explosion proof properties of the enclosure, detailing the make, model no, serial no, basic technical details and statutory marking/ license no. etc.

13.0. SPARES AND SPECIAL TOOLS

13.1. The instrument manufacturer shall list down all the spares available for the instrument and requirement of any special tools in hardware/ software for maintenance/ diagnosis of the instrument to facilitate ordering of the same by owner/ PMC.

13.2. The spares shall include

a. Commissioning spares
b. Two years operation spares
c. Mandatory spares

13.3. The list of spares attached along with the TPS to be referred for typical list of spares. Manufacturer to quote all the recommended spares even if not listed in spares document.

14.0. CERTIFICATIONS

- SIL2 certification shall be available certified from TUV, Exida or other equivalent agencies.
- The alarm relays shall be approved for overfill protection.
- OIML type certification shall be available (In case of custody transfer/ inventory control)
- Other certificates like Calibration, material test, CCOE/PESO etc shall be available.
- W&M (India)- For inventory control
- CE Mark / ATEX certified
- Material test certificate from Manufacturer
- Routine certificates
- Wherever IBR certification is specified in data sheets (Normally for guided wave), vendor to provide certificate as a proof for the same.

Note: SIL rating is required only if specified in data sheet and is based on the SIL requirement/ risk assessment.

CHAPTER 5
MULTI SPOT TEMPERATURE PROBE WITH OPTIONAL INTEGRATED WATER LEVEL SENSOR

1.0. GENERAL

1.1. The common industrial Pt 100 mineral insulated type sensor shall be used in the multi spot temperature probe with copper lead wires.

1.2. The temperature element shall be 3 wire type and ungrounded type.

1.3. An interface transmitter if used shall be of die cast aluminium enclosure with epoxy coating.

1.4. The ingress protection shall be min IP65for the interface transmitter. The probe shall be IP68 certified.

1.5. The water interface probe shall detect the water level based on the principle of change in capacitance.

1.6. Temperature range - 10 to 100Deg C
Water level range 0-500mm
Temperature Accuracy shall be 0.1Deg C
Resolution of min. 0.01Deg C
Accuracy of water probe shall be min.2mm.

1.7. The water probe shall operate satisfactorily from 0 to 100 deg C

1.8. The RTDs shall be placed at 2m interval along the height of the tank. The bottom RTD shall be placed at 300mm from bottom (Within water sensor if provided). The design of the MST/MSTW shall ensure that minimum 6 temperature elements shall be fully submersed at tank full operating level.

1.9. The sheath material shall be SS316 minimum.

1.10. The ingress protection of the immersed portion of the sensor shall be IP68 applicable for exposed installation to the wetted medium (i.e except pressurized installation for which a thermo well is being used).

1.11. The minimum detectable water level shall be 25 mm above the lowest part of the water probe.

1.12. The probe length shall be carefully assessed by the vendor from the drawings/ documents provided by the purchaser. Necessary extra length shall also be accounted for fine adjustment at site.

1.13. In case of any discrepancy between the selected length and the actual installation due to improper length selection, the necessary correction/ replacement of the probe shall be at vendor's own responsibility without any cost implication to owner. This includes any mechanical modification of nozzles also/ or the cost of the same shall be recovered from the TFMS vendor if nozzles modified through alternate contractor.

1.14. The temperature probe used shall have a bottom anchor weight (Especially when installing without still well) so as to keep it straight under flow load while filling/ recycle mode of tank.

1.15. Probe connection- Threaded- adapted on flange with check nuts.

1.16. If installed inside still well, the water bottom sensor shall use concentric flanges to center the sensor inside the still well.

1.17. Sufficient slack length in both direction shall be considered for the probe length for slight adjustment at site for compensation of any mismatch in tank / nozzle heights.

2.0. WETTED PARTS

2.1. The probe shall be covered with corrugated SS sheath with an ingress protection if IP68.

3.0. PROCESS CONNECTION

3.1. The MST/MSTW shall be of flanged construction with check nuts for adjustment of the probe length inside the tank.

4.0. STILL PIPE

4.1. For floating roof tanks, the instrument is mounted inside a still well. For cone roof tanks, it is either directly mounted inside the tank or a still well is used optionally. If still well is used, the slots and its distribution shall be approved by the OEM before manufacturing the well at site.

5.0. COMMUNICATION

5.1. The communication protocols of the instrument shall be compatible to the associated radar or servo gauge. The instrument shall communicate in digital formats to the associated level gauging instrument in TFMS system.

6.0. EARTHING

6.1. The instrument shall have one no of earthing bolt for safety earth connection.

7.0. ACCESSORIES

7.1. The instrument shall be supplied along with cable glands and adapter flange for the probe.

8.0. NAME PLATE

8.1. Tag plate shall be provided in SS tied to the instrument with SS wire/ chain.

8.2. The OEM nameplate shall be firmly attached to instrument by way of SS screws not affecting the explosion proof

properties of the enclosure, detailing the make, model no, serial no, basic technical details and statutory marking/ license no. etc.

9.0. SPARES AND SPECIAL TOOLS

9.1. The instrument manufacturer shall list all the spares available for the instrument and requirement of any special tools in hardware/ software for maintenance/ diagnosis of the instrument to facilitate ordering the same by owner/ PMC.

9.2. The spares shall include

a. Commissioning spares
b. Two years operation spares
c. Mandatory spares

9.3. The list of spares attached along with the TPS to be referred for typical list of spares. Manufacturer to quote for all the recommended spares even if not listed in the spares document.

10.0. CERTIFICATIONS

- Ingress protection- For the probe and the instrument
- Flameproof
- Calibration certificate for both the temperature spots and water level sensor if applicable.

CHAPTER 6
PRESSURE/ DIFF.PRESSURE TRANSMITTER FOR DENSITY / VAPOR PRESSURE
PART A- TECHNICAL REQUIREMENTS

1.0. GENERAL

1.1. The enclosure of the instrument shall be of die cast aluminium with epoxy painting.

1.2. The instrument ingress protection shall be min IP65.

1.3. Intrinsic safe explosion protection shall be the preferred method. See the data sheet for the details of area classification. All the accessories like cable glands and plugs shall retain the apparatus protection i.e IP65 and Exd for flameproof.

1.4. The instrument shall have an integral LCD display which is configurable in both mm and percentage units.

1.5. Accuracy shall be min.+/-0.1% of calibrated span for standard type and min.+/-0.2% for the diaphragm type.

1.6. The transmitter shall have the standard feature for zero suppression and elevation across its entire range of span.

1.7. The turn-down ratio shall be 100:1 for standard type and 50:1 for diaphragm type.

1.8. For diaphragm seal instruments, flushing rings/ dripping rings shall be provided with vent/ drain connection and associated valves.

1.9. The transmitter shall be provided with external surge/ lightning protection device

1.10. The transmitter shall be provided with mounting brackets for 2" pipe in SS with SS nuts and bolts and U clamp for the standard type/ remote seal diaphragm type.

1.11. For vertical tanks, flanged type differential pressure transmitter used shall have process connection at its side. (Vertical installation)

1.12. In case of installation on cathodically protected tanks/ bullets, a dielectric fitting shall be incorporated in the tubing to avoid electrical earthing of the bullet through the body and armor of the pressure transmitter. Alternate methods for achieving the same level of insulation shall be explored by the vendors and submitted for approval.

2.0. WETTED PARTS

2.1. The flange / diaphragm shall be SS316 minimum. Alternate material/ coating if demanded by the process conditions shall be advised by the manufacturer.

3.0. PROCESS CONNECTION

3.1. For flanged type instruments, the process connection shall be 2 to 3". The instrument shall be vertical with flange side mounted.

3.2. For NPT type connection (For vapor space pressure), the process connection shall be ½".

4.0. COMMUNICATION

4.1. The pressure/ differential pressure transmitter used for the density measurement/ vapor pressure measurement shall be Smart with FF/ 4-20mA HART/ Wireless protocol as demanded by the associated radar or servo gauge communication requirements.

5.0. EARTHING

5.1. The instrument shall have provision for external grounding pins for the safety earth connection.

6.0. ACCESSORIES

6.1. For pressure transmitter (Pressurized tanks), 2 way manifold shall be supplied along with the instrument. For differential pressure transmitter (atmospheric tanks), if the process connection is threaded, 3 way manifold shall be supplied. For differential pressure transmitter with flanged connection, flushing ring, pair of nipples, valves and plugs also shall be supplied.

6.2. Other accessories to be considered are cable glands and plugs for spare cable entries. Minimum two cable entry of ½" NPT shall be considered for each instrument.

7.0. NAME PLATE

7.1. Tag plate shall be provided in SS tied to the instrument with SS wire/ chain.

7.2. The OEM nameplate shall be firmly attached to instrument by way of SS Screws not affecting the explosion proof properties of the enclosure, detailing the make, model no, serial no, basic technical details and statutory marking/ license no. etc.

8.0. CERTIFICATIONS

- ❖ Ingress protection
- ❖ Explosion proof
- ❖ Material test (for diaphragm seal)
- ❖ Routine test certificate
- ❖ SIL-2 (wherever specified)

CHAPTER-7
CONTROL LEVEL ATG SYSTEM

1.0. GENERAL

1.1. The control level ATG system includes all hardware situated in control room i.e, TFMS panel/ Cabinet, redundant Communication interface unit/ field communication units, redundant TFMS server/ computer/ Workstations, operator consoles, Printer, Printer tables and chairs, communication devices (Like Ethernet switches, gateways etc and GSM modem if any) and cables (Including OFC/ coaxial/ wireless) to integrate the TFMS system to third party systems like PLC/ DCS/ ESD/ TAS/ SCADA/ Other TFMS systems at local or remote locations etc. Refer the special requirements for detailed scope of supply and installation

1.2. The availability of the system shall be 99.99% with MTTR of 8 hours and MTBF of eighty thousand hours or more.

1.3. The minimum specification of the Control level ATG system is given below:

1.4. Minimum 6 ports shall be considered for the connectivity to other systems like PLC/ DCS/ TAS/ SCADA/ SAP/ Blending system if any etc

2.0. TFMS SERVER/ TFMS PC/ TFMS WORKSTATION

2.1. The system offered shall be redundant with hot standby feature. Optionally the vendor may quote for a server with built in redundancy. It shall have 99.999% availability with in-memory data protection, zero down time, full data redundancy, and port level redundancy (Including LAN) etc See project specific data sheet for detailed specification. Brief specification is provided below:

- Type Tower
- RAM min 2GB
- HDD min 320GB
- LCD monitor
  - Size 21",
  - Resolution 1280x1024
  - Contrast ratio 400:1
  - Viewing angle 150/140 (H/V)
  - Response time <20mS
  - Brightness 250Cd/Sqm
  - Flicker free and glare free
- USB Keyboard QWERTY/ Spill proof membrane type,
- USB Optical mouse,
- CD/DVD RW drive
- IO ports- 1 serial, 1 parallel, 6 USB
- Audio- Microphone jack line in and line out
- High resolution Graphics- Intel Graphics media accelerator, NVIDIA
- Ethernet- With RJ 45
- Redundant power supply with cooling fan

3.0. FIELD COMMUNICATION UNIT/ COMMUNICATION INTERFACE UNIT

3.1. The CIU/ FCU acts as the interface between the Field level ATG system and the TFMS server/ PC/ workstation. The CIU/ FCU shall accept the serial data from field level ATG system and transmit it to TFMS server/ computer in redundant link.

3.2. Microprocessor based redundant CIU/FCU shall be used with hot standby feature. The switching of the CIU/ CU shall be alarmed.

3.3. The required number of FCU/ CIU shall be calculated by the OEM based on the number of instruments, distance limitations if any and the spare philosophy of minimum 2 spare instruments in each loop.

3.4. The CIU/ FCU shall be mounted inside the TFMS cabinet unless otherwise specified.

3.5. The CIU/FCU shall allow for remote monitoring/ trouble shooting of the field level ATG system.

3.6. CIU/ FCU shall have full galvanic isolation on all its field and host ports

3.7. CIU shall have inbuilt OPC server to communicate with other systems via Ethernet / LAN.

3.8. CIU shall operate at 230V 50HZ AC standard power supply.

3.9. The system shall provide RS 232/485 interface for data transmission

4.0. TFMS PANEL/ CABINET

4.1. A separate panel shall be considered for housing the TFMS hardware like CIU/FCU, MCBs for field ATG instruments, powering of TFMS servers, printers etc

4.2. The cabinet shall be 2000mmHx800mmWx800mmD size with 15mm Anti vibration pad and 100mm plinth. The minimum cabinet protection shall be IP52.

4.3. Minimum two type of earth bar shall be provided: Safety earth and instrument earth which is insulated from rest of the panel structure. Cable entry shall be from bottom.

4.4. Refer the attached panel/ cabinet specification document for detailed specification, utilities and wiring in the panel.

5.0. PRINTER

5.1. The following specification shall be the minimum to be followed for the printer for TFMS package:

a. Wireless/ LAN (RJ45)/ Local printer through USB (For wireless connection, the TFMS server/PC shall have the corresponding wireless option)
b. Resolution 1200x1200 DPI
c. Print speed 12ppm
d. Paper size A4
e. Color- Monochrome
f. Power supply 230V AC 50Hz
g. Compatibility- With all operating system software supplied
h. Pages per month- 5000min
i. Duplex printing- Yes
j. Memory- 8MB
k. Paper input- Manual feed slot and tray (150 sheets)
l. Paper output- 125 sheet tray
m. Make- Refer to sub-vendor list attached

6.0. COMMUNICATION INTERFACE

6.1. The field interface and Host interface like PLC/ DCS/ SAP/ TAS/ Other TFMS System interface provided shall be dual serial link (Modbus/ TCP/IP) for redundancy. Failure of one communication path shall be alarmed with automatic change-over. Necessary modem or other hardware required, if any shall be included in offer. Manual change-over to the redundant serial link also shall be possible.

6.2. The secondary communication path shall be used on time division or checked regularly at fixed time intervals for healthiness.

6.3. The integration of TFMS system to third party devices and software shall be in TFMS vendor scope and the same shall be coordinated with other parties as required for customization of program etc.

6.4. The TFMS architecture shall support peer to peer client/ server LAN and WAN network.

7.0. SPARES AND CONSUMABLES

7.1. Vendor to notify the client about all the spares available for the instruments and spares offered, which includes:

a. Mandatory spares
b. Two years operation (includes Consumables like fuses, CD / DVDs, printer cartridges etc. Vendor to note down any other consumables required for trouble fee operation) and maintenance spares
c. Commissioning spares (Includes paper and printer cartridges also).

8.0. SPECIAL TOOLS

8.1. Special tools in hardware/ software required if any for the operation, maintenance, diagnosis etc shall be clearly stated by the vendor in his offer for ordering by client/ PMC.

CHAPTER-8
SOFWARE SPECIFICATIONS

1.0. GENERAL

1.1. The TFMS software shall be from the same OEM of the ATG system at field through standard communication protocols like Modbus TCP/IP, HART, FF, OPC DA etc. (Applicable for a comprehensive tender including the ATG system hardware at field)

1.2. The TFMS software offered shall be of the latest version released at the time of FAT.

1.3. The software shall be modular design to add additional modules/ facilities/ Modifications in future if required.

1.4. The software shall be of open connectivity to extract data using standard software like MS word/ Excel.

1.5. The software shall support hot standby operation of the hardware connected to it.

1.6. The systems offered shall have the windows operating system of latest version loaded.

1.7. Software shall support minimum 1000 point strapping table for each tank.

1.8. The tank gauging system together with the field level ATG system and Control level ATG system shall be able to perform inventory calculations and custody transfer operations based on level, pressure, temperature and density complying with local/ national/ international/ statutory rules and regulations.

1.9. The software shall support remote commands to the ATG systems at field i.e, Density profiling command to servo gauge etc

1.10. The software shall support SCADA functions such as pumps and valve monitoring and control in association with the PLC/ DCS/ plant control systems.

1.11. The software shall be able to communicate with field devices using different communication protocols such as Ethernet, Modbus, 4-20mA HART, Profibus, and Foundation Field bus.

1.12. The software shall allow manual entry of field data for the tanks -which are not having the ATG –for integrating these tanks to TFMS system.

1.13. The TFM software shall be suitable to be integrated with TFM software from different OEM, through necessary protocol adapters/ hardware. The details of the same shall be included with the offer. (including the hardware requirement if any)

1.14. System shall hold the last healthy value of density when the level is below the set minimum for density determination.

1.15. The hysteresis value of each alarm shall be programmable.

1.16. The software shall reject wrong user inputs with alarm/ warning to the user.

1.17. The software shall have batch handling facility if integrated with TAS/ PLC/ SCADA to handle with the fixed volume transfer from different sources to different destinations.

1.18. The system shall have features for remote connectivity for viewing data/ diagnosis through remote support through internet/ telephone/ web access connection.

1.19. The software shall allow an instrument to be placed into maintenance mode.

1.20. The TFMS system shall acquire the following data from the field mounted ATG system and perform necessary calculations. Both the raw data and calculation intermediates/ results shall be available to the operator.

a. Level from Radar and/or servo gauges
b. Pressure- and perform density calculations based on temperature also.
c. Spot temperature and Average temperature from the temperature probe based on the immersed/ Vapor space spot elements
d. Density profiling from servo (See data sheet for specific requirement) gauge
e. Water interface level from the water bottom sensor integrated to the temperature probe (See specific requirement on data sheet)

1.21. SCAN TIME
The scan rates of each instrument shall be programmable in TFMS system and shall normally be less than 4 sec for the entire tank farm.

1.22. OPC COMPLIANCE
The TFM software shall be OPC compliant for simple data exchange with TAS/ PLC/ DCS/ SCADA/ HMI.

1.23. CLOCK SYNCHRONISATION
The TFMS system shall have clock synchronizing with TAS/ PLC/ DCS/ or with all workstations of TFMS.

1.24. EXPANDABILITY
The system offered shall have license for addition of 100% spare tanks in future. This shall include necessary soft tags in SCADA also and any other license as required.

1.25. SELF DIAGNOSIS AND MAINTENANCE

The system shall have powerful diagnostic tools for revealing the faults in its own software, hardware, communication and up to field level gauge diagnosis of hardware/ software in nature.

1.26. HELP FILE

A help file shall be available for all functions. User manual/ documentation shall also be available for quick reference online.

2.0. CALCULATIONS

2.1. The TFMS calculations shall be based on servo gauge only. In case of failure of the primary servo gauge, the radar gauge data shall be used for calculations.

2.2. The following are fetched from the field for each tank

a. Product level
b. Water level
c. Pressure
d. Temperature
e. Density (Direct or inferred- based on instrument configuration)

2.3. API density calculator shall be provided as per API standard.

2.4. The TFM software shall be able to calculate the following in real time based on the fetched data:

a. Gross product level/ Volume
b. Observed temperature
c. Average temperature (Liquid and/ or Vapor)
d. Water volume
e. Observed Density
f. Average density
g. Standard density (at 15Deg.C)
h. Inventory of each tank/ group of tank/ product wise
i. Mass calculations
j. Volume calculations (as per ASTM/API tables)- Innage and Ullage
k. Total Observed volume (TOV)
l. Net observed volume (NOV)
m. Gross Observed Volume (GOV)
n. Gross Standards Volume (GSV=GOV corrected with temp),
o. Net Standard Volume (NSV=GSV-Water volume)
p. Water volume (Water level and strapping table)
q. Net volume (Gross volume- water volume) at 15 Deg C
r. Ullage (Safe filing capacity- gross volume)
s. Volume calculations based on initial and final level difference
t. Pumpable volume
u. Tank wise/ Product wise calculation of all the above
v. Flow rate based on level difference
w. Expected Time calculations for filling/ emptying/ switching to another tank
x. Correction for tank shell expansion based on ambient and product temperature, level and pressure

3.0. ALARMS

3.1. Alarm shall be able to be defined based on conditions and calculated parameters also in addition to the basic field fetched data.

3.2. Alarms and events shall be able to be assigned to multiple levels of priorities (Critical, Normal, for information, warning etc) and categories (Process, system hardware, system software, communication etc). An indicative list of alarm prioritization is given in the table below:

Table 1-Indicative Alarm Prioritization

Alarm/ Event	Priority
High High Alarm	3
High alarm	2
Low	2
Low Low	3
Operator high	1
Operator low	1
Pressure high (Pressurized tanks)	3
Pressure Low (Pressurized tanks)	3
Level deviation (Difference between primary and secondary gauges beyond tolerance)	1
Redundancy switch over (Hardware/ communication etc)	2
Field communication failure	2
All other diagnostic alarm	1

3.3. The following alarms are required in TFMS system:

Category 1- Process alarms

a. Level HH, H, L, LL for each tank from all level measuring devices (Normally two no per tank)
b. Operator Hi/ Lo for each tank (For tank switching purpose- Operator configurable within the logical ranges of tanks)
c. Temperature H/L
d. Pressure H/L

e. Level deviation alarm (In case of more than one level measuring device on a tank)
f. Parameter out of range (Due to wrong calibration or unknown reasons) for level, pressure, temperature, density, interface level etc
g. Leakage alarm (In communication with PLC/ TAS/ DCS for the tank operation modes/ valve status)

Category 2- System/ Diagnostic alarms

a. ATG not communicating from field (Either one instrument or group of tanks)
b. Server (hardware) switch over/ failure
c. Software errors
d. CIU/ FCU switch over
e. LAN failure
f. PLC/ DCS/ TAS communication failure/ communication switchover to redundant path
g. Diagnostic alarms from panel (if any)- Hardwired

3.4. The above list is indicative. The vendor to modify the list of alarms based on software capability.

3.5. The alarm list shall be available in the screen all the time with scroll bar (Newest on top of the list).

3.6. The alarm list shall be able to be filtered based on multiple criteria i.e, for a particular tank/ product, priority, category etc to refine the alarms.

3.7. The list of acknowledged alarm and unacknowledged alarm shall be available

3.8. ALARM SEQUENCE

a. The alarm shall be of manual reset type i.e, in case of an alarm, the alarm shall flash and audible alarm also to be provided. When the alarm become normal before operator attends it, it shall be steady and audio shall be silenced. The steady indication shall continue until operator reset the alarm
b. In case the alarm is acknowledged by the operator, the audio shall be silenced.
c. When the alarm become normal after acknowledging, the indication shall not change (Continue to be steady) and after resetting the alarm, the alarm shall return to normal
d. Alarm first out sequence shall be available
e. Alarm masking, Alarm suppression, alarm disabling, alarm silencing etc shall be available.
f. Condition based alarm definition through scripts/ programming shall be available with which an alarm condition can be defined based on a sequence of alarms/ events.
g. The system shall be able to send auto SMS following an alarm or event (If the hardware for the same is specified in the hardware requirement/ as per scope of project)

4.0. CAUSE AND EFFECT

4.1. The software cause and effect is shown in the table below.

Table 2- Indicative Cause and effect

Cause / Effect	SMS*	Alarm	E-mail
Hi Hi	Y	Y	-
Hi	-	Y	-
L	-	Y	-
Lo Lo	-	Y	-
Operator Hi	-	Y	-
Operator Lo	-	Y	-
End of Shift/ day/ week / Month	-	-	Y
Admin Group log in	Y	-	Y
Configuration changes	-	-	Y
Major events of priority 3	Y	Y	Y
Tank Auto switch over for integrated systems	-	Y	-
*Applicable if hardware for the same included in tender/ scope included in tender i.e hardware supplied by others			

4.2. For an integrated system with PLC/ DCS/ TAS etc, further process cause and effect will be handed over during the detailed engineering phase.

5.0. DISPLAY

(See the table for the details to be provided in each display)

5.1. The following major types of graphical displays shall be developed in TFMS systems.

a. TFMS system architecture screen
b. Graphical Overview display -One display with all tanks. - Preferably in site layout/ approved layout with specific symbol for each type of tank and specific color for each product.
c. Group display -Based on product/ Geographical area criteria- Same tank shall be able to be assigned to more than one group for display and calculation purposes
d. Tank detail (For each specific tank)
e. Product detail (For all tanks of a particular product)
f. Tabular data for all tanks/ specific tank/ Product wise

g. Comprehensive Alarm list and set point list display for each alarm limits
h. Maintenance list

5.2. All the above displays shall be developed and a sample shall be submitted for approval (One Overall layout, one specific layout for each type of tank, sample of tank group displays etc) in advance and on approval of the same, shall proceed for all other tanks to avoid re-work in graphics design.

5.3. For each parameter, display shall be available in Graphic form, alphanumeric, or in real time/ historic trend, histogram, bargrpah format etc

5.4. All display shall be dynamically updated from field fetched data at the same frequency as of scanning.

5.5. The alarm display (Currently active list of alarms) shall not be hidden by the user. Even if the user switches to different types of displays, the alarm list shall remain at the bottom of the screen.

5.6. Real time trending of parameter values shall be available. Multiple trend windows shall be able to be opened simultaneously. Multiple data shall be able to be included into one trend graph with different color.

6.0. EVENTS

6.1. All important events shall be available on Event display screen with time stamp. See the list of events in the table below: The table is indicative. The TFM software vendor to explore the events further for complete event listing based on software capability.

6.2. All events shall be time stamped.

6.3. A typical list of various events are mentioned below:

- User log off/ Log On with workstation ID
- Alarm acknowledge time
- Pass word changes
- Date change
- Re-installation/ change/ updating of software
- Communication failure
- Program/ configuration changes (Set points, calculations etc)
- Display changes (Addition of display/ editing of existing display)
- Hardware switch over for redundant systems
- Process bypass activation(If any implemented)

7.0. REPORTS

7.1. The types of reports to be generated (Either automatically/ manually) are listed in the table below.

7.2. Additionally, the approved format reports shall be automatically generated at pre-defined intervals and kept in PDF format to retrieve at any time/ for auto E-mail option

Table 3- Report types

Report type	For	Generation method
Current Inventory status report	Tank/ Group of tanks/ All tanks	On demand
Process and system alarm report	All tanks/ All systems	Automatically appended on alarm report (and printed if separate alarm/ event printer considered)
Process and system alarm report	For a particular tank/ group of tanks	On demand for specified duration
Logged data report	For Tank/ Group of tank/ All tanks	On demand
Event report	For Tank/ Group/ All	Automatically appended on event report (And printed if separate Alarm/ Event printer considered) Also, On demand for specified Duration
Stock Inventory report	Tank/ Group/ All	Automatic at end of shift, End of day, End of week, End of month – Auto printed and auto E-mailed
Tank wise trend	For Group/ All	On demand

8.0. ACCESSIBILITY/ PROTECTION

8.1. The system shall be secured against inadvertent activities from unauthorized people. At least Three levels of accessibility protection shall be provided- Operator, supervisor and administrator with the access privileges programmable to the administrator for the other two groups

8.2. The number of users in each group (For example, administrator group) shall be unlimited.

8.3. Auto log off from the system shall be configured in every machine with programmable time duration.

8.4. The same user shall be restricted from logging into different system at the same time in the network.

8.5. All the HMI shall be sealed meteorologically to prevent unauthorized tampering of the System, in a manner approved by the prevailing standards like NMI/ PTB etc

9.0. SYSTEM DATA BACKUP AND RECOVERY

9.1. The software shall have the features for automatic scheduled and manual back up of configuration settings and field level data and reports. In case of failure of the software/ hardware, the configuration and field level data can be imported from latest backup file manually.

9.2. The system shall be capable of providing redundancy options for data storage.

9.3. It shall also be possible to transfer data to removable media for long term storage and/or archiving.

Table 4- Access rights - Indicative

Privileges	Administrator group*	Supervisor group	Operator group
Change of Software/ calculations	Y	-	-
Change of networking parameters/ architecture	Y	-	-
Addition of new tank/ instrument	Y	Y	-
Change tank settings	Y	Y	-
User password change	Y	Y	Y
Operator H/L setting	Y	Y	Y
Alarm acknowledging, silencing	Y	Y	Y
On demand Report printing	Y	Y	Y
Editing reports	Y	Y	-
Password expiry setting	Y	Y	-
Auto log off settings	Y	Y	-
New display/ edit display	Y	Y	-
New alarm definition/ Alarm disabling	Y	Y	-
View all settings/ Displays/ Reports	Y	Y	Y
Print displays	Y	Y	Y
Alarm inhibit (Specific or group)	Y	Y	Y
*Normally OEM representative- But password shall be disclosed to the highest level authority of client at site			

Table 5- Display types and information displayed

	Display												
Data/ Functionality	architecture display	Overview	Group	Tank	Tabular Reports	Trend	Tank spec. detail	Alarm set point* display	Event list	Alarm summary	Alarm History	Log	Config. screen
Hardware detail, network details etc in graphic form and Status	Y	-	-	-	-	-	-	-	-	-	-	-	Y
Tank ID	-	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Product Description	-	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Tank mode (If information available from PLC/ TAS)	-	Y	Y	Y	-	Y	-	-	Y	-	-	Y	-
Gross Product Level		Y	Y	Y	Y	Y		Y					-
Level in percentage	-	Y	Y	Y	-	-	-	Y	-	-	-	-	-
Water level		-	-	Y	Y	-	-	Y					-
Avg. Temperature		-	Y	Y	Y	Y	-	Y					-
Spot temperature		-	-	Y	-	-	-	-					-
Average Vapor temperature (only for pressurizes tanks)		-	-	Y	Y	Y	-	Y					-
Pressure (Pressurised tanks)		Y	Y	Y	Y	Y	-	Y					-
Density (Atmospheric tanks)		Y	Y	Y	Y	Y	-	Y					-
Density Profile (Graph)		-	-	Y **	-	Y	-	-					-
Gross Product Volume		-	Y	Y	Y	Y	Y	-					-
Gross volume in percentage		-	-	Y	-	-	-	-	-	-	-		-
Net volume		-	-	Y	Y	Y	-	-	-	-	-		-
Water volume		-	-	Y	Y	-	-	-					-
Flow rate (Receipt/ discharge)		-	Y	Y	-	-	-	-					-
Reference height							Y	-					-
Strapping table							Y	-					-
Safe tank capacity		-	-	-	Y	Y	Y	-	-	-	-		-
Dead volume (Below datum plate)		-	-	-	-	-	Y	-					-
Alarm limits, delay, Hysteresis etc		-	-	-	-	-	-	Y					-
Alarm priority	-	-	-	-	-	-	-	Y	-	Y	Y		-
All events								-	Y				-
All Acknowledged alarms								-		Y			-
All alarms								-			Y		-
Recent alarms (Shall be available on displays ie it shall not be hidden)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
User lists, User group definition etc	-	-	-	-	-	-	-	-	-	-	-		Y
Current user log in detail	Y	Y	Y	Y	-	Y	Y	Y	-	-	-		-
Settings for: User access rights, Password, Pass word expiry, Auto log off time, Scan time, Auto SMS/ Email etc													Y
User input for ambient temperature	-	-	-	-	-	-	-	-	-	-	-	-	Y #
Units/ units selection	-	Y	Y	Y	Y	Y	-	Y	-	-	-	-	Y
Operator comments on tanks	-	Y	Y	Y	Y							Y	
*Alarm set points shall be available as numeric as well as percentage in the Alarm set point display **On demand # with access to operator													

Table 6- Indicative List of software

Software	Version and validity	Qty	License Limitations: (Vendor to fill in)
Windows based Operating system software	Latest / As per TFM software requirement (Server OS if required by TFM software) Validity- Unlimited	As per Architecture	Version- License offered for….no
TFM software	Latest version released at the time of FAT Validity- Unlimited	As per architecture	Make and version- Number of instruments supported- Number of tags- Number of server+ Client Maximum capability of tanks (With extended license)-
Antivirus	Vendor to note the make and version Validity – End of warrantee/ guarantee & SAT whichever is later. (If AMC included in scope, the validity shall cover AMC period also.)	For all system offered	License offered for- … no for --- duration
Firewall	Vendor to suggest Validity- Unlimited	For all external access points	Version---
OPC server/ client	Latest Validity- Unlimited	For all system offered	Version---
Other software required: Vendor to note below for network configuration etc			

1.0. SCOPE

1.1. The scope of this specification provides the general guidelines for the design, construction, testing and supply of marshalling panels and system cabinets/ panels for packages DCS/ ESD/other control systems.

1.2. This specification is applicable to purged field panels also. However, the additional requirements for purged panels shall be as per the relevant international standards or special requirements of the project in additions to the requirements specified in this specification.

2.0. STANDARDS

IEC 60529 Degrees of Protection provided by Enclosures

IEC 60079 Electrical Apparatus for explosive atmosphere

IEC-60079-2 Electrical Apparatus for explosive atmosphere, Equipment Protection by pressurized enclosure, "p"

ISA 71.04 Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants

3.0. DESIGN AND CONSTRUCTION

3.1. The instrument panel / cabinet shall be designed and manufactured so that it caters fully to the operational requirement of its associated equipment/ plant.

3.2. The panel/ control cabinet shall be self contained free standing, floor mounted, dust, damp and vermin proof, sheet steel cubicle in folded construction with requirements as specified in the data sheet. Workmanship shall be of the highest grade and the entire construction shall be in accordance with the most modern engineering practices.

3.3. The cabinets shall preferably be separate for AI/AO, DI/DO and FF, segregated to Intrinsic Safe and non-Intrinsic Safe type based on project requirement. This is applicable to control room panels of large projects only. When applied to field panels/ small projects, only segregation at terminal block level is sufficient.

3.4. Panel components shall be selected from sub-vendor list attached. In case for any specific item the sub-vendor detail is not available in the list, the vendor shall intimate the same to client/ PMC. Vendor shall suggest the sub-vendor list for such items or obtain the acceptable sub vendor list from client/ PMC. Selection of sub-vendors solely by the vendor is not recommended and any delay due to rejection of unapproved makes is attributable to vendor only.

3.5. Deviations if any from the sub-vendor list shall be referred to prior approval from FEDO/ client with necessary justifications. Approval/ rejection of such requests by FEDO/ purchaser shall be final.

3.6. Each and every component used for the instrumentation panel shall be approved make and of proven design for the performance, reliability and durability.

3.7. ESD cabinets shall have transparent windows to view status of various signals without opening the cabinet.

3.8. All electronic cards in the panel shall have coating to withstand an environment of G3 as per ISA S 71.04 if specified in data sheet/ special requirements of the project.

3.9. All accessories fitted on the door shall be fully gasketed and removable including the bottom entry gland plate. The mounting of accessories including the name plate shall not deteriorate the panel ingress protection.

3.10. Doors shall be lifting off type.

3.11. All cabinets shall have removable lifting lugs/eyebolts.

3.12. The vendor shall ensure that the internal items in the panel can be replaced without disturbing other installed items and necessary working clearance is provided for all components in the panel. For maximum interchangeability of materials, generic items shall be selected and integrated instead of manufacturer specific materials.

3.13. When Panel mounted Human machine interface displays are provided for field panels, these displays shall be protected from mechanical impact by use of openable glass/ metallic guards.

4.0. DIMENSIONS

4.1. The field panel/ cabinets shall have minimum IP54 and the control room

panel shall be minimum IP 44 weather protection.

4.2. The panel shall be fabricated of minimum 2 mm thick CRCA/ SS plate, 2100mm(H) including a 100mm plinth height, 800mm(W), 800mm (D). The gland plate shall be minimum 3mm thick.

4.3. The panel shall have front and rear doors and with identical lock and keys with handle for both the doors for all panels. The door shall have concealed hinges.

4.4. All doors and removable louvers shall be gasketed all around with non-ageing rubber/ neoprene gaskets.

5.0. PAINTING

5.1. The cabinet shall be painted internally and externally (RAL 7035) with two coats of epoxy paint over epoxy zinc phosphate primer. SS panels shall not be painted. Channel base shall be painted with two coats of self-priming Black Coal tar Epoxy Paint finish. Panels shall be non-reflective.

6.0. NAME PLATE/ IDENTIFICATION

6.1. Cabinets shall have acrylic nameplate front and rear with cabinet number and service on white black white lettering fastened using SS screws. ESD labels shall be white red white and intrinsic safe information on white blue white.

6.2. All cabinet internals and externally mounted items shall be suitably labeled with a scheme acceptable to FEDO/ purchaser, which will be discussed during detailed engineering of panel General arrangement drawings.

7.0. TERMINALS AND WIRING

7.1. All cables including all inter-panel cabling shall be bottom entry only unless otherwise specified in the data sheet.

7.2. Where specified, terminals shall have fuse blown indication to facilitate fast maintenance.

7.3. No cabinets shall have more than 600 terminals connected to it. No terminal or terminal strip, MCB shall be located on the side panel of the rack / cabinet.

7.4. Both Wire ends shall be provided with ferrules marking source/ destination on a black/ white lettering that reads from left or bottom. No wire shall be observed without ferrules in a finished panel/ cabinet. The ferrule marking shall exactly match with that indicated in the drawing.

7.5. Spring loaded compression type quick release/connect type terminals shall be used for field end connection.

7.6. All terminals and terminal groups shall be identified by black-white lettering. Intrinsic safe and non-intrinsic safe signals shall not be mixed, discrete terminal rails and differently coloured trunks shall be used. Alternately, sparking guards shall be used in between. Trunk cover length shall not exceed 1m. Trunk to Terminal block distance shall be 50mm minimum. The field cables shall terminate from right side or bottom of the terminal block.

7.7. The internal wiring shall be of copper stranded, generally 0.5mm2, crimped with right tool to proper size, through covered PVC trunks with insulation rating not less than 600 Vrms. Solid wires shall not be crimped. Not more than one wire shall be inserted to one crimp or more than one crimp to one terminal.

7.8. Parallel connections shall be achieved by shorting bars provided by the terminal manufacturer.

7.9. Power supply looping in the field side is not permitted. It shall be possible to remove any component without affecting the operation of the other. If relay blocks are used, power looping is to be done elsewhere not in the relay blocks. Powering to the relays and other units shall be in bus form, looping through wires is not permitted.

7.10. The colour codes listed below shall be followed for the panel:

AC live-	Brown,
AC neutral –	Blue,
Safety ground-	Green/Yellow,
Instrument ground	Green,
DC +ve-	Red
DC -ve-	Black
Intrinsic Safe signals –	Blue
All other signals	Grey

7.11. Only printed ferrules of appropriate size for the cable shall be used. The plastic prefabricated numbered block type ferruling is not recommended.

7.12. The cable glands for the cables entering/ leaving the panel need not have to be supplied by the vendor, unless otherwise specified in special requirements of the project. These cable glands are normally supplied and erected by the field erection contractor. However, when a large

number of panels are supplied as part of DCS/ ESD, the inter-panel cabling related cable glands are to be supplied and erected by the vendor. This includes special cable glands suitable for the prefabricated cables as well.

7.13. If cable glands are included in the scope of panel vendor, the cable sizes will be communicated to the vendor only when such detail is available and supply and erection of these cable glands will not be treated as additional item for payment.

8.0. UTILITIES

8.1. The panel/ cabinet shall have light fittings with separate fuses, switches and isolation, actuated with a door switch. For lighting, fans and consumer sockets, 240 VAC non-UPS based supply shall be used.

8.2. The lamp shall be fluorescent/ LED/ incandescent type of appropriate wattage fitted at the inner top surface of the cabinet.

8.3. The panel/ cabinet shall be force ventilated by two fans and its failure shall be alarmed through potential free contact, wired to terminals. The suction/discharge shall be fitted with finger guards and door opening shall be louvered with dust filters.

8.4. Cabinet temperature shall be within limits specified by manufacturer and if it exceeds, shall be alarmed to DCS via a suitable transducer. This requirement applied to control room panels by default. For field panels, it is applicable only if specified specifically or as per manufacturer recommendation.

8.5. The door shall have pockets 40mm deep at inner side for placing A4 sized paper and other documents/ files and for placing multi-meter.

8.6. The panel/ cabinet shall have access control by means of electronic finger print based or access card based controller, wherever specified in addition to the regular mechanical key.

8.7. For purged type panels, the required accessories as per standards shall be included in the design and manufacture of the panel as required such as pressure regulator, tubes and fittings, pressure transmitter/ switch, tripping relays, water draining facility etc

8.8. Wherever condensation is expected, (due to ambient conditions or due to water carry over through purging air) anti-condensation heating and/ or drain facility shall be provided as per manufacturer's standard practices.

8.9. An anti-vibration pad of 10mm thickness shall be provided between the base channel frame and panel to resists the vibration which is typically observed in industrial plants.

9.0. EARTHING

9.1. Normally the earth resistance will be less than 1 ohm. However, vendor shall confirm this with the client and specify the requirements for system earth if any. The following types of earths are required, which shall be located at the bottom of the cabinet:

- Intrinsic Safe instrument earthing bar- Used for earthing screens of intrinsic safe instruments
- Non intrinsic safe instrument earthing bar- Used for earthing screens of non-intrinsic safe instruments
- Safety ground- Used for earthing cable armour and the cabinet/ panel body. Each metallic panel/ cabinet/ cubicle shall be connected to the main earth bus in duplicate with copper cable of size not less than 25sqmm. A dedicated earth bolt of M8 minimum size shall be provided with an earth symbol marker for the safety earth connection. Conducting parts such as doors and frames etc., which are not permanently connected to the safety earth, shall be connected to the cabinet frame with flexible braided earth strips of 6 mm2 minimum. The safety earth shall be interconnected to the electrical main earth. If zener barriers are provided, their earths shall be connected to the safety earth.
- System earth where required-

9.2. The instrument earth shall be isolated from the cabinet. All spare cables and screens shall be connected to terminal blocks or earth. All connections to earth shall be soldered or crimped compression types lugs with sizes as following:

Stranded insulated leads 2.5 mm2
Flexible bonding connectors 25 mm2
Copper bonding strips 12mm x 1.5mm
Earth bars 25mm x 5mm.

9.3. The entire earth bar shall be tinned copper with holes and sufficient screws available for making the connections.

The signal earth bar shall be insulated from the cabinet frame. Earth connections shall be as short as possible and of adequate cross sectional area. All signal-earths shall be connected to the signal earth pit.(Intrinsic safe earth pit or non-intrinsic safe earth pit as the case may be)

9.4. The door of the panel/ cabinet shall be connected to the safety ground by a flexible wire of appropriate size which shall resist periodic stress (By coiling or otherwise). Similar way, the metallic gland plate also shall be connected to the safety ground with a visible wire. (Contact through metallic body is not acceptable)

9.5. The construction of earth pits is not in vendor's scope. However, the earth pit resistance shall be verified by the package vendor/ erection contractor before connecting the leads.

10.0. SPARES

10.1. This section is not applicable to bare panels. This is applicable when panels are supplied with complete wiring of all inside accessories and components from factory/ vendor.

10.2. The following spares shall be provided in the panel.

Item	Spare
DIN Rail	20% spare space
Trunks	40% space
MCBs	10% of each type and / or rating- Loose supplied, 10% pre- wired in panel for ready use
Terminals	10% of each type and / or rating- Loose supplied, 20% pre- wired in panel for ready use
Fuses	20% of each size/ rating – installed
Earth bar	10% spare Holes
Power Supply	40% additional load capacity In redundant Power supply system, each power supply shall not exceed 80% of rated capacity when handling the total load (One failed situation)
Indicator lamps	10% of each type/ size / color in loose supply and 10% pre-wired and ready to use
Pushbuttons	10% of each type/ size / color in loose supply and 10% pre-wired and ready to use
Annunciator windows	20% fully wired and ready to use

11.1. The specified spare capacities will be judged by the inspecting personnel visually.

11.0. DOCUMENTATION

11.1. The following documents shall be provided for the panel. The list is indicative and documents beyond the listed ones if required, shall be specified by the vendor or will be communicated to the vendor during the detailed engineering/ vendor drawing review stage/ as built stage and vendor is responsible to furnish the same.

a. Panel General Arrangement drawing
b. Panel internal General Arrangement Drawing (Each component shall be numbered and the number shall be visible in drawing)
c. Wiring Drawing for Power, Utilities, field cables and internal wiring details- The drawing shall indicate wire size, colour, fuses etc
d. Panel Bill of Material- With quantity, Make, Model and serial number
e. Test certificates for all Bought out items
f. FAT / Inspection certificate for the complete assembly
g. QAP/ ITP
h. Panel manufacturer data sheet

TECHNICAL PROCUREMENT SPECIFICATION	**ATTACHMENTS**	**32686-03-PS-002 ATT**
		PAGE ***1*** OF ***1*** R0

TPS No. ***32686-03-PS-002***

SL. No.	Doc. No.	Description	No. of Pages	Rev. No. with issue			
				1	2	3	4
1	32686-03-PS-002 VDR	VENDOR DATA REQUIREMENT	1	0			
2	32686-03-PS-002 SPL	SPECIAL REQUIREMENT (PIPING)	3	0			
3	03ES001	PIPING DESIGN	11	0			
4	03ES010	PIPING TURNKEY PACKAGE	2	0			
5	03ES012	WRAPPING & COATING					
6	25ES205	FABRICATION & ERECTION OF STEEL PIPING	28	0			
7	03ES009	UTILITY STATION					
8	03DS003	PIPING SPACING	1	0			
9	03DS007	GUIDE SPACING - VERTICAL LINES	2	0			
10	03DS010	STANDARD DRAIN & BY- PASS SIZE	1	0			
11	03DS013	VENTS & DRAINS FOR PIPE LINES	1	0			
12	03DS202	PIPING TRUNNION SELECTION	6	0			
13	03DS305	TABLE OF BASIC SPANS AND UNIT LIGHT WEIGHT WITHIN BATTERY LIMITS	3	0			
14	03DS342	BRANCH PIPING - DIMENSION OF REINFORCEMENT PAD	1	0			
15	32686-03-PS-002 SV	SUB VENDOR LIST	21	0			
16	32686-03-AP-0002	AREA PLOT PLAN - AMMONIA STORAGE TANK	1	0			
17	32686-03-SM-001	SCOPE MATRIX	1	0			

Note: 1. The receipt of all attachments shall be checked and asertained.

2. All attachments of this TPS shall be retained since only revised sheets, if any, shall be issued

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	***10/04/2021***	***FOR ENQUIRY***	***TKA***	***JTG***	***KK***

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

00FT011/10

TECHNICAL PROCUREMENT SPECIFICATION	**VENDOR DATA REQUIREMENTS**	32686-03 -PS-002 VDR
		PAGE 1 OF 1 R0

PROJECT	: 10000 MT Ammonia Storage Tank for FACT-CD	**ITEM**	PIPING SYSTEM
CLIENT	: M/s. FACT	**TPS No**	
STATUS	: ☑ ENQUIRY ☐ COMMITMENT	**PO No**	

Sl. No	Grp Code	Description	Offer	After Commitment				Final@@
			Qty	Qty	Lead time in week			Qty
					Reqd	Prop@	Agrd	
1.0	A	**Plot plan**	3P+1S	3P+1S	4			3P+1S
2.0	A&C	**Piping Layout drg.**		3P+1S	4			3P+1S
3.0	A&C	**Quality control procedure & plan for piping system.**		3P+1S	4			3P+1S
4.0	A&C	**Filled in Valve Data Sheet**		3P+1S	4			3P+1S
5.0		**Design data**						
5.1	A&C	Design basis		3P+1S	4			3P+1S
5.2	A&C	Piping material specification		3P+1S	4			3P+1S
5.3	A&C	Pipe support standard		3P+1S	4			3P+1S
6.0		**Issued for construction (IFC) Drawing.**			4			
6.1	C	Equipment layout/Plot plan		3P+1S	4			3P+1S
6.2	C	Piping GA DRGS.		3P+1S	4			3P+1S
6.3	C	Isometrics		3P+1S	4			3P+1S
6.4	C	Piping supports, operating platforms drg.		3P+1S	4			3P+1S
7.0	C	**Material Take-offs**		3P+1S	4			3P+1S
8.0		**Material and Purchase Requisitions**		3P+1S	4			3P+1S
8.1	C	All piping items(including valves,special items,bolts ,gasket,itemised supports etc.)		3P+1S	4			3P+1S
9.0		**Design calculation / Documents.**			4			
9.1	A	Flexibility Analysis of Piping		3P+1S	4			3P+1S
9.2	A	Support and load data		3P+1S	4			3P+1S
10.0		**Vendor Drawings**		3P+1S	4			3P+1S
10.1	C	Valves		3P+1S	4			3P+1S
10.2	C	Special piping items		3P+1S	4			3P+1S
11.0		**As Built Drgs**			4			
11.1	C	Piping GAD's		3P+1S	4			3P+1S
11.2	C	Isometrics		3P+1S	4			3P+1S
11.3	C	Plot plan and Elevation drawings		3P+1S	4			3P+1S
11.4	C	All inspection, testing & NDT Records.		3P+1S	4			3P+1S
12.0	B	Pipe stress analysis (CEASAR II) report		1S	4			1S
13.0	A&C	3D Model		1S	4			1S

Legend :

Group code : A - For review and detailed Engineering , B - For review , C - For information and record

Document type : R - Reproducible , P - Print , M - Microfilm, S - Soft Copy

Notes :

' @ ' Vendor shall fill in proposed lead time if different from the required lead time

' @@ ' Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV No	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	10/04/21	For Enquiry	TKA	JTG	KK

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

03FT044B / 2015

1. Piping system for this project shall be in accordance with the following specifications

    a. Process piping - ASME B 31.3 Process piping

    b. Utility piping - ASME B 31.3 Process piping

2. Piping and its components shall be designed as per the attached engineering specification 03ES001(Piping Design)

3. Bidder shall follow the attached engineering specification 03ES010 (Piping turnkey package) for the piping scope, design consideration, battery limits for piping, details of drawing and documents, general requirements etc.

4. Bidder shall submit documents as per attached Vendor Data Requirement

5. Bidder should accommodate the Ammonia storage and handling system including barge unloading facility at jetty within the area allotted in drawing 32686-03-AP-00002.

6. All piping (Process lines, Utilities etc.) within the battery limits are under the scope of bidder.

7. Piping scope of work also includes overhead piping from jetty to storage tank, road crossovers at peripheral roads and modification of existing piping if any at proposed roads. Refer scope matrix 32686-03-SM-001.

8. Piping scope includes design, detail engineering, procurement, testing at vendor's shop and supply of all piping items as per the approved material classes and specification.

9. Design of piping system shall be as per the relevant codes and regulations specified in the engineering specifications.

10. Bidder shall furnish drawings & documents necessary for approval from statutory bodies and that all materials used shall be accompanied by the necessary certificates as per the applicable codes.

11. All lines terminating at the battery limit provided with a flange and mating flange, gasket, bolt & nuts.

12. Bidder shall provide break flanges on pipe lines where ever required for maintenance access .

13. Bidder shall provide temporary piping for blow-out, blank & spacers' gaskets etc. for isolation during the line testing and temporary & permanent strainers.

14. For pressure relief valve and safety valve, reaction load calculation shall be carried out and adequate supporting to be provided and outlet vent to safe height without pockets or to flare stack.

15. If the pipe line at the floor level, bottom of the pipe shall be at the height of 500 mm from the floor level

16. Fabrication & Erection steel piping shall be as per the attached engineering specification 25ES205

17. Piping stress analysis and equipment nozzle loading analysis shall be in accordance with ASME B31.3 and relevant API codes.

18. Nozzle analysis shall follow the guide lines of ASME Section VIII, Division 1, and WRC 297 & 107 (Latest editions). Nozzle stresses shall fall within the allowable as per ASME.

19. Bidder shall use latest version of CEASAR II for the pipe stress analysis of critical piping

20. All insulation and gaskets shall be asbestos free.

21. All alloy steel and higher alloyed piping material shall be subjected to Positive Material Identification (PMI).

22. Sufficient number of safety showers & eye wash shall be provided in the ISBL area.

23. Bidder shall carry out detailed engineering of the plant area specified in the scope elsewhere using 3D intelligent software.

24. Bidder shall use any of the following software for 3D modeling

    a. PDS by Intergraph USA
    b. PDMS by AVEVA UK
    c. CADWORX by Intergraph USA
    d. Smart plant 3D(SP3D)

25. The objective of 3D modelling is to carry out detail engineering and produce deliverables using 3D tools and conduct reviews for obtaining approvals from FACT. 3D model shall be developed and demonstrated with dynamic walk-through facility to check any interference requirements of operation and maintenance for getting the approval of FACT. Bidder shall deliver to FACT a complete 3D model which shall be utilised for all future maintenance, operation, revamping and any de-bottlenecking of the plant. The 3D Design Reviews through dynamic walkthrough, through LCD projector system shall assist the Owner's operation and maintenance personnel in

reviewing the project prior to construction and suggest modifications for efficient operation of the plant or shall use it for review of design.

26. Scope of modeling shall be included piping system, structural, Instrumentation and electrical. Exact geometry of pipe, flanges, valves, beams etc. for clash checking and identification of object in 3D. Near exact geometry of special items like bellow, traps etc for the purposes of clash checking. Approximate geometry of items like transmitter, floor stand mounted instruments can be used. Skid mounted Equipment / Package units (if applicable) shall be modeled as a Block and Piping connections at Skid/Package unit battery limit to be precisely modeled depicting complete connectivity.
27. Isometrics shall be extracted from 3D model using ISOGEN software along with Bill of material.

28. Complete 3D model along with as built GAD's, Isometrics, and MTO reports, nozzle orientations for Piping all extracted from the model.

29. Review Models shall be installed at site having latest version of design review software and all other pre requisite software and any other software required for smooth running and minimum configuration as stated in by the Contractor sufficiently at start of Mechanical work & plotter at site shall be decided in consultation with Owner

30. 3D modeling is not limited to new ammonia tank but extended to all new facilities of the tankage project and tie point existing facilities

31. Bidder shall be responsible for arranging model review at his design center with dynamic walkthrough

32. At least 3 design stages to be reviewed as per the following progress

    a. Equipment layout review from erection, construction, operation and maintenance point of view & conceptual review of critical lines (30% progress)

    b. Before issue of model for engineering (60% progress)

    c. Before issue of model for construction i.e. before isometric generation commences (90% progress)

33. Painting shall be as per FEDO spec 02ES023

34. As the new ammonia tank is double wall double integrity storage tank and outer wall of tank itself is secondary containment; hence dyke wall is not required & only spill wall of height 600 mm shall be provided around new ammonia tank.

35. Underground piping shall be provided with external wrapping and coating as per FEDO spec 03ES012.

36. Bidder shall provide utility hose station of size 20 NB at all working area along with utility hoses & hose coupling. For arrangement refer spec 03ES009.

37. The clear headroom over platforms, walkways, passage ways and working areas shall be at least 2.2 m

38. For piping cold insulation refer Engineering spec 02ES042.

CONTENTS

1.0.0 GENERAL

1.1.0 SCOPE

1.1.1 This specification together with the Piping Specification and design data sheets is applicable for the piping located within the Plant Battery limits.

1.1.2 No variation shall be permitted unless approved in writing.

1.2.0 MODIFICATIONS

1.2.1 Piping which is furnished as a regular part of proprietary or standardized equipment shall be in accordance with the equipment manufacturer's standards for the design conditions.

2.0.0 DESIGN

2.1.0 GENERAL

2.1.1 The design of piping shall conform to the requirements of the ASME Process Piping B31.3 except as modified by Paragraph 2.12.4. When a code, rule, or regulation is speciied in the Piping Specification Sheets, the design shall conform to such specified requirements and to such portions of this specification as do not conflict.

a. Snubbers shall be furnished as proprietary piping equipment, designed and fabricated in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code.

b. Knockout pots and like items shall be furnished as piping equipment designed and fabricated as follows.

1. Sizes 600NB outside diameter and smaller in accordance with ASME B31.3.

2. Sizes greater than 600NB outside dia. in accordance with ASME section VIII

c. Piping, snubbers, knockout pots, and like items with design pressures below those covered by the applicable listed code shall be designed and fabricated in accordance with ASME B31.3.

2.1.2 Piping connected to power boilers, waste heat boilers, dowtherm boilers or unfired steam generating equipment shall be designed in accordance with section I of the ASME Boiler and Pressure Vessel Code, with all addenda, Power Piping ASME B31.1 and IBR to the extent required thereby.

2.2.0 DESIGN PRESSURES & TEMPERATURES

2.2.1 The expected continuous operating conditions shall be specified on the process flow sheets / line schedule.

2.2.2 The design pressure and metal temperature shall be in accordance with ASME B31.3 / ASME B31.1 and the following.

a. In vacuum service, the normal design pressure shall be the lowest value which the vacuum producing means is capable of attaining.

b. Piping circuits on the upstream side of control valve shall be designed for pressures resulting from minimum flow conditions (closed or throttled control valve) and downstream of the control valve shall be designed for the downstream terminal pressure plus friction losses (pressures due to closed or throttled block valves shall not be considered except as short time conditions) and head losses.

c. The design metal temperature of the piping conveying fluids with temperatures below 15 deg.C shall be equal to the minimum, normal operating tempera ture of the fluid in the pipe or fluid temperature during normal startup or shutdown. Metal temperatures resulting from emergency conditions caused by equipment failures such as ruptured tubes, etc. or operational errors shall not be considered.

2.2.3 The short time design pressure and design metal temperature shall be those of higher value which are expected to occur during starting-up, shutting-down, or in any other short time operating condition.

2.2.4 A freezing climate shall be defined as one with a January average temperature of 4 deg.C or lower.

2.3.0 LOADS

2.3.1 The design for wind and earthquake shall be based on and considered to the extent required by the Bureau of Indian Standards.

2.3.2 Piping shall be designed to resist the effects of the following combinations of loads within the limits of stress specified herein. Wind and earthquake loads shall not be assumed to occur simultaneously.

a. Operation : The design pressure, the operating dead load, and the maximum operating contents load, combined with or without wind or earthquake load.

b. Test : The test pressure, the test dead load, and the fluid test load.

c. Short time : The operating condition without wind or earthquake load but modified or supplemented by the changes resulting from the short time conditions defined in 2.2.3.

2.3.3 For the design conditions given, the calculated principal stresses for pressure parts shall not exceed the following.

a. Operation and short time condition stresses are covered by ASME B31.3/ ASME B31.1.

b. Test: Based on the test thickness and the test temperature, the basic allowable stresses increased by 50%.

2.3.4 The basic allowable stresses for non-pressure parts, including attachments (except threaded parts and attachment welds to pressure parts) and devices for supporting or bracing piping, shall be one-third of the ultimate tensile strength, two-thirds of the yield strength, or the stress producing a creep rate of 0.01% in 1000 hours, whichever is lower.

a. The maximum allowable tensile stress for carbon steel threaded parts, such as anchor bolts and rods, based on the root area of the thread, shall be 15,000 psi (1055 kg/sq.cm)

2.3.5 The calculated principal stresses for non-pressure parts shall not exceed the basic allowable stresses for the operating conditions; the basic allowable stresses increased by 20% for the test or short time conditions; and the basic allowable stresses in creased by 33 1/3% when combined with wind or earthquake.

2.4.0 CORROSION ALLOWANCE & THK. OF PIPE

2.4.1 The allowance for corrosion or erosion in piping shall be determined by the intended service and material of construction. This shall be added to all surfaces exposed to the flowing medium. In general, beyond that inherent in the thickness of the pipe selected, a minimum allowance of 1.3 mm (0.05 inches) shall be provided for carbon steel in process service and no allowance provided for carbon steel in utility service or for alloy steel and non-ferrous materials.

2.4.2 For threaded or grooved pipe the greater of either the corrosion allowance or the threading or grooving allowance, shall be added to the pipe wall thickness.

2.4.3 The corrosion allowance may be more than the above based on severity of service.

2.5.0 SIZING OF PIPING

2.5.1 Piping shall be sized on the basis of the operating conditions and, when required, with an allowance for normal control of approximately 25% of the design friction losses in pipe and equipment, except for the following.

a. Pump, compressor, and blower piping shall be sized on the basis of maximum pump, compressor, and blower design capacities (at the equipment normal design speeds) with allowance for control reduced, to zero if necessary.

b. Circulating fuel oil systems shall be sized to supply 125% of the specified equipment design requirements with 25% being recirculated.

c. Piping in intermittent service (such as starting- up and bypass lines) shall be sized on the basis of the available pressure differentials.

d. Inlet and outlet piping at pressure-relieving safety devices shall be sized in accordance with the requirements of 2.6.0.

2.5.2 Gravity flow oil-water sewers shall be sized to carry all normally flowing streams plus the maximum rainfall in one hour when running at three - quarters depth of flow or to carry all normally flowing streams plus the maximum expected fire water in the area, with an upper limit of 2840 litres (750 gpm), when running full, whichever results in the larger line size.

2.5.3 Sanitary sewers and chemical sewers shall be sized to carry the design quantity when running at three-quarter depth of flow.

2.5.4 The minimum nominal size of underground sewer mains shall be 100 NB (4 inches).

2.6.0 OVER PRESSURE PROTECTION

2.6.1 Over pressure protection (relief valves, safety valves, rupture discs, open vents, and design for maximum pressure) shall be provided for pressure equipment (pressure systems when units are connected without intervening block valves) as outlined in the following paragraphs. These provide the protection required by API RP520 though it is not followed in detail.

a. Vessels and heat exchangers shall be protected in accordance with Table 1 when pressures greater than the stamped maximum allowable working pressure of the equipment may be produced by the causes indicated.

b. Pumps, compressors, and blowers shall be protected with relief valves or other automatic shut down devices when pressures greater than the casing design pressure may be produced at normal equipment design speeds.

c. Steam ends of reciprocating pumps and steam turbines shall be provided with relief valves when the casing design pressure may be exceeded.

d. Piping systems shall be protected when pressures may be produced which are greater than 133 1/3% of line equipment (separators, etc.) design pressures or more than 133 1/3% of the service rating of fittings, valves, etc., or when the pressure stress in the pipe may exceed 133 1/3% of the basic allowable stress.

e. Vacuum exhaust systems shall be provided with atmospheric relief valves when the system may be over pressured during a loss of vacuum.

f. Vents shall be properly sized so that no additional protection need be provided against vacuum caused by emptying water after a hydrostatic test or condensing steam after steaming out the equipment.

g. Fired furnace coils shall not be provided with separate over pressure equipment except as required for steam generators and superheaters by Section I of the ASME code.

h. Pumps, compressors, blowers, and piping systems shall not be provided with over pressure protection for pressures caused by fire.

i. Fixed roof atmospheric tanks shall be provided with open vents or vacuum breakers.

j. Airfin condensers and coolers shall be protected by water fog nozzles with a remote, manually operated valve. A means shall be provided for remotely shutting off fan motors.

2.6.2 Relief valves may be of the conventional, back pressure, or spring pilot operated type.

2.6.3 Relief valves, safety valves, rupture discs and vents shall be sized in accordance with the following.

a. For vessels and heat exchangers, the initial and maximum relieving pressures of relief and safety valves and the relieving pressure of rupture discs shall be as specified in Table 1. Values are given as functions of the equipment maximum allowable working pressure, P, stamped on the vessel.

b. For pumps, compressors, turbines, and blowers, the initial and maximum relieving pressures shall not exceed the values recommeded by the manufacturer.

c. For piping the maximum relieving pressure shall be as determined from 2.6.1.d. with the initial relieving pressure 90% of this value.

d. It is mandatory that the nominal size of the inlet and oulet piping be same as, or greater than, the nominal size of the pressure relief valve inlet and outlet connection.

Refer Table I and Notes - Page 11 of 11.

2.7.0 SUPPORTS

2.7.1 Piping sections requiring frequent dismantling such as for removal of burners, etc., shall be provided with permanent supports for the dismantled condition.

2.7.2 All piping with insulation, and piping operating at temperatures 343 deg.C (650 F) and higher shall have steel shoes with bearing surfaces outside the insulation. Insulated piping in low temperature service shall have the insulation locally reinforced at the point of support. All other piping may rest directly on the supporting members. Small diameter lines may be supported by, or suspended from larger diameter lines.

2.8.0 CLEARANCES

2.8.1 The clear headroom over platforms, walkways, passage ways, and working areas shall be at least 2 metres.

2.8.2 The clear headroom over outside areas designated for use as truckways shall be at least 3.6 metres. Clear headroom over pump access roads shall be at least 3 metres.

2.8.3 The clear headroom over railroads as measured from the top of rails shall be at least 6.7 metres.

2.8.4 Walkways shall be at least 750 mm.

2.9.0 ARRANGEMENT OF PIPING

2.9.1 When located below grade, piping provided with protective heating and piping in acid, caustic, phenol, and similar services requiring inspection and servicing shall be in trenches; other piping shall be buried in earth with at least 300 mm coverage except that trenches may be used at changes in direction to provide for thermal expansion of hot lines. The center line of underground water lines shall be located below the frost line or furnished with other means to prevent freezing. Minimum cover for water pipelines not in trenches is 900 mm.

2.9.2 Burner fuel piping shall conform to the following requirements.

a. Valves used to adjust the flame shall be located at the side of low floor - fired furnaces convenient to peep holes, and adja cent to the burners of elevated floor fired furnaces and wall- fired furnaces.

b. Fuel oil supply piping shall be arranged as a circulating system for continuous recirculation through the headers.

c. Fuel gas supply piping shall be arranged to produce equal distribution of flow to allow condensate drainage.

2.9.3 Relief and safety valves shall discharge to a closed system when the valves release lethal vapors, mixtures of hydrocarbon vapors and other vapors (such as steam) with a molecular weight of the mixture greater than 80, or lethal, hazardous, or hydrocarbon liquids; and to atmosphere when they release mixtures of hydro carbon vapors and other vapors (such as steam) with a molecular weight of the mixture of 80 or less, non-hazardous liquids, or non-hazardous vapors. Bonnet vents of back pressure type relief valves may discharge to atmosphere.

a. Lethal vapors or liquids shall be defined as poisonous gases or liquids of such a nature that a very small amount of the gas or of the vapor of the liquid mixed or unmixed with air is dangerous to life when inhaled. It is the intent of this specification that the following are not lethal: chlorine, ammonia, natural or manufactured gas, any liquefied petroleum gas (propane, butane, butadiene, etc.), and vapors of any other petroleum products. This corresponds to the definition contained in Paragraph UW-2 of the ASME Code, Section VIII.

2.9.4 Relief and safety valve piping shall conform to the following requirements:

a. All relief and safety valves on towers shall preferably be located in the overhead line.

b. Relief and safety valves discharging vapor to the atmosphere in hydrocarbon service shall have the outlet piping extend to at least 3 metres above the highest working level or building roof within a radius of 12 metres. The requirements of the local pollution control board shall be followed if its more stringent.

c. Relief valve header shall not be pocketed. Wherever this requirement cannot be met, a drain line discharging to a knockout pot shall be provided, with the vent from knockout pot connected back to the header.

d. There shall be no isolation valves on the inlet lines to pressure safety devices. Isolation valves if provided at inlet lines to pressure safety devices shall be locked open.

2.10.0 MAINTENANCE & OPERATION REQUIREMENTS

2.10.1 Means shall be provided in the piping at pump and driver nozzles to permit the removal of the pump or driver without removing the block valves. For this purpose, a flanged valve, fitting, or strainer against the nozzle shall be considered satisfactory.

2.10.2 Piping requiring removal of coke shall be provided with flanged clean out points and bends of a radius suitable for the cleaning tool or with flanged fittings at turns. The run of pipe between clean out points shall be limited as follows.

a. Straight runs:

Cleaning from one end - 12 metres.

Cleaning from both ends - 24 metres.

b. Bends:

Cleaning from both ends - 12 metres developed length.

2.10.3 All piping equipment requiring frequent attention of the operating personnel shall be readily accessible. Equipment such as automatic control valves preferably shall be grouped at main operating levels. Equipment such as motor operated valves and relief valves shall be accessible from platforms or grade.

a. Manually operated valves requiring manipulation during operation or an emergency shall be located so that hand wheels are convenient to operate from a platform or grade and so that the bottom of the hand wheel is not higher than 2 metres above a platform or grade, otherwise such valves shall be equipped with chain operators or extension stems. Valves with chain operators shall be located or have stems turned so that chains do not hang in passageways.

2.10.4 Driver steam exhaust lines shall be provided with exhaust heads when discharging to the atmosphere.

2.10.5 Funnels and drain lines shall be provided at sampling connections, gauge glasses, level controllers, etc..

2.10.6 Access shall be provided for heat exchanger tube removal, tower tray removal, catalyst removal and for crane access to compressors.

2.11.0 VALVING

2.11.1 Block valves shall not be provided at vessel nozzles, except as required for operating and process control and for storage vessels containing hazardous or toxic materials.

2.11.2 Block valves shall be provided on the water side of exchanger units as follows:

a. Exchangers that are essential for the operation of the unit shall have one valve.

b. Exchangers provided with process isolation valves for frequent inspection and cleaning during operation of the unit shall be provided with block valves in the inlet and outlet piping. All water cooled exchangers will have isolating valves on the inlet and outlet water lines. In freezing climates, an antifreeze bypass from the inlet to the outlet piping or other means to prevent freezing shall be furnished.

2.11.3 Block valves shall be provided at the following locations in pump, turbine, and compressor piping.

a. In suction and discharge piping to pumps.

b. At the equipment in auxiliary piping for gland oil, flushing oil, and cooling water.

c. At the header in overhead water supply branches located outdoors in freezing climates and in all auxiliary piping when necessary to allow removal of the equipment during operation of the unit.

2.11.4 Block valves shall be provided at the following locations in steam piping.

a. At the steam main: In steam headers serving grouped equipment such as steam drivers located in a pump room.

b. At the equipment: In steam piping to steam driven equipment.

c. At the steam header: In steam piping to steam driven equipment when the steam pressure exceeds 21 kg/sq.cm g.(300 psig)

d. At the equipment: In pressure exhaust steam piping from steam driven equipment.

e. Adjacent to the equipment: In vacuum exhaust steam piping from steam driven equipment when the equipment may be shut down for sustained periods during operation of the unit.

2.11.5 Arrangements for block valves at spare equipment that is to be isolated for maintenance and equipment that may be removed from service during the operation of the unit shall conform to the following.

a. In chemical and other process liquid services, single block valves shall be used for all pressure temperature ratings up to and including 600 # ANSI. In services of higher ratings, double block valves shall be considered for each individual case.

b. In gas or vapor services block valves shall be as indicated in the following table.

Pressure	Temperature	Valve size	Selection
Upto and including 300 psig (21 kg/cm^2g)	232°C (450 °F) and below	Upto 300 NB	Single Gate Valve
		350 NB and above	Single Plug Valve
	Above 232°C (450 °F)	All sizes	Single Gate Valve
Above 300 psig (21 kg/cm^2g)	232°C (450 °F) and below	All sizes	Single Plug Valve
	Above 232°C (450 °F)	All sizes	Double Gate Valve

2.11.6 A block valve shall be provided for the fire steam system. Other utility systems shall be provided with valves at service connections only.

2.11.7 Block valves shall be provided and located as required for bleed and aeration systems.

2.11.8 A block valve shall be provided in the main line of fuel oil and fuel gas piping to furnaces or fired heaters, be located remote from the equipment, and be accessible for rapid operation in an emergency.

2.11.9 Block valves shall be provided for piping crossing the unit limits as follows.

a. In outgoing lines only when required to divert product streams.

b. In all steam lines except exhaust steam lines.

2.11.10 Automatic control valves shall be furnished with either block valves for isolating the control valve and a bypass for hand control, the sizes of which shall conform to Table given below,or an auxiliary means for manual operation.

Control Valve Size	Line Size	By-Pass & Block Valve Size
50 NB and smaller	50 NB and smaller	Line size
50 NB and smaller	65 NB and larger	50 mm
65 NB and larger	65 NB and larger	Control valve size

a. All three-way control valves shall be furnished with an auxiliary means for manual operation.

b. Control valves in lethal, phenol, and ethanolamine services shall be furnished only with block valves located adjacent to the control valves and an auxiliary means of manual operation.

c. Control valves in services containing abrasive solids or viscous material (viscosity at ambient temperature so high that one-half the design flow rate cannot be attained with the pressure available for starting circulation), boiler feed water services, services with a pressure drop across the control valve greater than 14 kg/sq.cm (200 psi), and steam services with a pressure of 5 kg/sq.cm (75 psig) or higher shall be furnished with block and bypass valves except that when control valves are paired (separate control valves furnished for drivers and their standbys) neither block and bypass valves nor auxiliary means of manual operation shall be furnished.

d. When the pressure drop across the control valve is over 70 kg/sq.cm (1000 psi) two by-pass valves in series shall be furnished.

2.11.11 Two block valves with a bleeder shall be provided in piping connecting systems in services in which contamination cannot be tolerated.

2.11.12 Two valves shall be provided in connections used during operation for venting, draining, or sampling in liquid hydrocarbon services with a vapor pressure over 4.5 kg/ sq cm-a (65 psia) at 37 deg.C (100 F) for venting or draining in all services with an ANSI rating of 900 # or higher; and for sampling in all services with an ANSI rating of 400 # or higher.

2.11.13 Block valves shall generally be gate valves except as follows.

a. Lubricated plug valves shall be used in vacuum and caustic services and in fuel gas piping except burner leads and may be used in gas compressor services and services with an ANSI rating of 600 # and over.

b. Non-lubricated mechanical lift plug valves shall generally be used in services containing abrasive solids in a gas or liquid. Branch line block valves, however, shall be of the type required for the branch line service.

c. Non-lubricated plug valves shall be used at service air hose connections.

d. Globe valves shall be used in furnace blowdown lines, for venting and sampling connections in caustic services and may be used in services with an ANSI rating of 2500 #.

e. Butterfly type valves with resilient seats may be used in water services.

2.11.14 Check valves shall be provided for the common discharge of centrifugal and rotary pumps and centrifugal compressors when the pumps or compressors discharge into a system whose pressure or volume is likely to cause backward rotation of the pump or compressor.

2.11.15 Check valves shall be provided in process steam and steaming out services connected to process equipment or lines when such services are subject to contamination from the process equipment or lines. The check valve shall be located between the block valves required by Section II, Part M, Paragraph 11 and adjacent to the valve nearest the process equipment or line.

2.11.16 Hand control valves shall generally be of the type specified in Table below with the following exemptions.

a. Globe valves shall be used for all sizes when the operation pressure differential across the valve is greater than 35 kg/sq cm (500 psi).

b. Angle type globe valves shall be used for all ratings and sizes in slurry services.

c. Gate valves shall be used in services containing abrasive solids in a gas.

d. Non-lubricated reducing port plug valves shall be used for regulating fuel oil to burners, gate valves for fuel gas.

Valve size NB	150#, 300#, 400# & 600#	900#	1500# & 2500#
150 & larger	Gate	Gate	Gate
100 & larger	Globe	Gate	Gate
80 & larger	Globe	Globe	Gate
65 & smaller	Globe	Globe	Globe

2.11.17 The following flanged and butt welded valves 65 NB and larger shall be bossed, if required, and drilled, tapped and plugged at the locations indicated, in accordance with MSS SP-45, latest revision.

a. In water and steam service, all gate valves

at locations “A” and “G” and all globe valves at location “C”.

b. In services containing abrasive solids, in a gas all gate valves at locations “G” and “H”.

c. All ball check valves above the seat and all swing check valves at location “G”.

2.11.18 Steel valves shall have the following construction.

a. Flanged and butt welded valves of the gate, globe, and angle type shall have bolted bonnets and glands, and of the check type, bolted bonnets. Threaded and socket welded valves of the gate, globe, and angle type shall have gasketed union bonnets and bolted glands, and of the check type, gasketed union bonnets. Pressure sealed, welded or integral bonnet for threaded and socket welded gate, globe and angle valves may be used for corrosive or high pressure services.

b. Gate, globe and angle valves shall be of the outside screw and yoke type.

c. Gate valves shall be provided with pressure equalizing by-passes and by-pass valves of the minimum sizes and ratings listed in Table below when a differential pressure approximately equal to the pressure rating of the valve may exist across the closed valve (eg. 600 lb across a 600 lb valve).

Gate-Valve Size NB	By-pass and By-pass Valve Size, NB						
	Gate and By-pass Valve Pressure Rating						
	150#	300#	400#	600#	900#	1500#	2500#
100	-	-	-	-	15	15	15
150	-	-	-	20	20	20	20
200	-	-	20	20	20	20	20
250	-	25	25	25	25	25	25
300	25	25	25	25	25	25	25
350	25	25	25	25	25	25	()
400	25	25	25	25	25	()	()
450	25	25	25	25	25	()	()
500	25	25	25	25	()	()	()
600	25	25	25	25	()	()	()

d. Globe and angle valves shall be selected for the required sensitivity of control. Specially designed plugs may be used when the operating differential pressure is greater than 35 kg/sq.cm (500 psi). Geared operators shall be furnished for the valves listed in Table below.

ANSI Rating	Valve size
150#	300 NB and over
300#	200 NB and over
400# & 600#	150 NB and over
900 #	100 NB and over
1500# & 2500#	80 NB and over

e. Threaded and socket welded check valves shall be of the ball type. Flanged and butt welded check valves shall be of the swing -non-slam type in sizes 350 NB and over and of the swing type in sizes 300 NB and under except that valves with ANSI ratings of 900 and 1500 # shall be of the ball type in sizes 100 NB and under.

f. Lubricated plug valves shall be wrench operated in the sizes listed and gear operated in larger sizes.

125 # ANSI - 250 NB size and smaller

150, 250 and 300 # ANSI - 200 NB size and smaller

400 to 1500 # ANSI - 100 NB size and smaller

2500 lb ANSI - 50 NB size and smaller

Such valves shall be fitted with giant button-head lubrication.

g. Non-lubricated mechanical lift plug valves for use in services described in Section II, Part M, Paragraph 13 b. shall be of the single operation mechanical lift type, designed to permit sealing the plug and blowing or flushing the seat. Such valves shall be wrench operated in sizes 150 NB and smaller and gear operated in sizes 200 NB and larger except that for chain operation, valves in sizes 150 NB and larger shall be gear operated.

h. Control valves shall have flanged or threaded end connections.

i. Gate valves in the 150 # and 300 # ANSI ratings may be reduced port.

2.11.19 Cast iron valves shall have the same construction as steel valves except as follows.

a. Flanged gate valves used in buried lines shall be of the inside screw non-rising stem type.

b. Threaded gate valves shall have a clamp type bonnet and be of the inside screw non-rising stem type.

c. Threaded check valves shall have a threaded bonnet and be of the swing type.

2.11.20 Bronze and brass valves shall have threaded end connec tions. Gate, globe and angle valves shall be of the inside screw rising stem type, check valves shall be of the swing type. Plug valves shall be manufacturer’s standard.

2.12.0 PIPES AND BENDS

2.12.1 In general, for all except alloy steel pipe, seamless and fusion welded pipe shall be used. Welded pipe may be used for services with an ANSI rating of 300 # or less, and for utility services with a temperature of 175 deg.C (350 F) or less. For alloy steel pipe, only seamless shall be used.

2.12.2 Pipe, in sizes 32 NB, 65 NB and 125 NB shall not be used.

2.12.3 Changes in direction shall be made with fittings preferably or bends. Bends shall be used for unlined pipe conveying abrasive solids suspended in gas or liquid.

a. One weld miter elbows: atmospheric air

compressor intake lines when flow straightening vanes are used. Vent lines from compressor and sewer lines.

b. Two weld/ three weld miter elbows: process lines larger than 600 NB in diameter with an ANSI rating of 125, 150 or 250 # and all utility (water, steam, air, etc.) and auxiliary (vent, flare, etc.) lines.

c. Four weld miter elbows: process lines larger than 600 NB in diameter with an ANSI rating of 300 # and over and internally lined pipe conveying abrasive solids in gas or liquid.

2.12.4 The minimum radius for pipe bends shall be 5 times the nominal pipe size for upto 350 NB inclusive and 6 times the nominal pipe size for pipe over 350 NB size. When bends are required with smaller radius or of any radius in pipe operating at temperatures above 400 deg.C (700 F), the possible thinning in the wall of the outer periphery due to bending shall be taken into account.

2.12.5 Equal size 90 degree intersections, except in low pressure utility piping (ANSI rating of 250 # or less and temperature of 232 deg.C less (450 F)) shall be made with tee fittings. In general, all other intersections and all intersections in low pressure utility piping shall be made by welding. When reinforcement is required for branches, branch welding fittings may be used.

2.13.0 FITTINGS END CONNECTIONS, FLANGE FACINGS AND GASKETS

2.13.1 Fittings and end connections in carbon and alloy steel piping shall be as follows:

a. In austenitic steel pipe at service temperatures over 400 deg.C (750 F) butt welded or flanged for sizes 25 NB and larger. Socket welded or threaded in smaller sizes.

b. In galvanized steel pipe - flanged in sizes 150NB and larger, threaded in smaller sizes.

c. In all other services - butt welded or flanged for sizes 50 NB and larger, threaded or socket welded in 40 NB and smaller.

2.13.2 Threaded connections shall be made up with Teflon taped threads when the temperature is 260 deg.C (500 F) and below. Threaded connections shall be seal welded when the temperature is above 260 deg.C (550 F). When so required in vent, drain, or sample piping discharging to an open system or in instrument leads, seal welding shall be done only to the upstream side of the first block valve.

2.13.3 Except for removable sections of pipe, erection requirements, and piping requiring dismantling for clean ing, the use of flanges in piping shall be limited to connections at flanged equipment.

2.13.4 Raise faced flange shall be used for ANSI ratings of 900 # and below and ring joint flanges for process services with ANSI ratings of 1500 # and higher. All steam systems with ANSI ratings of 150 to 2500 # shall have raised face flanges when flanges are used.

2.13.5 Gaskets for ring joint flanges shall be of the octagonal type.

2.14.0 BLANKS

2.14.1 Blanks shall be provided in the piping at the following locations only.

a. At inlet and outlet connections of equipment, other than pumps, compressors, and blowers, which must be periodically taken out of service for maintenance, inspection, or alternate operation without interfering with the operation of the unit and when the omission of such blanks would present a hazard to personnel.

b. In furnace piping at locations which will permit the simultaneous testing of the furnace and as much of the piping as may be sub ject to the test pressure.

c. At the unit limits in utility piping conveying hydrocarbons and in process piping connected to other plant piping which may be in use during a shut down of the unit.

2.14.2 The selection of the type of blank shall be in accord ance with Table VI and the following subparagraph:

a. Blanks for piping in service at temperatures below -18 deg C (zero degrees F) shall be of the circular type with spades for rigid connections and without spacers for flexible connections.

Nominal size of pipe (NB)	Rigidity of connection	
	Rigid	Flexible
100 and smaller	Figure 8	Circular without spacer
150 and 300 incl.	Figure 8	Figure 8
Larger than 300 NB	Circular with spacer	Circular with spacer

2.14.3 Circular type blanks and spacers shall be provided with attach ments for handling.

2.15.0 UTILITY OUTLETS

2.15.1 Utility steam, air, and water service outlets of 25NB minimum size for hose and fittings shall be provided as required at such locations that working areas at grade, in structures, and in buildings can be reached with 15000 mm length of hose.

a. The steam supply to hose connections shall be limited to a pressure of 8.75 kg/sq.cm g (125 psig).

b. Service outlets for water shall be located at grade for furnaces and at grade and the lowest main operating level in structures.

c. Hose and fittings will not be furnished.

2.16.0 VENTS, DRAINS AND SAMPLE OUTLETS

2.16.1 Valved vent and drain connections shall be furnished on all equipment not self venting or self draining. Connections shall be located on equipment if practicable but may be located in connected piping when there are no valves or blocks between the vent or drain connections and the equipment. Vents and drains for pumps in services containing abrasive solids shall be located in connected piping.

2.16.2 Valved vent connections shall be furnished for trapped high points of piping 65 NB and larger except that when the connection is used for test purposes only, the valve shall be omitted and a plug substituted. Valved drain connections shall be furnished for the low points of lines located above grade.

2.16.3 Vent connections shall be 20 NB minimum size drain connections and sample outlet connections shall be 20 NB minimum size, except as follows.

a. All piping connections from equipment shall be the equipment connection size.

b. All connections from piping in services involving abrasive fluids or materials which are of high viscosity when cold shall be 25 NB minimum size.

2.16.4 Vent and drain connections from vessels shall be at least the sizes given in Table given below.

Volume of Vessel (liters)	Nominal size of vents and drains (NB)	
	Vents	Drains
1400 and smaller	25	25
1400 to 5650	25	40
5650 to 17000	25	50
17000 to 70800	40	80
over 70800	50	80

2.16.5 All single valved vents and drains in process services only shall be provided with plugs or blind flanges except for the following.

a. Casing vents and drains for pumps in non-volatile services shall be piped to the pump base plate or into a gutter or sewer.

b. Casing vents for pumps in services handling materials near the auto-ignition point shall be piped to a cooler and from the cooler to a sewer.

2.16.6 Vent and drain connections used during operation in fuel gas supply piping and in services with a vapor pressure over 4.5 kg/sq.cm-g (65 psig) at 37 deg.C (100 F) shall discharge to a closed system or to a sealed and vented sewer inlet.

2.16.7 Sample outlets in piping or equipment in hot services shall be provided with means for cooling the sample. One cooler may be used for grouped sample outlets.

2.16.8 Means shall be provided for clearing sampling lines and coolers with steam in services involving materials which are of high viscosity when cold and in all services when grouped sample outlets use the same cooler.

2.17.0 EMPTYING, STEAMING OUT AND WATER FILLING

2.17.1 Means shall be available for removing the operating liquid contents from all vessels and heat exchange units and the connected piping. Process lines and pumps shall be used for this purpose as far as practicable; or steam or other medium shall be used to remove the liquid by pressure; otherwise, an auxiliary pumping out system shall be provided.

2.17.2 Connections for emptying vessels shall be at least the drain sizes given in table 2.16.4: and on heat exchanger units they shall be 40NB when provided.

2.17.3 When required by the service, means shall be available for purging process equipment with steam or inert gas. Unless steam or inert gas is otherwise available, the following provisions shall be made:

a. Vessels of volume from 2832 to 141600 liters (100 to 500 cu.ft.) and all sizes of vessels of low temperature service, shall be provided with a 25NB connection to which a steam hose may be at tached. Other vessels of volume greater than 141600 liters (5000 cu.ft.) shall be serviced by a 40 NB line connected to a source of steam.

b. Furnace coils shall be serviced by piping permanently connected to each coil inlet line and to a source of steam.

2.17.4 When required by the service, means shall be available for filling process equipment with water for washing out.

a. Vessels requiring frequent maintenance shall be serviced by piping permanently connected to a source of water.

b. Vessels not requiring frequent maintenance shall be serviced by hose connected between a service water outlet and the vessel drain connection.

2.18.0 FIRE, SMOTHERING, SERVICE, SNUFFING AND PROTECTIVE HEATING SYSTEM

2.18.1 Smothering system shall be provided to furnace combustion chambers, header boxes, and to the spaces above the furnace arch and shall be controlled by valves remote from the furnace area.

2.18.2 Smothering steam shall be provided to enclosed rooms housing pumps or compressors in flammable liquid or gas service and shall be controlled from outside the building.

a. Flammable liquids shall be defined as liquids having a flash point below 93 deg.C (200 F) as determined by ASTM D56-70 or D93- 66.

b. Flammable vapors shall be defined as vaporized flammable liquids with molecular weights greater than 80.

2.18.3 Snuffing steam shall be provided to relief valve outlet piping discharging hydrocarbon vapors to the atmosphere and shall be controlled from grade.

2.18.4 The steam supply for fire smothering, fire fighting, snuffing, service hoses and protective heating shall be from a separate steam system connected to the plant steam header on the supply side of the unit limit block valve.

a. A separate fire steam header shall not be required if steam is normally available at a pressure 3.5 and 8.75 kg/ sq.cm-g (50 and 125 psig) in the plant steam system.

2.19.0 STEAM TRAPS AND SEPARATORS

2.19.1 Steam traps shall be provided for the removal of condensate from collection points in steam system.

2.19.2 Steam traps discharging to the atmosphere shall be provided with upstream block valves. Steam traps discharging to a condensate collecting system shall be provided with upstream block valves and downstream block valves except that steam traps for unit heaters shall be provided with downstream block valves only.

2.19.3 Condensate from vacuum steam systems shall be re-evaporated into the system by means of a condensate flash pot.

2.19.4 A steam separator shall be provided in the steam piping to each group of steam turbines and to each group of steam driven reciprocating compressors.

2.19.5 Drip legs shall be provided on steam headers for collecting condensate.

2.20.0 STRAINERS AND FILTERS

2.20.1 Permanent strainers shall be provided in the piping for the protection of the following equipment when not furnished as part of the equipment.

a. All pumps - in suction line.

b. Steam turbines and steam jet ejectors - in steam inlet line.

c. Pumps and compressors - in sealing, gland, and flushing oil and cooling water supply piping.

d. Reciprocating compressors taking suction from process equipment in suction line.

e. Burners - in main fuel oil supply piping.

f. Hydraulically actuated equipment - in hydraulic oil supply piping.

g. Pneumatically actuated equipment - in air supply piping.

h. Restriction orifices in bleed gas or air service - in gas or air piping.

2.20.2 In addition to permanent strainers, temporary strainers with a mesh finer than the permanent strainer mesh shall be placed over the permanent strainers, for use in preliminary operation in the suction piping to all pumps.

2.20.3 Reciprocating compressors taking suction from process equipment shall be furnished with temporary strainers.

2.20.4 A filter shall be provided in the air piping upstream of air driers.

2.20.5 Screened intakes shall be provided for air compressors and air blowers.

2.21.0 SEWERS

2.21.1 An underground oil water sewer system shall be provided to collect and convey all oil drainage, waste water, and storm water from paved areas to the unit limits. Sewers, if required for raw sanitary and chemical waste, shall be run separately to the unit limits. Treated chemical and sanitary waste may be conveyed through the oil water sewer system.

2.21.2 The oil water sewer system shall conform to the following:

a. Paved areas at grade, the bottoms of trenches, and the floors of pumps or compressor rooms shall be provided with drains for the collection of surface drainage except that drains shall not be furnished for concrete floors of elevated open sided com pressor rooms. The floors of control rooms, switch rooms and lavatories shall not be provided with drains. Drains located within enclosed buildings shall be provided with drain fittings of the sealed type.

b. All equipment such as pumps, compressors, and vessels shall be provided with sewer inlet receptacles as required..

c. Roof areas upon which process equipment is located shall be connected to the sewer system through the down spouts.

d. Sewers discharging from seperately defined areas such as pump rooms, furnaces, and grouped equipment shall connect to the system through sewer boxes having sealed inlets. When it is not prac ticable to connect trench drains individually to sewer boxes, such drains shall be sealed by means of “P” traps. Sewer boxes in hazardous areas, such as around furnaces, shall have sealed covers and be vented to a safe location.

2.22.0 EMERGENCY FIXTURES

2.22.1 Eye wash fountains and emergency showers shall be provided near equipment or pipe manifolds in acid, caustic, phenol service and any other lethal service.The fixtures shall be installed at locations conveniently accessible for emergency use. Emergency showers shall be arranged for overhead delivery of water spray.

2.22.2 Water for eye washing fountains and emergency showers shall be taken from the drinking water system. Self closing valves shall be used.

2.22.3 Eye washing fountains & emergency shower heads shall be as per the relevant IS codes only

3.0.0 MATERIALS

3.1.0 GENERAL

3.1.1 The selection of materials for a given piping system shall be based on the fluid conveyed and the design temperature and pressure. The materials of special elements, such as steam traps and separators shall conform to the manufacturer’s standards for the operat ing conditions. The material and corrosion allowance for a particular service will be specified in the design data sheets.

3.1.2 Low temperature piping (design metal temperatures below -28.9 deg.C (-20 F) shall have materials for pressure containing parts in accordance with the applicable code. Materials for non- pressure parts shall be as follows.

a. Structural attachments which are welded directly to any pressure part and which normally will be subject to dynamic loads while the pipe is at operating temperature such as vacuum stiffener rings, pipe supports,

guides, anchors, platform and ladder clips.

b. Structural attachments which are welded directly to any pressure part but which are not normally subject to dynamic loads while the pipe is at operating temperature such as davit clips,. lifting lugs, Nelson studs, insulation clips and rings, etc.. mild carbon steel (not impact tested) for piping of carbon or ferrite alloy steel and AISI Type 304 steel for piping of austentitic alloy steel.

3.1.3 Valve body materials shall be steel conforming to the relevant codes / manufacturer's standards for the valve type and pressure ratings except as follows. Generally all valves 40 NB and below shall be forged and 50 NB and above shall be of cast material.

a. For water and low pressure air service, cast iron and bronze or brass shall be used.

b. For low pressure steam, cast iron may be used but not within 7.5 metres of furnaces. Bronze and brass shall not be used.

c. For corrosive and high temperature service, the material will be comparable to that indicated on the Design Specification Summary Sheet.

3.1.4 Valve body material may be ductile iron in 150 # and 300 # ANSI ratings. However, ductile iron shall not be used in compressor piping.

3.1.5 Valve trim material shall be as per code or as per the manufac turer's standards for the service conditions.

3.1.6 Bolting and gasket materials shall conform to the relevant code/ IS/ ASTM standards.

3.1.7 In selecting materials the following are special considerations.

a. When piping systems or equipment are inter- connected by a valve, the valve shall be suitable for the services connected. However should the particular service require the use of alloy valves because of high temperature or corrosion, the block valve located in connected piping which normally is deadened or in which the service temperature is lower may be of carbon steel of the required pressure rating if suitable.

b. When a change in pressure or temperature occurs at equipment such as a control valve, a heat exchanger unit, or a trap, the up stream block valve and the by-pass valve (if any) shall be suitable for the upstream conditions whereas the downstream block valve need be suitable for the downstream design conditions only.

3.1.8 All steel pipe and fittings 100 NB and under for drinking water service and air transmission service to air motor operated valves shall be galvanized.

4.0.0 FABRICATION, HEAT TREATING, INSPECTION AND PRESSURE TESTING

4.1.0 Fabrication, heat treating, inspection and pressure testing shall be as per the specification for Fabrication And Installation of Steel Piping 25ES205.

TABLE 1 FOR CLAUSE 2.6.0 - OVER PRESSURE PROTECTION FOR EQUIPMENT

EQUIPMENT SELECTED	CAUSE OF OVER PRESSURE (NOTE 1)	PROTECTIVE DEVICE	RELIEVINGPRESSURE	
			Initial	Maximum
Towers, Drums & Kettle Type Evaporators	Open Inlet (Control valve opens wide) Closed Outlet Failure of Cooling Medium Top or Side Stream Reflux Failure Lean Oil Failure to Absorber Failure of Tower Pressure Controller in the Closed Position Driver Electric Failure Steam Power Failure Chemical Reactions Exclusive of Explosions	Relief Valve or Safety Valve or Rupture Disc	1.00 P	1.10 P
	External fire (Note 2)			1.20P
Heat Exchanger (Shell & Single Type)	Thermal Expansion of Liquid when closure of a Single Valve isolates contents or if exchanger can be dispensed with or is spared.	Relief Valve (Min size)	1.00 P	
	Light hydrocarbon service-blocked inlet & outlet when the pressure exceeds the Design Pressure	Safety Valve (Min size)		
	External Fire (Channel Side)	Safety Relief Valve (Min size except when dealing with large exchangers)		1.20 P
	External Fire (Shell Side)	Safety Relief Valve or Safety Valve		
Heat Exchangers	Ruptured Tube (Note 3) Open Inlet (Contro Valve opens wide) Closed Outlet	Relief Valve or Safety Relief Valve or Rupture Disc		1.10 P
Exchangers (Double Pipe)	Thermal Expansion of Liquid when closure of a single valve isolates contents or if Exchanger can be dispensed with or is spared.	Relief Valve (Min. Size)	1.00 P	

P - Maximum available working pressure (MAWP) of equipment

NOTES:

1. Each cause of overpressure shall be considered individ ually.
2. The heat input shall be calculated in accordance with the formula

$$Q = \frac{0.82}{21000} FA$$

In which

Q = the total heat input to the wetted surface in Btu per hour

F = 1.0 for uninsulated vessels and 0.3 for insulated vessels.

A = the total wetted surface exposed to fire in square feet. The surfaces of vessels or heat exchangers up to 25 ft. above grade or other fire supporting level shall be considered subject to fire expo sure.

3. Area of rupture assumed equal to the flow area of two tubes. Relieving device will not be required when sufficient quantities of material can be discharged through the low pressure connecting system (with block valves assumed thro' open) to prevent an overpressure of more than 1.10 P.

CONTENTS

1.0.0 SCOPE

1.1.0 GENERAL

1.1.1 The scope of work includes but is not limited to basic design, detailed engineering, supply, fabrication, erection, testing, painting, insulation, commissioning and guarantee run of the Piping / Ducting on turnkey basis.

1.1.2 The supply of hardware and engineering shall be completed as there will be no other supplier other than the vendor within the battery limit indicated.

1.2.0 IDENTIFICATION

1.2.1 The scope of work includes but not limited to:

a. Basic engineering for the piping / ducting for the Package.

b. Detailed engineering for piping/ducting within the Package. This includes preparation of plot plan, piping layouts, isometrics, support drawings, bill of materials, procurement, special instructions for storage, special instructions for identification of pipe lines and components, special instructions for erection, special instructions for testing, special instructions for pickling of oil lines if any, blowout procedure etc.. Submission of these drawings to FEDO, incorporating comments made by FEDO and obtaining necessary IBR / Statutory approvals.

c. Stress Analysis of all pipe lines and ducts above 100 deg.C, all IBR lines and all lines connected with rotating equipments.

These stress analysis reports shall be submitted to FEDO for review and comments. Compensators and spring supports shall be finalized and provided based on the stress analysis reports.

All pipe lines shall be anchored at the Battery Limit.

Nozzle loads on rotating equipments, viz, turbines, etc., shall comply to API/ NEMA codes and the reports shall be submitted to FEDO for review.

d. Supply of all materials based on the piping bill of materials and any additional material required for the satisfactory completion of the system. Supply includes all materials for piping such as pipes & ducts, pipe & duct fittings, flanges, gaskets, bolts and nuts, pipe supports, valves, expansion bellows, spring supports, shut-off plates, safety valves, etc. as per approved piping layouts and P&IDs. Supply inclusive of testing, packing and forwarding.

e. Insulation of all insulated lines and Painting of all uninsulated CS / AS pipes and ducts shall be as per specification attached. Color coding shall be as per FEDO color coding.

f. All piping items covered by Indian Boiler Regulations (IBR) shall be supplied along with IBR certificate

g. Any other work related to the completion of the Package.

h. All items included in the vendor's scope may be subjected to inspection by FEDO / Client. The items are to be cleared by the designated inspector before dispatch.

i All piping larger than 50 NB shall be prefabricated. Pipes smaller than 50 NB shall be delivered in commercial lengths, properly marked with type and material. 10% excess pipe shall be supplied for all sizes and materials.

j. All vents shall be at a safe location and shall include necessary supports.

2.0.0 DESIGN CONSIDERATIONS

2.1.0 Design of all piping systems, except those listed below, shall be as per ANSI / ASME B 31.3.

a. All boiler feed water and steam lines shall be as per the latest issue of IBR and ANSI / ASME B31.1.

2.2.0 All dimensions and elevations shall be given in metric units.

2.3.0 Flange and valve ratings shall be as per class designation in ANSI B16.5 and ANSI B16.34 respectively.

2.4.0 32, 65 & 125 NB pipe sizes shall not be used.

2.5.0 Traps & strainers shall be provided wherever necessary. Normally a shut off valve shall be provided ahead of each strainer /trap. Union or flanges shall be provided for removal of traps.

2.6.0 The clear headroom over platforms, walkways, passage ways and working areas shall be at least 2.2 m.

2.7.0 All pipes shall have a slope of minimum 1 in 1000 and shall be provided with drain line at the lower most point.

2.8.0 All equipment location, layout, design and general arrangements shall conform to the relevant statutory requirements.

2.9.0 Valves shall be located where there is ease of operation and maintenance. Gear arrangement shall be provided for all valves as per clause 5.5.

3.0.0 BATTERY LIMITS FOR PIPING

3.1.0 All incoming and outgoing lines shall be terminated at the Battery Limits specified in the battery limit list attached.

4.0.0 DETAILS OF DRAWINGS/ DOCUMENTS

This is only a general guide line for preparing various drawings / documents, highlighting the

minimum details to be furnished. The vendor is obliged to include any other details found to be wanting in the drawing/document, after review of the same by FEDO.

4.1.0 GENERAL LAYOUT DRAWING

4.1.1 The Layout should be of A1 size and should give the following details using the coordinate system to locate each item.

a. Size Location and Point Of Support (POS) elevation of all equipments, location and size of buildings.

b. Battery Limits.

c. Pipe Bridge Locations.

d. Sewer and Drain Details.

e. Free area required around equipment / exchangers for maintenance / tube removal.

f. Paved area and elevations.

g. Plant North.

h. The Layout shall also contain a table showing the complete list of equipments with location and point of support details.

4.2.0 PIPING LAYOUT

4.2.1. The Piping Layout shall be drawn on a scale of 3:100. The layout shall give the following details using the coordinate system to locate each equipment and line.

4.2.2. Routing of all pipelines and ducts showing all fittings, valves, strainers, springs, bellows, line Nos., direction of flow, location and elevations, pipe supports etc.

4.2.3. Nozzle schedule of all equipments giving the following details of all nozzles on each equipment.

a. Size and Rating

b. End Connection

c. Orientation

d. Elevation

e. Standout

f. Description

4.2.4 Separate details for lines / areas which cannot be clearly drawn on the layout.

4.2.5 All platforms on vessels and structural platforms.

4.2.6 All instruments, control valves, MOV, PSV, traps, etc.

4.2.7 Any other detail required by FEDO during review.

4.3.0 ISOMETRICS:

4.3.1 Isometrics shall be drawn for all lines irrespective of size, including isolation valves on equipments. The isometric shall include a Bill of Materials showing the complete list of materials and quantity required for fabrication and erection of the line.

4.3.2 The isometric drawings shall indicate the relevant line numbers, flow direction, pipe specification, insulation / painting details, stress analysis requirements, pipe supports like trunnions, line fluid conditions such as pressure, temperature, hydrotesting pressure, etc.

4.3.3 Steam tracing isometrics:

This shall be produced from the relevant isometrics with details of steam tracing incorporated. However the bill of materials will be that for the steam tracing line.

4.4.0 PIPE SUPPORT PLAN

4.4.1 This drawing should indicate the location and type of all supports used and should also give the pipe support detail sheet number to be referred for getting details of the support.

4.5.0 PIPE SUPPORT DETAIL SHEETS

4.5.1 This detail sheet should give all the data required for the fabrication and erection of a particular pipe support.

4.6.0 LINE SCHEDULE

4.6.1 This document should give all line numbers, the detail of connecting equipment lines, operating conditions, service and insulation details.

4.7.0 VALVE SCHEDULE

4.7.1 This document should furnish tag numbers, type, pressure rating, size, material of construction and service of all valves.

5.0.0 GENERAL

5.1.0 All piping items shall be procured from the attached sub vendor list of approved vendors for indigenous vendors. For any deviation, prior approval from FEDO shall be obtained before placement of order.

5.2.0 Operating spares for valves, steam traps, strainers etc. for two years of trouble free service be included in the offer.

5.3.0 A layout shall be included in the package for reference.

5.4.0 Bypass, drain and vent connections for valves shall be as specified in MSS-SP 45.

5.5.0 Geared Operators for valves shall be provided as per the following table.

ANSI Rating	Valve Size
150 #	300 NB and over
300 #	200 NB and over
400 # & 600 #	150 NB and over
900 #	100 NB and over
1500 # & 2500 #	80 NB and Over

1.0 SCOPE

This specification covers the minimum requirements for materials cleaning, priming, coating & wrapping, inspection and testing of Coal Tar Coating to be provided on the underground pipe lines.

2.0 MATERIALS

All materials used shall conform to the quality and testing requirement indicated in AWWA C 203-73 /IS 10221 latest editions.

3.0 COAL TAR PRIMER

3.1 Coal Tar Primer shall conform to the characteristics given below,

3.2 The primer shall consist of processed Coal Tar pitch and refined Coal Tar Oils only, suitably blended to produce a liquid coating which may be applied by brushing or spraying.

i)	Curing time to touch at normal humidity at 30 deg C (70%)	:	Less than an hour
ii)	Maximum Boiling Point	:	215 deg. C of solvent
iii)	Penetration of residue 100 gwt 5 sec (ASTM D5-597)	:	Under 7 at 25 deg. C
iv)	Softening point of residue (ASTM D 36-26)	:	104 deg. C (Min.)

4.0 COAL TAR ENAMEL

4.1 Coal Tar enamel shall conform to the characteristics given below,

4.2 Coal Tar enamel shall be composed of a specially processed Coal Tar pitch combined with an inert mineral filler. No asphalt of either petroleum or natural base shall be acceptable as part of the ingredients. The enamel shall have the characteristics conforming to AWWA C-203 or equivalent. Other physical characteristics shall be as follows:

	PARAMETERS	Min	Max
i)	Softening Point (ASTM D 36)	105 Deg C	-
ii)	Filler (ash) ASTM A 271	25%	-
iii)	Fineness filler, through 200 mesh (ASTM D 546)	90%	35%
iv)	Specific gravity at 25 deg. C (ASTM D 71)	1.40	1.60
v)	Penetration (ASTM D 5)		
	- At 77 deg. F – 100g. wt – 5 sec.	10	20
	- At 115 deg. F – 50 g. wt – 5 sec	15	35
vi)	High Temperature Test at 162 deg. F (Sag) AWWA C 203	-	1.6 mm
vii)	Low temperature test at 20deg. F (cracking)	-	None
viii)	Peal Test		No peeling
ix)	Spark test 10,000 Volt low amperage		None

5.0 FIBRE GLASS WRAPPER FOR INNER WRAPPING

5.1 The wrapper shall conform to the characteristics given below,

5.2 Reinforced fibre glass wrapper – 150 mm width, consisting of a uniform bonded mat. The binder to be inert to coal tar enamel.

5.3 The fibre glass mat shall be thin, flexible & strong. The glass fibre shall be longitudinally reinforced by continuous filament glass embedded in the mat at 9.35 mm nominal centers.

i) No disbanding of individual glass fibre shall occur during or following the embedding process.

ii) The fibrous glass mat shall not give rise to any air gap when applied.

iii) The wrapper shall be sufficiently porous so that it can be embedded in the hot coal tar enamel.

Other physical characteristics shall be as follows:

a)	Weight	:	45 – 50 gms/sq.m
b)	Normal Thickness		0.5 / 0.1 mm
c)	Longitudinal Tensile Strength (20" x 5" wide specimen)		45.36 kg min
d)	Tear strength in the transverse direction		3.63 kg
e)	Moisture absorption (by wt. at relative humidity of 95% at 50 deg. C for 24 hours)		5% (max)

6.0 GLASS FIBRE FELT FOR OUTER WRAP

The Outer Wrap shall be Coal Tar impregnated Glass Fibre Felt. The Outer Wrap shall confirm to the characteristics as per AWWA C-203 latest edition.

7.0 SURFACE PREPARATION

The surface to be wrapped and coated shall be properly cleaned. Surface shall be free of all rust, grease, dirt, weld scales, weld burrs etc. Surface preparation shall be immediately followed by priming.

8.0 PRIMING

The primer shall be applied on the pipeline with uniform coating leaving no drips, floods, sags or runs. Any holidays or unprimed places shall be re-primed immediately. The surface shall be dry at the time of applying primer coat. Primer shall not be applied during rain or fog. Drying time shall be 24 hours.

9.0 COATING BY COAL TAR ENAMEL

9.1 Enamel shall be placed in a melting kettle and heated at a uniform rate to 240 – 250 deg. C or as recommended by the manufacturer.

9.2 Coating material shall be stirred properly in the kettles at regular intervals of maximum 15 minutes.

9.3 First coat of coal tar enamel shall be poured and spread over the primed surface to a maximum thickness of 2.00 mm.

9.4 The application shall be so manipulated as to achieve a uniform thickness throughout the surface. The variation in thickness should not exceed 0.5mm

10.0 INNER WRAPPING WITH GLASS FIBRE MATERIAL

After the first coat of coal tar, the fibrous glass mat shall be applied on the surface while the enamel coating is still tacky. The wrap shall be applied with a lap of 25 mm minimum.

11.0 FINAL COAT OF ENAMEL & OUTER WRAPPING

11.1 Immediately after the application of the first inner coating of enamel and wrapping of the mat a final coat of coal tar enamel shall be applied.

Along with the final coat of enamel, coal tar impregnated fibre glass felt outer wrap shall be spirally wound round the pipe with a minimum of 25 mm overlap on each spiral.

11.3 The coated final thickness shall be minimum 4.5 mm.

11.4 The contractor shall furnish and operate at his own cost an electric powered holiday detector of 10,000 volts output for certifying that lining is free from holidays.

11.5 Spark testing shall be done after minimum of 24 hours after the final coat.

CONTENTS

1.0.0 GENERAL

1.1.0 SCOPE

1.1.1 This specification covers the general requirements for fabrication and installation of steel piping (including carbon steels, low-alloy steels, and stainless steels) within petroleum refineries and chemical plants.

1.1.2 When conflict occurs between this specification and the piping drawings or the individual specification, the order of precedence shall be piping drawings, individual specification, and this specification.

1.2.0 REFERENCES

1.2.1 The requirements contained in the latest editions of the following standards shall form a part of this specification, in the manner and to the extent indicated herein:

1. Indian Boiler Regulation (IBR)
2. ANSI B2.1, Pipe Threads
3. ANSI / ASME B31.3, Chemical Plant and Petroleum Refinery Piping
4. ASME, Boiler and Pressure Vessel Code: Section V- Non-destructive Examination, Section VIII - Division 1, UW-51- Radiographic Examination of Welded Joint, Section IX- Welding and Brazing Qualifications.

1.3.0 DEVIATIONS

1.3.1 When piping cannot be fabricated and installed as shown on the piping drawings, or when it is deemed to be more appropriate to fabricate and to install the piping in a manner other than as shown on the drawings, the FEDO Engineer / Representative shall be consulted and the piping shall be fabricated and installed in accordance with his instructions.

2.0.0 FABRICATION

2.1.0 MATERIAL CONTROL

2.1.1 Packages of piping materials delivered to the jobsite shall be opened immediately, and the quantities, specifications, sizes, and identification (color identification and die stamp) shall be checked and recorded in the material ledger. The materials shall be stored promptly and neatly in the designated warehouse or storage yard.

2.1.2 When the identification is inadequate, the material shall be marked according to the colour identification or an identification mark such as die stamp shall be applied before storing the material.

2.1.3 Piping materials shall be issued only upon presentation of Material Issue Slips signed by the FEDO Engineer / Representaive. Piping materials shall be issued only against the relevant isometrics.

2.1.4 Issued materials shall be indicated on the drawings or material use charts, etc., to prevent duplication of issues.

2.1.5 Any surplus materials found on the job - site shall be returned promptly to the warehouse or storage yard.

2.1.6 When more material is needed as a result of faulty fabrication or other similar reasons, the FEDO engineer shall promptly be in formed of the matter so that he can give further directions and advice.

2.1.7 Special precautions shall be taken to keep electrodes and gaskets dry during storage.

2.2.0 PRECAUTIONS FOR PREPARATION & FABRICATION

2.2.1 When the location of piping connections by field welding is not shown on the piping drawings, consideration shall be given to preparation and fabrication of piping materials so that the field welding position is flat or horizontal as far as possible.

2.2.2 The minimum clearance between the edges of two adjacent welds shall exceed 25mm or 4 times the pipe nominal wall thickness, whichever is greater.

2.2.3 When both welded pipes and piping components having a longitudi nal welded joint are joined at the end, in the girth butt welds the dimension between the longitudinal welded joints shall exceed 5 times the nominal pipe wall thickness of the thicker of those being joined. In unavoidable circumstances when the dimension is less than 5 times, both longitudinal welded joints in the girth butt welds shall be examined by radiography over 100mm. In addition, Section 8.1 (14) shall be considered in the preparation and fabrication.

2.3.0 CUTTING

2.3.1 Pipes shall be marked accurately and then cut according to the dimensions shown in the piping drawing or the dimensions most suitable for the conditions of field installation.

23.2 When irregular cutting is required for single and multiple branch connections and for curved and mitred segments of pipe, the cutting shall be performed by using a template.

2.3.3 In principle, pipes shall be cut mechanically with a pipe cutter or a high speed cutter. When cutting ss pipe using a high speed cutter, an

abrasive wheel for stainless steel shall be used.

2.3.4 When pipe is of a large diameter, or when a pipe cutter or a high speed cutter cannot be used the following methods may be used.

a) Carbon Steel

Carbon steel pipe may be cut with automatic or manual oxygen- acetylene gas apparatus. However, base metal with a carbon content of more than 0.35% shall not be cut with oxygen-acetylene gas apparatus.

b) Low-alloy steel pipe

Only when unavoidable, low-alloy steel pipe may be cut with oxygen-acetylene gas apparatus pursuant to Subitem (a) above.

c) Stainless steel pipe

Only when unavoidable, stainless steel pipe may be cut by plasma arc cutting or arc air gouging. In this case, the pipe shall be coated with spatter deposit prevention paint to avoid adhesion of spatter.

2.4.0 END PREPARATION

2.4.1 Shape of Grooves

1. In principle, grooves for butt welding ends shall be shaped in accordance with ANSI B16.25 However, the grooves shall be in accordence with the approved Procedure Qalification Records(PQR).
2. Unless otherwise specified, the grooves shall be in accordance with the requirements shown in Table below which conform to ANSI B16.25.

PIPE WALL THICKNESS (t)	GROOVE
3 mm or less (stainless steel) and 4mm or less (carbon steel and low alloy steel)	Square groove or slightly bevelled
Over 4mm (but over 3mm for stainless steel) to 22mm	Single v groove asper figure 1a
Over 22 mm	Double v groove as per figure 1b

2.4.2 Shape of Internal Trimming and Misalignment

1. Radial misalignment at the joining ends of piping components shall be such that full penetration can be attained.
2. Where component ends have an internal misalignment over 1.6mm, the thicker component with the wall extending internally shall be trimmed internally to an angle less than 30^0C as shown in Figure2. However, such trimming shall not result in a finished wall thickness less than the required minimum design thickness plus corrosion and erosion allowances.

2.4.3 End Preparation method

In principle, the end preparation shall be performed by machine. However, when the preparation is other than by machine, any cracks, flaws, burrs or oxidation scale (rust) shall be removed from the surface with a grinder.

2.4.4 Treatment after End Preparation

When carbon or low-alloy steel pipes and piping components with the ends prepared are to be stored for an extended period, a groove face rust preventive that will not damage the welding shall be applied to the ends (Appendix I). The rust preventive shall be removed prior to welding, as far as possible.

2.5.0 BENDING

2.5.1 In principle, ready-made elbows shall be used for bends of piping. However, when bends of a large radius are required due to fluid characteristics or plant performance, the pipe may be bent to shape.The procedure for bending shall be as follows:

1. In principle, pipe shall be cold bent with a pipe bender. However, when the pipe bender cannot be used because of the large pipe diameter, the pipe may be bent by heating or by high frequency induction.Low-alloy and stainless steel pipes shall not be bent by heating.
2. Pipe bends shall be made of one piece of pipe with no welds at the bend.
3. The pipe shall be smooth on both the exterior and interior, and shall be bent so as not to form any cuts, cracks, wrinkles, dents, etc.
4. Flattening of a bend shall not exceed the requirements shown in Section 2.8 figure 6.
5. The minimum bending radius shall be greater than 1.5 times the nominal diameter of pipe, unless otherwise specified on the piping drawings or the individual specification.
6. Low-alloy and stainless steel pipe shall be heat treated in accordance with the individual specification to relieve residual stress and work hardening of the bend. However, the heat treatment may not be applied to austenitic stainless pipe or to nickel-alloy steel pipe.
7. For carbon steelpipe of 25 NB and smaller, steam tracing, or discharge-end piping of vents, drains, etc., the pipe may be bent to the required angle by heating with an oxygen-acetylene gas torch. However, precautions shall be taken to prevent damage to the pipe by overheating and to ensure that the roundness of the steel pipe is maintained.

2.6.0 MITRE BENDS

2.6.1 Unless otherwise specified, mitre bends shall be used for piping 350NB and larger. For piping of 300 NB and smaller, ready-made smooth elbows shall be used.

2.6.2 Mitre bends shall be fabricated as follows unless otherwise stated in the piping drawings or the individual drawings.

1 Mitre bends to be used at bends greater than 45^0C shall consist of not less than three segments. The minimum distance (l) between alternate segments of the mitre bend shall be 4 times the pipe nominal wall thickness or 25mm, whichever is greater (Figure3)

FIGURE 1 A

WHEN t - 4mm to 22 mm

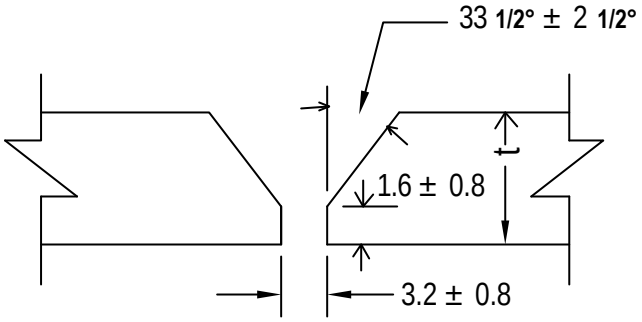


FIGURE 1 B

WHEN t > 22 mm

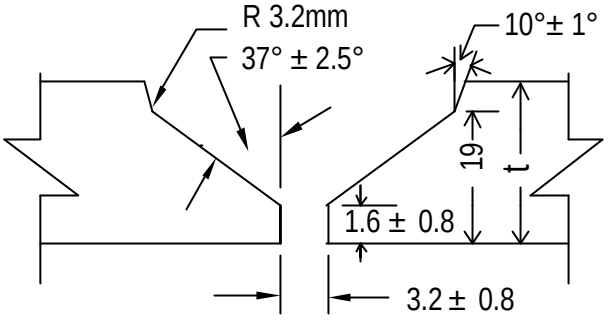
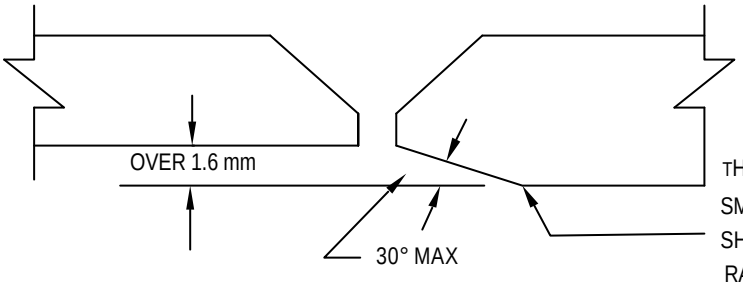


FIGURE 2

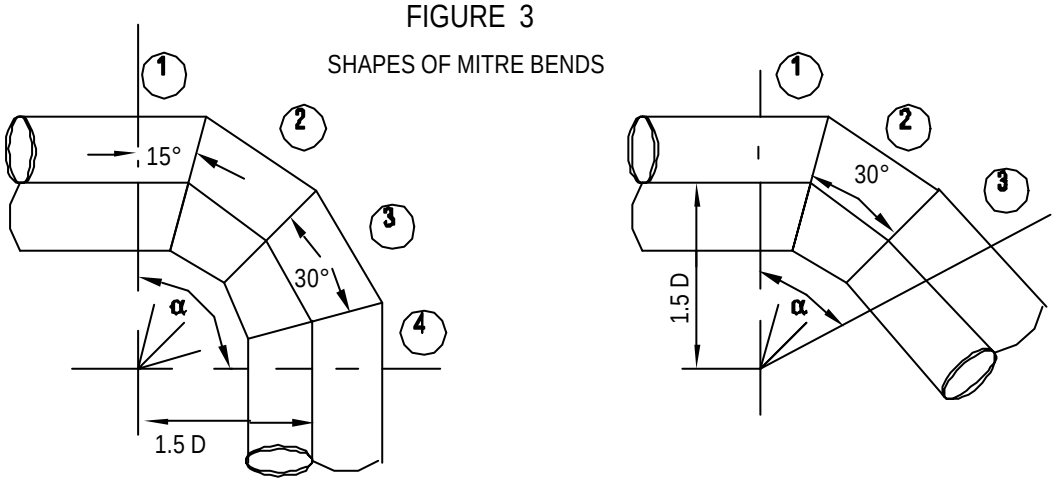
TRIMMING AND PERMITTED MISALIGNMENT



THIS PORTION SHALL BE FINISHED SMOOTHLY SO AS NOT TO HAVE A SHARP EDGE, WHICH MAY HINDER RADIOGRAPHIC EXAMINATION

FIGURE 3

SHAPES OF MITRE BENDS



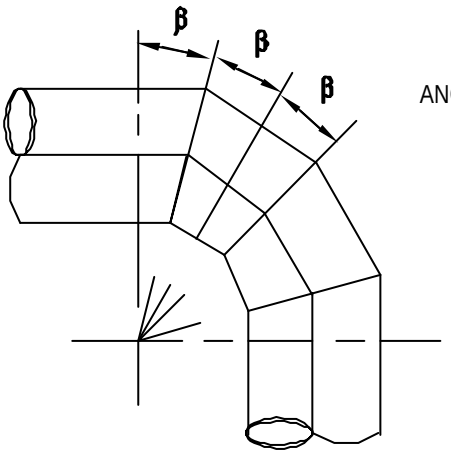


FIGURE 4

ANGLE OF MITRE BENDS

2 The radius of the mitre bend shall be greater than the nominal diameter of the pipe.

3 The maximum mitre angle (ß of Figure 4) of each segment shall be as follows:

When design pressure is 8kgf / cm^2G or less : $\beta \leq 22^0 30'$

When design pressure is 28 kgf / cm^2 G or less : $\beta \leq 15^0 00'$

When design pressure exceeds 28 kgf / cm^2G : $\beta \leq 11^0 15'$

4 The segments shall be neatly cut so that they will closely fit with each other when assembled. Cutting and end preparation of pipe shall be in accordance with the requirements (Sections 2.3 and 2.4)

5 When designing the shape of a groove, the mitre angle shall be considered and the shape of the groove shall be suitable for the welding process used.

6 When assembling the mitre bend, the segments shall be laid out and tack welded on a surface plate or other flat surface to keep the centers of the segments aligned.

7 After welding is completed, the interior of the pipe shall be inspected and any internal weld protrusions shall be removed.

8 Welding and heat treatment shall be performed in accordance with the requirements specified in Sections 3.0.0 and 4.0.0 of this specification.

2.7.0. BRANCH CONNECTIONS

2.7.1 Branch connections shall be fabricated by assembling the fittings that have dimensions and configurations shown in the piping drawings.Unless otherwise specified, branch connections shall be made in accordance with Figure 5 and as follows:

2.7.2 Branch connections, which are made by providing a hole in the main run pipe and inserting a branch pipe or a coupling, shall be as follows:

a The hole provided in the main run pipe shall conform to the requirements of Section 6.

b When the main run pipe is welded pipe, the welds of branch connections shall be made so as to avoid the welds of the main run pipe.

2.7.3 Branch connections shall be made by means of fully penetrated groove welds. The groove welds shall be made in accordance with the same welding procedure as for girth butt welds.

2.7.4 In no case shall scraps of metal resulting from making the hole be left inside the pipe.

2.7.5 When making branch connections, a jig or a metal fitting shall be attached to the main run pipe to prevent distortion of the main run pipe or bending of the branch pipe due to welding. The material of the metal fitting shall be similar to the main run pipe.

2.7.5 If reinforcement pads are used, unless otherwise specified, a 3.0mm dia vent hole shall be provided (at the side and not at the crotch) in the reinforcement pad to reveal leakage in the weld between branch and main run, and to provide vent ing during welding and heat treatment operations. If the reinforcement pad is made in more than one piece, each piece shall be provided with a vent hole.

2.7.7 The material of reinforcement pads shall be the same as the main run pipe.

2.7.8 An examination of the welds joining reinforcement pad to the branch shall be made by FEDO Engineer/ representative before installing the reinforcement pad.

2.8.0 FABRICATION TOLERANCES

2.8.1 To avoid misalignment when joining a pipe or fitting to a pipe, the pipe or fitting shall be turned to check for any irregularities and shall be joined correctly.

2.8.2 Unless otherwise specified, tolerances for fabrication shall be in accordance with the requirements shown in Figure 6.

2.9.0 GALVANISED PIPING

2.9.1 Galvanised carbon steel piping shall be completly cold worked so as not to damage galvanised surfaces

3.0.0 WELDING SPECIFICATION

3.1.0 GENERAL

3.1.1 This specification shall be adopted to all welded pipe joints of carbon steel, alloy steel and stainless steel piping system.

3.1.2 The welded pipe joints are defined as under:

1. All line joints of the longitudinal and circumferential butt welded and socket welded type.
2. Attachments of castings, forgings, flanges and other supporting attachments to pipes.
3. Welded manifold headers and other sub - assemblies
4. Welded branch connections with or without reinforcement pads.
5. Manufacture of welded / fabricated piping components.
6. The attachment of smaller connections for vents, drains, drips and other instrument tappings.

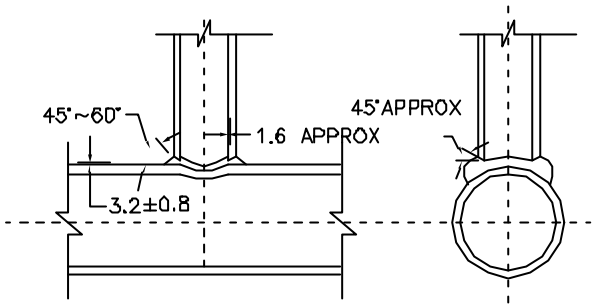
3.1.3 All welding, and heat treatment, shall be in accordance with the applicable codes and specifications.

a.	codes for petroleum refinery piping	ANSI B31.3
b.	Welding Qualifications.	ASME Sec. IX.
c.	Code of procedure for metal arc welding of mild steel (structural work only)	IS : 823
d.	The Indian Boiler Regulations	IBR

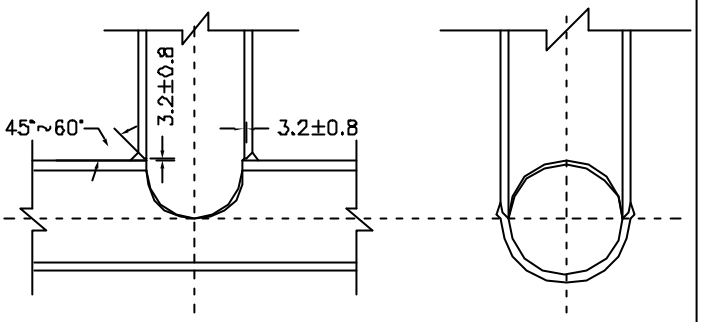
All codes referred shall be the latest editions. In adition to the codes mentioned above, other relevant international codes such relating to the work, shall also be applicable. In case of conflicts between different codes or between codes

FIGUER 5
DETAIL FOR WELDED BRANCH CONNECTION

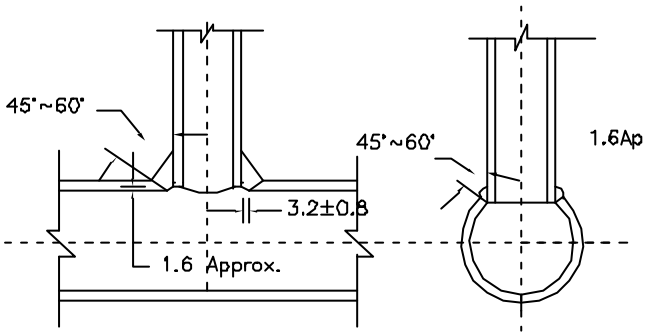
FIGUER 5A
SAME BRANCH (STUB-ON)



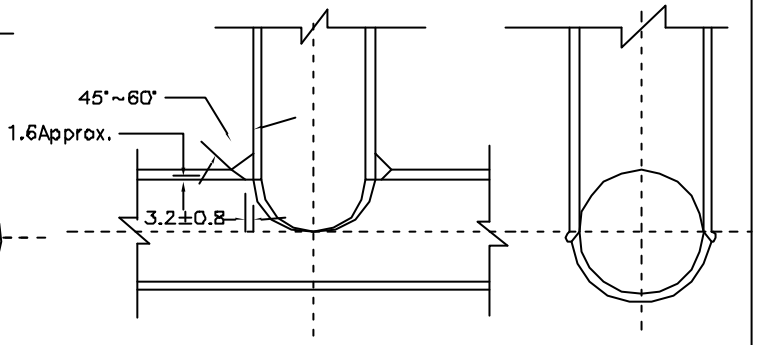
FIGUER 5B
SAME BRANCH (STUB-ON)



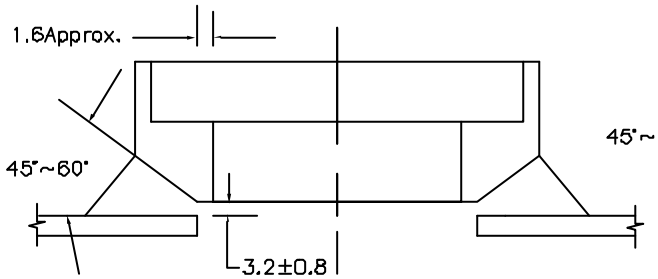
FIGUER 5C
REDUCED BRANCH (STUB-IN)



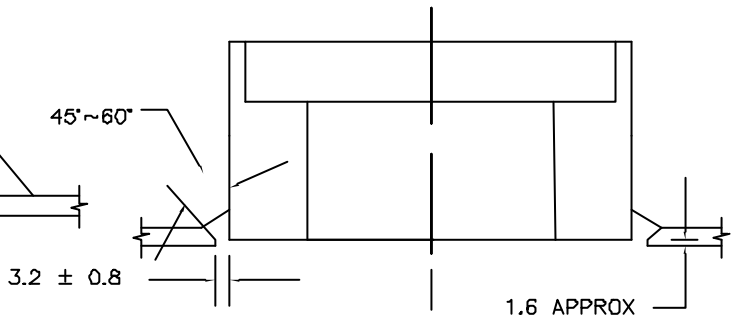
FIGUER 5D
SAME BRANCH (STUB-IN)



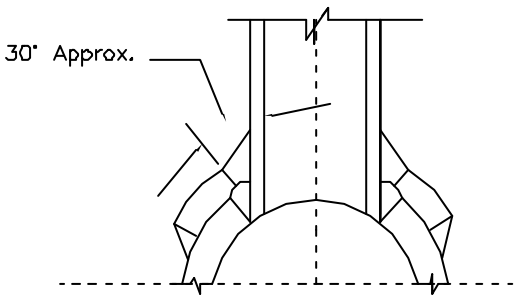
FIGUER 5E
BOSS (STUB-ON)



FIGUER 5F
HALF COUPLING (STUB-IN)



FIGUER 5G
BRANCH ATTACHMENTS WELDS (STUB-IN)



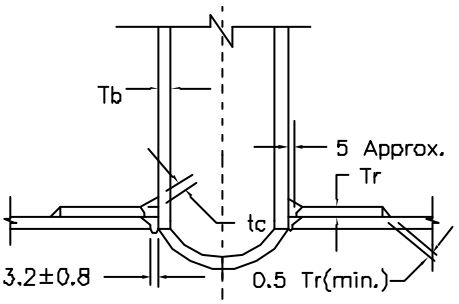
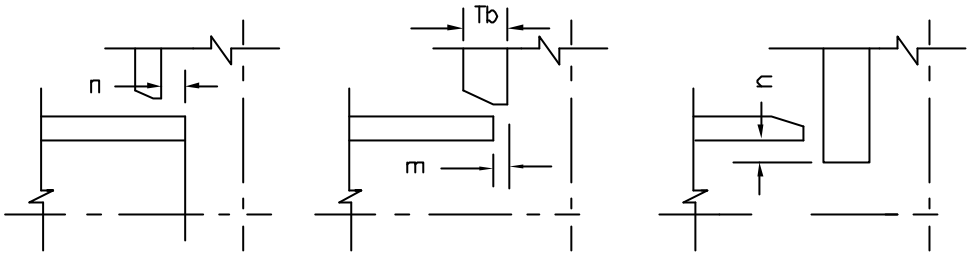


FIGURE 5H
PREPARATION OF BRANCH CONNECTIONS

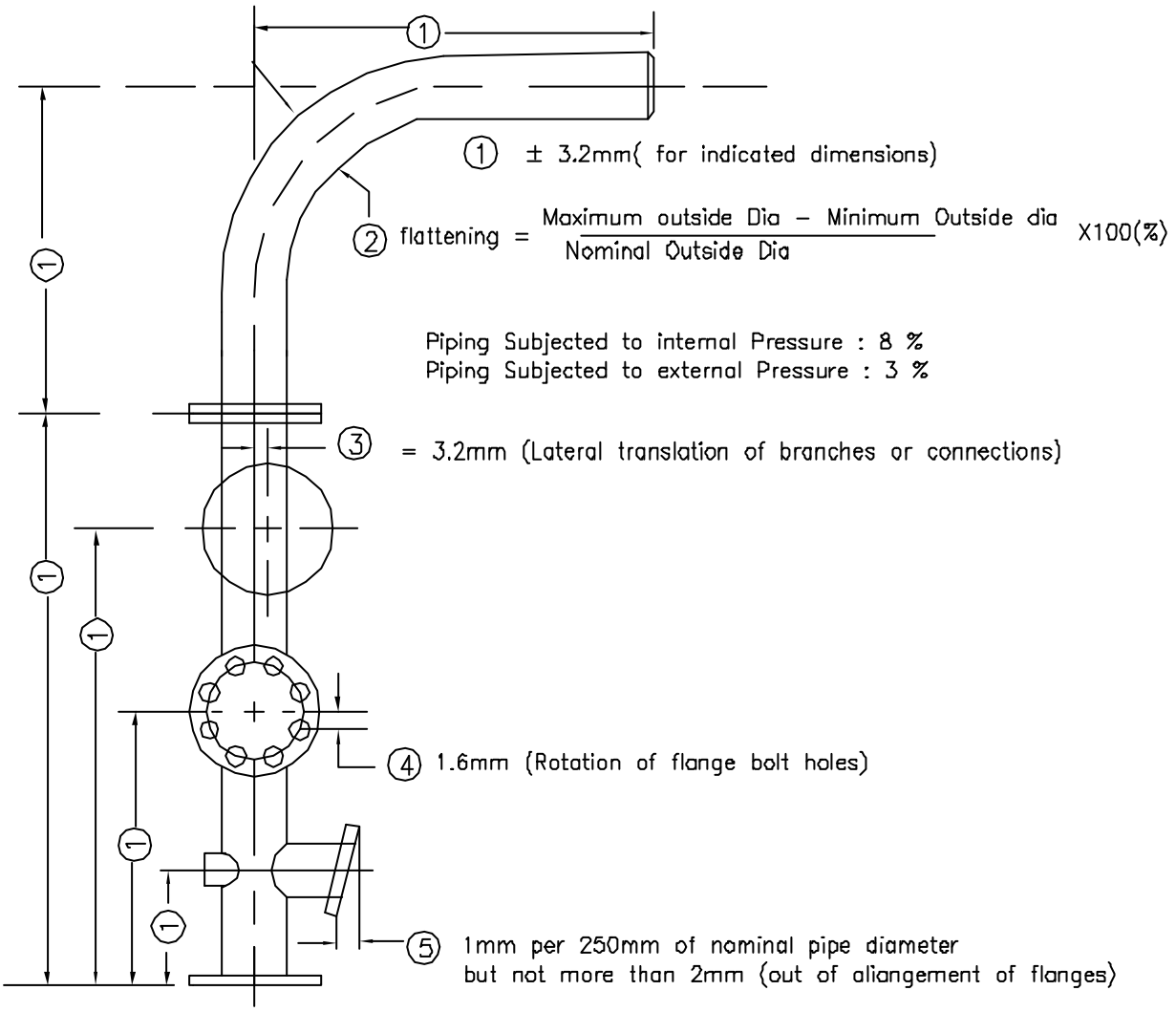


m : the lesser of 3.2 or 0.5 Tb

n : in case of stub–in, insert as far as the inside surface of the run pipe at all points, but not more than 3mm

(n < 3mm)

FIGURE 6
DIMENSIONAL TOLERANCE FOR FABRICATED PIPINGS



and tender specifications the more stringent shall be applicable.

3.2.0 INSPECTION & TESTING

3.2.1 General

1. The owner's inspector shall have free access to all concerned places, where the actual work is being performed. The contractor shall also provide the owner's inspector all means and facilities necessary for carrying out inspection.
2. The owner is entitled to depute his own inspector to the field or shop where prefabrication and erection of pipe lines are being done with (but not limited to) the following functions :
   a. To check the quantity, consumables and welding equipments used on the job
   b. To supervise welding procedure & welders performance qualification tests.
   c. To ensure that only qualified welders are engaged for welding.
   d. To check that shop / field welding is in conformity with the relevant specification and codes of practice followed in pipe line construction.
   e. To carry out Non Destructive Examination of welds.
3. Contractor shall intimate sufficiently in advance the commencement of qualification tests and welding work to enable the owner's inspector to be present to supervise them.

3.2.2 Welding procedure qualification

Welding procedure qualification shall be carried out in accordence with the job requirements and relevant requirements laid down in the standard ASME Sec. IX and other relevant applicable codes. The contractor shall submit the welding procedures in QW — 482 format given in ASME Sec. IX. immediately on receipt of work order. Owner's inspector will review, check and approve the welding procedure after conducting the necessary tests. It shall be the responsibility of the contractor to carry out the tests, at his costs. All the necessary arrangements for the procedure qualification i.e. supply of material for assembly welding consumables, welding equipments, preparation of test coupons, welding, heat treatment, machining of test specimen, conducting N.D.T, mechanical & chemical test and maintaining qualification records, shall be by the contractor at his cost. He shall submit the test results to the Engineer-in-charge in QW-483 format given in ASME Sec. IX. for approval.

3.2.3 Welder's Qualification

1. Welder's qualification shall be in accordance with the relevent codes specified in scope of work. Owner's inspector shall witness the test and certify the qualification of each welder. Contractor shall submit the welder qualification report as per Format before the commencement of work. It shall be the responsibility of the contractor to carry out the qualification tests of welders.

   For piping covered by Indian Boiler Regulations, welders with valid IBR certificate, qualified by Boiler Inspectors and acceptable to the local Boiler Authority shall only be employed.
2. The welders shall always have in their possession the identification card as per Format and shall produce it whenever demanded by owner's Inspector. It shall be the responsibility of the contractor to issue the identity cards after duly certified by the Inspector.
3. The identity card shall contain the following minimum details.
   a. Name of Contractor
   b. Name of welder
   c. Stamp No.
   d. Address
   e. Recent passport size photograph
   f. Details of qualifications
      i Welding process and P numbers
      ii Range of pipe diameters
      iii Range of thickness
      iv Welding positions
   g. Date of qualification test
   h. Period of validity
   i. Signature of manufacturer
   j. Signature of Engineer —in—charge
4. No welder shall be permitted to work without the possession of identify card.
5. If a welder is found to perform a type of welding or in a position for which he is not qualified, he shall be debarred from doing any further work. All such welds so performed shall be cut and redone at the expense of the Contractor.
6. Engineer-in-charge reserves the right to ask the contractors to perform requalification test at their cost for welders whose workmanship technique etc. are found unsatisfactory during the execution of the job.

3.3.0 SELECTION OF WELDING MATERIALS

3.3.1 Selection of welding electrodes shall be as per Appendix - II

Table - I : Selection of welding electrodes & rods for joining similar materials except Aluminium

Table - II : Selection of welding electrodes & rods for joining dissimilar materials except Aluminium

3.4.0 STORAGE AND ISSUE OF ELECTRODES

Electrodes shall be stored and issued as follows:

3.4.1 Electrodes shall be stored indoors free from moisture as far as possible.

3.4.2 Electrodes shall be dried in a heating cabinet in accordance with the manufacturer's recommendation before welding.

3.4.3 Immediately after drying, electrode shall be stored in a portable dryer, or in a heating cabinet at the following temperature, and shall then be used.

a. Illumenite : 70 - 100^{0}C

b. Others : 100 - 150^{0}C

3.4.4 During welding, electrodes shall be kept in a portable dryer or equivalent. The electrodes shall not be laid down directly on the ground or any other damp places.

3.4.5 Electrodes exposed to the atmosphere for more than 4 hours shall be redried. However, only two redryings are permitted.

3.4.6 When the day's work has been completed, the electrodes shall be collected and stored in a heating cabinet at the temperature specified in 3.3.2 above.

3.4.7 Issue of electrodes shall be controlled by the assigned person.

3.5.0 SURROUNDING CONDITIONS FOR WELDING

3.5.1 Welding shall not be performed under the following climatic conditions.

1. In the rain
2. In winds of 8 m/s or more
3. In snow

However, welding may be performed if the area is fully protected from the inclement weather.

3.5.2 When the item to be welded is wet with rain or covered with snow or ice, the snow or ice shall be removed and the surface dried completely before welding.

3.6.0 GENERAL FOR WELDING

3.6.1 Welding shall be performed in accordance with welding procedure specification (WPS), which has been approved by FEDO/Representative. Before welding, the WPS shall be prepared which has been qualified by the welding procedure qualification test based on the specification for welding procedure qualification, according to this specification and ASME Section IX.

3.6.2 As a general rule, welding for steel pipes shall be performed as follows.

1. The welding process used shall be SMAW, GTAW, or GMAW (MIG Welding). Any other welding process may be used only when approved by FEDO / Representative.
2. Preferably, the first layer of butt welded joint shall be made by GTAW. For the first layer on 3Cr. and higher low-alloy steel pipe, or stainless steel, GTAW shall be performed with back shielding gas such as argon.
3. The surface to be welded shall be cleaned thoroughly and any paint, rust, scale, oil, dust, moisture, or any other foreign matter that would be detrimental shall be removed at least within the extent of 50mm from the groove end before welding.
4. The welding position shall be performed in flat position as far as possible.
5. Full consideration shall be given to the welding progression to keep distortion to a minimum.
6. In multi-layer welding, before welding the following layer, the surface of each layer shall be removed of any slag or other foreign matter with a chipping hammer, a grinder, or a wire brush. To prevent spatter adhering to the base metal, a spatter deposit prevention paint may be applied around the outside of the groove. Wire brushes and abrasive wheels shall be distinguished so that those for stainless steel shall not be confused with those for carbon steel or low-alloy steel. Moreover, any arc starts, craters, or inferior beads of each layer shall be removed before the welding is continued.
7. Peening on the welds is prohibited.
8. Unless required, the external surfaces of welds shall not be finished with a grinder or any other tool. However, when finishing the end of weld beads with a grinder, special precautions shall be taken not to reduce the thickness of base metal by over grinding.
9. Arc strike shall not be generated on the pipe surface. Care shall be taken not to lay down the electrode holder or move it around by the electrode.
10. To prevent damage from sparks, care shall be taken to ground the welding equipment by strict use of ground clips and to ground each piece of material.
11. When welding galvanized steel, the coating shall be removed from the surface to be welded, 50mm on either side.
12. For the joints of P-Number 5 materials, when welding is unavoidably interrupted, postheating shall be applied and the welds shall be cooled gradually by the use of insulation or other suitable materials. (Para 4.3.0).

3.7.0 BUTT WELDS

3.7.1 When welding a pipe to a pipe, fitting, valve, etc., the components shall be placed on a revolv ing stand, aligned accurately within the tolerances specified in Section 2.8. of this specifica- tion by the use of tack weld pieces (fit-up pieces), line-up clamps, etc., and shall then be welded.

3.7.2 Backing rings shall not be used unless otherwise specified.

3.7.3 The number of tack welds made shall be the minimum required to secure the pipe, and a minimum of three shall be made for pipes of 50 NB and larger.

3.7.4 When tack weld pieces are used for pipe materials of stainless steel,the material of the pieces shall be similar to that of the pipe. When the pipe material is low-alloy steel, carbon steel may be used for the pieces unless otherwise specified.The welding for the tack weld pieces shall be performed with electrodes equivalent to those used for the base metal and shall be performed by a welder or welding operator qualified for fillet welds.

3.7.5 Tack welds, which are made directly at the root of the joint, shall be made by a qualified welder or welding operator specified in Section 3.2.3 and shall be made by the same welding procedure as the product welding. Tack welds that are cracked or not fused properly shall be removed.

3.7.6 Pieces for tack welds shall be removed with a grinder. If a concave surface due to overgrinding, etc., is produced on the pipe, the repair welding shall be performed in accordance with WPS, which has been approved by FEDO Engineer / Representative. Any convex weld beads formed on the pipe surface shall be removed. When defects are found while removing tacks / cleats they shall be fully removed, repaired by welding, and a magnetic particle or liquid penetration examination shall be performed to confirm that there are no defects.

3.7.7. Internal weld protrusions of butt welds for orifice flanges shall be finished smoothly to the pipe inside diameters with a grinder.

3.7.8. The root pass of all buttwelds on pipe of size less than 50NB shall be made in GTAW grove only.

3.8.0 FILLET WELDS

3.8.1 Fillet welding shall be performed as follows:

1. Fillet welds shall be multi-layered and of sufficient strength.
2. Fillet welds shall be as shown in Figures 7A and 7B.
3. Fillet welds for socket welding flanges shall be as shown in figure 7C.
4. Fillet welds for socket welding components shall be as shown in figure 7D.

3.9.0 SEAL WELDS

3.9.1 Seal welding shall be performed as follows:

1. Threaded joints to be seal welded shall not be coated with a compound or covered with a seal. After any oil on the threads has been fully removed, the threads of joint shall be screwed in securely in accordance with Section 5-1.0, and shall then be welded.
2. If threaded joints are seal welded, all exposed threads shall be covered by a seal weld.
3. Seal welding shall be performed by a qualified welder.
4. Electrodes of 3.2 mm dia or less shall be used.

3.10.0 FLANGE ATTACHMENT WELDS

Flange attachment welding shall be performed as fol lows:

3.10.1 Unless otherwise shown on the drawings, in principle, flange bolt holes shall straddle the established centerlines. The only exception is at equipment flanges required for matching orientation.

3.10.2 When installing flanges, flange square or other jig shall be used, and the center line of the pipe and the perpendicular of the flange face shall be within the tolerances specified in Section 2.8.

3.10.3 Joining welding neck flanges to the pipe shall be performed in accordance with the requirements of Section 3.7.

3.10.4 Front welding shall be performed on slip-on flange joints except for pipes class less than 50NB (Figure 8). Care shall be taken so that the weld reinforcement does not protrude on to the gasket contact face and that the gasket contact face is not damaged by welding. If the gasket contact face is damaged,or weld reinforcement protrudes onto the gasket contact face, such defects shall be removed by polishing the gasket contact face.

3.10.5 When welding flange joints, care shall be taken to handle the flanges carefully so that the gasket contact face will not be damaged. The gasket contact face shall not be in direct contact with the ground, and grounding shall not be taken directly from the gasket contact face.

3.10.6 In the case slip-on flanges which are to be heat treated, and also require to be front welded,they shall be provided with a 3mm dia vent hole at the hub as shown in FIG.8.

4.0.0 HEAT TREATMENT

4.1.0 PREHEATING

4.1.1 Unless otherwise specified, the preheating applies to gas cutting and welding (all welds including butt welds, fillet welds, socket welds, repair welds, tack welds, and seal welds of thread ed joints). Preheating shall be performed as follows:

1. Materials to be pre heated and preheating temperature shall be in accordance with relevant codes as a rule, but for steam lines fallen under the purview of IBR, the same shall be followed.
2. If the maximum specified carbon content is more than 0.38, or if the material is under a high degree of restraint (weld-all- around such as pipe shoe), carbon steel shall be preheated to a minimum of 80^0C and maintained at that temperature for surface welding.
3. When welding dissimilar metals, unless otherwise specified, the preheating temperature shall be that for the higher grade steel
4. The width of the heated circumferential band shall be 4 times the pipe nominal wall thickness or 100mm, whichever is greater, extending on both sides of the welds.
5. Heat shall be applied by the use of a gas burner or a heating coil. The use of a gas burner for cutting shall not be permitted since it tends to heat locally.

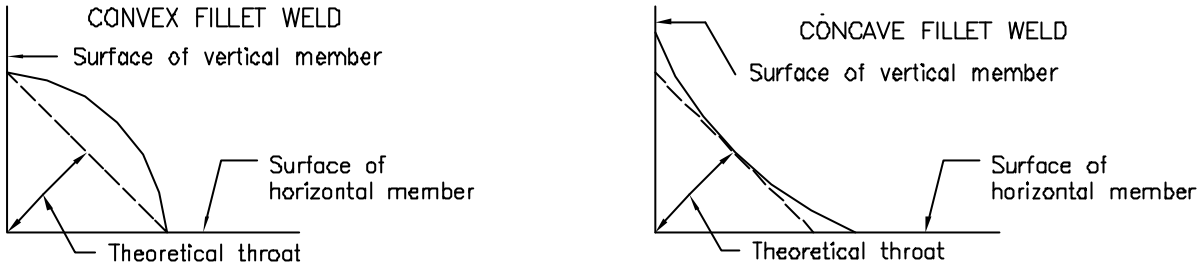
4.1.6 Temperature measurements of preheating, interpass temperature, and postheating shall be performed by a temperature crayon (tempil stick), thermocouple temperature indicator, etc., and it shall be confirmed that the specified temperature is maintained.

4.2.0 INTERPASS TEMPERATURE

4.2.1 The following items shall be confirmed for interpass temperature:

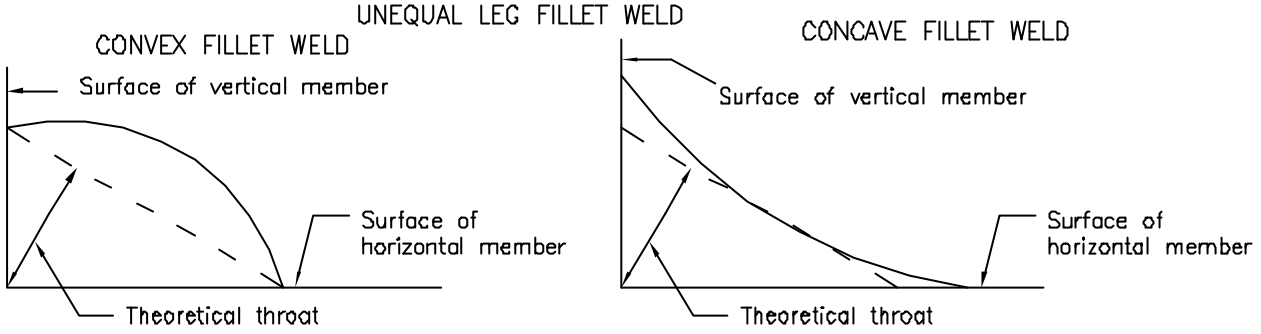
1. Interpass temperature of the materials that require to be preheated shall be the same as the preheating temperature and shall be maintained until welding has been completed.
2. Interpass temperature of austenitic stainless steel pipe shall not exceed 150^0C.

FIGURE 7A
EQUAL LEG FILLET WELD



The size of an equal leg fillet weld is the length of the largest inscribed isosceles right triangle (theoretical throat = 0.707 X size)

FIGURE 7B
UNEQUAL LEG FILLET WELD



NOTE : The size of an unequal leg fillet weld is the leg lengths of the largest right triangle which can be inscribed with the weld cross section (eg. 12.7 X 19.2)

FIGURE 7C
FILLET FOR SOCKET WELDING FLANGE

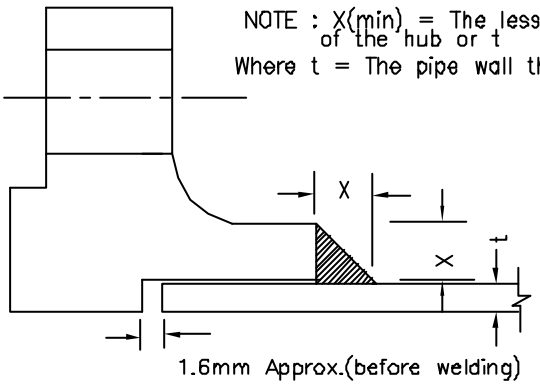
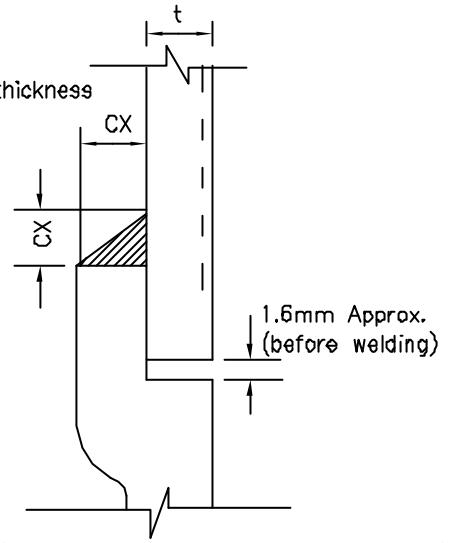
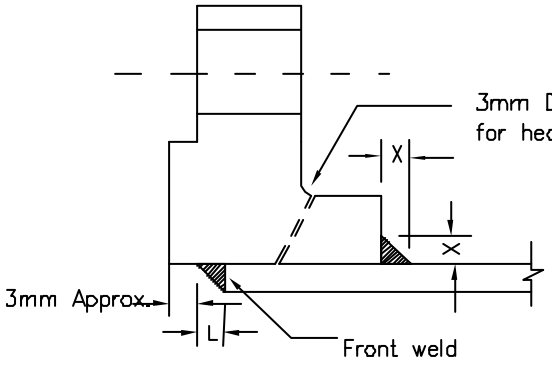


FIGURE 7D
FILLET WELD FOR SOCKET WELDING COMPONENTS OTHER THAN FLANGES



NOTE : CX (min) = 1.25 t (but not less than 3.2mm)
Where t = pressure design thickness (normal wall thickeness (manufacture's tolerance + corrosion allowance)

FIGURE 8
FILLET WELD FOR SLIPON FLANGES



NOTE : X(min) =The lesser of 1.4 t or the thickness of the hub
L(min) = The lesser of t or 6.4mm
Where t = The pipe wall thickness

4.3.0 POSTHEATING

4.3.1 When postheating is required it shall be carried out for more than 30 minutes within the temperature range of 300 to 400^{0}C, and the material shall be cooled gradually by the use of insulation, etc. However, when post weld heat treatment is performed immediately after welding, post - heating is not necessary.

4.4.0 POST WELD HEAT TREATMENT

4.4.1 Procedure

Unless otherwise specified, post weld heat treatment shall be performed in accordance with the following procedure. However, post weld heat treatment for dissimilar metals shall be in accordance with the individual specification.

1. The requirements for heat treatment shall be in accordance with applicable codes. But for steam lines IBR shall be followed. Heat treatment of welded joints between dissimilar ferritic metals shall be within the temperature ranges for the higher grade steel.
2. All the machined surfaces shall be protected adequately by the use of paint or compound to prevent damage from scaling during heat treatment.
3. In case of furnace heat treatment, all the pipes shall be supported properly during heat treatment to minimize warps and other distortions.
4. In principle, after heat treatment has been completed, neither rewelding nor reheating shall be performed. However, if rewelding is performed because of repairs, etc., heat treatment shall be performed again.
5. If welding is intrrupted before completion or the weldment is allowed to cool prior to heat treatment, adequate heat treatment or controlled rate of cooling shall be applied to ensure that no effects detrimental to the piping shall result. The pre-heat temperature in the welding must be applied before welding is resummed.
6. When heat treatment is performed, the holding temperature, holding time, rate of heating and cooling, and the hardness after heat treatment required shall be recorded and the records shall be submitted to FEDO Engineer / Representative.
7. The measurement of heat treatment temperature shall be performed by measuring the metal temperature by the use of a thermocouple,or by other suitable methods. However, when the heat treatment temperature is measured by the furnace temperature, the relation between the temperature of metal and furnace shall be considered.
8. A hardness test shall be performed in accordance with Section 9.4.0 to determine if the heat treatment has been performed satisfactorily.
9. Throughout the cycle of heat treatment, the portion out side the heated band shall be suitably wrapped under insulation so as to avoid any harmful temperature gradient at the exposed surface of pipe. For this purpose temperature at the exposed surface of pipe should not be allowed to exceed 400^{0}C.
10. All online pipe item (eg. Valves, Instruments etc.)within 500mm of the weld which is beingheat treated, shall be dismantled prior to commencement of heat treatment of weld.
11. The no. of thermocouples to be used for the monitoring of tempreature shall be as follows.(HAZ - Heat Affected Zone)

DIA OF PIPE	NOS.	OrientatIO N (^{0})	LOCATION
15NB & below	2	0 , 180	One on weld & one in HAZ
200 to 500 NB	3	0 , 120 , 240	one on weld & rest in HAZ on either side of weld
600 Nb & above	4	0 , 90 , 180 , 270	two on weld & rest in HAZ on either side of weld

4.4.2 Heating Methods

For heat treatment, application of heat in a furnace is preferable, however, heat may be applied locally by the following methods:

1. Heating by electrical resistance

   This is a method where a programmed movable automatic heater applies heat by means of nickel-chrome wire applied around the welds. Special attention shall be given to the following items:

   a. Protective measures shall be taken to prevent damage to the pipe surface or injury to the workers due to a short circuit of the lead wire, and to prevent persons other than the operator entering the work area.

   b. The width to be heated shall extend 25mm beyond the edges of the weld on each side

   c. The width to be insulated shall extend at least 150mm on each side of the weld.

   d. The heating and cooling rates above 315^{0}C shall be determined by the following formula, but in no case shall the rate exceed 220^{0}C per hour.

$$\frac{25 \times 220}{\text{wall thickness (mm)}} \quad (^oC/\ h)$$

2. Heating by gas burner

   a. This is a method where heat is applied by a propane or butane gas burner. This method shall not be used unless specified by FEDO Engineer/ Representative.

5.0.0 THREADED AND FLANGED JOINTS

5.1.0 THREADED JOINTS

Threading of joints shall be as follows.

5.1.1 Taper pipe threads shall be as per ANSI B2.1,

ANSI Standard Taper Pipe Thread (NPT).

5.1.2 Unless otherwise specified, when threading on pipes of NPS $1^1/_2$ or smaller, the pipe thickness shall be Schedule 80.

5.1.3 In principle, all threads shall be cut with a threading machine or lathe. When threading with hand dies such as an oster or reed type, a lubricant shall be used to avoid an irregularity of screw thread or scratches due to coarse machining.

5.1.4 All the threads shall be cleaned thoroughly.

5.1.5 In principle, teflon seal tape shall be used for threaded joints used in services of 150^0C and lower. Once the joints are screwed, they shall not be unscrewed. Fillers such as hemp, jute, lead scraps, and white paint shall not be used.

5.1.6 Seal welding of threaded joints shall be in accordance with Section 3.9

5.1.7 In no case shall threaded joints be made with a length of engagement less than specified.

5.1.8 When pipe is screwed into a threaded flange, the pipe end shall not extend beyond the gasket contact face. If the pipe end protrudes even slightly, the pipe end shall be ground off with a grinder or a file so that the gasket contact face is not scratched.

5.1.9 When screwing a pipe into a threaded bronze valve, the pipe shall be gripped by a pipe vice and the valve shall be screwed on by clutching the end of the valve with a wrench. Threading and screwing shall be carried out carefully so that the pipe does not enter the valve too far and damage the valve due to the threads being overcut on the pipe.

5.1.10 Scraps of metal due to threading and oil used for cutting shall be removed before screwing on instrument air piping.

5.1.11 Any compound or lubricant used on the threads shall be suitable for the service conditions, and shall not react unfavourably with either the service fluid or piping material.

5.2.0 FLANGED JOINTS

Flanged joints shall be made as follows:

5.2.1 In principle, Class 125 and 250 flanges of valves and other equipment made of gray cast iron shall be of flat face with full contact area gaskets.

5.2.2 Steel to gray cast iron flanged joints shall be assembled with care to prevent damage to the cast iron flange.

5.2.3 Unless otherwise specified, gasket paste shall be applied uniformly on the gasket contact face of the flange when a metal jacketed gasket or a metal gasket is used. However, when the flange material is austenitic stainless steel, the use of gasket paste shall be approved by FEDO Engineer / Representative. As the choice of paste is limited by the fluid handled, the paste shall be suitable for the service fluid. The gasket paste shall be kept in a container with a lid and handled with care to prevent entry of sand, dust or other foreign matter.

5.2.4 For asbestos-sheet gasket, gasket paste may not be applied.

5.2.5 For spiral-wound gaskets or ring-joint gaskets, gasket paste shall not be applied.

5.2.6 The thread and bearing surfaces of bolts and nuts to be used on piping at temperatures of 250^0C or higher shall be coated thinly and uniformly with a lubricant to prevent them becoming burnt and stuck.

5.2.7 Lubricant shall not be applied to machine bolts unless other wise specified.

5.2.8 Bolts shall be of material and length as specified. In principle, all the bolts shall extend 2 or 3 threads through their nuts.

5.2.9 Flanges shall be tightened with a wrench or spanner of the specified length and with a hammer if required, or with a torque wrench. Care shall be taken so that the bolt is not tightened excessively or unevenly.

5.2.10 As the tightening force varies according to the flanges, gaskets, and bolts used, the tightness shall be controlled with care. In particular, flanges of piping for low temperature and dangerous services shall be tightened only with a torque wrench. For large diameter bolts, the use of an impact wrench with torque control or a power machine (hydraulic torque wrench) is preferred.

5.2.11 Bolts of flanged joints shall be successively and evenly tightened in a symmetrical pattern (Appendix IV).

5.2.12 Cast iron flanges of equipment such as pumps, turbines, compressors, or other similar equipment shall be tightened carefully so that the flange does not break.

5.2.13 The flange clearance with connections of pumps, compressors, or other similar equipment, and ring-joint flanges shall be measured by the use of a clearance gauge and the parallelism shall be checked, and then the bolts shall be tightened evenly.

5.2.14 Ring-joint gaskets shall be ground with the groove of the flange for a tight fit prior to installation. The grinding shall be performed by using a compound (coarse, intermediate, or fine), and red paste shall be applied to confirm the roughness of the contact face between the ring and the groove of the flange. The paste shall be removed completely before the ring is installed.

5.2.15 If the gasket contact face of the flange is damaged, the defects shall be removed by polishing evenly the gasket contact face, or the flange shall be replaced.

6.0.0 PROTECTION OF PREFABRICATED PIPE SPOOLS AND SIZE

6.1.0 PROTECTION OF PREFABRICATED PIPE SPOOLS

6.1.1 All prefabricated pipe spools that have been inspected shall be protected as follows until they are installed in a plant.

1. All dust, rust, weld slags, or other foreign matter in the pipe shall be removed carefully by brushing or by flushing with compressed air, or by other suitable means. After cleaning, all openings of austenitic stainless steel shall be blanked.
2. Pipe spools to be stored temporarily shall be laid on suitable sleepers and not directly on the ground.

3. Pipe spools shall be marked with the area number (major divisions such as offsite, onsite), line number, and piece number. After cleaning the pipe spool surface and applying rust preven tive, it shall be marked clearly with paint by the use of a stencil. When specified, in showing the line number, etc., a color code identification or tag plate (die stamped to the sheet metal) for each area shall be made, and it shall be attached with coated iron wire. However, zinc coated iron wire shall not be used for austenitic stainless steel.
4. If hydrostatic test is performed, the water shall be removed completely.

6.1.2 When prefabricated pipe spools are to be stored for a long period of time or are to be shipped, the pipe interior shall be checked to see that it is clean, and the openings of pipe ends shall be protected as follows:

1. When the pipe ends are prepared, the ends shall be coated with rust preventive (Appendix — **1**) and covered with a plastic cap, etc.
2. When the pipe ends are flanged, the gasket contact face shall be coated with rust preventive and be protected with a wooden or plastic cover bolted on to the flange. In case of a wooden cover, poly ethylene or other suitable film shall be inserted between the flange and the cover.
3. When the pipe ends are threaded, the threads shall be coated with rust preventive and threaded end connections shall be covered with wooden or plastic plugs or caps.
4. When masking tape is intended to be used instead of the protection mentioned above, it shall be subject to FEDO Engineer's/ Representative's approval.

6.1.3 However, austenitic stainless steel pipes and prefabricated pipe spools that may be affected by chlorine ions, shall be protected in accordance with the individual specification.

6.2.0 SIZE OF PREFABRICATED PIPE SPOOLS

6.2.1 The size of prefabricated pipe spools shall be determined by consideration of the conditions of transportation, etc. Consideration shall be given to the conditions of inland transportation, size of the carrier's hatch, means of transportation, traffic regulations in the country and the economy.

6.2.2 The standard size of a package to transport prefabricated pipe spools is limited to 2.5 meters width by 2.5meters height by 13 meters length with a weight of 5 tons per package.

7.0.0 INSTALLATION OF PIPE SUPPORTS

7.1.0 PIPE SUPPORTS

7.1.1 Pipe supports whose materials & dimensions conform to fabrication drgs, shall be installed accurately at the positions shown on the drawings prior to piping installation. When installing the pipe supports, pay attention to the following:

1. Each support shall be fabricated and assembled so that piping does not become disengaged from the support by movement of the piping itself due to operation.
2. Stanchions requiring foundations shall have anchor bolts of the correct size, position, projection, etc.
3. Before installing the supports, the finished conditions of the cut ends of all members and welded conditions shall be checked.
4. Pipe supports shall be made level and plumb to facilitate alignment during piping installation.
5. In principle, when the main run pipe is low-alloy steel or ss, either a pad plate or support members of the same material as the main run pipe shall be used, and carbon steel supports shall not be welded directly to these. In this case, when welding the pipe to the support, the same electrodes as applied to the pipe shall be used, and the qualified welder specified in Section 3.1.0 shall perform the welding in accordance with WPS. When the main run pipe requires heat treatment, the welds for attachment of pipe supports shall be heat treated if required,as per ANSI B31.3.
6. Welds for anchor supports shall be double-layer welds to provide a bond of sufficient strength.
7. When welding dummy pipe to elbows, tees, etc., the welding shall not melt through to their interior.

7.2.0 SLIDING SUPPORTS

7.2.1 Sliding supports shall be assembled so that the expected movement of the supported piping due to thermal expansion and contraction or other design requirements is possible.

7.3.0 SPRING HANGERS

7.3.1 The lock-pin or preset-piece of spring hangers shall not be taken off until pressure testing and flushing have been completed, except only when a high temperature fluid such as flushing steam is streamed.

7.3.2 Adjustment of spring hangers shall be performed by taking off the lock-pin or preset-piece prior to ini tial operation. It shall be confirmed that spring hangers operate on the expected movement according to temperature increase in the initial operation.

7.4.0 ADDITIONAL SUPPORTS

7.4.1 If additional supports are required to prevent shaking of piping in the field, they shall be installed in accordance with the instructions of the FEDO Engineer's / Representative's Engineer in consideration of the effects due to thermal expansion of the piping.

7.5.0 INSULATION SUPPORTS

7.5.1 The configuration, material, and installation procedure of support rings for hot or cold insulation of vertical piping shall be in accordance with the individual specification.

8.0.0 PIPING INSTALLATION

8.1.0 GENERAL ITEMS FOR PIPING INSTALLATION

The general items for attention relating to piping installation shall be as follows:

8.1.1 Pipes shall be stored in accordance with each category of material, and stacked on sleepers with wedges or stakes provided to prevent the stack from collapsing.

8.1.2 Before installation, pipe spools shall be checked with the piping drawings as to dimensions, material, class, etc. In principle, the installation of pipe spools shall start from elevated lines or larger size lines. The precedence for installation shall be determined after confirming that all equipment has been installed and aligned, and steel structures and pipe racks are ready for installation of the piping. The part which cannot be painted after piping installation shall be painted beforehand.

8.1.3 In principle, underground piping shall be installed before above ground piping.

8.1.4 Before installation, the pipe spool shall be suspended at one end by a crane, etc., and ham mered to remove the dust inside.

8.1.5 Supports such as stanchions shall be checked for the accuracy of position, dimensions, elevation, levelness and plumbness.

8.1.6 When temporary supports are installed unavoidably to the piping, welding shall not be performed on the main run pipe.

8.1.7 Temporary work for piping installation shall be planned in advance, and the necessary equipment and materials shall be selected and prepared in time with the schedule. Moreover, the scaffolding required for field connections shall be checked, and whether the required number of scaffold pipes and boards shall be sufficient.

8.1.8 Scaffolding shall be provided to permit safe operation, and the use of small size piping, pumps, instruments, etc., in lieu of scaffolding shall be prohibited. All scaffold boards shall be securely tied to the scaffold pipes or piping with metal connectors or iron wire.

8.1.9 The primary cards, cables, and grounding wires of all welding equipment shall be of sufficient size, and any conductors with damaged insulation shall not be used. They shall be inspected periodically.

8.1.10 Piping components such as pipe spools and valves shall be lifted with the designated wire rope slings, and the use of iron wire shall be prohibited.

8.1.11 Piping components shall be hauled by mechanical equipments as far as possible. Even for a short haul, the components shall be securely tied to prevent them from falling.

8.1.12 Piping requiring cold spring may become misaligned during field welding, therefore, the dimensions shall be checked thoroughly in accordance with the piping drawings. After it has been confirmed that guides and anchors have been installed at the specified location, the piping shall be installed. Furthermore, when there are flanged joints in the same direction requiring cold spring, a spacer with the same thickness as the dimension of cold spring shall be inserted between the flanges, and when the entire piping system has been assembled, the spacer shall be removed and the flange fastened.

8.1.13 Alignment tolerances of flange connections installed in piping shall be as per **Figure 9** (Page 28 of 28). However, alignment tolerances of pipe flanges for the rotational equipment nozzle shall be as per Section 8.3.0 (Item 6).

8.1.14 In principle, the longitudinal welded joint of welded pipe shall be located above the horizontal centerline, if the pipe is installed horizontally.

8.2.0 PIPING AROUND COLUMNS, DRUMS AND HEAT EXCHANGERS

The piping installation around columns, drums, and heat exchangers shall be as follows:

8.2.1 Piping for columns shall be installed in the order of the overhead line and the risers, and the installation of instrument take-off nozzles, supports, spring hangers,etc. The levelness and plumbness of piping shall be complete and true.

8.2.2 For piping installed at high elevations at the top of columns, drums, etc., assembly and nondestructive examination and pressure testing shall be performed on the ground, as far as possible, to minimize work at high elevations. When piping installation is unavoidably performed at high elevations, the area below shall be fenced in with a safety rope and “MEN AT WORK ABOVE” signs shall be posted.

8.2.3 When piping components are to be lifted into place at high elevations by means of large cranes, in advance, the work data such as the weight, position of center of gravity, reach of crane, crane boom length, and other vital data shall be ob tained, and they shall be studied sufficiently.

8.2.4 Temporary supports shall not be taken from the shell (body) of equipment.

8.2.5 After the pipe spool has been installed accurately to the nozzle of the equipment, field welding shall be performed. In such cases, blinds shall not be inserted for purposes of pressure testing, etc.

8.3.0 PIPING AROUND PUMPS AND COMPRESSORS

The piping installation around pumps and compressors shall be as follows.

8.3.1 All piping except for the connections to the nozzle of rotating machinery shall be assembled on the ground.

8.3.2 Before installation of piping to rotating machinery, the required heat treatment, pressure test ing, interior cleaning, etc., shall be completed. Pressure testing shall not be performed by inserting the blinds directly between the nozzle of rotating machinery and the flange of the connected piping.

8.3.3 The protective cover placed on the nozzle of rotating machinery shall not be removed until the piping is to be connected.

8.3.4 The preset-piece of spring hangers shall be taken off and spring hangers shall be adjusted, so that piping is located accurately.

8.3.5 It shall be confirmed that alignment work of rotating machinery and measurement preparation for inspecting misalignment has been completed.

8.3.6 Pipe flanges shall be aligned with all the nozzles of rotating machinery. The alignment shall be performed by the adjustment of pipe supports and flange connections. Unless otherwise speci fied, the misalignment between flanges shall be within the following permissible limits:

a.	Flange face separation (space for gasket)	: ± 0.8mm
b.	Flange face parallelism	: 0.2mm
c.	Rotational offset	: 0.8mm
d.	horizontal and vertical bolt hole offset	: 0.8mm

8.3.7 If the piping alignment specified in Item (6) above is not within the permissible limits, it shall be corrected. The correction of piping alignment or the adjustment work of supports shall be performed by dismantling piping from rotating machinery. Care shall be taken so that expansion or distortion due to welding, etc., does not have a detrimental influence on the rotating machinery.

8.3.8 When connecting piping to a rotating machine, if the machine misalignment is more than the values specified, alignment work of the machine and piping shall be performed again by dismantling the piping from the machine.

8.3.9 After piping is connected to rotating machinery, the rearrangement of pipe supports or retightening of flange bolts shall not be performed without permission.

8.4.0 PIPING AROUND FIRED HEATERS

Piping installation around fired heaters shall be as follows:

8.4.1 Since piping around the burner tends to become complicated, piping for one or two burners shall be installed first, and after confirming operability, clearance, safety, and other matters, other piping shall be installed.

8.4.2 Drain piping around the burner shall not be placed on the ground or in such a way as to obstruct passage of persons.

8.5.0 PIPING ON PIPE RACK

Piping installation on pipe rack shall be as follows:

8.5.1 Generally, since air cooled heat exchangers are placed on top of the pipe rack, and pumps are placed underneath, the precedence for installing piping shall be determined in consideration of the time of installing such equipment, the number of stages of the pipe rack itself, etc. In principle, piping installation will be performed from the bottom to the top level. When installing piping, a check shall be performed to ensure that the pipe rack beams have been painted.

8.5.2 Before connecting piping to other equipment, piping on pipe racks shall be laid down accurately in the places specified beforehand, and then slide shoes and stoppers shall be installed accurately in accordance with the drawings, so that baseline for dimensional adjustments in field installation may be made. However, elbows, tees, etc., required for take-off connections to outside the pipe rack may be left in place temporarily since it may be re quired to perform adjustments.

8.5.3 After the pipe has been laid on the rack, the pipe shall be tied with wire to prevent it from falling off until the weld joints are made.

8.5.4 The pipe fittings and welded lines shall be installed so as not to be positioned on the beams.

8.6.0 OFFSITE PIPING

Installation of offsite piping shall be as follows:

8.6.1 Piping installation inside the dike shall be performed after a thorough study of the work schedule has been made, with consideration given to other related work such as the confirma tion of time of tank water filling and of access for handling materials.

8.6.2 Pipe sleepers and support footings inside the dike shall be installed after confirming that the levelness of the ground has not been disturbed by the water filling test of the tank.

8.6.3 Piping to be connected to the tank nozzle shall be installed after checking that the valve and accessories installed on the tank are in accordance with the specification.

8.6.4 Flexible hoses and expansion joints to the tank nozzle shall be installed accurately in accordance with the drawings.

8.6.5 When laying pipe on sleepers, the sleepers shall be checked to confirm that they are at the specified elevation, level in line, and painted.

8.6.6 Piping on pipe sleepers shall be laid on sleepers that have been marked off. Slide shoes and stoppers shall be installed accurately in accordance with the drawings. The pipe fittings and welded lines shall be installed so as not to be positioned on the sleepers.

8.6.7 For piping penetrating an oil dike, the flanged, threaded, or welded joints shall not be embedded in the dyke.

8.7.0 INSTALLATION OF VALVES

The installation of valves shall be as follows:

8.7.1 The valve shall be installed accurately so that its location and the orientation of the handle is in accordance with the piping drawings. However, when the orientation of the handle is deemed inappropriate from the viewpoint of operation or passage, the FEDO engineer shall be contacted for directions.

8.7.2 The valve shall be checked for its class, body materials, and trim materials to prevent any misuse.

8.7.3 Before installing the valve, the flange faces of the valve and the connected piping shall be checked to see that they are not damaged or dirty, and that they are parallel with each other.

8.7.4 Valves shall be installed in the closed position, except for plug valves and ball valves. After being installed, valves shall not be opened except for pressure testing. Especially, welding for installation of the butt weld and socket weld type valves shall be performed in the closed position, to prevent the valve seat being damaged.

8.7.5 For lubricant plug valves, the disc shall be left in the open position and the lubricant shall be replenished to prevent loss of the sealant.

8.7.6 Globe valves, check valves, control valves, and other similar valves shall be installed in accord ance with the marked direc tion by checking the flow direction.

8.7.7 To prevent the stem threads from rusting, grease shall be applied prior to installation of the valve.

8.8.0 INSTALLATION OF SAFETY VALVES

The installation of safety valves shall be as follows:

8.8.1 Until line pressure testing has been completed, in principle, the safety valves shall not be in stalled with the piping. If safety valves are necessary to assemble the piping, a spool of the same face-to face dimension shall be fabricated and installed. For threaded safety valves, the piping shall be capped. However, the safety valve with test gag may be installed with piping and subjected to line pressure testing.

8.8.2 All safety valves shall be installed after the specified set pressure has been tested in the field.

8.8.3 The seal securing the cap to the safety valve body shall not be removed without FEDO / Representative's approval.

8.8.4 The safety valve with a lever shall be installed with the lever oriented as shown on the drawing.

8.9.0 Installation of expansion joints

The installation of expansion joints shall be as follows:

8.9.1 Expansion joints shall be installed accurately and shall be at the location and of the dimensions shown on the piping and detailed drawings, and in a manner so as not to be connected eccen tric with the pipe.

8.9.2 Expansion joints shall be installed after confirming that the line has been completely assembled with all anchors, guides, and stoppers installed in place as shown on the piping drawings.

8.9.3 Expansion joints shall be installed so that no stress except in the direction intended occurs.

8.9.4 After pressure testing and flushing, all shipping bolts and fixtures shall be removed and the joints shall be checked to ensure that nothing obstructs the expansion movement.

8.9.5 Prior to installation, expansion joints with inner sleeves shall be checked to ensure that the sleeve inlet (fixed) is on the upstream side.

8.9.6 Bellows of expansion joints shall be handled with utmost care, so that no objects will be dropped upon it.

8.9.7 Each expansion joint shall be blown free of dust / foreign matter with compressed air or shall be cleaned with a piece of cloth.

8.9.8 For handling and installation of expansion joints, great care shall be taken while aligning. An expansion joint shall never be slinged with bellows corrugations/external shrouds, tie-rods, angles etc.

8.9.9 An expansion joint shall preferably be slinged on the end pipes/flanges or on the middle pipe.

8.9.10 The pipe ends in which the expansion joint is to be installed shall be perfectlyaligned or shall have specified lateral deflection as noted on the relevent drawings.

8.9.11 The pipe ends / flanges shall be spaced at a distance specified in the drawings.

8.9.12 The Expansion Joint shall be placed between the mating pipe ends/flanges and shall be tack welded/bolted. The mating pipes shall again be checked for correct alignment.

8.9.13 Butt welding shall be carried out at each end of the expansion joint. For flanged Expansion Joint, the mating flange shall be bolted.

8.9.14 After the Expansion Joint is installed the contractor shall ensure that the mating pipes and Expansion Joint are in correct alignment and that the pipes well supported and guided.

8.9.15 The Expansion Joint shall not have any lateral deflection. The contractor shall maintain parallelism of restraining rings or bellows convolutions.

8.10.0 INSTALLATION OF INSTRUMENTS

8.10.1 Kinds of instrument handled

1. The following instruments shall be installed in the scope of piping installation work:
   a. Flow meters to be installed directly on the line (area type, volume type, magnetic type, etc.).
   b. Orifice flanges and orifice plates
   c. Displacer type or ball float type level meters
   d. Control / self control valves & safety valves
   e. Other instruments installed directly on the line
2. In addition, instruments up to the first valve or flange in the nozzle take-off connections for the instrument lead piping are included.

8.10.2 General Procedure : General installation procedure for instruments shall be as follows:

a. All instruments shall be checked as to instrument number and shall be installed true to level, plumbness, or the specified angle

b. The instruments and the associated piping (excluding instrument piping) shall be supported so that problems will not result due to distortion or vibration

c. It is preferred to have all the instruments installed after the interior of piping, columns and drums have been cleaned. When instruments are to be installed unavoidably during piping construction, measures shall be taken to prevent the instruments from being damaged and to prevent foreign matter from entering the instruments. Orifice plates shall be installed only after testing and flushing of pipes.

d. Flow control valves shall be installed after checking the flow direction mark.

8.10.3 Installation of Flow Meters : The installation of flow meters shall be as follows:

a. When installing orifice flanges, the straight lengths of pipe required upstream and downstream shall be checked to see that they comply with the piping drawings. In principle, the upstream straight pipe length shall be of one piece. When there is an unavoidable welded line in the length, the distance between the orifice and the weld

line shall be not less than 14 times the pipe diameter. The straight lengths of pipe shall not be provided with a vent, drain, or other similar branch.

b. Jack screws for orifice flanges shall be installed so that they are 180^{O} apart from each other.

c. When taps are to be taken off from a pipe, the holes shall be drilled where shown on the drawings, the burrs removed and the holes made smooth. Sockets shall not be embedded in the pipe.

d. The orientation for pressure differential taps shall be accurate as shown on the drawings

e. Orifice plates shall not be installed until the pipe interior has been cleaned.

f. When installing orifice plates, the orifice plate number and the flow direction shall be checked. In general, the handle is pointed upwards and the inlet die stamp mark end is pointed upstream.

g. An orifice plate shall be installed with its center coinciding with the center of the pipe and with the gasket not protruding into the pipe.

g. An orifice plate shall be installed with its center coinciding with the center of the pipe and with the gasket not protruding into the pipe.

h. Installation of flow meters such as area type, column type, and magnetic type shall be in accord ance with the instructions of the FEDO Engineer.

8.10.4 Installation of Control Valves : The installation of control valves shall be as follows:

a. Control valves shall be installed by checking the flow direction and, except for special cases, with the diaphragm at the top in a vertical position.

b. To prevent internal and external damage and entry of foreign matter during construction, control valves shall be installed during the last stage after pressure testing and flushing of the line. In this case, a spool having the same face-to-face dimension as the control valve shall be inserted to keep the distance during construction. Further more, after the piping around the control valve has been installed, the dimensions shall be checked to confirm that the valve can be fit in place.

c. When installing control valves unavoidably during construction, a blind gasket, galvanized iron sheet, or other suitable material of the same thickness as the main gasket shall be inserted to prevent entry of foreign matter. During construction, control valves shall be covered with vinyl sheet or other suitable material, and care shall be taken not to damage the valves. During pressure testing and flushing of the line, the valve shall be removed and the end flanges of the valve shall be covered up.

9.0.0 INSPECTION AND TEST

9.1.0 DOCUMENTS

The Contractor shall submit the following inspection records for each items of test and inspection:

9.1.1 Non-destructive inspection

a. Record of radiographic inspection

b. Record of magnetic particle inspection

c. Record of liquid penetrant inspection

d. Record of ultrasonic inspection

e. Records of stress relieving

f. Records of hardness test

g. Records of hydrostatic & pneumatic pr. tests

9.1.2 Destructive inspection

Record of welding procedure qualification test

9.1.3 Others specifically instructed

Following are to be indicated on the test and inspection record

1. Name of customer
2. Job number and name of work
3. Name of contractor
4. Line number
5. Date of test and inspection
6. Name(s) of attendant (FEDO, Customer, or third party)

9.2.0 ITEMS OF INSPECTION AND TEST

9.2.1 Prior to, during and after completion of the works, the following tests and inspections shall be performed.

ITEMS FOR INSPECTION AND TEST

PRIOR TO COMMENCING WORK	
Checking materials	Legal qualification certificate
Welding procedure test Welder's technique qualification test Welding rod check	welder's technige qualification certificate
PRIOR TO WELDING WORK	
Edge preparation	Angle, Root opening, Thickness of land, Cleanliness
Shape of pipe end	Out of roundness, Thickness, Uneven thickness
Bending	Degree of flattening at bent part, Radius of curvature, Thickness reduction at bent part
Tack welding	Bevelled end misalignment, Root opening
Preheating	Method of preheating, Temperature of preheating, width of heating, Temperature measurement, Heating temperature, Others

Welding rod	Drying temperature, Drying time
DURING WELDING WORK	
Welding condition	Welding parameters, Flow rate of sealing gas, Protecting measure for welding, Condition of ambient temperature
Inter-layer temperature	
Re-examination of welder	
AFTER COMPLETION OF WELDING WORK	
Visual appearance inspection	Inside surface misalignment, Outer surface misalignment, Inside surface weld protrusion, Wave irregularity, Uneven leg length, Irregular height of bead, Undercut, Overlap, Bead centre shift, Height of reinforcement welds
Non-destructive inspection	Radiography, Dye penetrant, Magnetic particle
Stress relieving temperature and method	
Hardness test	
DURING OR AFTER COMPLETION OF WELDING WORK	
Product inspection	Dimension, Condition of connection to equipment, Visual apperance inspection
Treatment of pipe inside	
Thread	
Seal welding of threaded portion	
AFTER COMPLETION OF WORK	
Completion of work w.r.t piping drawings	
Pneumatic pressure test	
Flushing	
Removal of temporary supports / scafoldings	
AT TRIAL OPERATION	
Appearance inspection	

9.3.0 VISUAL APPEARANCE EXAMINATION

9.3.1 Following shall be met, checking visually or in using measuring instrument

1	Inside surface misalignment	: 1.5mm or less
2	Outer surface misalignment due to difference of diameter of thickness	: 3.0mm or less
3	Inside surface weld protrusion	
	Nominal Wall Thk.	
	Up to 6.4mm	: 1.6mm or less
	Over 6.4mm to 12.7mm	: 3.2mm or less
	Over 12.7 up to 25.4mm	: 4.0mm or less
	Over 25.4mm	: 4.8mm or less
4	Wave irregularity	; 2.5mm or less
5	Irregular height of bead	: 2.0mm or less
6	Under cut No under cut is allowed for piping of cold or high temperature service.	: Within 0.8mm or 12.5% of thickness whichever smaller
7	Over lap	: 1.5mm or less
8	Height of reinforcement	
	Nominal Wall Thk.	
	Up to 6.4mm	: 1.6mm or less
	Over 6.4mm up to 12.7mm	; 3.2mm or less
	over 12.7mm up to 24.5mm	: 4.0mm or less
	Over 24.5mm	: 4.8mm or less
	Throat thickness of fillet welds	: 70% of thickness of the inner plate or more

9.4.0 Non-destructive inspection

9.4.1 Non-destructive inspection shall be performed according to the grade of inspection stipulated in the next table. (Pressure classes in accordance with ANSI B16.5)

Material		Grade of Inspection I	Grade of Inspection II	Grade of Inspection III
		Pressure classes - ANSI B16.5 (psig.)		
P - NO: 1				
Carbon steel	Service temp. below 350^0C	Less than 300 lb	400 lb - 1500 lb	2500 lb and above
	Service temp. 350^0C or more	-	150 lb - 900 lb	1500 lb and above
Al-killed Steel		-	150 lb - 900lb	1500 lb and above
P - NO: 3, 4, 5				
C- 0.5 Mo Steel Cr- Mo Steel		-	150 lb - 900 lb	1500 lb and above
P - NO: 9				
3.5 Ni steel		-	150 lb - 900 lb	1500 lb and above
P - NO: 8				
Austenitic stainless steel	A312 Gr. TP304	Less than 150 lb @	300 lb - 600 lb	900 lb and above
	Other than above	-	150 lb - 300 lb	400 lb and above

Note: @ When A312 Gr. TP304 is used for cold or high temperature service, the grade II of inspection shall be applied even if it is not above 150 lb.

9.4.2 Items of non-destructive inspection and number of samples for the random inspection shall be as follows:

ITEM OF INSPECTION
R - Radiographic Inspection
M - Magnetic particle Inspection
L - Liquid PenetrantInspection

	Material		Object of inspection			
			Peri phery	Noz-zle (1)	Soc ket	Non pres-sure part
GRADE - I						
R	Carbon steel	Less than 150 lb	3 %	-	-	-
		Over 150 lb to 300 lb	10 %			
	A312 Gr. TP304		10 %			
GRADE - II						
R	All materials		20 %	-	-	-
M (3)	Carbon steel		-	10 %	10 %	10 % (4)
	C-0.5 Mo steel Cr-Mo steel Al-killed steel 3.5-Ni steel		10 % (2)			
L (3)	Austenitic stainless steel Non-ferrous metals					
GRADE - III						
R	All materials		100 %	-	-	-
M (3)	All materials except for austenitic stain-less steel, non-fer-rous metals & non-magnetic metal		20 %	100 %	100 %	20 % (4)
L (3)	Austenitic Stainless steel Non-ferrous metal					

Notes

(1) In “nozzle welding”, welded parts of reinforcing plate and slip-on flange are included.

(2) This inspection shall be performed for the welded parts other than those to which radiographic inspection was applied.

(3) Either magnetic particle inspection or liquid penetrant inspection shall be performed.

(4) This inspection shall be performed for Cr-Mo steel (A335 Gr. P5 or over grade) and 3.5Ni steel.

Remarks

1. Radiographic inspection for peripheral joint shall be performed for pipes of nominal diameter of 2" or more having the same condition.
2. Number of random sampling test shall be at least one, when less than one is obtained in percentage of sampling
3. Number of photographs to be taken for one peripheral joint at radiographic inspection shall be as follows:

PIPE SIZE NB	NO. OF PHOTOGRAPHS
50 to 80	150 x 2 sheets
100 to 150	300 x 3 sheets
200 to 300	300 x 4 sheets
350 to 400	300 x 5 sheets
450	300 x 6 sheets
500	300 x 7 sheets
600	300 x 8 sheets
650 & above	With film overlap of 25mm or more, no of photographs shall be equivalent to peripheral length of the pipe

9.4.3 Radiographic examination

Unless otherwise specified, radiographic examination shall be as follows:

1. Radiographic inspection shall be performed in accordance with Article 2, Section V of the ASME Boiler and pressure vessel code.
2. The welds to be examined shall be selected based on the number of work products of each welder and welding operator engaged in all welding operations. A minimum of one weld per sample shall be examined.
3. All welded joints in a designated lot of piping shall be radiographed over the complete circumference.
4. When a random type examination reveals a defect, additional examination shall be performed in accordance with the requirements of appendix IV.
5. The radiation source shall, in principle, be x-ray or Gama-ray.
6. Film such as Sakura RR, Fuji #100, Kodak AA, or Equivalent shall be used.
7. Identification mark as shown in **Figure 10** (Page 28 of 28) shall be marked on every radiograph, and radiographs of repair weld shall be marked with repair mark (R).
8. The image quality indicator (IQI) specified in B UB-51, ASME Section VIII, Division 1, or equivallent shall be used.
9. Limitations on imperfection shall be in accordance with ANSI B31.3 TABLE 327.4.1 (A) for the degree of radiography involved.

9.4.4 Magnetic Particle/Liquid Penetrant Examination

Liquid penetrant or magnatic particle examination shall be as follows:

1. Liquid penetrant inspection shall be performed in accordance with Article 6, section V of ASME Boiler and pressure vessel code.
2. Limitations on imperfection shall be in accordance with ANSI B31.3 Table 327.4.1 (A)
3. The weld surface, to which liquid penetrant or maganetic particle examination is applied, shall be finished smoothly with a grinder as necessary.
4. If a defect is found in welds, the defect shall be removed, and liquid penetrant examination or maganitic particle examination shall be performed again to confirm that no more defects exist., and then rewelding shall be performed. After rewelding has been completed, liquid penetrant examination or maganetic particle examination shall be

performed again to confirm that the rewelds are sound.

a. Magnetic particle inspection shall be performed in accordance with Article 7, Section V of the ASME Boiler & pressure vessel code

b. Limitations on imperfection shall be in accordance with ANSI B31.3 Table 327.4.1 (A)

9.5.0 HARDNESS TEST

9.5.1 After stress relieving (SR) is performed, hardness shall be tested as follows:

1. If SR is performed by heat coil, the hardness test shall be carried out for all welds.
2. If SR is performed in furnace, hardness test shall be performed for 10% of all welds (at least one-when 10% of all is less than one)
3. Point to be tested shall be finished flat with file before the test.
4. The hardness points shall be tested to weld and to heat affected zone. Hardness test of the heat affected zone shall be made at a point as near as practicable to the edge of the weld. When dissimilar materials are welded, both heat affected zones shall be tested.

9.5.2 Hardness limit is given in following table (Hardness In Brinell Max.)

P-No.	MATERIAL	HB (MAX)
P-3	A335 Gr.P1 (STPA12)	225
P-4	A335 Gr.P12 (STPA22) A335 Gr. P11 (STPA23)	225
P-5	A335 Gr. P22 (STPA24) A335 Gr. P5 (STPA25)	241

9.6.0 PRODUCT INSPECTION

Inspection for the finished product shall be performed as follows:

9.6.1 Dimension: Right angle, perpendicularity, parallelness, dimension, etc. shall be measured visually and by measuring tools and checked against the drawings. Dimensional tolerances are as follows:

1. Length + 0 ; -3.2mm or less
2. Inclination of flange surface: less than 0.5^{o} against the surface perpendicular to the axis of pipe. (but, not to exceed 2mm at outside circumference of flange).
3. Perpendicularity of vertical line: 2/1000 or less.
4. Horizontality: 2/1000 or less
5. Misalignment between flange center and pipe center: 1.6mm or less
6. Shift of bolt hole center: 1.0mm or less.

9.6.2 Inspection of connection to equipment: For those pipings which are connected with pump, compressor, turbine, etc., the above dimensional tolerance shall be submitted by the tolerances required by each of such machinery.

9.6.3 Appearance inspection:

1. Correction for jig mark.
2. Removal of spatter and slag
3. Any harmful flaw on the flange face, inner and outer surface of pipe.
4. As-erected condition
5. Shape and size of branches and other attachment shall comply with drawings.

9.7.0 Inspection for treatment of pipe inside

9.7.1 Inspection shall be performed visually and touching by hand to confirm that no rust, slag, spatter, sand, or other foreign matters are left. Inspector must confirm whether sufficient flushing was performed.

10.0.0 PRESSURE TEST AND OTHERS

10.1.0 GENERAL

10.1.1 Prior to initial operation, the installed piping shall be pressure tested under witness of FEDO Engineer/ Representative.

10.1.2 Prior to the pressure test, a line check shall be performed based on P&I diagrams and the piping draw ings, in accordance with the instructions of the FEDO Engineer/ Representative.

10.1.3 Types of pressure test are as follows, however the test shall be performed in accordance with the individual specification:

1. Pressure tests

   Hydraulic test (using water or other liquids)

   Pneumatic test
2. Leak test

   Overall air tightness test

10.1.4 Before filling it with the test fluid, the entire line to be pressure tested shall be examined in the manner described in Section 9.0.0, and any faults shall be repaired. The piping affected by any repairs or additions made after the pressure test shall be retested.

10.1.5 In principle, piping shall be pressure tested at a metal temperature not less than 2^{0}C. However, carbon and alloy-steel piping exceeding 25mm in thickness shall be pressure tested at a temperature not less than 16^{0}C.

10.1.6 The following equipment and instruments shall not be connected to the piping before completion of the pressure test:

1. Rotating machinery such as pumps, turbines, and compressors.
2. Pressure relieving devices, such as rupture discs and pressure relief valves.
3. Equipment that has a castable or lining material .
4. Instruments.
5. Piping which is normally open to the atmosphere such as drains, vents, and discharge piping from pressure relieving devices.
6. Any other designated equipment.

10.2.0 TEST FLUID

Test fluid shall be as follows:

10.2.1 In principle, the fluid for hydrostatic testing shall be fresh water. Unless otherwise specified, the

chlorine ion concentration in the fluid used for austenitic stainless steel piping shall not exceed 30 ppm. After completion of the test, the water shall be drained immediately, and the interior of the pipe shall be dried by an air blower, etc.

10.2.2 For piping systems having strong acids and So2 where water may become corrosive, or piping systems operated at a temperature of 0^0C or less, kerosene or similar light oils (with a flash point not less than 50^0C) or air is preferred as the test fluid.

10.2.3 The air to be used for pneumatic testing shall be compressed air from a portable compressor. However, for instrument air lines or where specifically specified, oil-free dry compressed air or inert gas shall be used. For high pressure piping (not less than 100 kgf/cm^{2}G), the use of inert gas is preferable. When pneumatic testing is performed by the use of an air compressor, precautions against combustion shall be taken by blowing clean the oil separator thoroughly so that no lubricant enters the air.

10.3.0 TEST PREPARATION

The preparation for pressure test shall be as follows:

10.3.1 All joints (including welds) are to be left uninsulated and exposed for examination during the test. However, joints previously tested in accordance with this standard may be insulated.

10.3.2 When filling water into piping that is designated for vapor, gas, etc., not filled with water during operation, temporary supports or other reinforcements shall be provided beforehand.

10.3.3 Special fittings in piping components, such as expansion joints, filters, and flame arrestors, shall be disconnected from the piping.

10.3.4 Equipment which is not to be subjected to the pressure test shall be either disconnected from the piping or isolated by blinds or other means during the test.

10.3.5 If a pressure test is to be maintained for a certain period and the test liquid in the system is subject to thermal expansion, precautions shall be taken to avoid excessive pressure. In particu lar, for hydrostatic testing, care shall be taken to ensure that the water will not be subject to thermal expansion so that the piping is not damaged during the test.

10.4.0 TEST PRESSURE

10.4.1 Hydraulic Testing of Internally Pressured Piping

1. The test pressure for piping subject to internal pressure shall be as follows:
   a. Not less than 1.5 times design pressure
   b. For a design temperature above the test temperature, the minimum test pressure shall be calculated by the following formula.

$$P_T = \frac{1.5PS_T}{S}$$

Where

P_T= minimum hydrostatic pressure in kgf/cm2 G

P = internal design pressure in kgf/cm^2 G

S_T= allowable stress in kgf/cm^2 at test temperature

S = allowable stress in kgf/cm^2 at design temperature

3. If the test pressure as defined in Item (2) above produces a stress in excess of the yield strength at the test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

10.4.2 Hydrostatic testing piping with vessels as a system

1. Where the test pressure of piping attached to a vessel is the same as or less than the test pressure for the vessel, the piping may be tested with the vessel at the test pressure of the piping. However, the test pressure shall be controlled carefully so as not to exceed the test pressure of the vessel.
2. Where the test pressure of piping exceeds the vessel test pressure, the piping shall be tested by isolating it from the vessel.

10.4.3 Hydrostatic testing of externally pressured piping : The test pressure for piping subjected to external pressure shall be as follows:

a. Lines in external pressure service shall be subjected to an internal test pressure of 1.5 times the external differential design pressure, but not less than a pressure of1.0 kg/cm^{2}G (15 psig).

b. In jacketed lines, the internal line shall be pressure tested on the basis of the internal or external design pressure, which ever is critical. The jacket shall be pressure tested on the basis of the jacket design pressure unless otherwise specified.

10.4.4 Pneumatic testing

1. In principle, pressure tests shall be performed hydraulically, however, when it is inappropriate to fill piping with water, the test may be performed with air or inert gas. The test pressure shall be 1.1 times the design pressure.
2. Any pneumatic test shall include a preliminary check at not more than 1.75 kgf / cm^{2}G (25 psig) pressure. The pressure shall be increased gradually in steps providing sufficient time to check for leaks.

10.5.0 TESTING METHOD

The method of pressure testing shall be in accordance with the instructions of FEDO. However, the general method by using water shall be as follows:

10.5.1 In principle, pressure tests shall be performed for each piping system. However, when design conditions do not permit testing in such a manner, the system may be tested in sections.

10.5.2 Test blinds shall have a handle extending out from the flange. The handle shall be painted in red, to ensure removal of blind after testing.

10.5.3 Installation and removal of blinds shall be performed in accordance with the instructions of

FEDO. The number or all the blinds used and the location of the insertion shall be recorded at all times.

10.5.4 Test pressure gauges with graduations up to two times the prescribed test pressure shall be provided. All the pressure gauges shall be certified by the national authority, and the calibrations shall be checked by periodic inspections.

10.5.5 Two or more pressure gauges shall be installed so that they are easily observed. When the piping system to be tested extends from a low to a high level, pressure gauges shall be installed at both the lowest and the highest points.

10.5.6 For each piping system, an outlet for discharging the pressure in case of emergency shall be designated and marked to that effect.

10.5.7 During pressure testing of piping, operation of valves shall be prohibited and the valves shall be marked to that effect.

10.5.8 Prior to pressure testing, it shall be confirmed that a strainer is provided at a designated location to remove foreign matter.

10.5.9 Vents on piping subjected to hydrostatic testing shall be opened to remove the air when filling the piping with water.

10.5.10 Prior to hydrostatic testing, the piping shall be checked to confirm that it is free from air pockets and if necessary, temporary vents shall be provided to eliminate the air pockets until testing is completed.

10.5.11 For piping systems with a check valve, the pressure shall be applied from upstream of the valve. If this is impractical, the check valve shall either be reversed or shut off with blinds. However, when reversed, the valve shall be reinstalled correctly after testing.

10.5.12 When the test pressure is not less than 50 kgf / cm^2G, pressure shall be increased gradually.

10.5.13 The test pressure during a pressure increase shall be read by the pressure gauge installed at the lowest point of the piping in consideration of the water head pressure.

10.5.14 The check for any leaks during the pressure test shall be performed after the prescribed pressure is maintained for a time not less than 10 minutes. All connections and all welded joints shall be inspected thoroughly.

10.5.15 After the completion of pressure testing, the water shall be drained immediately from the line to prevent the piping system from being damaged by freezing or thermal expansion. Also to prevent vacuum forming in the piping, the vents shall be opened when the water is being drained.

10.5.16 On completion of pressure testing, the line shall be checked to see that no residual pressure is present, and the line shall be drained. All blinds shall be removed.

10.5.17 Short pieces of pipe, which must be removed for installing blind plates and blind flanges, shall be tested separately.

10.5.18 All valves, orifice plates, expansion joints, short pieces of pipe, and other items removed or installed for the test, shall be reinstalled with the prescribed gaskets in the correct position.

10.6.0 REPAIR OF DEFECTS

The repair of defects found during test and inspection of piping systems shall be as follows. In principle, the repair shall be performed under witness of FEDO after the approval of the FEDO Engineer has been given.

10.6.1 Repair of welds

a. Repair welding shall be performed after the pressure and liquid remaining in the pipe have been removed.

b. The defects to be repair welded shall be removed completley with a grinder, etc.

c. The welding, the heat treatment, and the test and inspection shall be the same as required for the initial welding, and performed in accordance with the applicable provisions of this specification.

d. In principle, repair welding of the same portion shall not be performed more than twice.

10.6.2 Repair of Threaded Joints

All defective threaded joints shall be replaced with complete new ones.

10.6.3 Repair of Flange Joints

All defective flange joints shall be replaced with complete new ones, except those which can be repaired in accordance with Section 5.2 (15).

10.7.0 FLUSHING AND CLEANING

10.7.1 Selection of cleaning method

Cleaning method shall be selected in the following methods considering kind of fluid, pipe material and condition of internal surface of piping to be cleaned. Cleaning method and extend of cleaning shall be as per specific Project Requirements.

a. Water Flushing
b. Air Blowing
c. Steam Blowing
d. Acid Cleaning
e. Oil Cleaning
f. Others

10.7.2 Procedure of cleaning in general

1. Cleaning of fabricated pipings

Inside surface and face of weld of fabricated piping shall be made free from slag, chamfer, scale and other foreign matter, with grinder, chisel, wire brush, etc., and be air-blown. After completion of air blowing and checking, ends of the piping shall be covered with vinyl or veneer cap, etc. till the installation in the field.

2. Temporary Strainers

Temporary strainers shall be used as follows:

a. After installation of piping, and before commencement of flushing/cleaning.

b. The temporary strainers shall be installed at pump suction piping, upstream of control valve and other locations as specified.

c. Mark plate shall be attached to the temporary strainers to distinguish from other strainers.

d. After a constant period of initial operation, all temporary strainers shall be removed, cleaned and reinstalled.

10.8.0 WATER FLUSHING

10.8.1 Cleaning method by water

1. As a rule, pure water, service water, steam condensate, industrial water, etc. shall be used. If there is any requirement about the quality of water to be used, it shall be observed.
2. After flushing, drying by compressed air or natural drying shall be carried out. Drying by superheated steam shall be carried out with agreement between Customer and FEDO.
3. Flushing shall be performed till the water becomes free from foreign matter, scale, etc. This shall be decided by observing turbidity of water taken out (into beaker or cup).
4. Water flushing shall be performed by the method of running by pressurised water and hammering, or rapid draining with water filled. Hammering shall, however, not be performed for austenitic stainless steel pipe, copper pipe, aluminum pipe.
5. The primary cleaning shall be performed for each assembled piping system including the equipment.
6. Where instruments are included in piping system to be cleaned, the instruments shall, as a rule, be disconnected and spool pipe (distance piece) shall be inserted instead.
7. When cleaning is carried out in the condition that control valve is connected, the procedure shall be as follows:

   a. Disconnect companion flange at upstream side of the control valve and cover opening of the control valve.

   b. Clean the piping of upstream side.

   c. Connect the control valve and the piping of upstream side after cleaning.

   d. Close the control valve, open by-pass valve, and then clean the piping of down stream side. Where the by-pass valve is not installed, the temperory strainer having austenitic stainless steel screen of No. 50 specified in ASTM E-11 shall be inserted.

10.8.2 Air blowing

1. Air blowing shall be performed by the method of blowing by pressurized air and hammering. Hammering shall, however, not be performed for austenitic stainless steel pipe, copper pipe and aluminum pipe.
2. Blowing shall be performed till there remains no scale in the piping. FEDO personnel in charge shall make judgement of whether the result of the cleaning is statisfactory or not
3. The primary cleaning shall be performed for each assembled piping. The secondary cleaning shall, as a rule, be performed for piping from eqpt. to adjacent eqpt. Whether or not the equipment is included shall be determined considering shape, internal construction & packing of the eqpt. and according to overall cleaning planning.

10.8.3 Steam blowing

1. Execution of steam blowing

   Steam blowing shall be executed after completion of pressure test and insulation work.

2. Preparation of steam blowing

   a. Temporary piping work, countermeasure for safety & confirmation of preparation shall be done according to blowing plan.

   b. Support shall be attached to exhaust piping to prevent accident caused by the reaction force during blowing.

3. Procedure of steam blowing

   a. Warm up the piping with cooperation by operator

   b. Check expansion joints, spring hangers, etc., for expected thermal expansion.

   c. Steam blowing shall be performed at the temperature near to the operating temperature, considering operating condition of boiler.

   d. To remove the scale effectively by temperature change, it is required to perform flushing and cooling cyclically, having temperature difference as large as possible between the flushing and cooling.

4. Judgement criteria of steam blowing

   a. Judgement on result of steam blowing shall generally be done by checking color or quantity of foreign material present in the drain sampled.

   b. If necessary, especially for suction line of steam turbine etc., result of flushing shall be judged by observing whether scratch was produced or not on the test piece inserted in the line.

10.8.4 Acid cleaning

1. Applicable piping of acid cleaning

   Unless otherwise specified in specific job requirements, acid cleaning shall apply to oil piping system of rotating machinery.

2. Cleaning method by acid

   As a rule, acid cleaning procedure shall be as follows:

a. Ten-percent hydrochloric acid solution or Ten-percent sulphuric acid solution with temperature 30 to 40^0 C shall be used, and piping shall be pickled in the acid solution for 1 to 6 hours.

b. After pickling, the piping shall be washed sufficiently to remove the acid solution by water.

c. And the piping shall be rinsed for neutralization of the acid solution by sodium hydroxide solution, followed by water flushing.

d. The piping shall be well dried by super-haeted steam or dry air and the inside of pipes given a coat of the oil of the same quality as specified to be used in the oil piping.

Remarks: Oil piping of stainless steel shall not be acid cleaned.

10.8.5 Oil cleaning

1. Applicable piping of oil cleaning

   Oil cleaning shall apply to the oil piping system after the acid cleaning specified in par. 10.8.4 has been performed.

2. Cleaning method by oil

   The procedure shall be as follows:

   a. Oil to be used shall have good quality suitable for the machinery, and shall be completly replaced with the specified oil after cleaning.

   b. The cleaning shall be performed by the method of circulation of the oil and ham-mering. Hammering shall, not be per-formed for copper pipe.

   c. After completion of cleaning, it shall be checked that no foreign matter is present in temporary strainer screen of No.200 specified in ASTM E- 11 for oil pipings of centrifugal compressor, and screen of No.100 specified in ASTM E-11 for other oil pipings.

10.8.6 Other cleaning method

1. Cleaning method by pig or cushion ball

   Cleaning by the use of pig or cushion ball shall confirm to specific job requirements.

2. Cleaning method by sodium hydroxide

   Cleaning by sodium hydroxide solution shall conform to specific job requirements.

3. Special cleaning

   Special Cleaning, if specified for special piping components or systems, shall con-form to specific job requirements.

10.9.0 Overall airtightness test

10.9.1 When specified, an overall airtightness test shall be performed for the piping of process line by the use of air or inert gas after completion of flushing.

10.10.0 Disposition

10.10.1 All construction equipment used for the piping work, and all surplus, scrap and debris shall be disposed of in accordance with the instructions of the FEDO Engineer.

10.11.0 Test record

10.11.1 All inspection and test results shall be made into re cords in accordance with the instructions of FEDO. The records shall be submitted for ap-proval to FEDO.

11.0.0 APPENDICES

11.1.0 The following Appendices shall form a part of this manual:

TITLE	REFER TO:
Grove face Rust Preventive	APPENDIX **I**
Selection of welding electrodes	APPENDIX **II**
Procedure for Flange Bolt up	APPENDIX **III**
Additional Random Type Examination for weld defects	APPENDIX **IV**

APPENDIX — I

GROOVE FACE RUST PREVENTIVE

Features of Product

1. As rust preventive applied to the groove face, in general, deoxialuminite is used as it is not detrimental to the weld. Deoxialuminite is the brand name of a product of Special Chemical Co., Ltd.of USA. This was first produced in Japan by Nippon Oil & Fats Co., Ltd. and is sold under the brand name of Tasteto Silver.
2. The composition of the product is 40% resin, 50% solvent, 5% pigment, etc., and the percentage of resin in the compound is high to reduce the amount of gas produced during welding.
3. This product is recommended for both marine and overland transportation. The thickness of the applied product shall not be more than 30 microns.
4. The adherent durability is not more than three months.

Directions for Use

5. Before applying the rust preventive, it shall be confirmed that the groove face is clean.
6. After the rust preventive has been applied, welding shall not be performed within two weeks.
7. In principle, the application shall be sprayed by maintaining a distance not less than 30 cm from the spray nozzle to the object. Unless otherwise specified, the product shall not be applied with a brush.

APPENDIX — II

SELECTION OF WELDING ELECTRODES & RODS

Table - I : Selection of welding electrodes & rods for joining similar materials except Aluminium

Table - II : Selection of welding electrodes & rods for joining disimilar materials except Aluminium

(Tables overleaf)

APPENDIX — III

PROCEDURE FOR FLANGE BOLT UP

Confirmation Prior to Bolt Up

The following items shall be confirmed prior to bolt up:

1. The gasket has been inserted and centered.
2. Bolts and nuts have been lubricated.
3. Bolts have been inserted and are finger tight.
4. There are at least two threads extending beyond the nut on either side.

Procedure for Bolt Up

Procedure for flange bolt up shall be as follows

5. Hand tighten bolts with a short wrench by the procedure shown in Figure 11.
6. Tighten bolts a second time with a spanner wrench and light hammer (about 1 kg), again by the procedure shown in Figure 11.
7. Continue tightening gradually by the procedure shown in Figure 11, using a heavy hammer (about 2 kg) until bolts are completely drawn tight. This may take two or three additional rounds by the same procedure.
8. For bolts larger than 25mm in diameter, a final round or two with a heavier hammer (about 3.5 kg) is recommended to reach the correct bolt tension.

Precautions

Special precautions shall be taken for the following items for bolt up:

9. Never draw up tight on one or two bolts only. This will cause local gasket crushing or pinching, which will result in leaks.
10. After each round of tightening, the alignment may be checked by measuring the distance between flange faces.
11. The bolts should be gradually and evenly tightened with a wrench and hammer until the hammer begins to “bounce” with a distinct ring.

APPENDIX — IV

ADDITIONAL RANDOM TYPE EXAMINATION FOR WELD DEFECTS

(Taken from ANSI / ASME B31.3b-1982, 336.5)

When the required examination of a spot or random type reveals a defect requiring repair, two additional examinations of the same type shall be made on the same kind of item (if of a weld, others by the same welder or welding operator). If the second group of items examined is acceptable, all items represented by these additional examinations shall be accepted.

For each of the second group of items which reveals defects requiring repair, two additional items shall be examined. If all of the third groups of items examined are acceptable, the items requiring repair shall be repaired or replaced to meet the requirements of the code, and all items represented by the examined items shall be accepted.

If any of the third group of items examined reveal defects requiring repair, all comparable items may be replaced or they shall fully examined and repaired as necessary to meet applicable quality requirements.

TABLE - I : SELECTION OF WELDING ELECTRODES & RODS FOR SIMILAR MATERIALS EXCEPT ALUMINIUM

MATL. NO.	BASE MATERIAL		COVERED ELECTRODES		WELDING RODS	
			AWS SPEC	PREFERRED ELECTRODE	AWS SPEC.	CLASSIFICATION
1	carbon steel	UTS UNDER 60,000psi	A 5.1	E6010/E6013 (1)	(2) (3) (4)	—
2		UTS 60,000psi & above	A 5.1	E6010/ E7018 (1)	(2) (3) (4)	—
2a		A333 Gr - 1	A 5.1	E7018 -1(5)	(5)	--
3	carbon-molybdenum		A 5.5	E70XX-A1	(2) (3) (4)	—
4	$2^1/_4$ nickel		A 5.5	E80XXC1	(2)	—
5	$3^1/_2$ nickel		A 5.5	E80XX-C2	(2)	—
6	9 nickel		A 5.11	ENi Cr Fe - 3	A5.14	ER Ni Cr -3
7	low chromium ferrtic steels	$^1/_2$Cr–$^1/_2$Mo	A 5.5	E8015-B2L	(2)	0.05C max.
8		1Cr–$^1/_2$Mo	A 5.5	E8015-B2L	(2)	0.05C max.
9		$1^1/_4$Cr–$^1/_2$Mo	A 5.5	E8015-B2L	(2)	0.05C max.
10		$2^1/_4$Cr–1Mo	A 5.5	E9015-B3L (0.05C max.)	(2)	0.05C max.
11		5Cr–$^1/_2$Mo	A 5.4	E502-I5 (0.05C max.)	A5.9	ER502(0.05C max)
12		7Cr–$^1/_2$Mo	A 5.4	E7Cr-I5 (0.05C max.)	(2)	(0.05C max.)
13		9Cr–1Mo	A 5.4	E505-I5 (0.05C max.)	A5.9	ER505(0.05C max)
14	ferrtic stainless steels	AISI Type405	A 5.4	E410-I5 (0.05C max.)	A5.9	ER410(0.05C max)
15		AISI Type 410S	A 5.4	E410-I5 (0.05C max.)	A5.9	ER410(0.05Cmax)
16		AISI Type410	A 5.4	E410-I5 (0.05C max.)	A5.9	ER410(0.05C max)
17		AISI Type430	A 5.4	E430-I5	A5.9	ER430
18	austenitic stainless steels	AISI Types 304&304H	A 5.4	E308-I5 or 16	A5.9	ER308
19		AISI Type 304L	A 5.4	E308L-I5 or 16	A5.9	ER308L
20		AISI Types321&321H	A 5.4	E347-I5 or 16	A5.9	ER347
21		AISI Types 347 & 347H	A 5.4	E347-I5 or 16	A5.9	ER347
22		AISI Types 316 & 316H	A 5.4	E316-I5 or E 16 -8 -2	A5.9	ER316
23		AISI Type 316L	A 5.4	E316L-I5 or 16	A5.9	ER316L
24		AISI Type309	A 5.4	E309-I5 or 16	A5.9	ER309
25		AISI Type310	A 5.4	E310-I5 or 16	A5.9	ER310
26		Incoloy(32Ni46Fe20Cr)	A 5.11	ENi Cr Fe-2	A5.14	ERNiCr -3
27	non–ferrous metals & alloys	AluminiumBronze	A 5.6	ECu Al-A1	A5.7	RCu Al-A2
28		Phosphor Bronze	A 5.6	ECuSn-C	A5.7	RCuSn-A
29		Copper	A 5.6	ECu	A5.7	RCu
30		67Ni-30Cu Monel	A 5.11	ENiCu-4	A5.14	ERNiCu-7
31		Hastalloy(60Ni-28Mo-5Fe)	A 5.11	ENiMo - 1	A5.14	ERNiMo-4
32		Inconel(75Ni 15Cr8Fe)	A 5.11	ENiCrFe -1	A5.14	ERNiCrFe-5
33		70Cu-30Ni	A 5.6	ECuNi	A5.7	RCuNi
34		Nickel	A 5.11	ENi-1	A5.14	ERNi-3
35		20Cr-29Ni-$2^1/_2$Mo-3Cu	-	Alloy 20 Cb - 3	—	Alloy 20Cb3

Notes:

(1) For materials Nos.1 and 2 (Carbon steel) where SMAW is followed, the root run shall be with E 6010 electrodes.

(2) Where no AWS specification exists for base wire, it is acceptable to use wire or rods of the same nominal composition as the base material with substantially neutral flux or inert gas, provided they have been qualified in the procedure test.

(3) MIG wire shall conform to AWS A5.18 and A5.20

(4) SAW wire and flux shall conform to AWS A5.17

(5) The root run of butt welds for material No. 2a shall be made in GTAW process using ER70S - 2 wires.

TABLE II — SELECTION OF WELDING ELECTRODES & RODS FOR WELDING DISSIMILAR MATERIALS EXCEPT ALUMINIUM

Lower base mat'l No.	Higher base material number																								
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	35
1	A	A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	D	D	E	C
2		A	A	A	A	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	D	D	E	C
3			@	@	@	B	B	B	B	B	B	B	B	B	B	B	C	C	C	C	C	C	D	D	E	C
4				A	A	@	@	@	@	@	@	@	@	@	@	@	C	C	C	C	C	C	D	D	E	@
5					A	@	@	@	@	@	@	@	@	@	@	@	C	C	C	C	C	C	D	@	E	@
6						@	@	@	@	@	@	@	@	@	@	@	E	E	E	E	E	E	E	@	E	@
7							A	A	A	A	A	A	A	A	A	A	C	C	C	C	C	C	D	E	C	@
8								A	A	A	A	A	A	A	A	A	C	C	C	C	C	C	D	E	C	@
9									A	A	A	A	A	A	A	A	C	C	C	C	C	C	D	E	C	@
10										A	A	A	A	A	A	A	C	C	C	C	C	C	D	E	C	@
11											A	A	A	A	A	A	C	C	C	C	C	C	D	E	C	@
12												A	A	A	A	A	C	C	C	C	C	C	D	E	@	@
13													A	A	A	A	C	C	C	C	C	C	D	E	@	@
14														A	A	A	C	C	C	C	C	C	D	E	@	@
15															A	A	C	C	C	C	C	C	D	E	@	@
16																A	C	C	C	C	C	C	D	E	@	@
17																	C	C	C	C	C	C	D	E	@	@
18																		A	A	A	A	A	A	A	A	C
19																			F	F	F	A	F	F	F	C
20																				A	A	A	A	A	A	C
21																					A	A	A	A	A	C
22																						A	A	A	A	C
23																							A	A	A	C
24																								C	E	C
25																									E	C
26																										C

DESCRIPTION OF CODE LETTERS IN ABOVE TABLE

A As specified in table I for material corresponding to either the higher or lower base material number

B ASME SFA-5.5, E8015-82L electrode

C ASME SFA-5.4, E309 electrode. Acceptable alternatives shall be as specified in table I for the higher base material number

D As specify in table I for the material with the higher base material number

E ASME SFA-5.11, ENiCrFe-2 electrode and ASME SFA-5.4. ERNiCr-3 rods shall be used where design temperature exceeds 1000^0F (538^0C). ASME SFA-5.4, E310 electrodes are to be used where service temperatures are below 1000^0F (538^0C) and expected to be relatively constant after start up. All rods, excluding alternatives shall require written approval from designated authority.

F ASME SFA-5.4, E308 electrode or as specified in table I for the material with the higher base material number

@ Welding of these material combinations are not permitted without written approval from designated authority.

FIGURE 9

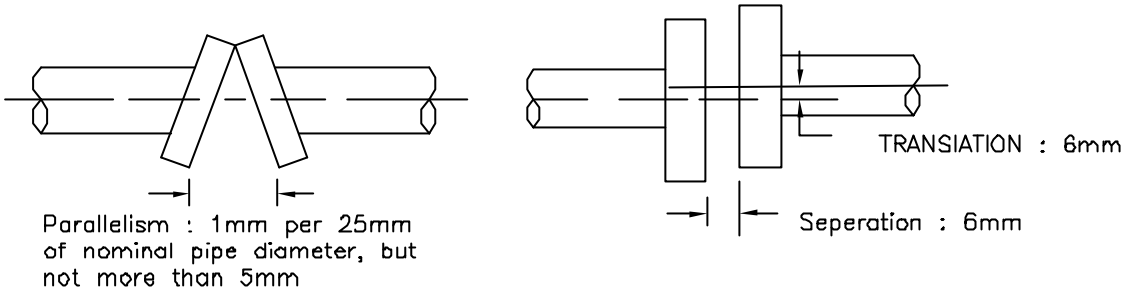


FIGURE 10
IDENTIFICATION MARK RADIOGRAPH

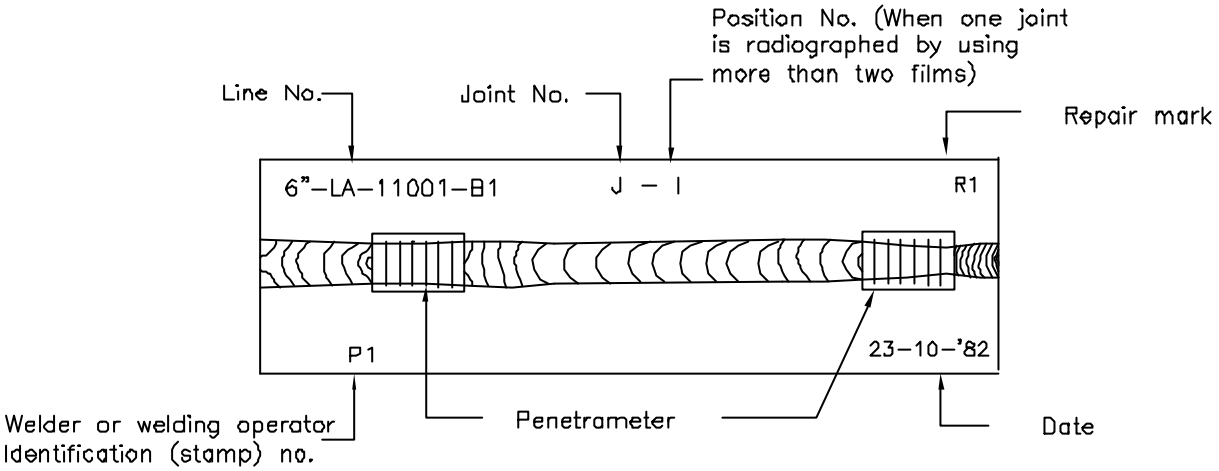
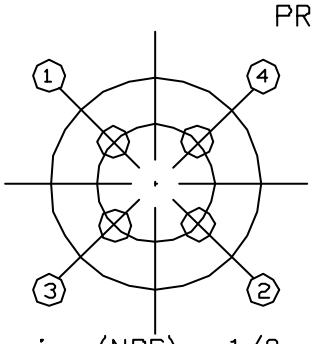
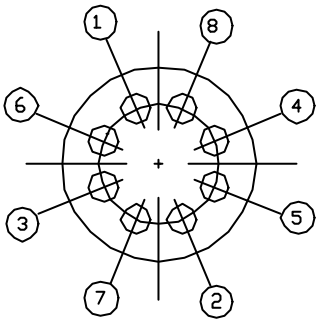


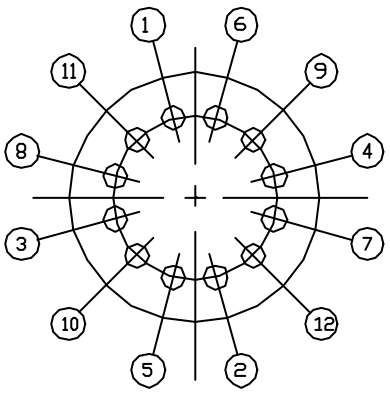
FIGURE 11
PROCEDURE FOR BOLT UP



Flange size (NPS) : 1/2 ~ 1 1/2



Flange size (NPS) : 2 ~ 5



Flange size (NPS) : 6 ~ 10
(Same as procedure for sizes of more than NPS 12)

iso1.sty

ENGINEERING SPECIFICATION	UTILITY STATIONS	03ES009 / 10
		PAGE 1 OF 1

1. All dimensions are in mm

2. All ground area inside plant unit battery shall be covered with hose of maximum length 20M except in heat exchanger areas, where 2 hoses can be connected for access to front areas.

3. Nitrogen hose connections shall be provided in P&I Diagram.

4. Utility station shall be provided on each platform / floors in the case of Heaters, Furnaces, Compressor buildings and other process plant building structures.

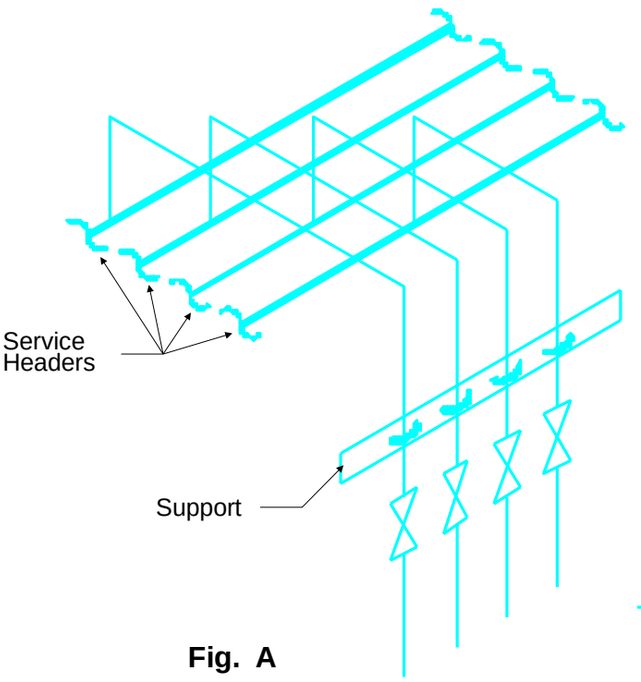


Fig. A

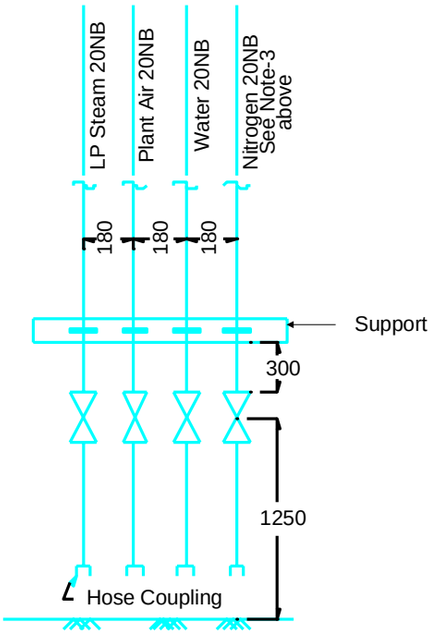


Fig. B

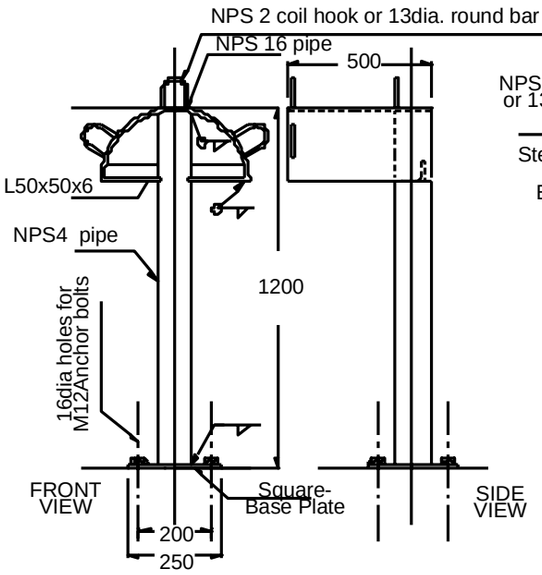


Fig. C

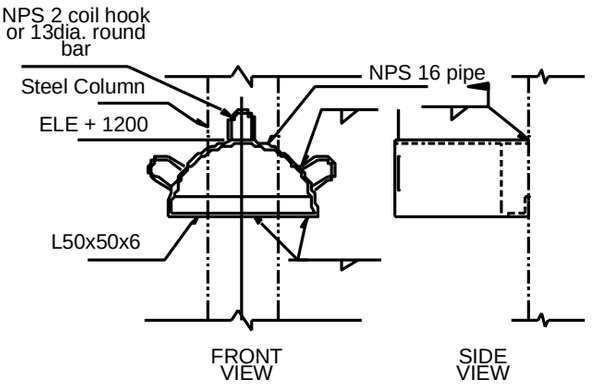


Fig. D

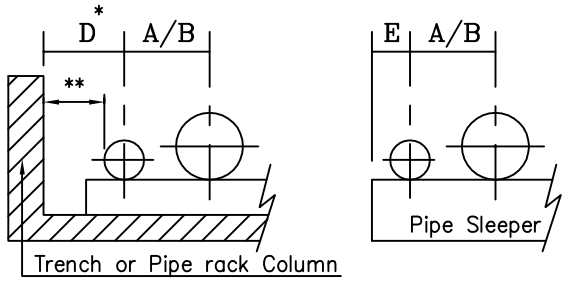
PRPD. BY:	CHKD. BY:	APPRD. BY:	ISSUED ON: APR '10

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

A (for class 150) NB	B (for class 300) 15	20	25	40	50	80	100	150	200	250	300	350	400	450	500	600	C 600#	C 900#	D	E	NB
15	90/80	100	100	120	120	140	170	200	230	260	300	330	360	390	430	500	0	20	260	100	15
20	90	100/90	100	120	120	150	170	200	230	260	300	330	370	400	480	500	0	10	270	100	20
25	90	100	110/100	120	130	150	170	200	240	270	310	340	370	400	430	500	0	20	280	110	25
40	100	110	110	130/120	140	160	180	210	240	280	310	360	380	410	440	510	0	20	290	110	40
50	120	120	120	130	140/140	180	190	220	250	280	320	360	380	410	450	520	0	30	300	120	50
80	140	140	140	150	150	180/170	200	230	260	300	330	370	400	430	460	530	0	20	320	140	80
100	150	150	150	170	170	190	210/200	250	260	310	350	380	410	450	470	540	10	20	340	150	100
150	180	180	190	190	200	210	230	270/250	300	340	370	410	440	470	500	570	20	40	370	170	150
200	210	210	220	220	230	250	260	280	330/310	360	400	460	460	490	530	600	20	50	410	200	200
250	240	250	250	260	260	290	290	320	340	390/370	430	460	490	520	550	620	40	50	580	230	250
300	280	280	290	290	300	320	330	350	380	410	450/430	480	520	550	580	650	20	50	610	250	300
350	310	310	310	320	330	340	360	380	410	430	460	500/470	530	560	590	660	10	30	650	280	350
400	340	340	340	350	360	370	380	410	440	460	490	500	580/580	590	620	690	20	30	680	300	400
450	360	360	360	370	380	390	400	430	460	480	510	530	560	610/580	650	720	20	40	710	330	450
500	390	390	400	400	410	420	440	460	490	520	540	560	580	610	670/630	740	20	40	740	350	500
600	450	450	450	460	470	480	490	520	550	570	600	610	640	670	690	790/740	20	70	810	450	600

All dimensions in mm



* : For Trench
** : Minimum 25mm for Pipe Racks

NOTES

1. The minimum center to center (C.T.C) distance between two pipes is the sum of flange radius of larger pipe, radius of adjascent pipe and 25mm clearance.
2. For space between insulated pipes, both insulation thicknesses shall also be added to the spacing A/B.
3. When the line is class 600 or 900 the dimension C for the higher rating shall be added to the pipe spacing B.
4. Where movement of pipes are caused by thermal expansion or contraction, adequate space shall be provided.
5. For ratings above class 900, calculate spacing as indicated in note 1 above maintaining a clearance of 25mm.
6. If any one pipe is class 300, use spacing B.

MAXIMUM SPACING OF GUIDES (h) – mm.						
PIPE SIZE (NB)	INSUL. THICK (mm)	WIND PRESS. 14.65 E-3 Kg/cm^2	WIND PRESS. 17.09 E-3 Kg/cm^2	WIND PRESS. 19.53 E-3 Kg/cm^2	WIND PRESS. 21.97 E-3 Kg/cm^2	WIND PRESS. 24.41 E-3 Kg/cm^2
25	25	6700	5200	4000	3700	3400
40	25	7000	5500	4900	4300	4000
50	25	7300	5800	5200	4600	4300
80	25	8200	6400	6100	5200	4300
100	25	8800	7300	6700	5800	5200
150	50	10100	7600	7000	6100	5800
200	50	11300	8200	7300	6400	6100
250	50	12500	8500	7600	6700	6100
300	50	13700	8800	8200	7000	6400
350	50	14300	8800	8200	7000	6400
400	50	15200	9100	8500	7300	7000
450	75	16200	9400	8500	7300	7000
500	75	17100	9800	8800	7600	7300
600	75	18300	10700	9800	8200	7600

GENERAL NOTES

1 FOR LINES WITH INSULATION THICKNESS LARGER THAN THOSE SHOWN, THE REDUCED GUIDE SPACING (h') MAY BE FOUND BY THE FOLLOWING FORMULA.

$$h' = h \times \frac{D1}{D2}$$

WHERE,
D1 = O.D. OF PIPE IN MM + TWICE THE GIVEN INSULATION THICKNESS IN MM. FROM THE ABOVE TABLE.
D2 = O.D. OF PIPE IN MM + TWICE THE ACTUAL INSULATION THICKNESS IN MM. AS SHOWN IN THE NOMENCLATURE.

2 THE GUIDE SPACINGS SHOWN ARE ONLY FOR LINES THAT ARE SUPPORTED ABOVE THE GUIDES, AS SHOWN IN FIGURES 1 THRU 4 ON THE FOLLOWING PAGE.

3 IN SETTING THE GUIDE ELEVATIONS, BE SURE TO CHECK FOR INTERFERENCES BETWEEN THE GUIDE CLIPS ATTACHED TO THE VESSELS AND ITEMS SUCH AS NOZZLES, NOZZLE REINFORCING PADS, PLATFORM CLIPS AND KNOWN WELD SEAMS.

GENERAL NOTES (CONTD)

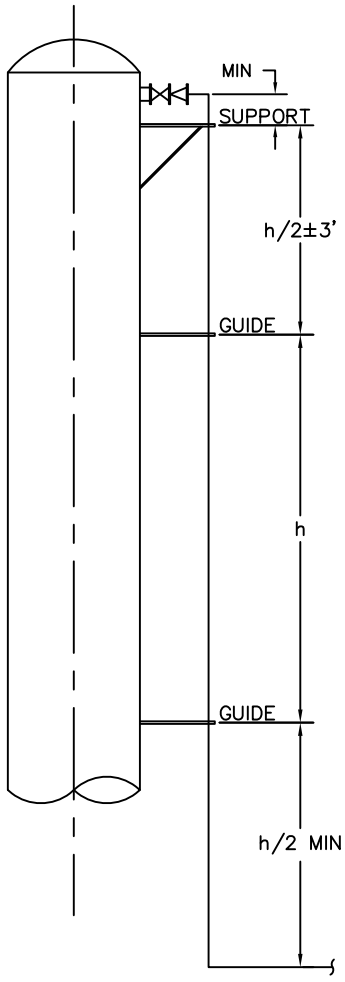


FIGURE 1

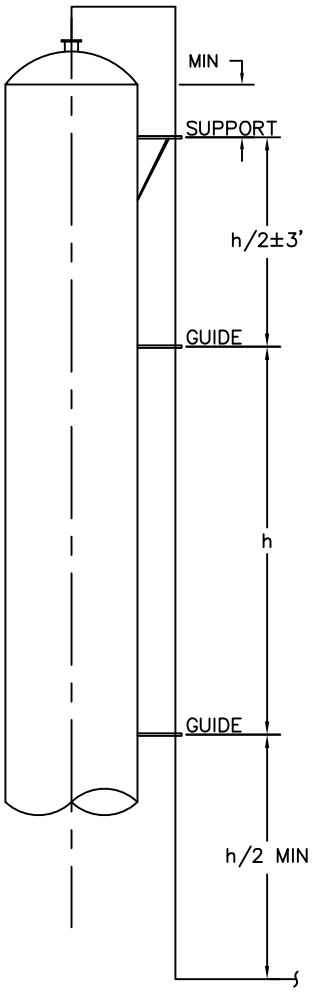


FIGURE 2

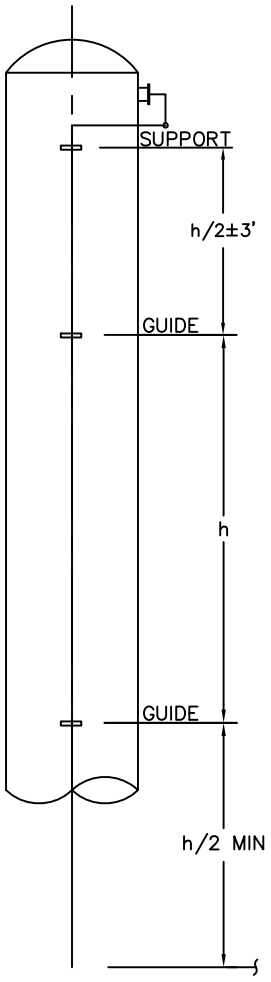


FIGURE 3

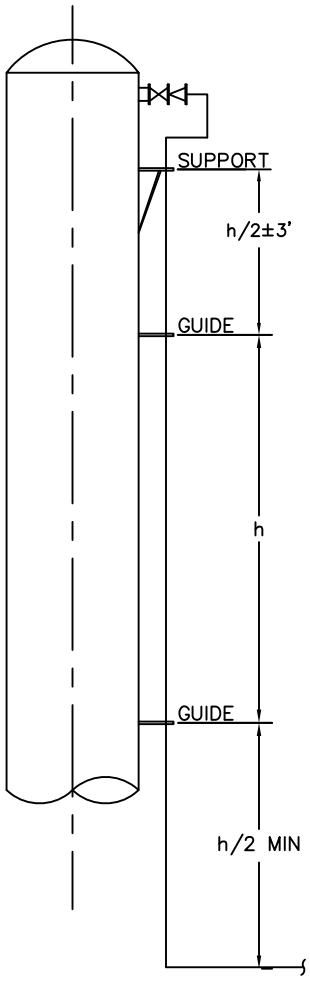


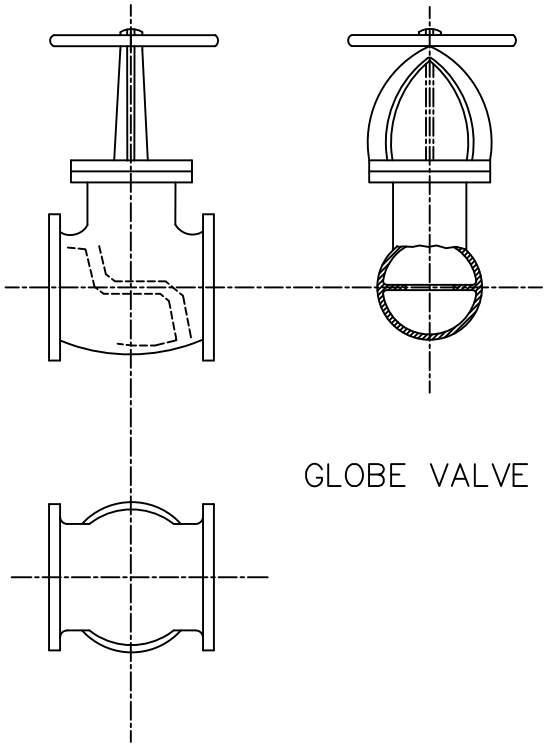
FIGURE 4

Main Valve Nominal Pipe NB Size (mm)	By – Pass Nominal Pipe Size	
	Type–A	Type–B
100 125 150 200 250	15 20 20 20 25	25 32 32 40 40
300 350 400 450 500	25 25 25 25 25	50 50 80 80 80
600 750 900 1050 1200	25 25 25 25 25	100 100 150 150 200

NOTES

(1) Type A for steam service for before the main line is opened and for balancing presures where the lines are of limited volume.

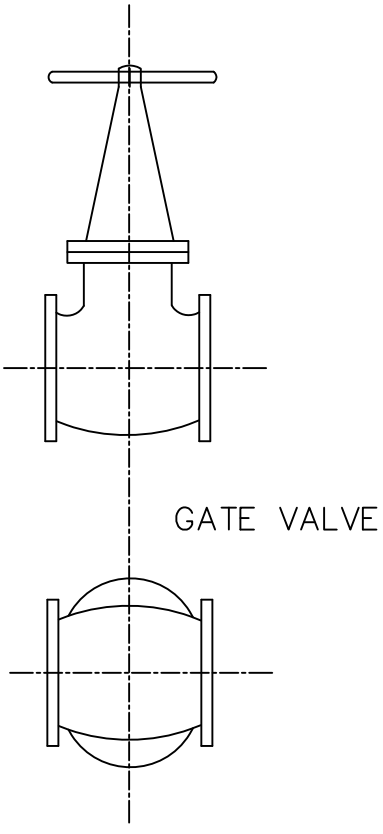
(2) Type B for lines conveying gases or liquids where by–passing facilitates the operation of the main valve through balancing the pressure on both sides of the disc or discs thereof. There in the larger sizes may be of the bolted on type.



GLOBE VALVE

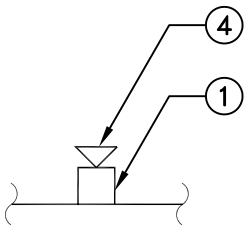
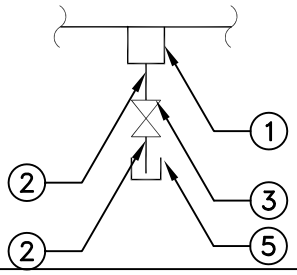
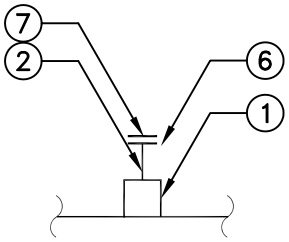
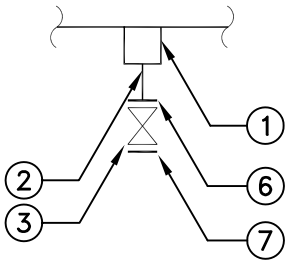
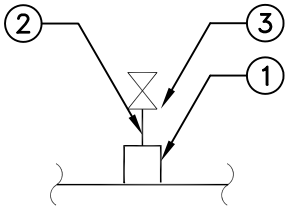
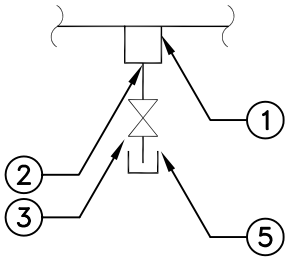
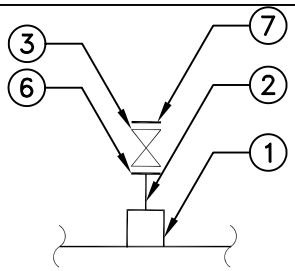
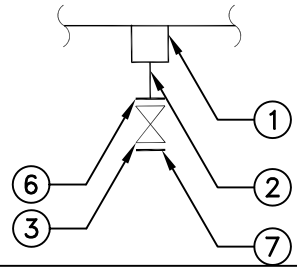
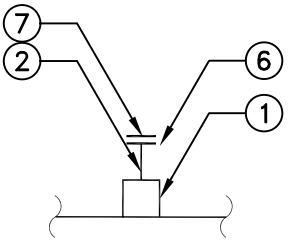
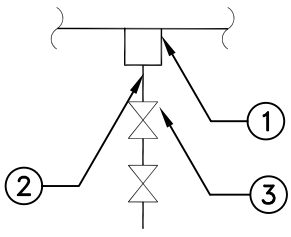
TABLE 1.STANDARD DRAIN SIZES

Nominal Size of Valve (mm)	50 to 100	125 to 200	250 to 600
Nominal Size of Drain Tapping (mm)	15	20	25



GATE VALVE

DESIGN STANDARD	VENTS & DRAINS FOR PIPE LINES	03DS013 / 15
		PAGE 1 OF 1

CLASS	VENT (20 NB)	DRAIN (20 NB)
I		
II		
III		
IV		
V		

DESCRIPTION

1 HALF COUPLING
2 NIPPLE
3 VALVE
4 PLUG
5 CAP
6 FLANGE
7 BLIND FLANGE

SERVICE

CLASS I
(LESS THAN 300#)

GAS LINES LIKE
INSTRUMENT AIR,
LOW PRESS. NITROGEN,
LINES TO SAFETY VALVE
LOW PRESSURE STEAM,
CARBON MONOXIDE,
PLANT AIR.

CLASS II
(300# AND ABOVE)

GAS LINES LIKE
NITROGEN, HYDROGEN,
FUEL GAS, NATURAL GAS,
HIGH PRESURE STEAM,
MEDIUM PRESS. STEAM.

CLASS III
(NON INFLAMMABLE)

LIQUID LINES
BOILER FEED WATER,
COOLING WATER,
DEMINERALISED WATER,
DRINKING WATER,
PROCESS CONDENSATE,
STEAM CONDENSATE,
PROCESS WATER,
RAW WATER, BLOWDOWN.

CLASS IV
(INFLAMMABLE)

LIQUID LINES LIKE
FUEL OIL, LUBE OIL,
SEAL OIL, NAPHTHA,
HIGH PRESSURE BOILER
FEED WATER.

CLASS V
(PRESSURE ABOVE 28 KG/CM^2)

ALL LINES
STEAM LINES ABOVE
1500# ONLY

NOTE

TEST VENT IS NOT
REQUIRED FOR LINES
BELOW 50 NB

PRPD. BY:	CHKD. BY:	APRD. BY:	ISSUED ON: SEPT '15

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

1 SCOPE

1. 1 THIS STANDARD COVERS THE FABRICATION DETAILS FOR TRUNNION BASE SUPPORTS.
1. 2 THE ISSUE OF RELATED CODES AND STANDARDS AS FOLLOWS:
ANSI B 31.3 LATEST ISSUE.

2. GENERAL

2. 1 MATERIAL

2. 1. 1 TRUNNION MATERIAL SHALL BE SAME AS THE SUPPORTED PIPE AND SHALL HAVE THE SAME NOMINAL ANALYSIS WITH EQUAL OR HIGHER ALLOWABLE STRESS UNLESS OTHERWISE SPECIFIED.

2. 1. 2 IF THE TRUNNION LENGTH IS GREATER THAN 450mm FROM THE OUTSIDE DIAMETER OF THE SUPPORTED PIPE THE MATERIAL FOR THE ADDITIONAL TRUNNION LENGTH MAY BE CARBON STEEL PIPE, OF THE SAME WALL THICKNESS. THE TWO MATERIAL SHALL BE PROPERLY JOINED TOGETHR BY BUTT WELDING BEVELED EDGES IN ACCORDANCE WITH THE APPROPRIATE WELDING PROCEDURE.

2. 1. 3 BASE PLATE MATERIAL SHALL BE ALUMINIUM FOR ALUMINIUM TRUNNION AND CARBON STEEL FOR OTHER MATERIALS.

2. 2 WHEN EITHER REINFORCEMENT PADS OR GUSSETS ARE REQUIRED, THE REINFORCING PAD OR GUSSET THICKNESS SHALL BE THE SAME AS THE SUPPORTED PIPE AND OF MATERIAL OF THE SAME NOMINAL ANALYSIS HAVING EQUAL OR HIGHER ALLOWABLE STRESSES. THE OUTER SURFACE OF THE WELD BETWEEN THE SUPPORTED PIPE AND THE TRUNNION SHALL BE ADEQUATELY PREPARED FOR PAD OR GUSSET PLACEMENT BY GRINDING AND SHALL BE INSPECTED AS REQUIRED BEFORE WELDING THE PAD OR GUSSET IN POSITION.

2. 3 WHEN REQUIRED, TRUNNIONS AT ELBOWS SHALL BE REINFORCED BY GUSSET PLATES, AS SHOWN IN FIGURE 14. REINFORCING PADS SHALL NOT BE USED AT ELBOWS UNLESS OTHERWISE SPECIFIED.

3 DESIGN

3. 1 TRUNNIONS ARE INDICATED ON PIPING DRAWINGS BY THE ABBREVIATION "TRUN" FOLLOWED BY A FOUR SYMBOL DETAIL DESIGNATION FOR TRUNNION SUPPORTS AND A THREE SYMBOL DETAIL DESIGNATION FOR TRUNNION BASE SUPPORTS. THE SYMBOLS HAVE THE FOLLOWING SIGNIFICANCE:

A FIRST SYMBOL — LETTER WHICH DEFINES THE SUPPORT TYPE. REINFORCEMENT REQUIREMENTS AND, FOR TRUNNION BASE SUPPORTS TYPE 'L' THROUGH 'Z', THE KIND OF BASE PLATE IN THE CASE OF MULTIPLE TRUNNIONS AS DESCRIBED IN DETAIL "A" FIGURE 1. MORE THAN ONE LETTER IS REQUIRED.

B SECOND SYMBOL — TRUNNION NOMINAL PIPE SIZE IN INCHES USING WHOLE NUMBERS ONLY.

C THIRD SYMBOL — TRUNNION PIPE SCHEDULE GIVEN IN TABLE 1.

D FOURTH SYMBOL — NOMINAL TRUNNION LENGTH 'L' IN INCHESS USING WHOLE NUMBERS ONLY WITH A MAXIMUM OF TWO DIGITS. THIS SYMBOL IS APPLICABLE ONLY FOR TRUNNION SUPPORTS TYPES 'A' THROUGH 'K' WHERE METRIC DIMENSIONS ARE REQUIRED THIS NUMBER SHALL BE MULTIPLIED BY THE CONVERSION FACTOR 25.4mm/INCH AND ROUNDED TO THE NEAREST 5 mm.

NOTE:
1 'L' EQUALS THE DISTANCE BETWEEN THE ℄ OF PIPE AND THE END OF TRUNNION.
2 FOR MULTI–TYPE TRUNNIONS (DETAIL"A") 'L' EQUALS THE DISTANCE BETWEEN ℄ OF PIPE AND ℄ OF VERTICAL SUPPORT TRUNNION.

EXAMPLE 1: FIGURE 1. DETAIL "A" DEMONSTRATES A MULTI–TYPE TRUNNION SUPPORT AND IS DESIGNATED BY:

TRUN EL80J500
℄ EL 104500
POS EL 104200

EACH SYMBOL IS DEFINED AS FOLLOWS:

SYMBOL

TRUN – IDENTIFIES A TRUNNION SUPPORT.

1 { E – DESIGNATES A TYPE "E" SUPPORT FOR VERTICAL LINES PER FIG 6
1 { L – DESIGNATES A TYPE 'L' BASE SUPPORT TO BE USED FOR THE TYPE "E" SUPPORT PER FIGURE 10. FIGURE 10 ALSO SPECIFIES THE BASE PLATE BY REFERENCING FIGURE 12.

2 80 – INDICATES A NOMINAL PIPE SIZE OF 3 IN. FOR TRUNNION SUPPORT.

3 J – PER TABLE "I" SCH 80 PIPE IS REQUIRED FOR THIS TRUNNION SUPPORT.

4 500 – INDICATES THAT THE TYPE "E" SUPPORT HAS A REQUIRED NOMINAL 'L' LENGTH OF 20 INCHES (NOT INCLUDED FOR BASE SUPPORTS) THE METRIC EQUIVALENT IS 510 mm.

℄ EL 104500 – LOCATES THE TYPE "E" SUPPORT IN THE VERTICAL POSITION (NOT INCLUDED FOR THE BASE SUPPORTS)

POS EL 104200 – INDICATES THE ELEVATION OF THE BOTTOM OF THE BASE PLATE – "END OF PIPE" IF BASE PLATE IS REQUIRED (FOR BASE SUPPORTS ONLY)

THE BASE SUPPORT LENGTH MAY BE DETERMINED FROM THE POS AND ℄ LINE ELEVATIONS AND THE BASE PLATE THICKNESS GIVEN IN TABLE III

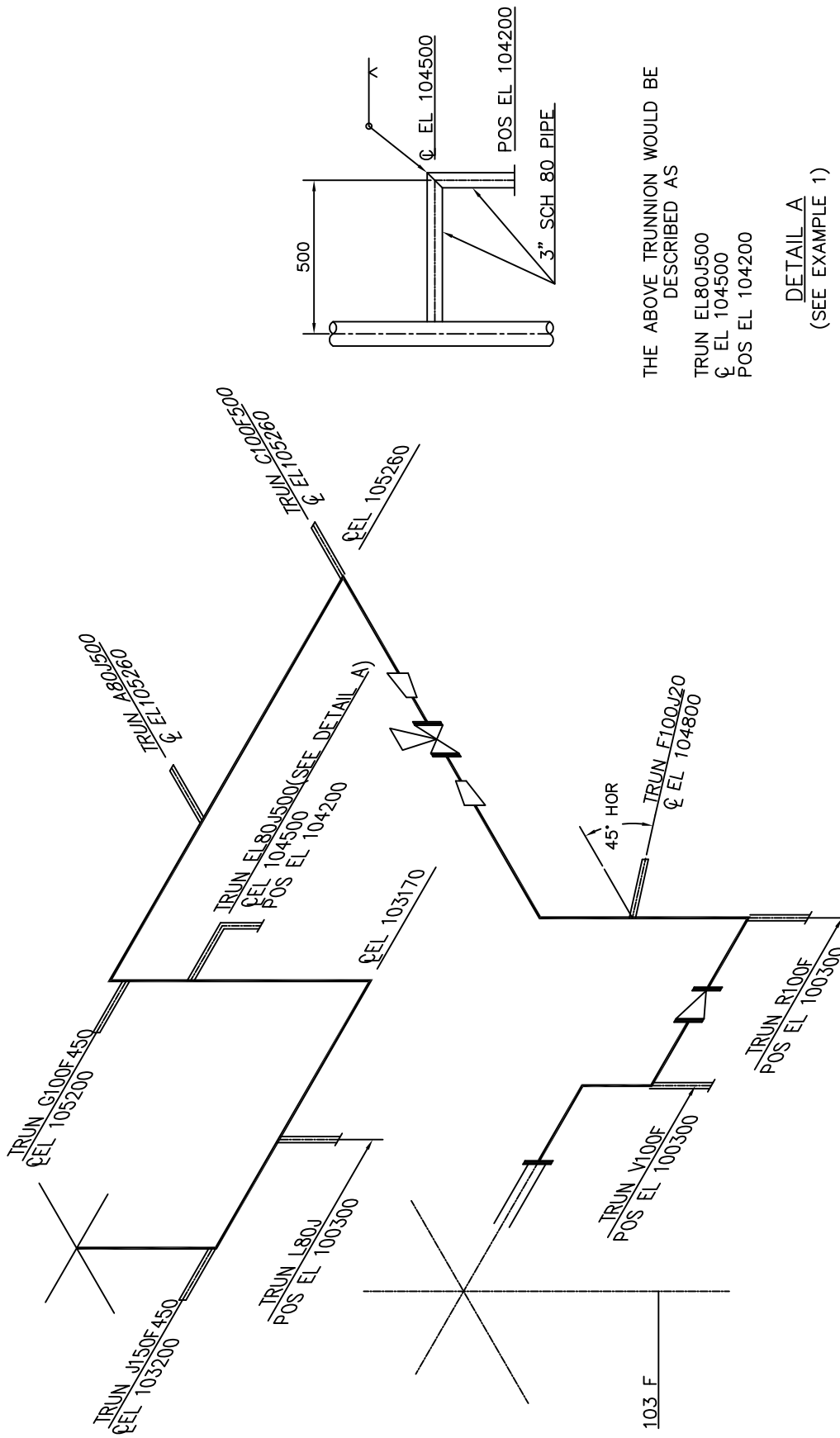

℄ EL 104500
POS EL 104200
3" SCH 80 PIPE
500
THE ABOVE TRUNNION WOULD BE DESCRIBED AS
TRUN EL80J500
℄ EL 104500
POS EL 104200
DETAIL A
(SEE EXAMPLE 1)
TRUN C100F500
℄ EL 105260
℄EL 105260
TRUN A80J500
℄ EL 105260
TRUN EL80J500(SEE DETAIL A)
℄EL 104500
POS EL 104200
℄EL 103170
45° HOR
TRUN F100J20
℄ EL 104800
TRUN R100F
POS EL 100300
TRUN G100F450
℄EL 105200
TRUN V100F
POS EL 100300
TRUN L80J
POS EL 100300
TRUN J150F450
℄EL 103200
103 F

TABLE I
TRUNNION PIPE
SCH. DESIGNATION

TRUNNION PIPE SCH.	SCH. DESIGNATION
5S	A
10, 10S	B
20	C
STD	D
30	E
40, 40S	F
XS	G
60	H
80, 80S	J
100	K
120	L
140	M
160	N
XXS	P

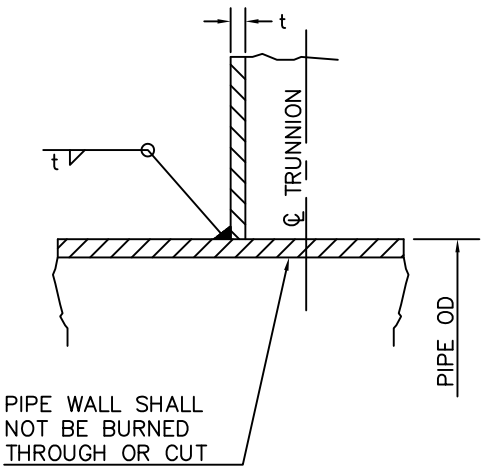


FIGURE 2
ATTACHMENT WITHOUT
REINFORCING PAD

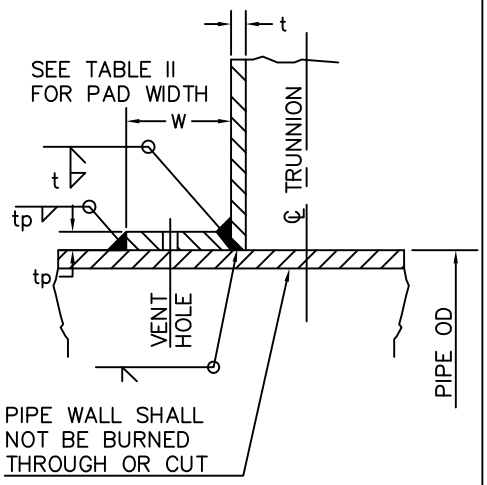


FIGURE 3
ATTACHMENT
WITH REINFORCING PAD

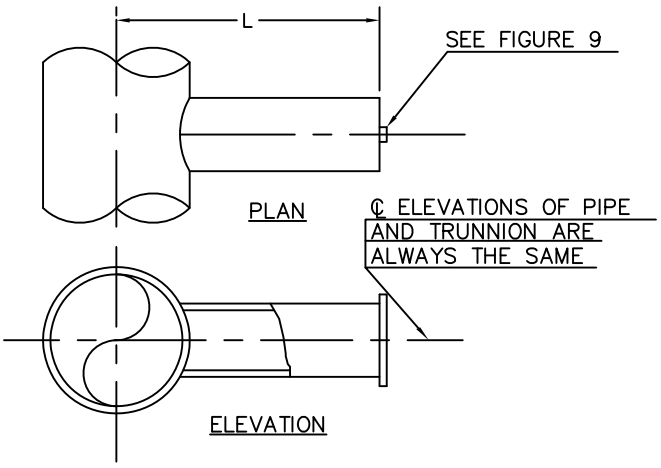


FIGURE 4
TRUNNION SUPPORT AT HORIZONTAL PIPE

TYPE	ATTACHMENT
A	NO PAD – FIGURE 2
B	WITH PAD – FIGURE 3

TABLE II PAD WIDTH	
NOM. PIPE SIZE IN. (mm)	PAD WIDTH(W) IN. (mm)
1 1/2 to 6 (40 to 150)	2 (50)
8 to 16 (200 to 400)	3 (75)
18 to 24 (450 to 600)	4 (100)

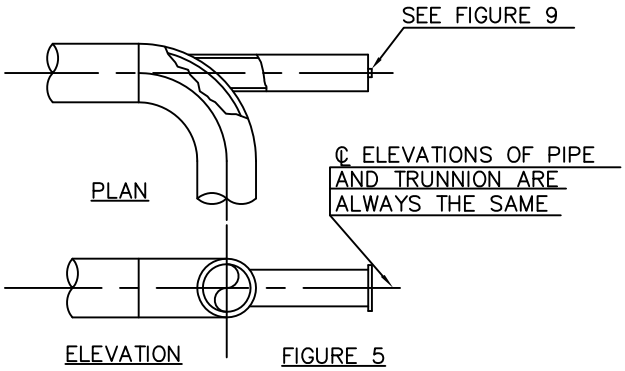


FIGURE 5
TRUNNION SUPPORT AT HORIZONTAL ELBOW

TYPE	ATTACHMENT
C	NO PAD – FIGURE 2
D	WITH PAD – FIG 3 & 14

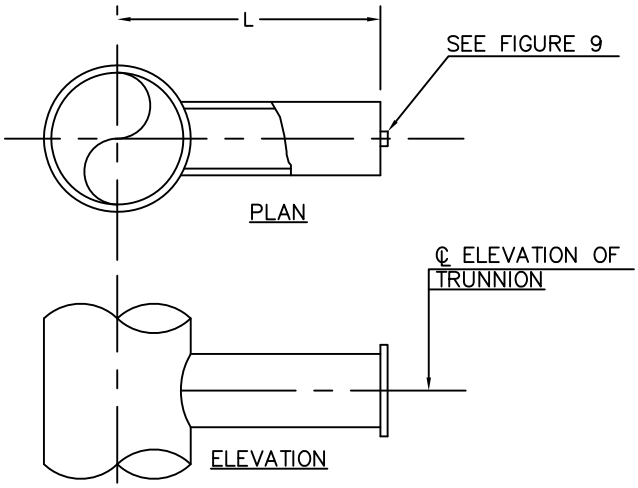
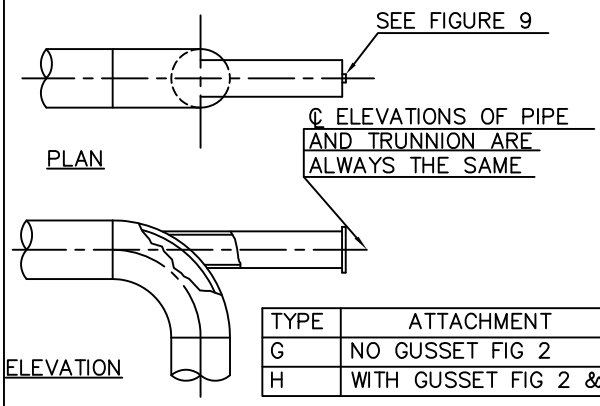


FIGURE 6
TRUNNION SUPPORT AT VERTICAL PIPE

TYPE	ATTACHMENT
E	NO PAD – FIGURE 2
F	WITH PAD – FIGURE 3



TYPE	ATTACHMENT
G	NO GUSSET FIG 2
H	WITH GUSSET FIG 2 & 14

FIGURE 7
TRUNNION SUPPORT AT VERTICAL ELBOW

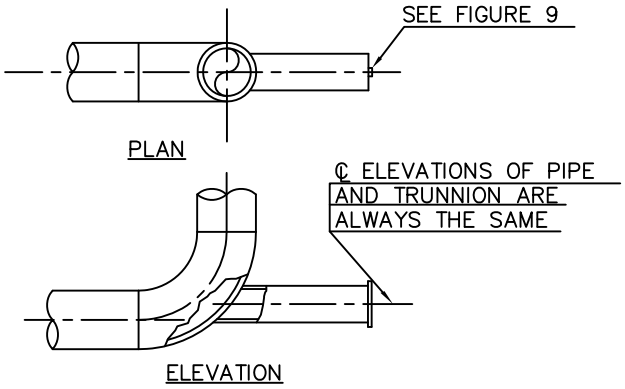
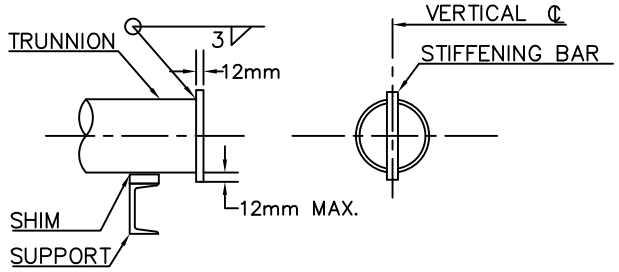


FIGURE 8
TRUNNION SUPPORT AT BOTTOM VERTICAL ELBOW

TYPE	ATTACHMENT
J	NO GUSSET FIG 2
K	WITH GUSSET FIG 2 & 14



NOTES

1 STIFFENING BARS 40 X 12 SHALL BE ALUMINIUM FOR ALUMINIUM TRUNNIONS AND CARBON STEEL FOR TRUNNIONS OF ALL OTHER MATERIALS.

2 SUFFICIENT SHIMS OR WEDGES SHALL BE PROVIDED BY THE FIELD TO UNIFORMLY DISTRIBUTE THE TRUNNION LOAD ON THE SUPPORTS.

FIGURE 9
TYPICAL DETAIL AT STRUCTURAL SUPPORT

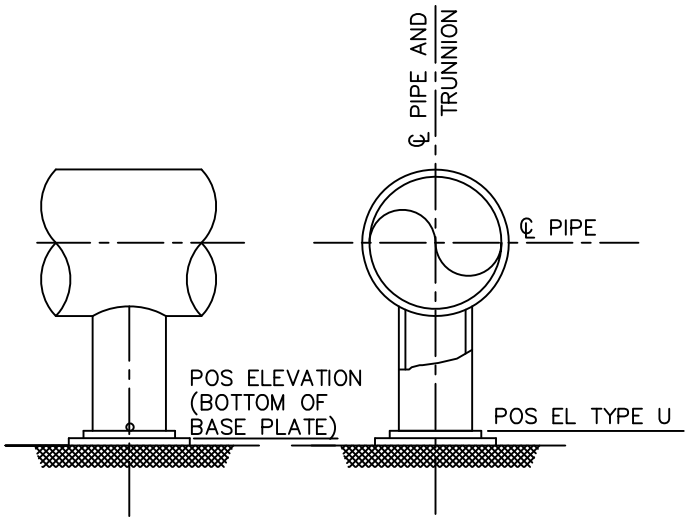


FIGURE 10
TRUNNION BASE SUPPORT AT HORIZONTAL PIPE

TYPE	ATTACHMENT	BASE PLATE
L	NO PAD FIG 2	UNDRILLED FIG 12
M	WITH PAD FIG 3	
N	NO PAD FIG 2	DRILLED FIG 13
P	WITH PAD FIG 3	
Q	NO PAD FIG 2	ROUND BASE PLATE OD = DIA + 25 mm
S	WITH PAD FIG 3	
U	NO PAD FIG 2	NO BASE PALTE

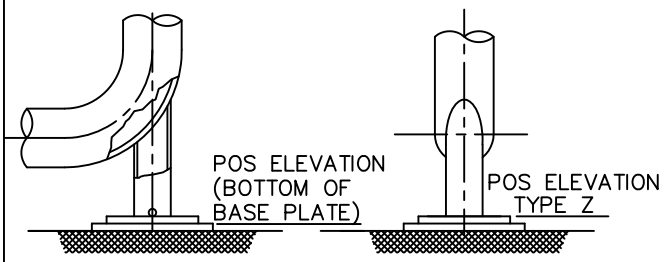


FIGURE 11
TRUNNION BASE SUPPORT AT ELBOW

TYPE	ATTACHMENT	BASE PLATE
R	NO GUSSET FIG 2	UNDRILLED FIG 12
T	WITH GUSSET *	
V	NO GUSSET FIG 2	DRILLED FIG 13
W	WITH GUSSET *	
X	NO GUSSET FIG 2	ROUND BASE PLATE OD = DIA + 25 mm
Y	WITH GUSSET *	
Z	NO GUSSET FIG 2	NO BASE PALTE

* SEE FIG 2 & 14

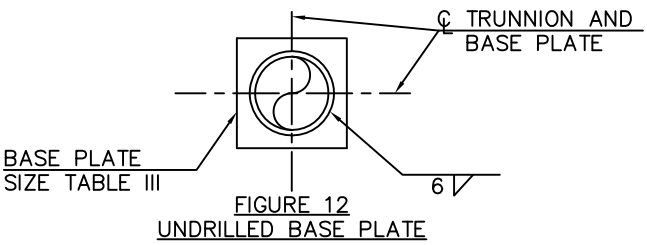


FIGURE 12
UNDRILLED BASE PLATE

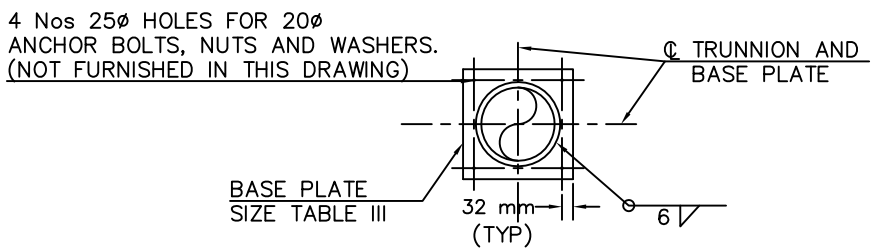


FIGURE 13
DRILLED BASEPLAE

TABLE III

TRUN. SIZE	BASEPLATE SIZE
25,40,50,80	200 X 200 X 10
100	200 X 200 X 12
150	255 X 255 X 20
200	305 X 305 X 20
250	305 X 305 X 20
300	355 X 355 X 25
350	380 X 380 X 25
400	430 X 430 X 25
450	490 X 480 X 25
500	535 X 535 X 25
600 *	635 X 635 X 25

SEE ISO FOR TRUNNION SIZE
* ALL LARGER TRUNNIONS PLATE SIZE = OD + 25 mm X 32 Thk.

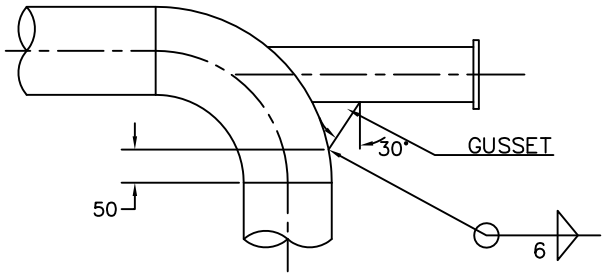


FIGURE 14
GUSSET REINFORCEMENT AT ELBOW

TABLE OF BASIC SPANS AND UNIT LINE WEIGHTS WITHIN BATTERY LIMITS

PIPE SIZE	SCH	CORR. ALLOW.	PIPE – VAPOUR – INSULATION						PIPE – LIQUID – INSULATION						BARE PIPE EMPTY		BARE PIPE WATER FILLED	
			UP TO 350°		351° TO 600°		601° TO 750°		UP TO 350°		351° TO 600°		601° TO 750°		UP TO 350°		UP TO 350°	
			SPAN	WEIGHT	SPAN	WEIGHT	SPAN	WEIGHT	SPAN	WEIGHT	SPAN	WEIGHT	SPAN	WEIGHT	SPAN	WEIGHT	SPAN	WEIGHT
IN		IN	FEET	LB/FT	FEET	LB/FT	FEET	LB/FT	FEET	LB/FT	FEET	LB/FT	FEET	LB/FT	FEET	LB/FT	FEET	LB/FT
1/2	40	0.05	12	1.75	11	2.50	8 *	4.33	12	1.98	10 *	2.73	7 *	4.56	14	1.13	13	1.36
1	40	0.05	14	2.37	13	3.23	10 *	5.12	14	2.74	12	3.60	9 *	5.49	16	1.68	14	2.05
1 1/2	40	0.05	18	3.58	16	4.51	14 *	6.77	17	4.46	15	5.39	12 *	7.65	19	2.72	17	3.59
2	40	0.10	18	4.80	16	6.76	11 *	10.11	17	6.35	15	8.11	11 *	11.56	21	3.65	18	5.10
2 1/2	40	0.10	23	7.22	19	9.25	16 *	12.03	19	9.29	18	11.32	15 *	16.10	25	5.79	21	7.86
3	40	0.10	24	9.23	21	11.45	18 *	15.53	21	12.43	19	14.69	16 *	18.73	26	7.57	22	10.77
4	40	0.10	27	13.03	25	15.40	22	20.53	24	18.53	23	20.91	19 *	26.05	29	10.79	25	16.30
6	40	0.10	33	22.09	31	27.05	28	32.10	29	34.42	27	39.38	25 *	44.62	34	18.97	29	31.30
8	40	0.10	39	32.95	36	38.36	33	44.70	33	54.55	32	59.96	29 *	66.38	40	28.55	33	50.15
10	40	0.10	44	45.77	42	52.20	39	60.80	37	79.89	35	86.31	34 *	94.96	46	40.48	38	74.59
12	STD	0.10	47	57.13	45	63.10	42	72.56	39	106.16	38	112.13	36 *	121.59	49	49.60	40	98.50
14	STD	0.10	49	63.12	47	69.00	44	80.00	40	122.82	39	129.22	37 *	139.75	52	55.00	41	114.70
16	STD	0.10	53	72.20	50	78.70	47	91.50	42	151.20	41	157.82	39 *	170.62	55	63.00	43+	142.10
18	STD	0.10	56	81.20	54	89.00	50	102.70	44	182.40	43	190.20	40 *	203.52	59	71.10	45+	172.20
20	STD	0.10	59	90.20	57	98.20	53	114.00	46	216.20	45	223.87	41 *	230.67	62	79.00	46+	205.00
24	STD	0.10	65	108.20	62	117.80	58	138.30	48	292.00	47	302.10	43 *	320.25	68 +	95.00	49+	278.80
1/2	80	0.10	12	2.09	10	2.81	7*	4.67	11	2.28	10	3.03	6 *	4.86	14	1.47	13	1.66
1	80	0.10	14	2.86	12	3.72	10*	5.61	13	3.17	12	4.14	9 *	5.98	16	2.17	14	2.48
1 1/2	80	0.10	17	4.49	16	5.42	14*	7.68	16	5.20	15	6.19	13 *	8.45	19	3.63	17	4.40
2	80	0.10	19	6.27	17	8.13	14*	11.48	18	7.55	16	9.41	13 *	12.76	21	5.02	19	6.30
2 1/2	80	0.10	22	9.09	20	11.12	18	13.80	20	10.92	19	12.95	17 *	15.73	23	7.66	21	9.46
3	80	0.10	24	11.91	22	14.17	20	18.26	22	14.77	21	17.03	19	21.12	25	10.25	23	13.11
4	80	0.10	27	17.21	26	19.59	23	24.38	25	22.19	24	24.57	22	29.36	29	14.98	26	19.96
6	80	0.10	34	31.72	32	36.67	30	41.20	31	43.01	29	47.96	28	52.99	35	28.80	31	39.89
8	XS	0.10	39	47.80	37	53.22	35	59.50	35	67.59	33	73.01	32	79.29	40	43.40	36	63.19
10	XS	0.10	44	60.09	42	66.50	39	75.10	38	92.44	37	98.85	35	107.45	45	54.80	39	87.15
12	XS	0.10	47	72.95	45	78.85	43	88.72	41	119.96	40	125.88	38	135.43	49	65.42	42	112.43
14	XS	0.10	50	80.22	48	86.50	45	97.50	42	137.76	41	144.04	40	155.04	51	72.10	44	129.64
16	XS	0.10	53	91.90	51	98.90	49	111.70	44	168.54	43	175.48	42	188.28	55	82.80	46 +	158.38
18	XS	0.10	57	103.70	55	111.50	52	125.80	47	202.11	46	209.91	44	224.01	59	93.50	48 +	191.91
20	XS	0.10	59	110.30	57	124.60	55	140.40	49	239.17	47	247.47	46	263.27	62	105.00	49 +	227.87
24	XS	0.10	65	138.80	63	148.60	60	167.10	52	318.93	50	328.73	49	347.23	68 +	125.50	52 +	305.63
1	XXS	0.25	14	4.45	13	5.21	10	7.10	13	4.57	12	5.33	10	7.28	15	3.66	14	3.78
1 1/2	XXS	0.25	17	7.27	16	8.20	14	10.46	16	7.68	15	8.61	14	10.87	18	6.41	17	6.82
2	XXS	0.25	20	10.29	18	12.14	15	15.48	18	11.05	17	12.91	15	16.25	21	9.03	19	9.80
2 1/2	160	0.25	21	11.44	19	13.23	17	16.23	19	12.98	18	15.01	16	17.77	23	10.01	21	11.55
3	160	0.25	24	15.96	22	18.22	20	22.26	22	18.31	21	20.57	19	24.61	25	14.30	23	16.65
4	120	0.25	27	21.19	26	23.57	23	30.30	25	25.66	24	28.04	22	34.17	29	18.90	26	23.43
6	80	0.25	33	31.72	31	36.67	28	41.20	28	43.01	27	47.96	26	52.99	35	28.60	29	39.89
8	XS	0.25	38	47.80	36	53.22	34	59.50	33	67.59	32	73.01	30	79.29	40	43.40	34	63.19
10	XS	0.25	43	60.09	41	65.50	38	75.10	36	92.44	35	98.85	33	107.45	45	54.90	37	87.15
12	XS	0.25	47	72.95	45	78.83	41	88.72	38	119.96	37	125.88	35	135.48	49	65.42	39	112.48
14	XS	0.25	49	80.22	47	86.50	44	97.50	39	137.78	38	144.08	37	155.04	52	72.10	40	129.64
16	XS	0.25	52	91.95	50	98.90	48	111.70	41	168.54	40	175.48	39	188.28	55	82.80	42+	159.38
18	XS	0.25	56	103.70	53	111.50	50	125.80	43	202.11	42	209.91	40	224.01	59	93.50	44+	191.81
20	XS	0.25	59	116.30	56	124.60	53	140.40	45	239.17	44	247.47	42	263.27	62	105.00	45+	227.87
24	XS	0.25	64	138.80	60	148.60	58	167.10	47	318.93	46	328.73	45	347.53	68+	125.50	48+	305.63

* SPANS LIMITED BY STRESS (ALL OTHERS LIMITED BY DEFLECTION)
\+ PIPE WALLS REQUIRE REINFORCING AT POINT OF SUPPORT BEARING FOR LARGE PIPE LINES AS PER DESIGN STD.

GENERAL APPLICATION:

1 SPANS SHALL BE CONSIDERED BASIC AND REPRESENT THE VALUE "L". THE ACTUAL WORKING SPANS SHALL BE A FUNCTION OF "L" AS INDICATED ON THE "TYPICAL PIPING DIAGRAMS".

2 UNIT LINE WEIGHTS SHALL BE USED IN CONJUCTION WITH THE "WEIGHT TABLES" FOR THE PURPOSE OF DETERMINING SUPPORT LOADINGS.

GENERAL NOTES:

HYDROSTATIC TESTING – SPANS ARE ADEQUATE WITHOUT THE ADDITION OF AUXILIARY SUPPORTS FOR INSULATED LINES AND LINES ON SHOES.
PULSATING LINES – SPAN SHALL NOT BE USED.

BASIC CONDITION

MATERIAL – SPANS SHALL BE USED FOR ALL PIPE MATERIAL OF EQUIVALENT OR HIGHER TENSILE STRENGTH THAN CARBON STEEL – ASTM A – 53, ASTM A – 106, API – 5L GR. "A".
INSULATION WEIGHT – IN ACCORDANCE WITH MATERIAL USED.
PRESSURE – IN ACCORDANCE WITH DESIGN PRACTICE.
TEMPERATURE(°F) – AS INDICATED (MAXIMUM – 750°F)
CORROSION ALLOWANCE – AS INDICATED. SPANS SHALL BE USED FOR LINES OF EQUIVALENT OR SMALLER CORROSION ALLOWANCE THAN THOSE SPECIFIED IN THE TABLE.
DEFLECTION – BASED ON (5/8" MAX.)

		PIPE – VAPOUR INSULATION			PIPE – LIQUID INSULATION			BARE PIPE EMPTY			BARE PIPE WATER – FILLED		
PIPE SIZE IN.	SCH.	SPAN FEET	DEFL. IN	WEIGHT LB/FT	SPAN FEET	DEFL. IN	WEIGHT LB/FT	SPAN FEET	DEFL. IN	WEIGHT LB/FT	SPAN FEET	DEFL. IN	WEIGHT LB/FT
0.10" CORROSION ALLOWANCE													
2	40	20	1 1/2	4.90	19	1 1/2	6.35	27	1 1/2	3.65	22	1 1/2	5.10
2 1/2	40	24	1 1/2	7.22	23	1 1/2	9.29	31	1 1/2	5.79	26	1 1/2	7.86
3	40	26	1 1/2	9.23	26	1 1/2	12.43	32	1 1/2	7.57	27	1 1/2	10.77
4	40	30	1 1/2	12.57	29	1 1/2	18.53	36	1 1/2	10.79	31	1 1/2	16.30
6	40	41	1 1/2	22.09	35	1 1/2	34.42	42	1 1/2	18.97	37	1 1/2	31.30
8	40	49	1 1/2	32.95	39		54.55	50	1 1/2	28.55	42		50.15
10	40	55	1 1/2	45.77	43	1 3/8	79.08	57	1 1/2	40.48	46	1 3/8	74.59
12	STD	56	1 1/2	57.13	46		100.03	61	1 1/2	49.60	49		93.50
14	STD	61	1 1/2	63.12	48	1 1/4	122.82	64+	1 1/2	55.00	50+	1 1/4	114.70
16	STD	65	1 1/2	72.20	50		151.20	69+	1 1/2	63.00	51+		142.10
18	STD	69	1 1/2	81.20	51	1 1/8	182.40	73+	1 1/2	71.00	52+	1 1/8	172.20
20	STD	73	1 1/2	90.20	52		216.20	77+	1 1/2	79.00	53+		205.00
24	STD	80	1 1/2	108.20	53	1	292.00	84+	1 1/2	95.00	55+	1	278.80
0.10" CORROSION ALLOWANCE													
1 1/2	80	21	1 1/2	4.49	20	1 1/2	5.26	23	1 1/2	3.63	21	1 1/2	4.40
2	80	24	1 1/2	6.27	22	1 1/2	7.55	26	1 1/2	6.02	23	1 1/2	6.30
2 1/2	80	27	1 1/2	9.09	25	1 1/2	10.92	29	1 1/2	7.65	26	1 1/2	9.49
3	80	30	1 1/2	11.91	27	1 1/2	14.77	31	1 1/2	10.25	29	1 1/2	13.11
4	80	34	1 1/2	17.21	31	1 1/2	22.19	36	1 1/2	14.98	32	1 1/2	19.96
6	80	42	1 1/2	31.69	36	1 1/2	42.98	43	1 1/2	28.57	39	1 1/2	39.86
8	XS	48	1 1/2	47.79	43	1 1/2	67.59	50	1 1/2	43.39	44	1 1/2	63.19
10	XS	54	1 1/2	60.03	47	1 1/2	92.33	56	1 1/2	54.74	48	1 1/2	87.04
12	XS	59	1 1/2	72.93	51	1 1/2	119.83	61	1 1/2	65.40	52	1 1/2	112.30
14	XS	62	1 1/2	80.12	53	1 1/2	137.52	64+	1 1/2	72.00	53+	1 1/2	129.40
16	XS	66	1 1/2	92.10	55	1 1/2	168.60	68+	1 1/2	83.00	57+	1 1/2	159.50
18	XS	70	1 1/2	103.20	58	1 1/2	201.40	73+	1 1/2	93.00	59+	1 1/2	191.20
20	XS	74	1 1/2	116.20	59	1 3/8	239.40	77+	1 1/2	105.00	60+	1 3/8	227.80
24	XS	82	1 1/2	138.20	61	1 1/4	319.30	84+	1 1/2	125.00	62+	1 1/4	306.00
0.25" CORROSION ALLOWANCE													
1 1/2	XXS	21	1 1/2	7.27	20	1 1/2	7.68	23	1 1/2	6.41	22	1 1/2	6.82
2	XXS	25	1 1/2	10.28	23	1 1/2	11.05	26	1 1/2	9.03	24	1 1/2	9.80
2 1/2	160	27	1 1/2	11.44	24	1 1/2	12.98	29	1 1/2	10.01	25	1 1/2	11.55
3	160	30	1 1/2	15.96	27	1 1/2	18.31	32	1 1/2	14.30	28	1 1/2	16.55
4	120	34	1 1/2	21.19	31	1 1/2	25.66	36	1 1/2	19.96	32	1 1/2	23.43
6	80	42	1 1/2	31.70	35	1 1/2	42.99	44	1 1/2	28.58	37	1 1/2	39.87
8	XS	48	1 1/2	47.80	42		67.60	50	1 1/2	43.40	42	1 1/2	63.20
10	XS	54	1 1/2	59.99	44	1 3/8	92.29	56	1 1/2	54.70	46	1 1/2	87.00
12	XS	59	1 1/2	72.83	46		119.93	61	1 1/2	65.40	48		112.40
14	XS	61	1 1/2	80.22	47		137.72	64+	1 1/2	72.10	49+	1 3/8	129.60
16	XS	65	1 1/2	91.90	48	1 1/8	168.40	69+	1 1/2	82.80	50+	1 1/4	159.30
18	XS	70	1 1/2	103.70	49		202.00	73+	1 1/2	93.50	51+	1 1/8	191.20
20	XS	73	1 1/2	115.30	50		238.10	77+	1 1/2	104.10	52+	1	226.90
24	XS	80	1 1/2	138.70	51	7/8	318.60	88+	1 1/2	125.50	53+	7/8	305.40

ALL SPANS REPRESENT THE VALUE "L*"

+ PIPE WALL REQUIRE REINFORCING AT POINT OF SUPPORT BEARING AS PER DESIGN STD.

GENERAL APPILICATION:

1 SPANS SHALL BE CONSIDERED BASIC AND REPRESENT THE VALUE "L*", IDENTIFIED WITH AN *. THE ACTUAL WORKING SPANS SHALL BE A FUNCTION OF "L*" AS INDICATED ON THE "TYPICAL PIPING DIAGRAMS"

2 WHERE DRAINAGE OF LINES IS REQUIRED, THE SLOPE BETWEEN ADJACENT SUPPORTS SHALL BE EQUAL TO THE DEFLECTION INDICATED WHEN THE ACTUAL SPAN EQULS THE CORRESPONDING BASIC SPAN. FOR OTHER SPAN:

$$\text{SLOPE} = \frac{\text{DEFLECTION X ACTUAL SPAN}}{\text{BASIC SPAN}}$$

3 UNIT LINE WEIGHTS SHALL BE USED IN CONJUNCTION WITH THE "WEIGHT TABLES" FOR THE PURPOSE OF DETERMINING SUPPORT LOADINGS.

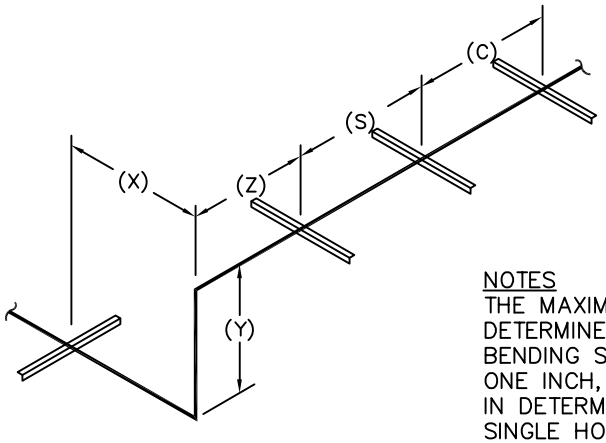
HYDRO TESTING – AS PER DESIGN STD.
PULSATING LINES – SPAN SHALL NOT BE USED.

BASIC CONDITIONS:

MATERIAL – SPANS SHALL BE USED FOR ALL PIPE MATERIAL OF EQUIVALENT OR HIGHER TENSILE STRENGTH THAN CARBON STEEL – ASTM A 53, ASTM A 106, API 5L GR. A.
INSULATION WEGHTS – IN ACCORDANCE WITH MATERIAL USED.
PRESSURE – IN ACCORDANCE WITH DSIGN PRACTICE.
TEMPERATURE – 400°F.
CORROSION ALLOWANCE – AS INDICATED. SPANS SHALL BE USED FOR LINES OF EQUIVALENT OR SMALLER CORROSION ALLOWANCE THAN THOSE SPECIFIED IN THE TABLE.
DEFLECTION – AS INDICATED (1 – 1/2" MAX.). WHERE LESS THAN THE MAXIMUM DEFLECTION AS INDICATED, THE SPAN IS LIMITED BY STRESS. ALL OTHERS ARE LIMITED BY DEFLECTION.

SUPPORT SPAN TABLE

PIPE SIZE (NB)	SUPPORT SPAN			
	GAS, VAPOUR, STEAM.		LIQUID	
	SINGLE(M)	CONTINUOUS(M)	SINGLE(M)	CONTINUOUS(M)
15	2.3	2.5	2.2	2.5
20	2.7	3.1	2.7	3.0
25	3.5	3.9	3.4	3.8
40	4.4	4.8	4.2	4.7
50	4.5	5.1	4.3	4.8
80	6.3	6.7	5.9	6.4
100	7.3	7.8	6.8	7.4
150	9.1	9.8	8.5	9.1
200	10.6	11.3	9.8	10.5
250	11.2	12.0	10.4	11.1
300	13.0	13.9	11.8	12.6
350	13.6	14.5	12.1	13.1
400	14.4	15.4	11.9	13.4
450	15.2	16.0	12.3	13.7
500	15.8	16.0	12.5	13.9
550			12.9	14.5
600	16.0	16.0	12.9	14.5
650			13.0	14.5
700			13.1	14.7
750			13.3	14.9
800			13.4	15.0
850			13.6	14.0
900			11.0	11.0
950			11.0	11.0
1000			10.0	10.0
1050			10.0	10.0
1100			9.0	9.0
1150			8.0	8.0
1200			8.0	8.0



(S)...SINGLE SPAN
(C)...CONTINUOUS SPAN
(S) = (X)+(Y)+(Z)

NOTES
THE MAXIMUM PIPE SUPPORT SPAN HAS BEEN DETERMINED BY TAKING LENGTH FROM MAXIMUM BENDING STRESS ON MAXIMUM DEFLECTION OF ONE INCH, WHICH IS SMALLER.
IN DETERMINING THE SUPPORT SPACING ON A SINGLE HORIZONTAL LINE, THE FOLLOWING FACTORS WERE CONSIDERED.

1) BENDING STRESS
(1) THE MAXIMUM BENDING STRESS WHICH IS LIMITED TO ONE HALF OF THE ALLOWABLE STRESS VALUE SPECIFIED IN ANSI B 31.3.

$S = 12.5\frac{WL^2}{Z}$ FOR SINGLE SPAN WITH FREE END.

$S = 10\ \frac{WL^2}{Z}$ FOR CONTINUOUS STRAIGHT LINE

WHERE S=MAXIMUM BENDING STRESS, KG/CM^2 L=LENGTH OF SPAN, M
Z=SECTION MODULUS OF PIPE CM^3 W=TOTAL UNIT WEIGHT, KG/M

2) DEFLECTION
(1)THE MAXIMUM DEFLECTION OF A PIPE BETWEEN SUPPORT IS ONE INCH.

$Y = \frac{5WL^4}{384EI}10^7$ FOR SINGLE SPAN WITH FREE END.

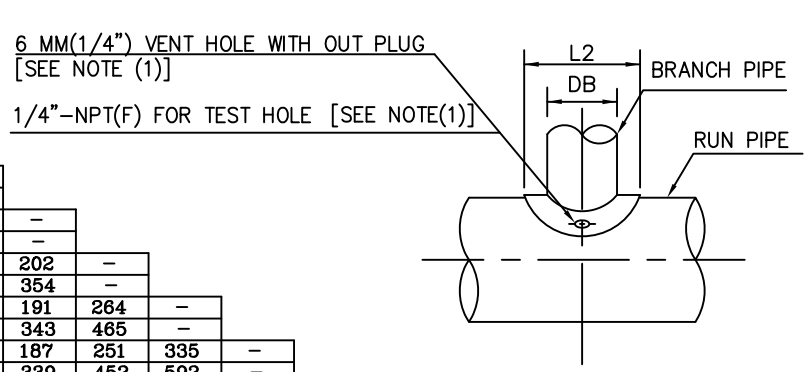
$Y = \frac{19WL^4}{1920EI}10^7$ FOR CONTINUOUS STRAIGHT LINE.

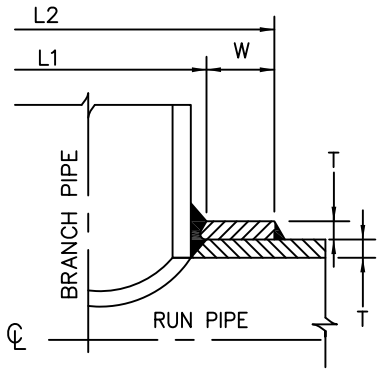
WHERE Y=MAXIMUM DEFLECTION, MM I=MOMENT OF INERTIA OF PIPE CM^4
E=MODULUS OF ELASTICITY, KG/CM^2

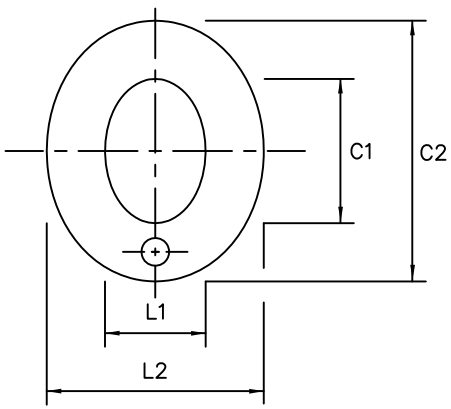
3) GENERAL CONDITION
(1) PIPE MATERIAL AND WALL THICKNESS WERE CONSIDERED AS FOLLOWS.

PIPE SIZE	PIPE MATERIAL	WALL THICKNESS	CORR. ALLOWANCE
15 – 40	A 106 B	SCH–160	2.54MM
50	API5L B	SCH–80	2.54MM
80 – 400	API5L B	STD	2.54MM
450 – 1200	A672 – A55	STD	2.54MM

(2) MAXIMUM TEMP. OF 316°C WERE TAKEN.
(3) PIPE WEIGHT WAS CONSIDERED WITH FULL OF WATER FOR LIQUID SERVICE AND 30% OF FULL OF WATER FOR GAS, VAPOUR AND STEAM SERVICE.







RUN PIPE (INCHES)		BRANCH (INCHES)	2	3	4	6	8	10	12	14	16	18	20	22	24
2	C 1		–												
	C 2		–												
3	C 1		76	–											
	C 2		126	–											
4	C 1		74	112	–										
	C 2		124	183	–										
6	C 1		72	104	136	–									
	C 2		122	175	232	–									
8	C 1		71	102	130	202	–								
	C 2		121	173	226	354	–								
10	C 1		71	101	128	191	264	–							
	C 2		121	172	224	343	465	–							
12	C 1		71	100	127	187	251	335	–						
	C 2		121	171	223	339	452	592	–						
14	C 1		71	100	126	185	246	321	417	–					
	C 2		121	171	222	337	447	578	723	–					
16	C 1		71	100	126	184	241	309	385	443	–				
	C 2		121	171	222	336	442	566	691	787	–				
18	C 1		70	99	126	182	238	303	370	417	511	–			
	C 2		120	170	222	334	439	560	676	761	905	–			
20	C 1		70	99	125	182	237	298	361	404	481	579	–		
	C 2		120	170	221	334	438	555	667	748	875	1022	–		
22	C 1		70	99	125	181	235	295	355	395	465	545	648	–	
	C 2		120	170	221	333	436	552	661	739	859	988	1140	–	
24	C 1		70	99	125	181	234	293	351	390	455	527	611	717	–
	C 2		120	170	221	333	435	550	657	734	849	970	1103	1258	–
26	C 1		70	99	125	180	233	292	349	386	448	515	590	676	787
	C 2		120	170	221	332	434	549	655	730	842	958	1082	1217	1377
28	C 1		70	99	125	180	233	290	346	382	443	507	576	653	742
	C 2		120	170	221	332	434	547	652	726	837	950	1068	1194	1332
30	C 1		70	99	125	180	232	289	345	380	439	500	566	637	717
	C 2		120	170	221	332	433	546	651	724	833	943	1058	1178	1307
32	C 1		70	99	125	180	232	289	343	378	436	496	559	626	699
	C 2		120	170	221	332	433	546	649	722	830	939	1051	1167	1289
34	C 1		70	99	125	179	232	288	342	377	433	492	553	618	687
	C 2		120	170	221	331	433	545	648	721	827	935	1045	1159	1277
36	C 1		70	99	125	179	231	287	341	375	431	489	549	611	677
	C 2		120	170	221	331	432	544	647	719	825	932	1041	1152	1267
38	C 1		70	99	125	179	231	287	340	374	429	486	545	606	670
	C 2		120	170	221	331	432	544	646	718	823	929	1037	1147	1260
40	C 1		70	99	125	179	231	287	340	373	428	484	542	602	664
	C 2		120	170	221	331	432	544	646	717	822	927	1034	1143	1254
42	C 1		70	99	125	179	231	286	339	373	427	482	539	598	659
	C 2		120	170	221	331	432	543	645	717	821	925	1031	1139	1249
44	C 1		70	99	125	179	231	286	339	372	426	481	537	595	655
	C 2		120	170	221	331	432	543	645	716	820	924	1029	1136	1245
46	C 1		70	99	124	179	230	286	338	371	425	480	536	593	651
	C 2		120	170	220	331	431	543	644	715	819	923	1028	1134	1241
48	C 1		70	99	124	179	230	285	338	371	424	479	534	590	648
	C 2		120	170	220	331	431	542	644	715	818	922	1026	1131	1238
	L 1		70	99	124	178	229	283	334	366	416	467	518	569	620
	L 2		120	170	220	330	430	540	640	710	810	910	1010	1110	1210
	W		25	35.5	48	76	100.5	128.5	153	172	197	221.5	246	270.5	295

RUN PIPE (INCHES)		BRANCH (INCHES)	26	28	30	32	34	36	38	40	42	44	46	48
26	C 1		–											
	C 2		–											
28	C 1		857	–										
	C 2		1507	–										
30	C 1		809	927	–									
	C 2		1459	1626	–									
32	C 1		781	876	998	–								
	C 2		1431	1575	1746	–								
34	C 1		762	846	943	1069	–							
	C 2		1412	1545	1691	1866	–							
36	C 1		748	825	911	1011	1140	–						
	C 2		1398	1524	1659	1808	1986	–						
38	C 1		737	810	888	976	1079	1212	–					
	C 2		1387	1509	1636	1773	1925	2108	–					
40	C 1		729	798	872	952	1042	1148	1283	–				
	C 2		1379	1497	1620	1749	1888	2044	2238	–				
42	C 1		722	788	859	934	1016	1108	1216	1355	–			
	C 2		1372	1487	1607	1731	1862	2004	2171	2359	–			
44	C 1		717	781	848	920	997	1081	1175	1285	1427	–		
	C 2		1367	1480	1596	1717	1843	1977	2130	2289	2480	–		
46	C 1		712	775	840	909	982	1060	1146	1242	1354	1500	–	
	C 2		1362	1474	1588	1706	1828	1956	2101	2246	2407	2602	–	
48	C 1		708	769	833	900	970	1044	1124	1211	1309	1424	1572	–
	C 2		1358	1468	1581	1697	1816	1940	2079	2215	2362	2526	2724	–
	L 1		670	721	772	823	874	924	975	1026	1077	1128	1178	1229
	L 2		1320	1420	1520	1620	1720	1820	1930	2030	2130	2230	2330	2430
	W		325	349.5	374	398.5	423	448	477.5	502	526.5	551	576	600.5

NOTES

1. REINFORCEMENT PAD MAY BE DIVIDED INTO TWO HALVES WITH A LONGITUDINAL WELDING SEAM , AND WITH A TEST HOLE ON EACH HALF.
2. MATERAIALS FOR REINFORCEMENT PADS SHALL BE THE SAME AS THAT OF RUN PIPE
3. IN PRINCIPLE, THICKNESS OF REINFORCEMENT PADS SHALL BE THE SAME AS THAT OF RUN PIPE. HOWEVER THE THICKNESS SHALL BE ANALYZED AND CONFIRMED IN ACCORDANCE WITH ASME B31.3 ON EACH PROJECT.
4. OUTSIDE DIAMETER OF PIPE IS BASED ON ASME B 36.10
5. DETAILS FOR BRANCH ATTACHMENT WELDS SHALL BE IN ACCORDANCE WITH ASME B31.3
6. DIMENSIONS ARE DETERMINED IN ACCORDANCE WITH THE FOLLOWING.

$L1 = DB + 10$

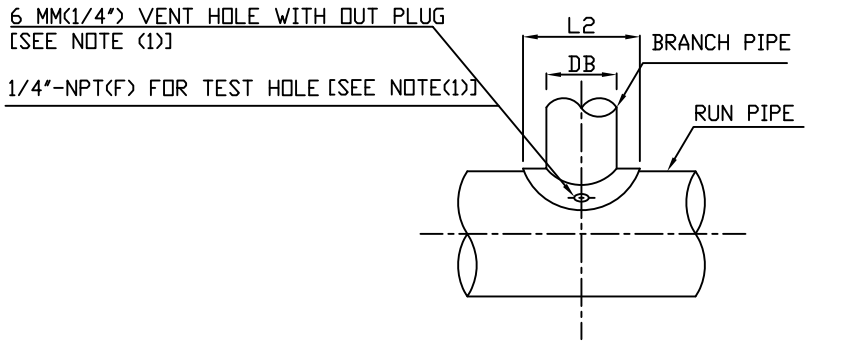
$L2 = 2 \times DB$

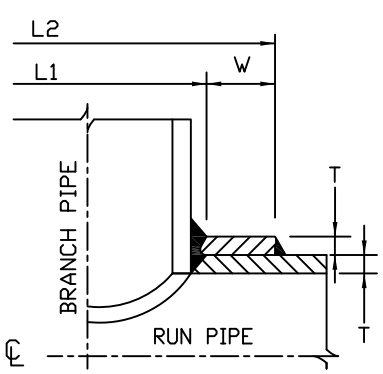
$W = (L2 - L1)/2$

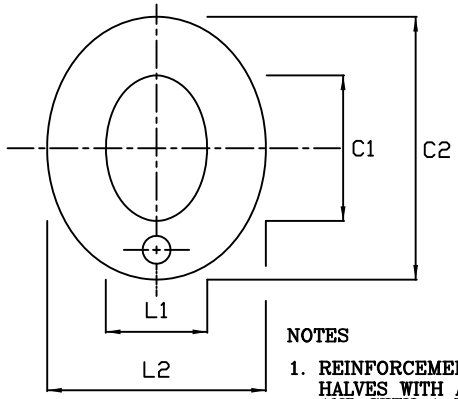
$C1 = DR \times \sin^{-1}(DB/DR) + 10$

$C2 = C1 + 2 \times W$

All dimensions in mm







NOTES

1. REINFORCEMENT PAD MAY BE DIVIDED INTO TWO HALVES WITH A LONGITUDINAL WELDING SEAM, AND WITH A TEST HOLE ON EACH HALF.
2. MATERAIALS FOR REINFORCEMENT PADS SHALL BE THE SAME AS THAT OF RUN PIPE.
3. IN PRINCIPLE, THICKNESS OF REINFORCEMENT PADS SHALL BE THE SAME AS THAT OF RUN PIPE. HOWEVER THE THICKNESS SHALL BE ANALYZED AND CONFIRMED IN ACCORDANCE WITH ASME B31.3 ON EACH PROJECT.
4. OUTSIDE DIAMETER OF PIPE IS BASED ON ASME B36.10
5. DETAILS FOR BRANCH ATTACHMENT WELDS SHALL BE IN ACCORDANCE WITH ASME B31.3
6. DIMENSIONS ARE DETERMINED IN ACCORDANCE WITH THE FOLLOWING.

$L1 = DB + 10$

$L2 = 2 \times DB$

$W = (L2-L1)/2$

$C1 = DR \times \sin^{-1}(DB/DR)+10$

$C2 = C1 + 2 \times W$

BRANCH (INCHES)		2	3	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
RUN PIPE (INCHES) 50	C 1	70	99	124	179	230	285	338	370	424	478	533	589	646	705	765	827	892	960	1031	1106	1188	1277	1376	1493	1644
	C 2	120	170	220	331	431	542	644	714	818	921	1025	1130	1236	1355	1464	1575	1689	1806	1927	2061	2192	2330	2478	2645	2845
52	C 1	70	99	124	179	230	285	337	370	423	477	531	587	644	702	761	822	886	951	1020	1092	1169	1252	1342	1444	1563	1717
	C 2	120	170	220	331	431	542	643	714	817	920	1023	1128	1234	1352	1460	1570	1683	1797	1916	2047	2173	2305	2444	2596	2764	2977
54	C 1	70	99	124	179	230	285	337	370	423	476	530	586	642	699	758	818	880	944	1011	1081	1154	1232	1316	1408	1512	1633	1790
	C 2	120	170	220	331	431	542	643	714	817	919	1022	1127	1232	1349	1457	1566	1677	1790	1907	2036	2158	2285	2418	2560	2713	2893	3099
56	C 1	70	99	124	179	230	285	337	369	422	475	529	584	640	697	755	814	875	938	1003	1071	1142	1216	1296	1381	1475	1580	1703	1863
	C 2	120	170	220	331	431	542	643	713	816	918	1021	1125	1230	1347	1454	1562	1672	1784	1899	2026	2146	2269	2398	2533	2676	2840	3012	3221
58	C 1	70	99	124	179	230	285	337	369	422	475	529	583	638	695	752	811	871	933	996	1062	1131	1203	1279	1359	1446	1541	1648	1774	1936
	C 2	120	170	220	331	431	542	643	713	816	918	1021	1024	1228	1345	1451	1559	1668	1779	1892	2017	2135	2256	2381	2511	2647	2801	2957	3132	3344
60	C 1	70	99	124	179	230	285	336	369	421	474	528	582	637	693	750	808	867	928	991	1055	1122	1192	1265	1341	1423	1511	1608	1717	1844	2009
	C 2	120	170	220	331	431	542	642	713	815	917	1020	1123	1227	1343	1449	1556	1664	1774	1887	2010	2126	2245	2367	2493	2624	2771	2917	3075	3252	3466
62	C 1	70	99	124	179	230	284	336	369	421	474	527	581	636	691	748	805	864	924	986	1049	1114	1182	1253	1326	1404	1487	1577	1675	1785	1915	2083
	C 2	120	170	220	331	431	541	642	713	815	917	1019	1122	1226	1341	1447	1553	1661	1770	1882	2004	2118	2235	2355	2478	2605	2747	2886	3033	3193	3372	3589
64	C 1	70	99	124	179	230	284	336	368	421	473	527	580	635	690	746	803	861	920	981	1041	1107	1174	1242	1314	1389	1468	1552	1642	1742	1854	1986	2156
	C 2	120	170	220	331	431	541	642	712	815	916	1019	1121	1225	1340	1445	1551	1658	1766	1877	1998	2111	2227	2344	2466	2590	2728	2861	3000	3150	3311	3492	3711
66	C 1	70	99	124	179	230	284	336	368	420	473	526	580	634	689	744	801	859	917	977	1039	1102	1166	1233	1303	1375	1451	1531	1616	1708	1809	1923	2057	2230
	C 2	120	170	220	331	431	541	642	712	814	916	1018	1121	1224	1339	1443	1549	1656	1763	1873	1994	2106	2219	2335	2455	2576	2711	2840	2974	3116	3266	3429	3612	3844
68	C 1	70	99	124	179	230	284	336	368	420	473	526	579	633	688	743	799	856	914	974	1034	1096	1160	1225	1293	1364	1437	1514	1595	1681	1774	1877	1992	2128	2303
	C 2	120	170	220	331	431	541	642	712	814	916	1018	1120	1223	1338	1442	1547	1653	1760	1870	1989	2100	2213	2327	2445	2565	2697	2823	2953	3089	3231	3383	3547	3742	3967
70	C 1	70	99	124	179	230	284	336	368	420	472	525	578	632	687	742	797	854	912	970	1030	1091	1154	1219	1285	1353	1425	1499	1577	1659	1746	1841	1945	2061	2199	2377
	C 2	120	170	220	331	431	541	642	712	814	915	1017	1119	1222	1337	1441	1545	1651	1758	1866	1985	2095	2207	2321	2437	2554	2685	2808	2935	3067	3203	3347	3500	3675	3863	4090
72	C 1	70	99	124	179	230	284	336	368	420	472	525	578	631	686	740	796	852	909	968	1027	1087	1149	1212	1277	1345	1414	1486	1561	1640	1723	1812	1907	2012	2131	2270	2451
	C 2	120	170	220	331	431	541	642	712	814	915	1017	1119	1221	1336	1439	1544	1649	1755	1864	1982	2091	2202	2314	2429	2546	2674	2795	2919	3048	3180	3318	3462	3626	3795	3983	4213
80	C 1	70	99	124	178	230	284	335	367	419	471	523	576	629	683	737	791	846	902	958	1016	1074	1133	1193	1255	1318	1383	1448	1516	1586	1658	1733	1812	1893	1981	2074	2175	2285
	C 2	120	170	220	330	431	541	641	711	813	914	1015	1117	1219	1333	1436	1539	1643	1748	1854	1971	2078	2186	2295	2407	2519	2642	2757	2874	2994	3115	3239	3367	3508	3645	3787	3937	4096
84	C 1	70	99	124	178	229	284	335	367	419	471	523	575	628	681	735	789	844	899	955	1012	1069	1127	1186	1246	1308	1370	1434	1500	1567	1636	1707	1781	1858	1938	2023	2112	2207	2700
	C 2	120	170	220	330	430	541	641	711	813	914	1015	1116	1218	1331	1434	1537	1641	1745	1851	1967	2073	2180	2286	2398	2509	2630	2743	2858	2975	3093	3213	3336	3472	3602	3736	3874	4018	4718
96	C 1	70	99	124	178	229	284	335	367	418	470	522	574	626	679	732	785	839	893	947	1002	1058	1114	1171	1228	1287	1346	1406	1467	1529	1592	1656	1722	1789	1858	1929	2002	2078	2412	2608
	C 2	120	170	220	330	430	541	641	711	812	913	1014	1115	1216	1329	1431	1533	1636	1739	1843	1957	2062	2167	2273	2380	2488	2606	2715	2825	2937	3049	3162	3277	3403	3522	3642	3764	3889	4430	4724
100	C 1	70	99	124	178	229	284	335	367	418	470	521	573	626	678	731	784	837	891	945	1000	1055	1111	1167	1224	1282	1340	1399	1459	1520	1582	1644	1709	1774	1841	1909	1980	2052	2365	2543	3279
	C 2	120	170	220	330	430	541	641	711	812	913	1013	1114	1216	1328	1430	1532	1634	1737	1841	1955	2059	2164	2269	2376	2483	2600	2708	2817	2928	3039	3150	3264	3388	3505	3622	3742	3863	4383	4659	5701
110	C 1	70	99	124	178	229	284	335	367	418	469	521	573	625	677	729	782	835	888	942	996	1050	1105	1160	1215	1272	1328	1386	1444	1502	1562	1622	1683	1745	1808	1872	1937	2004	2285	2438	2974	3198
	C 2	120	170	220	330	430	541	641	711	812	912	1013	1025	1215	1327	1428	1530	1632	1734	1838	1951	2054	2158	2262	2367	2473	2588	2695	2802	2910	3019	3128	3238	3359	3472	3585	3699	3815	4303	4554	5396	5728

BRANCH (INCHES)		2	3	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	80	84	96	100
	L 1	70	99	124	178	229	283	334	366	416	467	518	569	620	670	721	772	823	874	924	975	1026	1077	1128	1178	1229	1280	1331	1382	1432	1483	1534	1585	1436	1686	1737	1788	1839	2042	2144	2488	2550
	L 2	120	170	220	330	430	540	640	710	810	910	1010	1110	1210	1320	1420	1520	1620	1720	1820	1930	2030	2130	2230	2330	2430	2540	2640	2740	2840	2940	3040	3140	3250	3350	3450	3550	3650	4060	4260	4870	5080
	W	25	36	48	76	100	128	153	172	197	221	246	271	295	325	349	374	399	423	448	477	502	527	551	576	600	630	655	679	704	728	753	778	807	832	856	881	906	1009	1058	1211	1265

All dimensions in mm

	CS WELDED PIPES TO API 5L SPIRAL LONG. WELDED	
1	HEAVY METAL PIPE CENTRE (UPTO 24" (UPTO SCHXXS)	INDIA
2	JINDAL PIPES LTD. (2" TO 14")	INDIA
3	JOTINDRA STEEL & TUBES LTD. (½" TO 14")	INDIA
4	KALPESH TUBE(INDIA), (TRADER)	INDIA
5	LALIT PIPES & PIPES LTD.. (16" TO 64" THICKNESS UPTO 20MM)	INDIA
6	MUKAT PIPES LTD.	INDIA
7	P.K.FORGE & FITTING INDUSTRIES	INDIA
8	PRATIBHA INDUSTRIES LTD. (16" TO 24" THICKNESS 6MM TO 14.27MM)	INDIA

9	RATNAMANI METALS & TUBES LTD.	INDIA
10	SAGAR STEEL CORPORATION (TRADER)	INDIA
11	SAIL	INDIA
12	SURINDRA ENGINEERING CO. PVT. LTD.	INDIA
13	SURYA ROSHINI LTD (GR. A 3" TO 4", GR. B, 6" TO 14")	INDIA
14	THE BENGAL MILL STORES SUPPLY CO.(TRADER)	INDIA
15	WELSPUN GUJARAT STAHL ROHREN LIMITED (FOR ANJAR AND DAHEJ PLANTS) (UPTO 72" 50 MM THK FOR DAHEJ PLANT AND UPTO 100" 30 MM THK. FOR ANJAR PLANT.)	INDIA
16	PHOCEENNE	FRANCE
17	ETS TROUVAY & CAUVIN	FRANCE
18	MANNESMANN HANDEL AG	GERMANY
19	THYSSEN-KRUPP STAHLUNION GMBH	GERMANY
20	DALMINE SPA	ITALY
21	RACCORTUBI SRL	ITALY
22	KOSEI SANGYO LTD	JAPAN
23	MARUBENI ITOCHU STEEL	JAPAN
24	MITSUBISHI CORPORATION	JAPAN
25	NIPPON KOKAN	JAPAN
26	NIPPON STEEL CORPORATION	JAPAN
27	NISHITANI & CO. LTD.	JAPAN
28	NISSHO IWAI CORPORATION	JAPAN
29	OKURA & CO. LTD.	JAPAN
30	SOJITZ CORPORATION	JAPAN
31	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
32	HYUNDAI CORPORATION	KOREA
33	BRITISH STEEL CORPORATION	U.K.
34	CORUS TUBES LIMITED	U.K.
35	SAW PIPES USA, INC	U.S.A
	CS/AS LTCS SEAMLESS PIPES	
1	BHEL	INDIA
2	CHETAN STEELS (UPTO 12", SCH80)	INDIA
3	HEAVY METAL & TUBES (UPTO 8", THICKNESS	INDIA

	UPTO 18.26MM)	
4	HEAVY METAL PIPE CENTRE (UPTO 24" (UPTO SCHXXS)	INDIA
5	INDIAN TUBE CO. (TATA DEV. OF TUBES & PIPES)	INDIA
6	ISMT LIMITED	INDIA
7	JINDAL SAW LTD.	INDIA
8	MAHARASHTRA SEAMLESS LTD.	INDIA
9	P.K.FORGE & FITTING INDUSTRIES	INDIA
10	RATNADEEP METAL & TUBES PVT. LTD.	INDIA
11	SAINEST TUBES PVT. LTD. (½ " NB TO 3" UPTO SCH. 160 (ASTM A 106 GR. B, A333 GR. 1 & 6 & A335 GR. P11))	INDIA
12	PHOCEENNE	FRANCE
13	ETS TROUVAY & CAUVIN	FRANCE
14	MANNESMANN HANDEL AG	GERMANY
15	HORST KURVERS GMBH	GERMANY
16	DALMINE SPA	ITALY
17	GAM RACCORDI S.P.A	ITALY
18	IBF SEAMLESS PIPES SPA	ITALY
19	RACCORTUBI SRL	ITALY
20	MARUBENI ITOCHU STEEL	JAPAN
21	MITSUBISHI CORPORATION	JAPAN
22	NIPPON STEEL CORPORATION	JAPAN
23	NISHITANI & CO. LTD.	JAPAN
24	NISSHO IWAI CORPORATION	JAPAN
25	OKURA & CO. LTD.	JAPAN
26	SOJITZ CORPORATION	JAPAN
27	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
28	HYUNDAI CORPORATION	KOREA
29	AB SANDVIK STEEL	SWEDEN
30	VOMAL INTERNATIONAL LIMITED	U.K.
31	CORUS TUBES LIMITED	U.K.
32	BRITISH STEEL CORPORATION	U.K.
	SS SEAMLESS/ WELDED PIPES	

1	APEX TUBES	INDIA
2	BHANDARI FOILS & TUBES LIMITED (SEAMLESS UPTO 4" (SCH. 80) & WELDED UPTO 20" (THK. <= 8	INDIA
3	CHOKSI TUBE COMPANY LTD.	INDIA
4	CHETAN STEELS (UPTO 6" SCH. 40)	INDIA
5	HEAVY METAL & TUBES (UPTO 8" (THICKNESS UPTO 18.26 MM))	INDIA
6	HEAVY METAL PIPE CENTRE (UPTO 8" (UPTO SCH80S) (PDIL APPROVED MANUFACTURER'S MAKE ONLY))	INDIA
7	JINDAL SAW LTD.	INDIA
8	KRYSTAL STEEL MANUFACTURING PVT. LTD. (UPTO 2" (MATERIAL UPTO GRADE SS 321))	INDIA
9	MARDALE PIPES PLUS LTD.	INDIA
10	MODERN TUBE INDUSTRIES LTD. (UPTO 2" (UPTO SS GRADE 321))	INDIA
11	NUCLEAR FUEL COMPLEX	INDIA
12	P.K.FORGE & FITTING INDUSTRIES	INDIA
13	PRAKASH STEELAGE LTD. (SEAMLESS: UPTO 12" & WELDED: UPTO 24")	INDIA
14	QUALITY STAINLESS PVT. LTD.	INDIA
15	RAJENDRA MECHANICAL INDUSTRIES LTD.	INDIA
16	RATNAMANI METALS & TUBES LTD.	INDIA
17	RATNADEEP METAL & TUBES PVT. LTD. (SMLS. 6" , WELDED 2")	INDIA
18	SANDVIK ASIA PVT. LTD. (¾" TO 2" (THK: UPTO 8.74 MM))	INDIA
19	SANGHVI METALS (TRADER)	INDIA
20	SCORODITE STAINLESS (INDIA) PVT. LTD. (UPTO 2" (UPTO SS GRADE 321))	INDIA
21	SUBHLAXMI METALS & TUBES PVT. LTD. (SEAMLESS: UPTO 2" & WELDED: UPTO 8")	INDIA
22	SURAJ STAINLESS LIMITED	INDIA
23	THE BENGAL MILL STORES SUPPLY CO.(TRADER)	INDIA
24	ZHEJIANG JIULI STAINLESS STEEL PIPE CO. LTD.	CHINA
25	ETS TROUVAY & CAUVIN	FRANCE
26	PHOCEENNE	FRANCE
27	H. BUTTING GMBH & CO. (SEAMLESS : UPTO 30"	GERMANY

	(UPTO 16MM THK) & WELDED: UPTO 72" (UPTO 64MM)	
28	HORST KURVERS GMBH	GERMANY
29	MANNESMANN HANDEL AG	GERMANY
30	THYSSEN-KRUPP STAHLUNION GMBH	GERMANY
31	DALMINE SPA	ITALY
32	GAM RACCORDI S.P.A	ITALY
33	IBF SEAMLESS PIPES SPA	ITALY
34	RACCORTUBI SRL	ITALY
35	MARUBENI ITOCHU STEEL	JAPAN
36	MITSUBISHI CORPORATION	JAPAN
37	NIPPON STEEL CORPORATION	JAPAN
38	NISHITANI & CO. LTD.	JAPAN
39	NISSHO IWAI CORPORATION	JAPAN
40	OKURA & CO. LTD.	JAPAN
41	SOJITZ CORPORATION	JAPAN
42	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
43	AB SANDVIK STEEL	SWEDEN
44	T.T.I. – TUBACEX TUBOS INOXIDABLES, S.A.	SPAIN
45	SOSTA BV (UPTO 72" (THICKNESS UPTO 25.4 MM))	NETHERLAND
46	VOMAL INTERNATIONAL LIMITED	U.K.
47	CORUS TUBES LIMITED	U.K.
48	BRITISH STEEL CORPORATION	U.K.
49	HYUNDAI CORPORATION	KOREA
	SS SEAMLESS TUBES	
1	ANIL METAL CORPORATION	INDIA
2	APEX TUBES PVT. LIMITED (UPTO 50.8 MM OD (THICKNESS UPTO 4.00 MM))	INDIA
3	BHANDARI FOILS & TUBES LIMITED (UPTO 50MM OD)	INDIA
4	HEAVY METAL & TUBES (UPTO 8" (THICKNESS UPTO 18.26 MM))	INDIA
5	KRYSTAL STEEL MANUFACTURING PVT. LTD. (UPTO 50.8 MM OD (MATERIAL UPTO GRADE SS 321))	INDIA
6	MODERN TUBE INDUSTRIES LIMITED (UPTO 50.80 MM OD (UPTO SS GRADE 321))	INDIA

7	PRAKASH STEELAGE LTD. (SEAMLESS: UPTO114 MM OD, THICKNESS UPTO 6 MM)	INDIA
8	RATNAMANI METALS & TUBES LTD.	INDIA
9	SANDVIK ASIA PVT. LTD. (OD UPTO 60.33 (THK: UPTO 8.74 MM))	INDIA
10	SCORODITE STAINLESS (INDIA) PVT.LTD. (UPTO 50.80 OD (UPTO SS GRADE 321))	INDIA
11	SURAJ STAINLESS LIMITED	INDIA
12	T.T.I.-TUBACEX TUBOS INOXIDABLES, S.A.(OD 15.8 MM TO 250.0 MM, WALL THK.1.0 MM)	SPAIN
	FITTINGS: CS/AS/SS SEAMLESS & FORGED	
1	AMFORGE INDUSTRIES	INDIA
2	ANIL METAL CORPORATION	INDIA
3	CHETAN STEELS (UPTO 6" SCH. 80)	INDIA
4	COMMERCIAL SUPPLYING AGENCY	INDIA
5	CSA FITTINGS (FORGED ½" TO 2"-UPTO 900#, SEAMLESS: 2" TO 8"- UPTO SCHXXS)	INDIA
6	EBY FASTENERS	INDIA
7	EBY INDUSTRIES	INDIA
8	FIT-TECH INDUSTRIES (FORGED ½" TO 1 1/2"-UPTO 900#, SEAMLESS: 2" TO 8"- UPTO SCHXXS)	INDIA
9	FLASH FORGE(P) LTD.(FORGED UPTO 4"-UPTO 900#, SEAMLESS/WELDED: UP TO 42")	INDIA
10	GUJARAT INFRAPIPES PVT. LTD.	INDIA
11	KALPESH TUBE(INDIA),(TRADER) (UPTO A MAX ORDER VALUE RS.25.0 LAKH)	INDIA
12	M.S FITTINGS MANUFACTURING CO. PVT LTD.	INDIA
13	MARDALE PIPES PLUS LTD.	INDIA
14	NAVKAR FORGINGS & FITTINGS PVT. LTD	INDIA
15	NL HAZRA (UPTO SCH80)	INDIA
16	P.K TUBES & FITTINGS PVT. LTD.	INDIA
17	P.K FORGE & FITTING INDUSTRIES	INDIA
18	PARAS FITTINGS PVT. LTD. (FORGED: CS ½" TO 2" & CS SEAMLESS: 2" TO 8"- UPTO SCHXXS)	INDIA
19	PARMAR TECHNO FORGE (ELBOW, TEE, REDUCER- ½" TO 12" & CAP UPTO 18")	INDIA
20	PERFECT MARKETTING PVT. LTD.	INDIA

21	PETROCHEM INDUSTRIES (SEAMLESS: UPTO 16" (ALL FITTINGS) & UPTO 36" (CAPS) SCH : XXS /80S, FORGED: UPTO 3"-6000#)	INDIA
22	RAJENDRA FORGE INDUSTRIES (CS: UPTO 12" SCH 40 & SS: 6" SCH 40S)	INDIA
23	S & G ENGINEERS (P) LTD.	INDIA
24	SAGAR STEEL CORPORATION (TRADER)	INDIA
25	SANGHVI METALS (TRADER)	INDIA
26	SAWAN ENGINEERS	INDIA
27	SHIVANANDA PIPE FITTINGS LTD.,	INDIA
28	STEWARTS AND LLOYDS OF INDIA LIMITED	INDIA
29	TEEKAY TUBES PRIVATE LIMITED	INDIA
30	THE BENGAL MILL STORES SUPPLY CO.(TRADER)	INDIA
31	TOPAZ PIPING INDUSTRIES	INDIA
32	TUBE BEND (CALCUTTA) PVT. LTD. (CS FITTINGS ONLY)	INDIA
33	TUBE PRODUCTS INCORPORATE	INDIA
34	ZOLOTO INDUSTRIES (UPTO 6" (ONLY CS GALV.))	INDIA
35	PHOCEENNE	FRANCE
36	ETS TROUVAY & CAUVIN	FRANCE
37	VALLOUREC	FRANCE
38	SEIKMANN ANLAGEN-TECHNIK GMBH.	GERMANY
39	TPS-TECHNITUBE ROHRENWERKE GMBH	GERMANY
40	MANNESMANN HANDEL AG	GERMANY
41	HORST KURVERS GMBH	GERMANY
42	PETROL RACCORD S.P.A. (SEAMLESS: 1" TO 42" (ELBOW) & 1" TO 56" TEE/REDUCER/CAP))	ITALY
43	DALMINE SPA	ITALY
44	GAM RACCORDI S.P.A	ITALY
45	IBF SEAMLESS PIPES SPA	ITALY
46	IND MECCANICA BASSI LUIGI & C. SPA	ITALY
47	MANTOVANI SPA	ITALY
48	RACCORTUBI SRL	ITALY
49	TECHNO FORGE SPA	ITALY
50	MARUBENI ITOCHU STEEL	JAPAN

51	NIPPON KOKAN	JAPAN
52	NISHITANI & CO. LTD.	JAPAN
53	NISSHO IWAI CORPORATION	JAPAN
54	OKURA & CO. LTD.	JAPAN
55	SOJITZ CORPORATION	JAPAN
56	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
57	HAITIMA CORPORATION	TAIWAN
58	CORUS TUBES LIMITED	U.K.
59	BRITISH STEEL CORPORATION	U.K.
60	EUROTUBE LIMITED	U.K.
61	VOMAL INTERNATIONAL LIMITED	U.K.
62	BONNEY FORGE	U.S.A.
	FORGED FLANGES	
1	AJAY FORGING PVT. LTD	INDIA
2	AMFORGE INDUSTRIES	INDIA
3	ANANDMAYEE FORGINGS PVT. LTD.	INDIA
4	C D ENGINEERING	INDIA
5	CHAUDHARY HAMMER WORKS (P) LTD.	INDIA
6	CHETAN STEELS (UPTO 6", 150#)	INDIA
7	`ECHJAY INDUSTRIES LTD	INDIA
8	FERROUS ALLOYS FORGING PVT. LTD	INDIA
9	GOOD LUCK ENGINEERING CO. (½"-12" (UPTO 2500#), 14"-16" (UPTO 900#), 18"-32" (UPTO 600#), 34"-48" (UPTO 300#),	INDIA
10	J.K FORGINGS	INDIA
11	KUNJ FORGINGS PVT. LTD.(MATERIAL CS/SS/AS) (UPTO 60" (UPTO 300#) & UPTO 12" (UPTO 2500#))	INDIA
12	MAHESH INDUSTRIES (UPTO 8" -150#, MATERIAL ASTM A105 ONLY)	INDIA
13	P.K TUBES & FITTINGS PVT. LTD. (UPTO 24"(UPTO1500#) & UPTO 12"(UPTO2500#) SPECTACLE BLIND AND SPACER & BLINDS ONLY)	INDIA
14	PARAMOUNT FORGE (CS,AS & SS : ½" TO 42" (UPTO 600#), ½" TO 24" (UPTO 900#, ½ " TO 16" (UPTO 1500#), ½" TO 12" (UPTO 2500#)).	INDIA
15	PERFECT MARKETING (P) LTD.	INDIA

16	PUNJAB STEEL	INDIA
17	R D FORGE (A UNIT OF R D CHEMICALS PVT LTD) (UPTO 54" (150#), 42" (UPTO 600#), 20" (UPTO 1500#) & 12" (2500#))	INDIA
18	RAJENDRA FORGE INDUSTRIES (CS & SS : UPTO 12", 300#)	INDIA
19	S & G ENGINEERS (P) LTD.	INDIA
20	SANGHVI FORGINGS & ENGINEERING LTD	INDIA
21	SANGHVI METALS (TRADER)	INDIA
22	SAWAN ENGINEERS	INDIA
23	TECHNO FORGE LTD. (UPTO 42" (UPTO 300#), UPTO 24" (600#), UPTO 20" (900#), UPTO 16" (1500#),	INDIA
24	TUBE BEND (CALCUTTA) PVT LTD	INDIA
25	PHOCEENNE	FRANCE
26	ETS TROUVAY & CAUVIN	FRANCE
27	HORST KURVERS GMBH	GERMANY
28	I.S. INTERNATIONAL	ITALY
29	MANTOVANI SPA	ITALY
30	OFFICINE NICOLA GALPERTI & FIGLIO S.P.A	ITALY
31	RACCORTUBI SRL	ITALY
32	NICHINAN SANGYO CO. LTD.,	JAPAN
33	NISHITANI & CO. LTD.	JAPAN
34	SOJITZ CORPORATION	JAPAN
35	VOMAL INTERNATIONAL LIMITED	U.K.
	GATE/ GLOBE/ CHECK VALVES CS/SS/AS < 900 LBS	
1	AV VALVES LTD. (CAST UPTO 42" ,150#) 28" 300#, 24" (600#) & FORGE UPTO 2" (800#)	INDIA
2	ADVANCE VALVES (2"-80" (UPTO 600#) DUAL PLATE CHECK VALVES ONLY)	INDIA
3	ASSOCIATED TOOLINGS (I) PVT. LTD.	INDIA
4	AUDCO INDIA LIMITED (L&T VALVES DIVN.)	INDIA
5	AUTOCAP INDUSTRIES (1/2" TO 2" 800# (ONLY CS & SS)	INDIA
6	BELL- O-SEAL VALVES LTD.(FOR ZERO LEAKAGE , HAZARDOUS FLUIDS.)	INDIA
7	BHEL (VALVES DIVISION)	INDIA

8	BRIGHTECH VALVES AND CONTROLS PVT. LTD. (UPTO 8" X 300#)	INDIA
9	CHEMTECH INDUSTRIAL VALVES PVT. LTD.	INDIA
10	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD. (<=300#, (ONLY CS))	INDIA
11	DATRE CORPORATION LTD. (UPTO 300#, 2" TO 8" (GATE), 2" TO 6" (GLOBE & CHECK VALVES))	INDIA
12	DEWRANCE MACNEILL & CO. LTD.	INDIA
13	ECONO VALVES PVT. LTD.	INDIA
14	EXPERT ENGINEERING ENTERPRISES	INDIA
15	FLOCON SYSTEMS PVT. LTD. (CS UPTO 6" – 1500#)	INDIA
16	FLOVEL VALVES PVT. LTD.(SINGLE DISC , DULA PLATE & NOZZLE CHECK VALVES ONLY : UPTO 48" (150#) & 24 (UPTO 600#)	INDIA
17	FLUIDTECH EQUIPMENT PVT. LTD. (CAST # CS & SS 2" TO 12" 150# & 2 " TO 8" 300 # AND FORGED (CS AND SS) ½" TO 2" (800#)	INDIA
18	FORWARD ALLOYS & CASTINGS (UPTO 14")	INDIA
19	GURU INDUSTRIAL VALVES PVT. LTD. (CAST CS ONLY: UPTO 24"(150#), 20"(300#), 10" (600#) & FORGED : UPTO 2" (800#)	INDIA
20	HI-TECH VALVES PVT. LTD. (CS,<=800 #, SIZE ½-2, <=300# FOR SIZE 2-6")	INDIA
21	INTERVALVE INDIA LTD. (CAST UPTO 24" (UPTO 300#) & UPTO 12" 600# , FORGED UPTO 2" (800#))	INDIA
22	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 48" (150#) & 24" (UPTO 600#) & FORGED UPTO 2" (800#))	INDIA
23	KIRLOSKAR BROTHERS LTD.(CS UPTO 12" , 300#)	INDIA
24	KSB PUMPS LIMITED (VALVES DIVN)	INDIA
25	LARSEN & TOUBRO LIMITED (1/2" TO 24")	INDIA
26	M.H. VALVES PVT. LTD. (1/2" TO 1 1/2"-800#, 2" TO 6"-600#)	INDIA
27	MICROFINISH VALVES LTD.	INDIA
28	NSSL LTD. (UPTO 80" (150#), 56" UPTO 600# & FORGED UPTO 2" (800 #))	INDIA
29	NITON VALVES INDUSTRIES PVT. LTD.	INDIA
30	OSWAL IND. LTD. (UPTO 48" (150#), 32" (300#) & 24" (600#)	INDIA
31	S & M INDUSTRIAL VALVES LTD. (CS GATE &	INDIA

	GLOBE VALVES 2" – 24" <=300#)	
32	SHALIMAR VALVES PVT. LTD. (CAST UPTO 24" (UPTO 600#), FORGED: ½" TO 1 ½" (800#))	INDIA
33	SHREERAJ INDUSTRIES (CS UPTO 150#)	INDIA
34	STEEL STRONGVALVES (I) PVT. LTD. (UPTO 42")	INDIA
35	VENUS PUMP & ENGINEERING WORKS.	INDIA
36	VIBA FLUID CONTROL	INDIA
37	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (CAST UPTO 36" (150#); 24" (300#); 12" (600#) & FORGED: UPTO 2" (800#))	INDIA
38	ZED VALVES CO. PVT. LTD. (UPTO 14" (600#))	INDIA
39	VELAN INC. (UPTO 48", 600#)	CANADA
40	PEMTO VALVE	GERMANY
41	CESARE BONETTI SPA (CAST UPTO 42" (UPTO 300#), 24" (600#) FORGED: ½" TO 1 ½" (800#))	ITALY
42	FASANI S.P.A.	ITALY
43	FRIULCO SPA (UPTO 48" (150#), 32" (UPTO 600#)	ITALY
44	GTC ITALIA, S.R.L.	ITALY
45	MANTOVANI SPA	ITALY
46	OMB S.P.A.	ITALY
47	PETROL VALVES S.R.L.	ITALY
48	MATSURA H. P MACHINE WORKS CO.LTD.	JAPAN
49	NISHITANI & CO. LTD.	JAPAN
50	SOJITZ CORPORATION	JAPAN
51	REDPOINT ALLOYS BV	NETHERLAND
52	WALTHAN & WEIR	SPAIN
53	POYAM VALVES (AMPO S.CCP.) (SIZE UPTO 60" (RATING UPTO 800#)	SPAIN
54	BABCOCK BORSIG ESPANA , S.A	SPAIN
55	SUFA LIMITED	U.A.E.
56	BEL VALVES	U.K.
	GATE/ GLOBE/ CHECK VALVES CS/SS/AS > =900 LBS	
1	A V VALVES LIMITED (CAST UPTO 24" (900# & 1500#), 8" (2500#) FORGED: UPTO 2" (2500#))	INDIA
2	ADVANCE VALVES (2"-36" (900#) 2"-24" (1500#), 2"-12(2500#) FORGED: UPTO 2" (2500#)) FOR DUAL PLATE CHECK VALVES)	INDIA

3	AUDCO INDIA LIMITED (L&T VALVES DIVN.)	INDIA
4	BHEL (VALVES DIVISION)	INDIA
5	FLOVEL VALVES PVT. LTD. (DUAL PLATE CHECK VALVES: UPTO 24" (900#)	INDIA
6	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 12" (1500#),10" (2500#) & FORGED UPTO 2" (2500#))	INDIA
7	KSB PUMPS LIMITED (VALVES DIVN)	INDIA
8	LARSEN & TOUBRO LIMITED (1/2" TO 2")	INDIA
9	METROPOLITAN INDUSTRIES (SIZE=200MM, RATING=2500 LB)	INDIA
10	NSSL LIMITED. (CAST: UPTO 36"(900#), 24" (UPTO 2500#) & FORGED: UPTO 2" (UPTO 2500#))	INDIA
11	OSWAL INDUSTRIES LTD. (UPTO 12" (900# & 1500#))	INDIA
12	SHALIMAR VALVES PVT.LTD.(CAST: UPTO 20"(900#), FORGED: ½" TO 1 ½" (1500#))	INDIA
13	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (CAST UPTO 12" (UPTO 2500#) & FORGED: UPTO 2" (1500#), 1" (2500#))	INDIA
14	VELAN INC. (UPTO 24" (RATING UPTO 2500#))	CANADA
15	BFE BONNEY FORGE VALVE LICENSEE	ITALY
16	CESARE BONETTI SPA (UPTO 24" (UPTO 2500#)	ITALY
17	FASANI S.P.A.	ITALY
18	FRIULCO SPA (UPTO 32" (900#); 24" (1500#); 14" (2500#))	ITALY
19	GTC ITALIA S.R.L.	ITALY
20	OMB S.P.A.	ITALY
21	PETROL VALVES S.R.L.	ITALY
22	VALVITALIA SPA	ITALY
23	MATSURA H. P MACHINE WORKS CO.LTD.	JAPAN
24	NISHITANI & CO. LTD.	JAPAN
25	BABCOCK BORSIG ESPANA, S.A.	SPAIN
26	POYAM VALVES, (AMPO S. COOP.) (SIZE UPTO 30" (RATING UPTO 2500#))	SPAIN
27	SUFA LIMITED	U.A.E.
28	BEL VALVES	U.K.
	BALL VALVES (SOFT SEATED)	

1	A V VALVES LIMITED (UPTO 12" (UPTO 600#))	INDIA
2	AIRA EURO AUTOMATION PVT. LTD. (UPTO 6", RATING 150# & 300#),	INDIA
3	AQUA VALVES PVT. LTD.	INDIA
4	BRIGHTECH VALVES & CONTROLS PVT. LTD. (4" X 150# FOR CS, AS & SS MATERIAL)	INDIA
5	CHEMTECH INDUSTRIAL VALVES PVT. LTD.	INDIA
6	CRAWLEY & RAY (FOUNDER & ENGINEERS) PVT. LTD. (DN25)	INDIA
7	DELVAL FLOW CONTROLS PVT. LTD. (UPTO 12" (UPTO 900#))	INDIA
8	FLOCON SYSTEMS PVT. LTD. (CS UPTO 6", 150#)	INDIA
9	FLOW CONTROL	INDIA
10	FLOWCHEM INDUSTRIES (UPTO 300# AND UPTO 10")	INDIA
11	FLUIDTECH EQUIPMENT PVT. LTD(UPTO 4" (300#))	INDIA
12	FORWARD ALLOYS AND CASTINGS (UPTO 900#)	INDIA
13	GURU INDUSTRIAL VALVES PVT. LTD. (CAST CS ONLY: UPTO 12" (UPTO 300#), 4" (UPTO 900#) & FORGED: UPTO 2" (800#))	INDIA
14	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 28" (UPTO 600#),12" (900# , 1500#) & 10" (2500#))	INDIA
15	KSB PUMPS LTD. (VALVES DIVN.) (CS UPTO 100DN, 20 BAR)	INDIA
16	MICROFINISH VALVES (P) LTD.	INDIA
17	NSSL LTD. (UPTO 12" (150# & 300#))	INDIA
18	OSWAL IND. LTD. (UPTO 24" (150#, 300# & 600#))	INDIA
19	SHALIMAR VALVES PVT. LTD. (UPTO 18" (600#) MATERIAL: CS/AS/SS)	INDIA
20	VIBA FLUID CONTROL (UPTO 300#)	INDIA
21	VIRGO ENGINEERS LTD. (UPTO 16" (UPTO 600#))	INDIA
22	WEIR BDK VALVES (CAST: UPTO 30" (150# & 300#), 20" (600#), 16" (900#), 12" (1500#) & FORGED: UPTO 2" (800#))	INDIA
23	XOMOX SANMAR LTD.(FISHER XOMOX)	INDIA
24	BHDT GMBH	AUSTRIA
25	VELAN INC.(UPTO 16", 600#)	CANADA

26	ETS TROUVAY & CAUVIN	FRANCE
27	PERRIN GMBH (2500#, SIZE UPTO 24")	GERMANY
28	FRIULCO SPA (UPTO 48" (150# & 300#); 20" (UPTO 1500#); 12" (2500#))	ITALY
29	CESARE BONETTI SPA (CAST: UPTO 4" (150#) & FORGED: UPTO 1" (800#) FLOATING ONLY)	ITALY
30	GTC ITALIA S.R.L	ITALY
31	MANTOVANUI SPA	ITALY
32	PIBIVESSE SRL (UPTO 48" , 600#)	ITALY
33	PETROL VALVES S.R.L	ITALY
34	METSO AUTOMATION	SINGAPORE
35	POYAM VALVES (AMPO S. COOP.) (SIZE UPTO 42" (RATING UPTO 2500#))	SPAIN
36	HATIMA CORPORATION	TAIWAN
	BALL VALVES (METAL SEATED)	
1	AIRA EURO AUTOMATION PVT. LTD. (UPTO 6", RATING 150# & 300#),	INDIA
2	BRIGHTECH VALVES & CONTROLS PVT. LTD. (4" X 150# FOR CS, AS & SS MATERIAL)	INDIA
3	DELVAL FLOW CONTROLS PVT. LTD. (UPTO 12" (UPTO 900#))	INDIA
4	GURU INDUSTRIAL VALVES PVT. LTD. (CAST CS ONLY: UPTO 12" (UPTO 300#), 4" (UPTO 900#) & FORGED: UPTO 2" (800#))	INDIA
5	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 28" (UPTO 600#),12" (UPTO 1500#), 10" (2500#))	INDIA
6	MICROFINISH VALVES (P) LTD.	INDIA
7	NSSL LTD. (UPTO 12" (150# & 300#))	INDIA
8	OSWAL INDUSTRIES LTD. (UPTO 24" (150#, 300#, & 600#))	INDIA
9	VIRGO ENGINEERS LTD. (UPTO16" (UPTO 600#))	INDIA
10	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (CAST: UPTO 30" (150# & 300#); 20" (600#), 16" (900#), 12" (1500#) & FORGED: UPTO 2" (800#)	INDIA
11	VELAN INC. (SIZE UPTO 16" (RATING UPTO 600#))	CANADA
12	ALFA VALVOLE SRL	ITALY
13	CESARE BONETTI SPA (UPTO 24" (150#) & 4" (UPTO 1500#) TRUNNION MOUNTED ONLY)	ITALY

14	GE POWER (NUOVO PIGNONE SPA)	ITALY
15	GTC ITALIA, S.R.L.	ITALY
16	PETROL VALVES S.R.L	ITALY
17	PIBIVIESSE (48", 600#)	ITALY
18	VALVITALIA SPA	ITALY
19	PERRIN GMBH (SIZE UPTO 24" (RATING UPTO 2500#))	GERMANY
20	RED POINT ALLOYS BV	NETHERLAND
21	FRIULCO SPA (UPTO 48" (150# & 300#); 20" (UPTO 1500#); 12" (2500#))	ITALY
22	POYAM VALVES, (AMPO S. COOP.) (SIZE UPTO 42" (RATING UPTO 2500#))	SPAIN
23	METSO AUTOMATION	SINGAPORE
24	ORBIT VALVES PLC	SINGAPORE
	BUTTERFLY VALVES	
1	A V VALVES LIMITED (UPTO 48" (150#))	INDIA
2	ADVANCE VALVES (RUBBER LINED AND METAL SEATED)	INDIA
3	AIRA EURO AUTOMATION PVT. LTD. (UPTO 48", RATING UPTO 300#)	INDIA
4	AUDCO INDIA LIMITED (L&T VALVES DIVN.)	INDIA
5	BDK PROCESS CONTROL PVT LTD. (UPTO 1600MM)	INDIA
6	CHEMTECH INDUSTRIAL VALVES PVT LTD	INDIA
7	CRAWLEY & RAY (FOUNDER & ENGINEERS) PVT. LTD. (40MM-1000MM)	INDIA
8	DELVAL FLOW CONTROLS PVT. LTD. (UPTO 24" (UPTO 300#))	INDIA
9	FLOCON SYSTEMS PVT. LTD. (CS UPTO 12", 150#)	INDIA
10	FLUIDTECH EQUIPMENT PVT. LTD. (CS UPTO 12" (300#))	INDIA
11	FOURESS ENGINEERING (I) LTD.	INDIA
12	HI-TECH BUTTERFLY VALVES INDIA PVT. LTD (<300#,<30"(TEFLON/RUBBER) ,<72"(METAL))	INDIA
13	INSTRUMENTATION LTD. (PALAKKAD)	INDIA
14	JC VALVES & CONTROLS INDIA PVT. LTD. (UPTO 20" (150#) & 10" (300#))	INDIA
15	L&T LTD (1/2" TO 24")	INDIA
16	MATHER & PLATT (INDIA) LTD. A SUBSIDIARY OF	INDIA

	WILO SE GERMAN (UPTO DN 1600,PN10, DOUBLE FLANGE TYPE)	
17	METROPOLITAN INDUSTRIES (SIZE=2000MM)	INDIA
18	VENUS PUMP & ENGINEERING WORKS (UPTO 600NB, 150#)	INDIA
19	VIRGO ENGINEERS LTD. ((TRIPLE OFFSET ONLY): 3" TO 24", UPTO 600# (CS/SS))	INDIA
20	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (UPTO 56" (UPTO 250#), 24" (300#))	INDIA
21	XOMOX SANMAR LIMITED (FISHER XOMOX)	INDIA
22	TOMOE VALVE CO. LTD. (UPTO 48"(150# & 300#), UPTO 24"(600#, 900# & 1500#))	JAPAN
23	BHDT GMBH	AUSTRIA
24	VELAN INC. (SIZE UPTO 48"(RATING UPTO 600#)	CANADA
25	GRISS SAPAG INDUSTRIAL VALVES	FRANCE
26	ADAMS ARMATUREN	GERMANY
27	GTC ITALIA, S.R.L.	ITALY
28	HAITIMA CORPORATION	TAIWAN
29	WEIR VALVES & CONTROLS DIVISION.	U.K
30	LEEDS VALVE LTD	U.K
31	CURTIS WRIGHT FLOW CONTROL CORPOARATION	U.S.A.
32	LEAR SIEGLER MEAS. CTRLS. CORP	U.S.A.
33	TYCO INTERNATIONAL INC.,U.S.A.	U.S.A.
34	EMERSON PROCESS MGT	U.S.A.
35	SPX VALVES & CONTROLS	U.S.A.
36	XOMOS (CRANE CO.)	U.S.A.
	PLUG VALVES (NON LUBRICATED)	
1	A V VALVES LIMITED (UPTO 48" (150#))	INDIA
2	AUDCO INDIA LTD (L&T VALVES DIVN.)	INDIA
3	AZ ARMATUREN GMBH (1/2" TO 20"(150#, 300# & 600#), MATL. CS, AS &SS)	INDIA
4	BDK PROCESS CONTROL PVT LTD.	INDIA
5	CHEMTECH INDUSTRIAL VALVES PVT LTD	INDIA
6	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD (DN 200)	INDIA
7	FLUIDTECH EQUIPMENT PVT. LTD. (UPTO 4" (300#))	INDIA

8	GURU INDUSTRIAL VALVES PVT. LTD. (CAST CS ONLY: UPTO 12" (UPTO 300#), UPTO 4" (UPTO 900#)) & FORGED: UPTO 2" (800#))	INDIA
9	JC VALVES & CONTROLS INDIA PVT. LTD. (UPTO 12" (UPTO 300#))	INDIA
10	L&T LTD (1/2" TO 24")	INDIA
11	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (UPTO 16"(150#), 12" (300#), 3" (600#))	INDIA
12	XOMOX SANMAR LIMITED (FISHER XOMOX)	INDIA
13	O.M.S. SALERI DI SALERI P & FIGLI S.M.C.	ITALY
14	POYAM VALVES, (AMPO S. COOP.) (UPTO 30" (UPTO 900#) FOR LIFT PLUG VALVES ONLY.)	SPAIN
	FLAT GASKETS	
1	FERROLITE JOININGS (P) LTD.	INDIA
2	GASKETS (INDIA) PVT. LTD	INDIA
3	GOODRICH GASKET PVT. LTD. (UPTO 24")	INDIA
4	IGP ENGINEERS LIMITED	INDIA
5	MADRAS INDUSTRIAL PRODUCTS(UPTO 48")	INDIA
6	MECHANICAL PACKING INDUSTRIES LTD.	INDIA
7	PACKING & JOINTINGS (P) LTD.	INDIA
8	SPIRALSEAL GASKETS PVT. LTD. (CAF & TEFLON)	INDIA
9	STARFLEX SEALING INDIA PVT. LTD.	INDIA
10	UNIQUE INDUSTRIAL PACKINGS PVT. LTD.	INDIA
	SPIRALLY WOUND GASKETS	
1	GASKETS (INDIA) PVT. LTD	INDIA
2	GOODRICH GASKET PVT. LTD.	INDIA
3	IGP ENGINEERS LIMITED	INDIA
4	MADRAS INDUSTRIAL PRODUCTS	INDIA
5	PACKINGS & JOINTINGS PVT. LTD	INDIA
6	STARFLEX SEALING INDIA PVT. LTD.	INDIA
7	UNIQUE INDUSTRIAL PACKINGS PVT.LTD. (UPTO 42"(600#) & UPTO 24" (2500#))	INDIA
	EXPANSION JOINTS & BELLOWS	
1	CORI ENGINEERS PVT. LTD.	INDIA
2	D.WREN & CO. (FOR RUBBER & FABRIC)	INDIA
3	FLEXATHERM EXPANLLOW PVT. LTD. (CIRCULAR:	INDIA

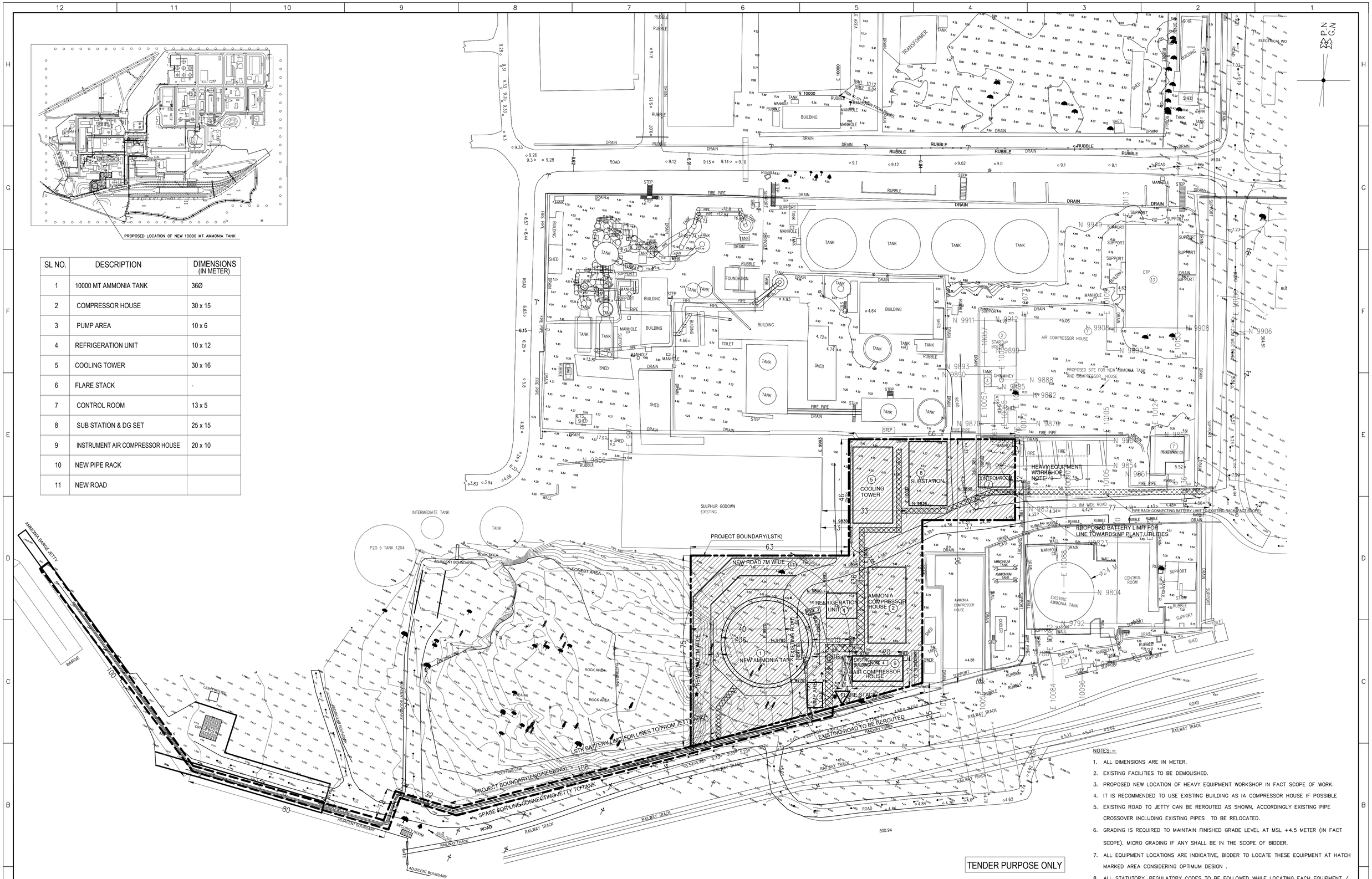
	UPTO 240", RECTANGULAR NO BAR FOR SIZE, (UPTO 600#))	
4	FLEXICAN BELLOWS & HOSES PVT. LTD	INDIA
5	FLUIDYNE ENGG. (I) PVT. LTD	INDIA
6	KELD ELLENTOFT INDIA PVT. LTD	INDIA
7	LONESTAR INDUSTRIES	INDIA
8	MB METALLIC BELLOWS (INDIA) PVT. LTD	INDIA
9	PRASHANT ENGG. STORES	INDIA
10	STANDARD PRECISION BELLOWS	INDIA
11	TUBOFLEX	GERMANY
12	FLEXIDER S.P.A.	ITALY
	STRAINERS (PERMANENT INCLUDING Y-TYPE)	
1	CHEMTECH INDUSTRIAL VALVES PVT. LTD	INDIA
2	FLAIR STRAINERS & FILTERS (SIZE UPTO 42" (RATING UPTO 1500#))	INDIA
3	GRAND PRIX ENGINEERING PVT. LTD. (UPTO 60" PIPELINE, UPTO ANSI 1500#)	INDIA
4	GREAVES LIMITED	INDIA
5	GUJARAT OTOFILT	INDIA
6	KWIKFLO FILTERS PVT. LTD.	INDIA
7	LEADER VALVES LTD. (UPTO 300# & UPTO 12" SIZE)	INDIA
8	MULTITEX FILTERATION ENGINEERS LTD	INDIA
9	MOD FABRICATORS	INDIA
10	ZOLOTO INDUSTRIES (15MM TO 100MM)	INDIA
	STEAM TRAPS	
1	GREAVES LTD.	INDIA
2	YARWAY CORPORATION	INDIA
3	GESTRA AG	GERMANY
4	ARMSTRONG INTERNATIONAL INC.	U.S.A
5	OGONTZ CORPORATION	U.S.A
6	TYCO INTERNATIONAL INC., U.S.A. MARSHALL	U.S.A INDIA
	SPRING SUPPORTS	
1	MYRICS PIPING SYSTEM PVT.LTD.	INDIA
2	PIPE SUPPORTS INDIA PVT. LTD.	INDIA

3	PIPING & ENERGY PRODUCTS (P) LTD.	INDIA
4	SARATHI ENGG. ENTERPRISES PVT. LTD.	INDIA
5	SPRING SUPPORTS MFG. CO.	INDIA
6	FLEXIDER S.P.A.	ITALY
	FASTENERS	
1	AEP COMPANY	INDIA
2	CAPITAL INDUSTRIES	INDIA
3	CONSOLE ENGG. & FASTNERS INDUSTRIES	INDIA
4	EBY FASTNERS	INDIA
5	FIT TIGHT NUTS & BOLTS LTD.	INDIA
6	FIX FIT FASTENERS MFG. PVT. LTD.	INDIA
7	INDUSTRIAL ENGINEERING CORPORATION (SIZE UPTO 4" (M100))	INDIA
8	MEGA ENGINEERING PRIVATE LIMITED (½" TO 3" MATERIAL: CS/AS/SS)	INDIA
9	METRO MECHANICAL PVT.LTD.	INDIA
10	NAGBHUSHANAM INDUSTRIES	INDIA
11	NIREKA ENGG. CO. PVT. LTD.	INDIA
12	PACIFIC FORGING & FASTENERS PVT. LTD. (M 10 TO M125)	INDIA
13	PERFECT MARKETING (P) LTD,	INDIA
14	PIONEER NUTS & BOLTS PVT. LTD.	INDIA
15	PRECISION AUTO ENGINEERS	INDIA
16	PRECISION ENGINEERING INDUSTRIES	INDIA
17	PTD FASTNERS PVT. LTD.	INDIA
18	SANGHVI METALS (TRADER)	INDIA
19	SUNDARAM FASTENERS LIMITED	INDIA
20	UDHERA FASTENERS	INDIA
	FIRE FIGHTING SYSTEM	
1	AGNICE FIRE PROTECTION LTD.	INDIA
2	BHARTIYA CACCIALANZA FIRE SYSTEMS LTD	INDIA
3	BLUE STAR LTD.	INDIA
4	DE'S TECHNICO	INDIA
5	DE'S TECHNICO PVT. LTD.	INDIA

6	FUTECH CONSULTANTS PVT. LTD.	INDIA
7	GENERAL MECHANICAL WORKS	INDIA
8	HD FIRE PROTECTION COMPANY	INDIA
9	LAL ENTERPRISES	INDIA
10	MATHER & PLATT (INDIA) LTD. (A SUBSIDIARY OF WILO SE GERMAN)	INDIA
11	MX SYSTEMS INTERNATIONAL PVT. LTD.	INDIA
12	NEWFIRE ENGINEERS SERVICES	INDIA
13	PRAGATI ENGG. (PVT.) LTD.	INDIA
14	PYROTEK INDUSTRIES (INDIA) PVT. LTD.	INDIA
15	RADIANT FIRE PROTECTION ENGINEERS	INDIA
16	STEELAGE INDUSTRIES LTD.	INDIA
17	TECHNOFAB ENGG.	INDIA
18	TRI-PARULEX FIRE PROTECTION SYSTEMS	INDIA
19	UNITECH MACHINES LTD	INDIA
20	VIJAY FIRE PROTECTION SYSTEM LTD.	INDIA
	HOSE PIPE (METALLIC) & CAM LOCK COUPLING	
1	AEROFLEX INDUSTRIES LIMITED (SIZE 6MM TO 250MM DIA. (SS CORRG. FLEX. HOSE WITH BRAID, BRAID & ASSEMBLY)	INDIA
2	CHHATARIA RUBBER CHEMICALS INDUSTRIES	INDIA
3	D. WREN & CO.	INDIA
4	FLEXATHERM EXPANLLOW PVT. LTD. (1/2" TO 6")	INDIA
5	GAYATRI INDUSTRIES	INDIA
6	GAYATRI INDUSTRIAL CORPORATION (UPTO 6" ID)	INDIA
7	HELIFEX HYDRAULICS & ENGG CO. LTD.	INDIA
8	SENIOR INDIA PVT. LTD.	INDIA
	HOSE PIPE (NON-METALLIC) & CAM LOCK COUPLING	
1	CHHATARIA RUBBER CHEMICALS INDUSTRIES	INDIA
2	D. WREN & CO.	INDIA
3	GAYATRI INDUSTRIES	INDIA
4	GAYATRI INDUSTRIAL CORPORATION (UPTO 8" ID)	INDIA
5	HELIFEX HYDRAULICS & ENGG CO. LTD.	INDIA
6	PADMINI INDUSTRIES LIMITED	INDIA

7	PYROTEK INDUSTRIES (INDIA) PVT. LTD.	INDIA
8	SENIOR INDIA PVT. LTD.	INDIA
	MARINE LOADING ARM	
1	UTTAM VALUE STEEL LTD., ENGINEERING DEV. LLOYDS STEEL INDUSTRIES. (8" TO 20")	INDIA
2	SVT	GERMANY
	TRUCK/WAGON LOADING ARM	
1	UTTAM VALUE STEEL LTD., ENGINEERING DEV. LLOYDS STEEL INDUSTRIES (2" TO 4"), SVT, GERMANY	INDIA
2	WOODFIELD SYSTEMS INDIA PVT. LTD. (UPTO SIZE: CORE-4" / JACKET:- 6") SVT, GERMANY	INDIA

SL NO.	DESCRIPTION	DIMENSIONS (IN METER)
1	10000 MT AMMONIA TANK	36Ø
2	COMPRESSOR HOUSE	30 x 15
3	PUMP AREA	10 x 6
4	REFRIGERATION UNIT	10 x 12
5	COOLING TOWER	30 x 16
6	FLARE STACK	-
7	CONTROL ROOM	13 x 5
8	SUB STATION & DG SET	25 x 15
9	INSTRUMENT AIR COMPRESSOR HOUSE	20 x 10
10	NEW PIPE RACK	
11	NEW ROAD	



TENDER PURPOSE ONLY

NOTES: –

1. ALL DIMENSIONS ARE IN METER.
2. EXISTING FACILITIES TO BE DEMOLISHED.
3. PROPOSED NEW LOCATION OF HEAVY EQUIPMENT WORKSHOP IN FACT SCOPE OF WORK.
4. IT IS RECOMMENDED TO USE EXISTING BUILDING AS IA COMPRESSOR HOUSE IF POSSIBLE
5. EXISTING ROAD TO JETTY CAN BE REROUTED AS SHOWN, ACCORDINGLY EXISTING PIPE CROSSOVER INCLUDING EXISTING PIPES TO BE RELOCATED.
6. GRADING IS REQUIRED TO MAINTAIN FINISHED GRADE LEVEL AT MSL +4.5 METER (IN FACT SCOPE). MICRO GRADING IF ANY SHALL BE IN THE SCOPE OF BIDDER.
7. ALL EQUIPMENT LOCATIONS ARE INDICATIVE, BIDDER TO LOCATE THESE EQUIPMENT AT HATCH MARKED AREA CONSIDERING OPTIMUM DESIGN .
8. ALL STATUTORY, REGULATORY CODES TO BE FOLLOWED WHILE LOCATING EACH EQUIPMENT / FACILITY, ALSO OPERATIONAL / MAINTENANCE REQUIRMENT TO BE ADDRESSED

CLIENT M/S FACT CD

DRAWING NO.	TITLE
	SURVEY DRAWING DATED 19.04.2021 (CONTOUR MAP)
	SURVEY DRAWING DATED 22.02.2020
REFERENCE DRAWING	

NO	ZONE	PARTICULARS	REVISED	CHECKED	APPROVED	DATE
REVISION						

SCALE	1.5:1000
DATE	17.05.2021
DRAWN	MAHESH
CHECKED	JTG
DESIGNED	JTG
CHECKED	KK
APPROVED	KK

FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD
UDYOGAMANDAL KERALA

FEDO

PROJECT NAME: CONSTRUCTION OF NEW 10000MT AMMONIA TANK | PROJECT NO: 32686

TITLE: PROPOSED SITE LOCATION FOR NEW 10000MT AMMONIA TANK AT FACT-CD, AMBALAMEDU , KOCHI

SHEET 1 OF 1 | DRG. NO. 32686-03-AP-00002 | REV. 0

00FT004/96

SCOPE MATRIX 32686-03-SM-001-R0

Sl. No.	Item	Area	Scope							
			BIDDER				FACT			
			Engineering	Procurement & Construction	Supervision	Commissioning	Engineering	Procurement & Construction	Supervision	Commissioning
1	Piping from Jetty to B/L of Ammonia Tankage facility		✓		✓	✓		✓	✓	

Sl. No.	Doc. No.	Description	No. of Pages	Revision No.			
				0	1	2	3
1.	32686-11-PS-002-DP	PROJECT DESCRIPTION	8		X		
2.	32686-11-PS-002-SW	SCOPE OF WORK	11		X		
3.	32686-11-PS-002-INS	SCOPE OF INSPECTION & TESTS	2	X			
4.	32686-11-PS-002-SPL	SPECIAL REQUIREMENTS OF PROJECT	1	X			
5.	32686-11-PS-002-DB	DESIGN BASIS	9		X		
6.	32686-11-PS-002-PH	DESIGN PHILOSOPHY - PROCESS	20		X		
7.	32686-11-PS-002-PGT	PERFORMANCE GUARANTEE TEST	9		X		
8.	32686-11-PS-002-VDR	VENDOR DATA REQUIREMENT	3	X			
9.	32686-11-PD-001to004	TENDER P&IDS	4		X		
10.	32686-11-PS-002-VL	SUB VENDOR LIST - PROCESS	2	X			
11.	32686-11-PS-002-SPR	SPARES-PROCESS	1	X			
12.	**ATTACHMENTS**						
1.	PIPING SPECIFICATIONS OF EXISTING LINES AT TIE-INS		1				
2.	WIND ROSE DIAGRAM		1				
3.	RAW WATER ANALYSIS		1				
4.	LOCATION OF UTILITY TIE-INS		1				
5.	SPECIFICATION OF FLEXIBLE HOSES		1				

TPS No. : **32686-11-PS-002**

Item : **Project Description**

Item No. : **32686-11-PS-002-DP**

Project : **10,000 MT AMMONIA STORAGE FACILITY AT CD**

Client : **M/s. FACT-CD**

Location : **Ambalamedu, Kochi**

1	Revised & Issued For Comments	23/04/2021	AT	KVR	KVR
0	For Comments	10/04/2021	AT	KVR	KVR
Rev.	**Description**	**Date**	**Prpd. By**	**Chkd. By**	**Aprd. By**

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1.0 INTRODUCTION

1.1 The Fertilisers and Chemicals Travancore Limited (FACT) a Government of India Enterprise is one of the first largest scale fertilizer companies in India. FACT has two manufacturing units, the FACT – Udyogamandal Complex (FACT-UC) at Udyogamandal & the FACT – Cochin Division (FACT-CD) at Ambalamedu, both located on the outskirts of Kochi city engaged in the production of various fertilizers and chemicals. The main products for FACT are Granulated NP-20:20:0:13 Complex Fertilizer, Ammonium Sulphate (Fertilizer) & Caprolactam (Petrochemical).

1.2 The Fertilisers and Chemical Travancore Ltd., (FACT) hereby referred to as 'OWNER' intend to install 10,000 MT capacity refrigerated ammonia storage, receipt and dispatch facility at FACT-CD, Ambalamedu.

1.3 FACT Engineering and Design Organisation (FEDO), the design, engineering and consultancy services division of FACT is entrusted with PMC job for construction of 1x10,000 MT Ammonia Storage Tank along with associated facilities at FACT-CD.

1.4 The basic emphasis of FACT on this project is on utilization of proven processes, proven technologies and proven equipment i.e., such of the processes, technologies and equipment that have been in successful operation elsewhere for Ammonia service.

1.5 The bidder/s would explore possibilities of maximizing supplies and services for the proposed plant from Indian resources without in any manner eroding the performance standards required as envisaged in the bid document.

1.6 In light of the above, FACT invites tender for a TURNKEY offer including design, engineering, procurement, fabrication, supply, transportation, handling, storage, erection, testing and commissioning of ammonia storage, receipt and dispatch facility.

2.0 PLANT LOCATION

2.1 The proposed 10,000 MT Ammonia Storage Tank System shall be located inside the existing manufacturing facility of FACT-CD. The proposed ammonia storage system shall be located on plot/land/area adjacent to the existing 5,000 MT capacity ammonia storage tank. Bidder/s shall visit location to familiarize with site conditions before submitting their offer.

2.2 The area plot plan vide Drg. No. *32686-03-AP-0002* indicating the location of proposed 10,000 MT ammonia storage system is attached with the tender document.

2.3 Geo Technical Investigation Report for the proposed 10,000 MT ammonia storage facility area is attached as with the tender for reference; However bidder/s has to conduct their own soil investigation for final design.

2.4 Site Location:

Plant Location	FACT Cochin Division (FACT-CD)
State	Kerala
Nearest Important Town/City	Kochi City
Nearest Railway Station	Tripunithura
Nearest Airport	Cochin International Airport
Nearest Highway	Seaport-Airport Highway

2.5 Meteorological Data:

Rainy Season	June to October
Maximum Ambient Temperature	40^{o}C
Minimum Ambient Temperature	17^{o}C
Earthquake Region/zone	Zone III
Annual Rainfall - Max.	1184 mm
Wind Speed	6 to 8 km/h
Site Elevation above Mean Sea Level	4.5 m

2.6 Site Condition: The area on the western side of the existing 5,000 MT ammonia storage tank's compressor shed is proposed for the Ammonia Storage Tank project. Approximately 5000 m^2 area is available (refer to the Geo Technical Investigation Report attached with the tender).

2.7 Bidder/s may visit the existing facility and proposed project site for inspection before pre-bid meeting and submission of the bid.

3.0 PLANT CAPACITY & CONFIGURATION

3.1 At present, FACT-CD has one (1) 5,000 MT capacity ammonia storage tank with associated facilities which is as follows:

Sl. No.	Plant & Facilities	Qty.	Specification
1.	Ammonia Storage Tank	1	Capacity: 5,000 MT; Type: Double Walled Double Integrity;
2.	Intermediate Vessel	1	Capacity: 5.5 m^3; Design Pressure: 16 kg/cm^2;
3.	Saturator	1	Capacity: 1.6 m^3; Operating Temperature: (-)33°C Operating Pressure: 0.018 kg/cm^2(G)
4.	Refrigeration Compressors	3	Type: Two Stage Reciprocating & Non-Lubricated (with Intercoolers); Capacity (Each): - First Stage: 1220 kg/h; - Suction: 1.02 kg/cm^2 & -20°C - Discharge: 4.2 kg/cm^2 - Second Stage: 1770 kg/h; - Suction: 4.1 kg/cm^2 & (-)2°C - Discharge: 16.7 kg/cm^2 Drive: Electric Motor;
5.	Condenser	2 (1W+1S)	Surface Area: 374.8 m^2 Each; Ammonia Flow Rate: 3400 kg/h In/Out Temperature: 117/42°C
6.	Receiver	1	Op. Pressure: 16.7 kg/cm^2 Op. Temperature:42°C
7.	Flash Cooler	1	Capacity: 0.35 m^3; Working Pressure: 4.1 atm(G); Temperature: 5°C
8.	Transfer Pumps	(2+2)	Capacity: Two (2) - 50 m^3/h Each; Capacity: Two (2) - 25 m^3/h Each; Dis. Pr.: 11.5 kg/cm^2; Dis. Temp.: (-)32.75°C; Type: Vertical Multi Stage Centrifugal; Drive: Electric Motor;
9.	Flare Stack	1	LPG fuel Capacity: 2440 kg/h (max.); Ammonia Vapor; Temperature: (-)33°C; Pressure: 0.05 kg/cm^2(G)
10.	Cooling Tower	1	Capacity: 250 m^3/h (Each); No. of Cells: Two (2);

3.2 The bidder's scope of work under this project for installation of 10,000 MT refrigerated ammonia storage tank system at FACT-CD, Ambalamedu shall comprise of following facilities:

Sl. No.	Plants & Facilities	Qty.	Specification
1.	New Ammonia Storage Tank	1	Capacity: 10,000 MT (excluding dead volume at tank bottom & vapor space including slosh height at top); Type: Double Walled Double Integrity;
2.	Holding/Boil Off Gas (BOG) Compressor (In case of no receipt/no transfer of ammonia condition)	1	Type: Screw; Capacity: 10,000 MT Storage Tank Boil-Off
3.	Unloading Compressors	3 (2W+1S)	Type: Screw; Capacity: Equivalent to Normal Boil-off + Liquid Ammonia Unloading from 350 MT Barge Bullets in 6 hours + Liquid Ammonia Pumping to User Plant/s and/or from existing transfer pumps;
4.	Refrigeration System		Shall comprise of but, not limited to Compressors (as mentioned in Sl. No.2&3) Condensers, Receiver, Economizer, Purger/Inert Gas Remover drain drum, vent vessel etc.,
5.	Barge Unloading System		Shall comprise of but, not limited to Ammonia Vaporizer, Ammonia Gas Cooler, and Separator, Liquid & Vapor Headers/Pipelines upto Jetty as per the Piping Scope Matrix vide Doc. No. 32686-03-SM-001.
6.	Ammonia Transfer Pumps	3 (2W+1S)	Capacity: 40 m^3/h; Dis. Pr.: 20 kg/cm^2(G); Type: Vertical Centrifugal; Drive: Electric Motor with VFD;
7.	Hot Flare System	1	Type: Low Pressure (LP) Flare System with LPG/RLNG Pilot & Ignition Panel; Capacity: Catering the flare load of proposed facility;
8.	Instrument Air Compressors (IAC)	2 (1W+1S)	Type: Screw; Capacity: Catering to the entire air requirement of the proposed facility;
9.	Instrument Air Receiver	1	Capacity: 15 minutes of total air requirement

Sl. No.	Plants & Facilities	Qty.	Specification
10.	Wet Air Receiver	1	Capacity: During Detailed Engineering
11.	Air Drier Unit	1	Capacity: As per Detailed Engg. for continuous supply of air; Type: Desiccant & Fully Automatic;
12.	Cooling Tower (CT)	1 (2 Cells)	Type: Induced Draft Configuration: 2 Cells i.e., 1W+1S each provided with cooling tower fan Accessories: Cooling tower sump, Side Stream Filter etc.,; Capacity: Catering to the proposed facility;
13.	Cooling Water Circulation Pump	3 (2W+1S)	Type: Horizontal Centrifugal; Capacity: As per Detailed Engg.;
14.	DG Set	1	For safe operation of the following sections till the electrical system is re-established: a. Holding Compressor b. Cooling Tower Fan c. Cooling Water Circulation Pump d. Flare Panel e. IAC & ADU f. Emergency Lighting g. Control System h. Battery Charger i. UPS
15.	Fire Fighting System		Inclusive of three (3) nos. HVLRM of 1000 gallons per minute capacity
16.	Instrumentation & Control System		Instrumentation System including PLC for existing and proposed facility
17.	Electrical System		Power Distribution System - Installation & integration with the existing system, etc.
18.	Communication System		Telephone etc.,
19.	Piping		All required piping including interconnection with existing, receipt & dispatch upto the battery limit as per Piping Scope Matrix vide Doc. No. 32686-03-SM-001 (also refer P&ID vide Drg. No. 32686-11-PD-101 to 104 and)

Sl. No.	Plants & Facilities	Qty.	Specification
20.	Civil & Structural Works		All Equipment Foundation, New Control Room, Buildings, Compressor sheds etc., required for the project as per Technical Procurement Specification for Civil & Structural Works vide Doc. No. 32686-12-PS-002.

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TPS No. : **32686-11-PS-002**

Item : **Scope of Work**

Item No. : **32686-11-PS-002-SW**

Project : **10,000 MT AMMONIA STORAGE FACILITY AT CD**

Client : **M/s. FACT-CD**

Location : **Ambalamedu, Kochi**

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LIST OF ATTACHMENTS

1.0 BIDDER'S SCOPE OF WORK/SUPPLY

1.1 The bidder's scope of work shall include Complete ENGINEERING for all Equipment & Accessories, PROCUREMENT & SUPPLY of Complete Materials & Bought-Out Items whatever deemed necessary for Mechanical, Electrical & Instrumentation, FABRICATION at shop/site as required, LOADING, UNLOADING & TRANSPORTATION, STORAGE at site, ASSEMBLY, CONSTRUCTION, ERECTION of Mechanical, Electrical & Instrumentation System, INSPECTION, TESTING, PAINTING, INSULATION, STATUTORY APPROVALS, COMMISSIONING, TRIAL RUNS, DEMONSTRATION of GUARANTEES, CALIBRATION, INTERFACE and SUPPLY of Complete New Ammonia Storage tank Package along with Spares & Maintenance Tools etc. In addition, all statutory rules & regulations shall also be complied with.

2.0 Scope of Supply:

The bidder's scope of supply shall include, but not limited to the following:

2.1 **Ammonia Storage Tank:** The ammonia storage tank designed as per API Standard 620, Appendix-R latest edition. The minimum specification of the storage tank is given below:

Sl. No.	Item	Specification
1.	Capacity	10,000 MT (excluding dead volume at tank bottom & vapor space including slosh height at top)
2.	Type	Double Walled Double Integrity
3.	No. of	ONE
4.	Design Overpressure	800 mmWC(G) at Top
5.	Design Vacuum	(-)50 mmWC(G)
6.	Operating Pr. & Temp.	500 mmWC(G) & (-)33^{o}C
7.	Design Temperature	(-)35^{o}C & (+)55^{o}C
8.	Nozzle Size	Minimum 250 NB Inlet/Outlet Liquid Connection
9.	Material of Construction	LTCS suitable for (-)35^{o}C
	Corrosion Allowance	
10.	- Inner Shell & Bottom	Nil
11.	- Outer Shell & Bottom	1.5 mm

Sl. No.	Item	Specification
12.	- Dome Roof	1.5 mm
13.	- Suspended Deck	1.0 mm
14.	- Roof Structure	1.5 mm
	Insulation	
15.	- Shell	Polyurethane Foamed in situ
16.	- Bottom	Foam Glass & Perlite Concrete (under inner tank bottom plate)
17.	- Roof	Suspended Deck of Resin Bonded Glass Wool
18.	Foundation	Raised Foundation to have free circulation of air beneath the concrete base to avoid frost formation

***Note**: LTCS – Low Temperature Carbon Steel*

2.2 **Ammonia Receipt/Unloading Facility**: ONE (1) 200 NB liquid, ONE (1) 150 NB vapor header and ONE(1) 50 NB pre-cooling line to be laid from ammonia storage tank system to the existing Barge Jetty along with necessary support. The liquid header to be provided with FOUR (4) 50 NB liquid connecting points and similarly the vapor header to be provided with THREE (3) 50 NB vapor connecting points for connecting to barge piping manifold using flexible hoses. Each liquid/vapor connections shall be provided with pressure gauge, temperature transmitter, isolation valves & flexible hoses. ***Note**: The unloading piping shall be provided with provision (i.e., tapping with isolation valve & blind flange as indicated in the tender P&ID) for extension to future tanker unloading adjacent to existing tanker unloading bay.* Refer Piping Scope Matrix vide Doc. No. 32686-03-SM-001 of this tender document for LSTK Contractor's scope w.r.t the Ammonia Receipt/Unloading Facility.

2.2.1 **Separator**: The barge liquid ammonia unloading from barge jetty shall be provided with a suitable separator to separate vapor ammonia from liquid ammonia unloaded from barge.

2.3 **Ammonia Transfer/Dispatch Facility**: ONE (1) 80 MB ammonia transfer pipeline from proposed transfer pumps to the battery limit of proposed ammonia storage tank on the eastern side. ***Note**: LSTK Contractor's scope is limited to providing isolation valve with blind flange at the battery limit point.*

2.3.1 **Ammonia Transfer Pumps**: THREE (3) nos. of vertical centrifugal type transfer pumps, each of 40 m^3/h capacity with discharge pressure of 20 kg/cm^2(G) and electric motor driven with suitable variable frequency drive (VFD) shall be provided.

2.3.2 The specification & nozzle/pipeline sizes indicated above for ammonia receipt/transfer are tentative & minimum. LSTK Contractor shall carryout the design & actual sizing as per the design philosophy requirement, specified codes and good Engineering practices without prejudice to the above".

2.4 **Refrigeration System**: The refrigeration system shall comprise of but limited to the following equipment/items:

1. Motor driven Unloading Compressors – THREE (3) nos. with all accessories (Lube oil pumps, oil filters, coolers, separators, etc).
2. Motor driven Holding Compressor – ONE (1) no. for no receipt / no transfer condition with all accessories (Lube oil pumps, oil filters, coolers, separators, etc).
3. Ammonia Condenser – TWO (2) nos.
4. Ammonia Receiver – ONE (1) no.
5. Economizer – ONE (1) no.
6. Purger/Inert Gas Remover – ONE (1) no.

Additionally one drain drum of 1 m^3 capacity minimum and vent vessel of sufficient capacity to be provided.

2.5 **Take-off Points from Proposed Facility**: The following Take-off points shall be provided:

1. Take-off from the liquid ammonia inlet line to the storage tank to the battery limit in the north east side.
2. Take-off from the transfer pump discharge header-1 to the battery limit in the north east side.
3. Take-off from the transfer pump discharge header-2 to the battery limit in the north east side.
4. Take-off from the effluent transfer pump discharge header to the battery limit in the north east side.

2.5.1 ***Note**: In addition to the above the LSTK Contractor shall do necessary header connection of utility facilities as specified in the Design Basis vide Doc. No. 32645-11-PS-002-DB of this tender document. The piping specification of utility lines at tie-ins is attached as **Annexure-1.0**.*

2.5.2 LSTK Contractor to provide necessary extension of pipelines, with valves & blinds upto the tie-in points. The interconnection will be done by OWNER at suitable time.

2.5.3 Tender purpose P&IDs indicating the tie-in points, scope of LSTK Contractor and the minimum process control requirement vide Drg. No. *32686-11-PD-101 to 104 is attached with the tender document.* ***Note****: However LSTK Contractor shall prepare detailed P&ID incorporating all process control schemes necessary for normal and safe operation of the plant/facility.*

2.6 **Cooling Tower**: TWO (2) cells of induced draft type with RCC sump, each cell capable of handling the maximum cooling water load of the proposed 10,000 MT ammonia storage tank facility with provision for individual isolation for maintenance job.

2.6.1 **Cooling Tower Fans**: TWO (2) nos. of cooling tower fans one for each cooling tower cell shall be provided along with suitable variable frequency drive (VFD) electric motor.

2.6.2 **Cooling Water Circulation Pumps**: THREE (3) nos. of horizontal centrifugal type pumps, each capable of handling 60% of maximum circulation rate shall be provided.

2.6.3 Side stream filter system to be provided as per design requirement. ***Note****: Chemical dosing system required for new cooling tower is not under the scope of LSTK Contractor. However the LSTK Contractor shall provide One (1) chlorine gas detector.*

2.6.4 For detailed scope of work refer to special requirements for FRP cooling tower vide Doc. No. *32686-01-PS-002 SPL* of this tender document.

2.7 **Instrument Air Compressors (IAC)**: TWO (2) nos. of rotary screw type with electric motor driven, each capable of handling 100% of maximum continuous demand of the entire ammonia storage tank system along with associated facilities shall be provided.

2.7.1 **Air Drier Unit (ADU)**: ONE (1) no. of Desiccant Type & Fully Automatic System capable of continuous supply of air shall be provided.

2.7.2 **Air Receiver**: for 15 minutes trouble free operation of entire storage (existing & proposed) facility in case of instrument air compressor failure. Additionally one wet air receiver of sufficient capacity catering to the service air requirement to be provided**.**

2.8 **Hot flare System with Flame Front Ignition Panel**: The capacity of the flare to be decided considering the maximum suction capacity of the TWO (2) unloading compressors**.**

2.9 **Effluent Handling System**: ONE (1) effluent collection pit and effluent transfer pump TWO (2) nos. (1 working + 1 standby) of suitable capacity (approximately 5 m^3/h & 3 $kg/cm^2(G)$) as per the design. The discharge of the effluent pumps shall be connected to the existing effluent treatment system. ***Note:*** *LSTK Contractor's scope is limited to providing isolation valve with blind flange at the battery limit point*.

2.10 **Diesel Generator (DG) Set**: The DG set capacity selection should be based on meeting of the emergency requirement in case of power failure. The equipment connected on DG set is as below:

1. 1 No. - Holding Compressor
2. 1 No. - Lube Oil Pump of Holding Compressor
3. 3 No. - Cooling Water Circulation Pumps (2 working + 1 standby)
4. 2 No. - Cooling Tower Fans (1 working + 1 standby)
5. Ignition Panel for Flare Stack
6. Emergency Lighting
7. 2 No. - Instrument Air Compressors (1 working + 1 standby)
8. Air Drier Unit
9. Control System
10. Battery Charger
11. UPS

2.10.1 ***Note: W.r.t Sl. No. 4 & 7, for estimating the DG Set load ONE (1) working equipment and w.r.t Sl. No. 3, TWO (2) working equipment are to be considered.***

2.11 **EOT Crane for Compressor House**: Necessary Hoists/Cranes of suitable capacity required for maintenance of equipment.

2.12 **Electrical & Instrumentation System**: Complete Electrical & Instrumentation System for New Ammonia Storage Tank. For detailed scope of supply refer to respective sections vide Doc. No. *32686-13-PS-002 SW & 32686-14-PS-002 SW INST* of this tender document.

2.13 **Piping:** Complete piping for the New Ammonia Storage Tank project. For detailed scope of supply refer to special requirement piping vide Doc. No. *32686-03-PS-002 SPL* & piping scope matrix vide Doc. No. *32686-03-SM-001* of this tender document.

2.14 **Safety Relief Valves:** Supply, installation and testing of safety relief valves as per the special requirements & scope of inspection & tests vide Doc. No. *32686-11-PS-002-SPL* & *32686-11-PS-002-INS* & piping scope matrix vide Doc. No. *32686-03-SM-001* of this tender document.

2.15 **Fire Fighting Network:** Suitable fire fighting network facilities shall be designed and supplied as per the statutory requirements. Refer to Design Philosophy - Firefighting System vide Doc. No. *32686–01–PS–002 PH2* of this tender document.

2.15.1 **HVLRM**: Minimum THREE (3) nos. of HVLRM for the proposed 10,000 MT ammonia storage tank shall be provided. Refer to Design Philosophy - Firefighting System vide Doc. No. *32686–01–PS–002 PH2* of this tender document.

2.15.2 **Fire Hydrants/Monitors/Portable Fire Extinguishers**. Sufficient numbers of fire hydrants to be located around the ammonia storage tank as per safety regulations and basis shall be clearly defined. ***Note:*** *Fire water line will be provided at battery limit. The fire line for the proposed facility is to be designed and provided by the LSTK Contractor.*

2.16 **Spare Parts:** for Pre-commissioning, Commissioning & Operational spares shall be supplied as per the respective spare list attached with this tender document.

2.17 **Ammonia Gas Detectors:** minimum TEN (10) nos. at strategic locations in compressor house as well as in refrigeration section, barge jetty, transfer pump section and ammonia tank top.

2.18 **Eye Washer & Safety Showers:** as per applicable standard with latest revision if any.

2.19 **Manual Call Points:** for new system and it shall be integrated to the existing system.

2.20 **Emergency Siren:** for alarming the nearby installations in case of emergency.

2.21 **Wind Socks**: minimum TWO (2) nos. of luminous wind direction indicator located such that it is visible at all time from the control room and nearby area.

2.22 **Civil Works:** Refer to technical procurement specification for civil & structural works vide Doc. No. *32686-12-PS-002* of this tender document.

3.0 SCOPE OF SERVICES:

3.1 Bidder's scope of services shall include but not limited to the following:

1. System engineering, preparation of heat and mass balance diagrams, system wise design criteria document, PFDs, P&IDs, utility balance diagram, system interlock logic diagram (ILD), plot plan etc.
2. Detailed engineering comprising of plant layout, piping stress analysis, civil and mechanical structures etc., electrical & instrumentation layouts.
3. LSTK Contractor shall carry out HAZOP study in presence of OWNER representatives for the entire ammonia storage tank system including that of existing facility. The CV of Independent HAZOP Consultant/Chairman shall be approved by PMC/OWNER. The LSTK Contractor shall incorporate all the recommended safe guards of HAZOP report at his own cost. In addition LSTK Contractor shall ensure implementation of all recommendations arising out of technical audit such as technical audit, including QRA (Quantitative Risk Assessment) recommendations and shall comply with applicable statutory regulations prevailing at the time of completion without any cost implication to the OWNER.
4. Preparation of documentation & obtaining OWNER reviews for the same.
5. Overall project management and progress reporting to OWNER.
6. Co-ordination and assistance for statutory approval from government/non-government bodies/agencies as per prevailing acts or rules before commencement of fabrication at his own cost. Necessary cost shall be reimbursed by OWNER.
7. Site clearing & cleaning as mentioned in the Technical Procurement Specification for Civil & Structural Works vide Doc. No. 32686-12-PS-002 of the tender.
8. Establishment of site office complete with all facilities and communication network.
9. Dispatch and transportation of equipment, consumables, construction aids and other materials to site.
10. Procurement of bought out components and transportation to site.
11. Supply of equipments & machineries including expediting & third party inspection (TPI).
12. Clearance from custom, etc. and related activities at ports, dockyards, railway heads, and road transport terminals as per requirement if any.
13. Storage, transportation, unloading, security & handling of the entire LSTK Contractor's material at site.

14. Insurance for all supply items to cover transit, storage, erection and commissioning till handing over to OWNER.
15. Manufacture, fabrication & assembly at site.
16. Complete Civil Work Construction as mentioned in the Technical Procurement Specification for Civil & Structural Works vide Doc. No. 32686-12-PS-002 of the tender.
17. Erection & installation of the complete Ammonia Storage Tank System.
18. Insulation, cladding & painting.
19. Flushing & cleaning.
20. Engineering for interfacing all the inputs and outputs.
21. Conducting technical audits & submission of report to OWNER.
22. Hooking up of all services with battery limit interface as mentioned in the scope of work.
23. Mechanical completion.
24. Calibration of tank shall be duly certified by competent authority or any other concerned government authorities. Such cost shall be considered by LSTK Contractor in his offer.
25. Pre-commissioning activities & rectification.
26. Commissioning & reliability run.
27. Performance Guarantee Testing (PGT).
28. Discrepancy Correction.
29. Training of the engineering & operating personnel at site.
30. Final as-built drawings & documentations.

4.0 FACT's OBLIGATION

4.1 All tie-in points in the existing piping system will be provided with an isolation valves at the battery limit of the existing ammonia storage tank system. ***Note**: The exact location & no. of tie-in points shall be finalized by LSTK Contractor in consultation with the OWNER.*

4.2 Details of existing ammonia storage tank facility at FACT-CD.

4.3 Safety Permit & Manpower Permit for job execution.

4.4 Supply of electrical power and water during construction at site, at single point, free of cost.

4.5 Providing skilled operating staffs during pre-commissioning/commissioning of the 10,000 MT ammonia storage tank. ***Note**: Unskilled personnel required during pre-commissioning/commissioning are in LSTK Contractor's scope.*

4.6 Utilities – RLNG, LPG, Raw Water, LP Steam & Power will be made available at the battery limit. *Note: However bidder's to indicate requirement of these utilities along with offer.*

4.7 Ammonia for plant commissioning & performance guarantee test activities.

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TPS No.:	32686-11-PS-002
Item:	Safety Relief Valve
Equipment No.:	--

The following inspection and tests shall be conducted and records submitted.

Sl. No.	Description	Inspection Required	Witness Required	Remarks
1.	Visual inspection of assembled valves - 100%	Yes	Yes	
2.	Physical inspection for dimensions and construction of assembled valves - 100%	Yes	Yes	
3.	Inlet/outlet hydrostatic test, set pressure test & seat tightness test as per procedure enclosed - 100%	Yes	Yes	
4.	For forged valves/components, manufacturer's test certificates for material composition & physical properties.	Yes		
5.	For cast valves, the foundry certificate checked & verified by the supplier.	Yes		

Notes:

TEST PROCEDURE FOR SAFETY RELIEF VALVES

1. Inlet/Outlet Hydrostatic Test

1.1 All assembled valves covered by this procedure shall have the inlet hydrostatically tested.

1.2 Test media shall be clean portable water for CS valve. For SS valves either distilled water or clean portable water containing less than 30 ppm of chlorine must be used.

1.3 Testing shall be conducted at room temperature.

1.4 Hydrostatic test pressure shall be one and one half (1½) times the inlet/outlet flange rating. Minimum hydrostatic test pressure shall be 7.03 kg/cm^2(G)

- The nozzle ring shall be set at minus two (-2) notches, by raising the ring to level position and then lowering the ring two (2) notches.
- The test cap and test rod shall then be installed with the test rod “finger-tight”.
- The hydrostatic test pressure shall then be applied.
- The hydrostatic test pressure shall be maintained for a minimum of three (3) minutes.
- Examination shall be made at the hydrostatic test pressure.
- Acceptance criteria – any visible leakage shall be caused for rejection.

2. Set Pressure Test

2.1 All valves covered by this procedure shall be tested to verify popping point consistency. Test fluid shall be air.

2.2 The nozzle ring shall be set at minus two (-2) notches, by raising the ring to level position and lowering the ring two (2) notches.

2.3 Adjust the valve to open at the set pressure or cold differential test pressure specified. Set pressure or cold differential test pressure for valves set on liquids shall be the pressure at which a continuous unbroken stream flows from the valve.

2.4 Cycle the valve twice to confirm that the popping point is satisfactory and that the popping point is within the specified tolerance for that set pressure.

2.5 Set Pressure (kg/cm^2(G)) : Tolerance

- 4.9 & less : +/- 0.14 kg/cm^2
- Above 4.9 : +/- 3% of set pressure
- Fire valves : -0%, +10% of set pressure

3. Seat Tightness Test

Test apparatus and procedure as per API 527.

3.1 All valves covered by this procedure shall be tested for seat tightness, irrespective of the fluid actually handled by the valve.

3.2 Waiting time before observation of leakage

Inlet Size (Inches) : Waiting Time2

- 2" & smaller : 1 Minute
- 2 ½”, 3” & 4” : 2 Minutes
- 6” to 8” : 5 Minutes

SPECIAL REQUIREMENTS

1. Safety relief valves are to be used for the service of liquid/vapor ammonia, cooling water, instrument/plant air, nitrogen, fuel gas lines of the 10,000 MT Ammonia Storage Tank facility at FACT-CD, Ambalamedu (Kochi), Kerala.
2. Direction of flow, pressure rating and size are to be embossed on the valves.
3. Copper or copper alloys shall not be used for ammonia services.
4. Nameplates as per API 526 must be attached to each valve. In addition, the nameplate must indicate the tag number of the valve as indicated in the data sheet.
5. Supply of valves shall be in one lot and shall have the completed data sheet dispatched with the valve. All documents packed inside crates must be protected with polyethylene covers.

TPS No. : **32686-11-PS-002**

Item : **Design Basis**

Item No. : **32686-11-PS-002-DB**

Project : **10,000 MT AMMONIA STORAGE FACILITY AT CD**

Client : **M/s. FACT-CD**

Location : **Ambalamedu, Kochi**

0	Revised & Issued For Comments	23/04/2021	AT	KVR	KVR
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LIST OF ATTACHMENTS

1.0 DESIGN DATA

1.1 Site Condition:

Country	India
State	Kerala
District	Ernakulam
Place	Ambalamedu
Longitude	76.3695 E
Latitude	9.9715 N

1.2 Weather Condition:

Mid October to February	Winter (Mild Cold)
March to May	Summer (Hot & Humid)
June to Mid October	Rainy (Monsoon)

1.3 Ambient Condition:

Temperature	
- Maximum	(+)40^{o}C
- Minimum	(+)17^{o}C
Wet Bulb Temperature	(+)29^{o}C
Barometric Pressure	
- Maximum	756 mmHg
- Minimum	752 mmHg
- Annual Average	754 mmHg
Rainfall	
- Maximum	1184 mm (August)
- Minimum	15 mm (January)
Relative Humidity	
- Maximum	89% (July)
- Minimum	66% (January)

1.4 Wind:

Wind load design should be done as per IS 875 (Part 3) : 2015

Design Wind Pressure:

$P_d = K_d \times K_a \times K_c \times p_z$, N/m^2 (Refer Clause No.7.2 of IS 875 (Part 3) : 2015)

Where,

- Wind Pressure, $p_z = 0.6Vz^2$
- Design Wind Speed, $V_z = V_b \times k_1 \times k_2 \times k_3 \times k_4$; (Refer Clause No.6.3 of IS 875 (Part 3) : 2015)
- Basic Wind Speed, V_b = 39 m/s
- Probability Factor (Risk Coefficient), k_1 = 1.0 (assuming design life of 50 years)
- Terrain, Height & Structure Size Factor, k_2 - based on terrain category-3 (Refer Table-2 of IS 875 (Part 3) : 2015)
- Topography Factor, k_3 = 1.0
- Cyclonic Factor, k_4 = 1.0

Note: The values of P_d, however shall not be taken as less than 0.70p_z

- Wind for Hydro Test = 25%

The wind rose diagram is attached as ***Annexure-2.0.***

1.5 Earthquake:

The plant structures must be designed for design basis earthquake (DBE) as per Clause No.8.0 and the design spectra given in IS 1893 (Part 4) : 2015, Annex B for Type-2 medium soil or site specific spectra (if available).

Following data are to be considered:

Seismic Zone	Zone III
Response reduction factor "R"	5.0
Damping for DBE	5% for Concrete & 2% for Steel
Importance Factor, I	Should be considered as per Table-3 of IS 1893 (Part 4) : 2015, based on the category of structure defined in Table-6 of IS 1893 (Part 4) : 2015. - Cryogenic bulk storage tank with refrigerated liquefied gases (e.g ethylene, LNG, NH3 etc.,) - Category-1, so Importance Factor I = 2.0

1.6 Pollution Control:

Gaseous Emission	
- SPM/TPM	Less than 125 mg/Nm^3
- SO_2	Less than 1 ppm
- SO_2 from Gas Fired Boiler	Less than 5 ppm
- NO_x from Stack	Less than 50 ppm
Liquid Effluent	
- pH	6.5 to 8
- Suspended Solids	100 mg/l
- BOD	NA
- COD	NA
- Oil & Grease	10 mg/l
- Ammoniacal Nitrogen	50 mg/l
- Free Ammoniacal Nitrogen	4 mg/l

1.7 Noise Level:

Noise generated shall not exceed 85 dBA at 1 m distance from the source of individual equipment under normal range of operating conditions.

2.0 AMMONIA SPECIFICATION

2.1 Supply Condition:

- Pressure : 1 kg/cm^2(G)
- Temperature : (-)26 to (-)29^oC

2.2 Ammonia Composition (Typical):

Composition	**Value/Range**
Ammonia	99.76%
Oil	3.8 ppm
Fe	0.14 ppm
Inerts	12.7 ml / 100 gm of NH_3

3.0 UTILITIES

3.1 All specified utilities will be supplied at the battery limit of proposed ammonia storage system by the OWNER. All utilities shall be provided with isolation valve at battery limit.

3.2 The following utilities shall be available for the proposed ammonia storage system:

1. Natural Gas – RLNG (Re-gasified Liquefied Natural Gas)
2. LPG
3. Raw/Service Water
4. Fire Water
5. Steam
6. Power

3.3 Bidder/s to specify any other utility required for proposed ammonia storage tank system in their offer. Incoming natural gas (RLNG), steam and raw/service water lines will be provided with individual flow meters of suitable type. However flow meter with upstream strainer at new ammonia storage tank battery limit shall be in the scope of successful bidder.

3.4 Natural Gas (RLNG):

Normally it is envisaged to utilize the RLNG available at FACT-CD as fuel for hot flare. However there shall be provision to use LPG as alternate fuel and for this purpose a tapping from the existing LPG cylinder manifold shall be provided. Bidder/s to specify the RLNG & LPG requirements in hourly basis in their offer.

3.4.1 Supply Condition:

- Pressure : 10 $kg/cm^2(G)$
- Temperature : (+)30^oC

3.4.2 RLNG Composition (Typical):

The characteristics of RLNG shall be as follow:

Sl. No.	Items	Specification
1.	**Component**	**Mole%**
	Methane	88.8391
	Ethane	7.2354
	Propane	2.4317
	Isobutane	0.4495
	Butane	0.7234

Sl. No.	Items	Specification
	Isopentane	0.0317
	N-Pentane	0.0127
	Nitrogen	0.2765
2.	**Gross Heating Value**	**9800 kcal/sm^3**
3.	**Net Heating Value**	**8500 kcal/sm^3**

3.5 Instrument Air:

The instrument air quality confirming to ISA-S7.0.01 to be provided by bidder/s.

3.5.1 Supply Condition (In Bidder/s Scope):

- Quality : As per ISA-S7.0.01 (Free of Dust, Water Drops & Oil)
- Dew Point : (-)40^{o}C at 7.5 kg/cm^2(G)
- Mechanical Design Pressure : 10.5 kg/cm^2(G)
- Mechanical Design Temperature : 65^{o}C

3.6 Cooling Water:

3.6.1 Cooling tower is in Bidder's scope of supply. Only makeup water (raw water) will be supplied by OWNER. Bidder/s to specify the makeup water requirement in hourly basis in their offer.

3.7 Raw Water:

3.7.1 Raw water from existing filter bed supply line will be made available at the plant battery limit.

3.7.2 The typical analysis of raw water is attached as ***Annexure-3.0.***

3.7.3 **Supply Condition:**

- Pressure : 3.5 kg/cm^2(G)
- Temperature : Ambient

3.8 Steam:

3.8.1 Low pressure (LP) steam will be made available at the plant battery limit. Bidder/s to specify the LP steam requirement in hourly basis in their offer.

3.8.2 **Supply Condition:**

- Pressure : 8 / 5 ATA (Absolute Technical Atmosphere)

- Temperature : 175 / 155°C

3.9 Power:

3.9.1 **Supply Condition:**

- TWO (2) 3.3kV & TWO (2) 415V Feeders

3.10 Nitrogen:

3.10.1 Nitrogen for normal operation **(**except for standby condenser**)** is not envisaged**.** The nitrogen requirement during construction, pre**-**commissioning, startup**/**commissioning activities shall be in the scope of bidder**/**s**.**

4.0 BATTERY LIMITS:

Sl. No.	Utility	Battery Limit
1.	Raw Water	At single point, at FIVE (5) m distance from B/L on eastern side
2.	Fire Water	At single point, at FIVE (5) m distance from B/L on eastern side
3.	Steam	At single point, at FIVE (5) m distance from B/L on eastern side
4.	Power	At the terminal of high & low tension incoming switchgears in the proposed substation of the ammonia storage tank facility
5.	RLNG as fuel	At single point, at FIVE (5) m distance from B/L on eastern side
6.	LPG as fuel	At single point, at FIVE (5) m distance from B/L on eastern side

The locations of tie-in points (except fire water & power) marked up in survey drawing is attached as ***Annexure-4.0.***

5.0 APPLICABLE CODES & STANDARDS

5.1 The design and the installation shall be in accordance with established codes, good engineering practices and shall conform to the statutory regulations applicable in the country. Latest version of main codes, standards and statutory regulations shall be considered as minimum requirements are as given below:

1. **API STD 520 –** Sizing, Selection and Installation of Pressure-relieving Devices in Refineries
2. **API STD 521** - Pressure-relieving and Depressuring Systems
3. **API STD 526 -** Flanged Steel Pressure Relief Valves
4. **API STD 610 –** Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
5. **API STD 619 –** Rotary-Type Positive Displacement Compressors for Petroleum, Petrochemical, and Natural Gas Industries

6. **API STD 620 – "Appendix R"** – Design and Construction of Large, Welded, Low-Pressure Storage Tanks "Low–Pressure Storage Tanks For Refrigerated Products"
7. **API STD 660 –** Shell-and-Tube Heat Exchangers for General Refinery Services
8. **ASME B 31.3 –** Process Piping
9. **ASME Boiler and Pressure Vessel Code Sec. VIII –** Rules for Construction of Pressure Vessels
10. **IS 4544 : 2000 –** Ammonia - Code Of Safety
11. **ISA-S7.0.01** – Quality Standard for Instrument Air
12. **TEMA –** Tubular Exchanger Manufacturers Association

5.2 In addition to above the applicable statutory regulations are to be taken care. The following regulatory authorities to be considered:

1. Factories Act
2. Manufacture, Storage and Import of Hazardous Chemical (MSIHC) Rules
3. Central Pollution Control Board (CPCB) Norms
4. Kerala State Pollution Control Board (KSPCB) Norms

5.3 In case of any conflict/deviation amongst various documents the order of precedence shall as be as follows:

5. Statutory Regulations
6. Design Philosophy
7. Engineering Standard Specifications/Installation Standards, etc.

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TPS No. : **32686-11-PS-002**

Item : **Design Philosophy - Process**

Item No. : **32686-11-PS-002-PH**

Project : **10,000 MT AMMONIA STORAGE FACILITY AT CD**

Client : **M/s. FACT-CD**

Location : **Ambalamedu, Kochi**

1	Revised & Issued For Comments	27/05/2021	AT	KVR	KVR
0	For Comments	13/04/2021	AT	KVR	KVR
Rev.	**Description**	**Date**	**Prpd. By**	**Chkd. By**	**Aprd. By**

CONTENTS

LIST OF ATTACHMENTS

1.0 GENERAL

1.1 The 10,000 MT Ammonia Storage Tank System along with associated facilities shall be located at FACT Cochin Division (FACT-CD), Ambalamedu, Ernakulam, Kerala State, India. Liquid ammonia at (-)26^{o}C to (-)^{29oC} & 1 kg/cm^{2}(G) will be made available (barge) at plant battery limit of the 10,000 MT ammonia storage tank system.

1.2 The composition of the liquid ammonia shall be as follows:

- Purity : 99.76%
- Moisture : 0.24%
- Oil : 3.8 ppm

1.3 From storage tank, liquid ammonia will be transferred to the user plant/s i.e., NP/NPK at (-)33^{o}C. Tank will be kept at near atmospheric pressure by reliable screw compressor based refrigeration system. Bidder/s to offer proven reliable and safe system designed to applicable international/national codes and standards with latest revisions (if any). The key design parameters are as follows:

2.0 TECHNICAL SPECIFICATIONS OF PLANT

2.1 The plant battery limit of the 10,000 MT ammonia storage tank system shall cover all facilities in conformity with the process requirement for which details are given below:

2.1.1 ONE (1) no.,10,000 MT capacity, refrigerated, low pressure ammonia storage tank of double wall double integrity type as per API-620, Appendix-R latest edition for design and construction, material selection, inspection and testing.

2.1.2 The effective storage of 10,000 MT of liquid ammonia shall be measured at (-)33^{o}C excluding the vapor space (including slosh height) and dead volume of the tank. The tank shall be designed for the maximum boil-off of 0.04 wt.% evaporation rate per day (24 hour basis).

2.1.3 The holding compressor (considering only boil-off without any receipt/transfer) of the 10,000 MT ammonia storage tank shall be designed for handling the maximum boil-off

from the 10,000 MT ammonia storage tank. Also the holding compressor shall be provided with emergency backup power provision from the proposed DG Set enabling to operate during power failure.

2.1.4 The following take-off points with positive isolation i.e., double block & bleed valve arrangement shall be provided in the proposed ammonia storage tank facility**:**

1. 80 NB Take-off in liquid inlet line to the proposed ammonia storage tank to enable transfer of liquid ammonia from the existing ammonia storage tank to the proposed ammonia storage tank using existing ammonia transfer pumps.
2. An exclusive discharge header from the proposed ammonia transfer pumps provided with 80 NB Take-off to enable transfer of liquid ammonia from the proposed ammonia storage tank to existing NP plants using proposed ammonia transfer pumps.

2.1.5 ***Note: Bidder's scope is limited to providing take-off points with double block & bleed valve arrangement and routing of the vent lines to the drain/vent vessel.***

2.2 **General Design Criteria:**

2.2.1 The tank side first isolation valves shall be butt welded & other side shall be flanged of RTJ type.

2.2.2 Control valves shall be provided with hand-wheel arrangement.

2.2.3 Copper (Cu) & copper alloys material shall not be used for any component of any equipment.

2.2.4 Generally all equipment/piping system shall be designed considering sufficient design margin as per applicable engineering design standards/good engineering practices/specified anywhere else in the tender document. However a minimum design margin of 10% to be considered if it is not specified.

2.2.5 Pipeline used in liquid ammonia services shall be low temperature carbon steel (LTCS) and instrument air piping shall be of stainless steel, SS304. Corrosion allowance of 1.5 mm shall be considered for all carbon steel pipelines. Unless otherwise specified corrosion allowance for all exchangers should be as per TEMA standard.

2.2.6 The exchanger design shall consider the following minimum fouling factors:

1. Steam : 0.0001 $m^2.^oC.h/kcal$
2. Cooling Water, Shell Side - CS/SS : 0.0006/0.0002 $m^2.^oC.h/kcal$
3. Cooling Water, Tube Side - CS/SS : 0.0004/0.0001 $m^2.^oC.h/kcal$

2.3 **Ammonia Storage Tank:**

2.3.1 The specification of 10,000 MT ammonia storage tank is given below:

Sl. No.	Item	Specification
1.	Capacity	10,000 MT (excluding dead volume at tank bottom &vapor space including slosh height at top)
2.	Type	Double Walled Double Integrity
3.	No. of	ONE
4.	Design Overpressure	800 mmWC(G) at Top
5.	Design Vacuum	(-)50 mmWC(G)
6.	Operating Pr. & Temp.	500 mmWC(G)&(-)33^{o}C
7.	Design Temperature	(-)35^{o}C & (+)55^{o}C
8.	Nozzle Size	Minimum 250 NB Inlet/outlet Liquid Connection
9.	Material of Construction	LTCS suitable for (-)35^{o}C
	Corrosion Allowance	
10.	- Inner Shell & Bottom	Nil
11.	- Outer Shell & Bottom	1.5 mm
12.	- Dome Roof	1.5 mm
13.	- Suspended Deck	1.0 mm
14.	- Roof Structure	1.5 mm
	Insulation	
15.	- Shell	Polyurethane Foamed in situ
16.	- Bottom	Foam Glass & Perlite Concrete
17.	- Roof	Suspended Deck of Resin Bonded Glass Wool
18.	Foundation	Raised Foundation to have free circulation of air

Sl. No.	Item	Specification
		beneath the concrete base to avoid frost formation

2.3.2 **Tank Instruments:**

The storage tank shall be provided with the following instruments:

Inner Tank/Cup : TWO (2) Independent Servo Type Level Transmitters
: TWO (2) Independent Pressure Transmitters
: TWO (2) Independent Multipoint Type Temperature Element (Minimum: SIX (6) nos. at Equal Heights with atleast ONE (1) at Lowest Tank Level & ONE (1) in Vapor Space)
: Pressure Relief cum Vacuum Breaker Valve with 100% Redundancy

Outer tank/Annulus : TWO (2) Differential Pressure Type Level Transmitter

Suitable Skin Temperature Measurement for tank cooling down is required at 8 points i.e., 4 at Inner Cup Bottom & 4 at Inner Cup Shell.

2.3.3 **Tank Insulation:**

- Tank Shell : Polyurethane Foamed in situ.
- Tank Bottom : Foam Glass & Perlite Concrete (under inner tank bottom plate)
- Tank Roof : Suspended Deck of Resin Bonded Glass Wool

2.3.4 **Pipe Insulation:**

- Piping Insulation : Polyurethane Foam

(Thickness of insulation and property of insulation shall be clearly defined)

2.4 **Ammonia Receipt/Unloading Facility:**

2.4.1 Operation: The barge bullets/road tankers containing liquid ammonia at (-)26°C to (-)29°C & 1 kg/cm^2(G) will be made available at the barge jetty/tanker bay. The unloading operation is carried out by pressurizing the bullets/tankers using vapor ammonia from unloading compressors and transferring the liquid ammonia to the storage tank.

2.4.2 Barge Unloading: TWO (2) different size barges of 192 MT & 350 MT capacities are to be unloaded. Accordingly, the liquid and vapor connections at jetty side are to be designed to enable unloading from these two types of barges with one barge at a time. The 192 MT capacity barge consist of SIX (6) bullets each having water volume of 60.9 m^3 & the 350 MT capacity barge consist of FOUR (4) bullets each having water volume of 142 m^3. The liquid ammonia in barge bullets is at (-)26°C temperature & 1 kg/cm^2(G) pressure. The barge bullets unloading operation involves the following operating sequence:

1. Connection & Leak Testing
2. Unloading
3. Depressurizing& Disconnecting

2.4.3 First operation involves connection of liquid & vapor lines of barge with jetty pipelines using flexible hoses, then slowly pressurize the hose connections using vapor ammonia either from the existing/proposed refrigeration system or from the barge bullets to check for any leaks. After completing the leak testing, the barge bullets will be pressurized (all at a time) by using vapor ammonia from the existing/proposed refrigeration system and the unloading of liquid ammonia from barge bullets to storage tank will commence. The unloading operation is carried out in TWO (2) sets i.e., THREE (3) bullets at a time in case of 192 MT barge & TWO (2) bullets at a time in case of 350 MT barge. On completion of the unloading operation (i.e., liquid level in bullets indicates zero) the barge bullets will be depressurized (all at a time) by opening the depressurizing valve in the vapor return line and once the depressurization is complete (i.e., equalizing with tank pressure), the liquid & vapor lines connection between the barge & jetty will be disconnected.

2.4.4 Required Unloading Cycle Time: The maximum time for unloading the 350 MT capacity barge bullets including pressurizing, rampup & depressurizing to 1 kg/cm^2(G) shall be 6.0 hour, excluding the time for connection/disconnection. This is subjected to the temperature of liquid ammonia from the barge bullets at unloading point shall not be warmer than (-)26^{o}C and the storage tank overpressure shall be limited to maximum of 600 mmWC(G) during the entire unloading operation in combination with simultaneous transfer to user plant/s at the maximum rate. ***Note: Bidder/s to arrive at the suitable unloading rate & pressure considering the above philosophy. The design calculations to be submitted along with their offer.***

2.4.5 Piping Requirement: ONE (1) liquid, ONE (1) vapor header, ONE (1) precooling line, ONE & ONE (1) instrument air line from the storage tank to the barge jetty located at approximately 450 m away from the proposed storage tank system with barge connecting pipes (including flexible hoses). The specification of flexible hose is attached as ***Annexure-6.0.*** However refer to piping scope matrix vide Doc. No. 32686-03-SM-001 of this tender document for LSTK Contractor's scope w.r.t this unloading piping.

2.5 **Ammonia Transfer/Dispatch Facility:**

2.5.1 Operation: To transfer liquid ammonia to the user plants.

2.5.2 Required Transfer Rate:

- Existing NP Plant : 22.73 MTPH of Liquid Ammonia at (-)33^{o}C
- Proposed NPK Plant : 19.55 MTPH of Liquid Ammonia at (-)33^{o}C
- **Total : 42.28 MTPH of Liquid Ammonia at (-)33^{o}C**

2.5.3 Required Battery Limit Pressure:

- Existing NP Plant : 11.5 kg/cm^2 at Existing Transfer Pump Discharge
- Proposed NPK Plant : 13.5 kg/cm^2(G) at Proposed NPK Plant Battery Limit

2.5.4 Pump Requirement:

- Temperature : (-)33^{o}C
- No of Pumps : THREE (3) no. with TWO (2) working + ONE (1) standby (EACH 40 m^3/h Capacity)

- Capacity : 40 m^3/h Each
- Discharge Pressure : 20 kg/cm^2(G)
- Type of Pump : Vertical Centrifugal
- Drive : Electric Motor

2.5.5 The transfer pump capacity & discharge pressure are to be optimized by bidder/s considering the ammonia transfer from storage tank to the user (existing NP & proposed NPK) plants at approximately 750 m distance & the maximum ammonia demand.

2.5.6 Piping Requirement: TWO (2) independent discharge headers connecting all the THREE (3) pumps enabling transferring liquid ammonia to two user plants using individual pumps.

2.5.7 Pump Design Consideration: Priming type of the pumps should be such that no ammonia is to be vented to atmosphere but should be taken back to the tank. Motors to be provided with suitable variable frequency drive (VFD) operating.

2.5.8 Fittings: Each pump shall be provided with suction strainer isolation valve, discharge line shall have pressure gauge, automatic recirculation valve, non return valve (NRV), minimum flow line and isolation valve. The common discharge headers shall be provided with pressure transmitter with LOW & HIGH pressure alarms.

2.6 **Ammonia Refrigeration System:**

In addition to the above mentioned ammonia receipt/transfer philosophy the following operating scenarios are also be considered in designing the refrigeration system:

2.6.1 During normal operation, the 10,000 MT ammonia storage tank should be able to unload liquid ammonia from the either 350 or 192 MT barge with one barge at a time along with simultaneous transfer of liquid ammonia to the user plants.

2.6.2 ***Note: Bidder/s has to ensure the proposed storage tank & its refrigeration system are capable of handling the liquid & vapor load corresponding to the refrigeration load during unloading of ONE (1) 350 MT barge or ONE (1) 192 MT barge along with***

simultaneous transfer of liquid ammonia to the user plants i.e., considering pump minimum flow. Accordingly, bidder/s shall size the liquid & vapor lines of proposed system considering the above philosophy. The design calculations to be submit along with their offer.

2.6.3 The refrigeration system shall be designed considering all the above mentioned operating scenarios along with simultaneous receipt and/or transfer to user plants at the maximum rate, boil-off conditions. ***Note: Refrigeration load of governing scenario with breakup to be submitted by bidder/s along with their offer.***

2.6.4 However the bidder/s shall take care of all factors influencing refrigeration capacity while design the ammonia storage system.

2.7 **Line Sizing Criteria:**

2.7.1 Bidder/s to choose the most economical line size to ensure the **liquid & vapor flow rates corresponding to the maximum refrigeration load as defined in *Clause No.2.6.3*** on continuous basis throughout the useful life of the plant/system. However bidder/s shall optimize the system to deliver maximum unloading rate.

2.8 **Design Pressure Philosophy:**

2.8.1 The basic concept in the design pressure philosophy is to set the design pressure of the equipment equal to the highest pressure expected during normal operation plus the margin required by the relief device for proper operation**.**

2.8.2 Bidder**/**s shall consider all applicable codes &standards and design philosophy of other disciplines relevant to the extent applicable**.**

2.8.3 If the equipment contains liquid, the design pressure shall not be less than the vapor pressure of the liquid at design temperature except if a safety device is installed to limit the pressure**.** Maximum operating pressure shall be the highest possible pressure during operation, start up, shut down & upset condition**.** Design pressure shall be regarded as acting at top of the vessel**.**

2.8.4 Safety Relief Valves shall be supplied with locked open isolating valves**.** Spares for safety relief valves shall be provided where necessary for process reasons. The set

pressure of pressure relief valves shall be equal to the design pressure**.** All safety valves will have bypass with exception of safety valves which are only for fire cases and if there is more than one safety valve**.** The discharge of all process safety valves & vent lines shall be routed to the storage tank**/**flare as applicable**.**

2.9 **Refrigeration System:**

The major equipment in refrigeration system are as follows:

1. Refrigeration Compressors (Holding & Unloading)
2. Condensers
3. Ammonia Receiver
4. Economizer
5. Purger/Inert Gas Remover

2.9.1 **Refrigeration Compressors:**- THREE (3) nos. for unloading operation i.e., TWO (2) working + ONE (1) standby and ONE (1) no. for pressure holding operation i.e., for Boil off duty, i.e., no ammonia receipt/no ammonia transfer condition

- Compressor Type: Screw
- Drive: Electric Motor

2.9.1.1 Compressors selected shall be 100% reliable and proven. It shall be designed for optimum energy at varying load with proven performance.

2.9.1.2 Unloading Compressors shall be motor driven and each compressor shall be each capable of handling 60% of maximum duty as per ***Clause No.2.6 considering the maximum refrigeration load scenario***. This compressor should be equipped with automatic capacity control from 10 - 100% step less and actuated by logic initiated by reliable pressure transmitters (2oo3 logic) installed on the ammonia storage tanks.

2.9.1.3 Holding Compressor shall be motor driven and capable of handling 120% of maximum boil-off duty as per design requirement as specified in the ***Clause No.2.1.3***. The holding compressor should have provision to run on emergency power from DG set, in case of main electrical power failure.

2.9.1.4 The lube oil pumps of the holding/unloading compressors shall have auto change over system. The lube oil pumps of holding compressors should have provision to run on emergency power from DG set, in case of main electrical power failure.

2.9.1.5 Each compressor together with its driver, oil system, inter-connecting piping, all auxiliary items, such as heat exchangers, separators, pumps, valves, etc., and instrumentation, shall be one integrated unit. Manufacturer shall provide adequate relief and venting at suction and discharge. All drains on the process side shall have double block valves.

2.9.2 **Condenser:** Connected to discharge of all compressors with ability to handle full load of unloading compressors in line with suitable design margin. ONE (1) equal capacity condenser as standby to facilitate maintenance job on condenser. The standby condenser will be inertized on both the sides with nitrogen. Cooling water shall be on tube side and the tubes shall be of SS 304 only. The isolation valves on cooling water supply/return lines to the individual condensers side shall be of SS304 minimum.

2.9.3 **Ammonia Receiver:** Shall be capable of handling maximum of single condenser's design load by the bidder/s.

2.9.4 **Economizer:** To cool liquid ammonia from receiver and reduce refrigeration load on compressor. The Economizer tubes shall be of SS 304 only.

2.9.5 **Purger/Inert Gas Remover:** Liquid ammonia from refrigeration system to the tank will contain inerts. Proper estimate of inert to be taken care while fixing the capacity of the purger/inert gas remover. Purger design should be such that no loss of ammonia should take place along with purge gases.

2.9.6 ***Note: Bidder/s shall consider all necessary equipment/item as per the refrigeration system design requirement. One (1) Drain tank of minimum 1 m^3 and vent vessel of suitable size to be provided.***

2.10 **Separator:** The barge liquid ammonia unloading from barge jetty shall be provided with a suitable separator to avoid/prevent hot vapor (from the barge) entering the storage tank during the barge unloading operation.

2.10.1 The separator to be located at ground level and provided with suitable level transmitter with low level alarm and independent level switch (float) which on actuation shall initiate tripping of barge unloading operation. Also the separator to be provided with a safety relief valve and vent line connected to flare header.

2.10.2 The barge/tanker unloading line, vapor pressurizing line, precooling line and separator shall be provided with polyurethane (PU) foam insulation.

2.11 **Ammonia Vaporizer & Ammonia Gas Cooler:**

2.11.1 ONE (1) ammonia vaporizer to vaporize liquid ammonia using low pressure (LP) steam to be considered & ONE (1) ammonia gas cooler (only if required) for aiding in unloading operation. Both the vaporizer & gas cooler shall be designed for maximum heat duty with suitable design margin. The bidder/s shall configure the unloading system such that colder gas to be used for barge unloading. ***Note: Bidder/s to specify the LP steam requirement in their offer.***

2.12 **Flare Stack:**

2.12.1 Hot flare stack with flame front ignition panel shall be provided. The flare stack height sufficient to maintain the ground level concentration (GLC) below 25 ppm in case of hot flare flame cut off as per the prevailing standard shall be provided.

2.12.2 The capacity of the flare to be decided considering all vents valves and safety relief valves (excluding storage tank safety relief valve) flow capacity of the proposed system, which must be specified clearly with the offer.

2.12.3 It shall be provided with dual firing system and flame scanners for flame detection for pilot flame indication of the same to be given in PLC. System with self-adjusting as well as manual adjusting of air/gas ratio to be considered. THREE (3) no. of pilot burners along with individual flame scanners shall be provided.

2.12.4 Fuel Source: Natural Gas/LPG

- Natural Gas – tapping from existing pipeline at battery limit
- LPG – tapping from existing cylinder manifold

2.13 **Cooling Tower System:**

2.13.1 Suitable cooling tower system shall be provided. The cooling tower system shall includes the following:

1. Cooling Tower preferably of induced draft type
2. RCC Sump
3. Cooling Water Circulation Pumps - Preferably Horizontal Centrifugal Type
4. Cooling Tower Fans
5. Side Stream Filter

2.13.2 Cooling tower having TWO (2) cells i.e., ONE (1) working + ONE (1) standby with provision for individual isolation for maintenance job shall be provided.

2.13.3 Cooling tower fans - each cooling tower cell shall have ONE cooling tower fan along with suitable variable frequency drive (VFD) electric motor.

2.13.4 Cooling water circulation pumps - THREE (3) nos. i.e., TWO (2) working + ONE (1) standby on"Auto mode" shall be provided.

2.13.5 Cooling Tower Design should comply below mentioned parameters:

- Approach : $\leq$3.5^{o}C
- Range : 6 to 8^{o}C
- Supply Pressure : 3.5 kg/cm^{2}(G) minimum (Bidder to decide)
- Return Pressure : 3.0 kg/cm^{2}(G) minimum (Bidder to decide)
- Design Wet Bulb Temperature : 29^{o}C
- Mechanical Design Pressure : 10.5 kg/cm^{2}(G)
- Mechanical Design Temperature : 65^{o}C
- Cycles of Concentration : 4 min

2.13.6 The cooling water return downstream of ammonia condensers/other heat exchangers shall be provided with relief valves. The online pH & conductivity meters, cooling water supply & return header temperature, pressure transmitters, cooling tower fans & circulation pumps motor running indication to be considered. Bidder/s to provide P&IDs of cooling tower system along with their offer.

2.14 **DG Set:**

2.14.1 Diesel Generator (DG) set along with load bank for DG set testing shall be provided.DG set capacity selection should be based on meeting of the emergency requirement in case of power failure. The equipment connected on DG set shall be as below:

1. 1 No. - Holding Compressors
2. 1 No. - Lube Oil Pump of Holding Compressors
3. 3 No. - Cooling Water Circulation Pumps (2 working + 1 standby)
4. 2 No. - Cooling Tower Fans (1 working + 1 standby)
5. Ignition Panel for Flare Stack
6. Emergency Lighting
7. 2 No. - Instrument Air Compressors (1 working + 1 standby)
8. Air Drier Unit (ADU)
9. Control System
10. Battery Charger
11. UPS

2.15 **Instrument Air System:**

2.15.1 Instrument air system shall be designed to meet the instrument air quality standard as per ISA-S7.0.01 by considering the instrument air & service/plant air requirement of the proposed ammonia storage tank system along with the associated facilities. The instrument air system shall include the following:

1. Instrument Air Compressors - TWO (2) Nos.
2. Air Receiver - TWO (1) No.
3. Air Drier Unit (ADU) - ONE (1) No.

2.15.2 Instrument Air Compressor (IAC): TWO (2) nos. with 100% standby i.e., ONE (1) working + ONE (1) standby.

- Compressor Type: Screw
- Drive: Electric Motor

2.15.3 Capacity: to be fixed by the bidder/s considering the maximum continuous air demand for the proposed ammonia storage tank facility. The service air for the proposed facility shall be taken care by the instrument air compressor. The service air piping shall be CS.

2.15.4 **Receiver:** ONE (1) no. Instrument air receiver of sufficient capacity considering at least 15 minutes trouble free operation on non-availability of IAC shall be provided. In addition ONE (1) no. wet air receiver of sufficient capacity shall be provided.

2.15.5 The ammonia barge bullets are envisaged to be fitted with TWELVE (12) nos. of pneumatic type ShutOff valves on 80 NB liquid/vapor lines and it is proposed to provide the instrument air supply line at the barge jetty. Accordingly, the IACs shall be designed to maintain sufficient header pressure (4.5 kg/cm^2(G) min.) at the farthest point.

2.15.6 **Air Drier Unit (ADU):** The air drier unit shall be designed to meet the quality standard, ISA-S7.0.01 for instrument air. ONE (1) no. fully automatic, desiccant type ADU suitable for the system for continuous supply of air (capacity shall be considered as per ***Clause No. 2.15.3***) at pressure dew point of (-)40^{o}C at 7.5 kg/cm^2(G) with online dew point meter for monitoring shall be provided.

2.16 **Safety &Security Equipment:**

2.16.1 Ammonia gas detectors of minimum TEN (10) nos. at strategic locations comprising of TWO (2) nos. in compressor house, TWO (2) nos. in refrigeration section, ONE (1) no.in ammonia transfer pump area, ONE (1) no. in ammonia barge unloading jetty, ammonia storage tank top TWO (2) nos. covering air flow direction shall be provided.

2.16.2 EYEWASHER&SAFETY SHOWERS as per applicable standard shall be provided.

2.16.3 MANUAL CALL POINTS in control room, compressor house, MCC and DG set room and any other strategic locations and it shall be integrated to the existing system.

2.16.4 EMERGENCY SIREN in control room for alarming the nearby installations to be provided.

2.16.5 Minimum TWO (2) nos. of luminous wind direction indicating WIND SOCKS located such that it is visible at all time from the control room and nearby area shall be provided.

2.17 **For Mechanical, Electrical, Instrumentation, Civil &Fire Fighting requirements refer to respective Design Philosophies/Special Requirements of this tender document.**

2.18 **Effluent System:**

2.18.1 There should be no liquid effluent from the ammonia storage tanks system during normal operation excluding leakages, cleaning etc., However considering the cooling water system effluent and routine cleaning activities ONE (1) effluent collection pit with TWO (2) nos. of effluent transfer pumps i.e., ONE (1) working + ONE (1) standby of suitable capacity (approximately 5 m^3/h & 3 $kg/cm^2(G)$) as per the design shall be provided**.** The process area drains are also to be routed to this pit**.**

2.18.2 The discharge of the effluent pump shall be pumped to the existing effluent treatment plant via above ground pipeline. The effluent collection pit shall be provided with online pH meter and a level transmitter of suitable type. The pump discharge shall have individual pressure gauges and discharge line shall be terminated at plant battery limit provided with suitable isolation valve and blind flange.

2.19 **List of Major Safety Interlocks:**

2.19.1 The ammonia storage tank system and associated facilities shall be provided with necessary safety interlocks as per applicable engineering design standards/regulations.

2.19.2 The minimum safety interlocks are listed below:

Sl. No.	Process Variable	Action
1.	Storage Tank Pressure HIGH	The ShutOFF valve in the tank liquid inlet line shall close with alarm. Pre-alarms to be provided. In case of extremely high pressure, emergency venting to flare is done by opening HIC control valve in vapor vent line.
2.	Storage Tank Liquid Level HIGH	The ShutOFF valve in the tank liquid inlet line shall close with alarm. Pre-alarms to be provided.
3.	Storage Tank Liquid Level / Pressure LOW	The ShutOFF valve in the tank liquid outlet line shall close with alarm & the ammonia transfer pump shall TRIP with alarm.
4.	Annulus Liquid Level HIGH	The ShutOFF valve in the tank liquid outlet line shall close with alarm.
5.	Ammonia Transfer Pump Discharge Pressure LOW	The ammonia transfer pump shall TRIP
6.	Compressor Suction Pressure LOW	Compressor shall TRIP. Pre-alarms to be provided.
7.	Compressor Discharge Pressure HIGH	Compressor shall TRIP. Pre-alarms to be provided.
8.	Compressor Discharge Temperature HIGH	Compressor shall TRIP. Pre-alarms to be provided.
9.	Compressor Lube Oil Temperature (Oil Cooler Outlet) HIGH	Compressor shall TRIP
10.	Compressor Oil Separator Level LOW	Compressor shall TRIP

3.0 SPARES

3.1 MANDATORY SPARES

The mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project is listed in the attached spares List vide Doc. No. *32686-11-PS-002-SPR*. These spares shall be purely warehouse spares. Bidder/s shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include

the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.

Bidder/s shall indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant

3.2 **RECOMMENDED SPARES FOR 2 YEARS OPERATION**

The Bidder/s shall submit the list including unit & quantity of recommended spares for two years normal operation & maintenance in un-priced part as per format attached and item wise price shall be submitted in priced part. The Purchaser reserves the right to buy any or all recommended spares.

Prices of recommended spares will not be used for the evaluation of Bids. Prices of Spares shall remain valid for two years from the end of Warrantee period; Owner may order such spares any time during this period.

3.3 **START-UP & COMMISSIONING SPARES**

Start-up commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. All spares used until the system is handed over to the Purchaser shall come under this category. The Vendor shall procure and supply spare parts for start-up and commissioning and shall be included in his scope of work without any extra cost to purchaser. The Lump sum quoted price in the price bid (supply) shall be deemed to be inclusive of provision for such spares and additional spares.

4.0 DOCUMENTATION SCHEDULE

4.1 Documents shall be submitted as per attached vendor data requirements for ammonia storage system including utility facilities vide Doc. No. *32686-11-PS-002-VDR* attached with the tender document.

5.0 SUB-VENDORS LIST

5.1 The safety relief valves, rupture disc shall be procured / fabricated as per approved vendor list vide Doc. No. *32686-11-PS-002-VL* attached with the tender document. Any equipment for which vendor list is not enclosed, the bidder/s may furnish a list of their

proposed vendors along with their references for supply of similar type of equipment along with bid. However all the additional proposed vendors shall have well proven track record and shall be subjected to owner's approval.

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TPS No. : **32686-11-PS-002**

Item : **Performance Guarantee Test**

Item No. : **32686-11-PS-002-PGT**

Project : **10,000 MT AMMONIA STORAGE FACILITY AT CD**

Client : **M/s. FACT-CD**

Location : **Ambalamedu, Kochi**

1	Revised & Issued For Comments	27/05/2021	AT	KVR	KVR
0	For Comments	13/04/2021	AT	KVR	KVR
Rev.	**Description**	**Date**	**Prpd. By**	**Chkd. By**	**Aprd. By**

CONTENTS

1.0 TIME SCHEDULE

1.1 CONTRACTOR shall render their services in accordance with the Time Schedule specified in the Tender.

1.2 CONTRACTOR guarantees completion of the project within TWENTY (20) months from the effective date of contract.

2.0 MATERIAL WARRANTY

2.1 CONTRACTOR warrants that the EQUIPMENT including the automatic controls and instruments etc. will be new and without defects in material and workmanship.

2.2 The warranty is valid for TWELVE (12) months from the date of preliminary acceptance of the plant.

2.3 Any deficiency with regard to this warranty that may be found during the warranty period under this article is to be reported in writing by OWNER to CONTRACTOR. In such case CONTRACTOR shall undertake the obligations under this warranty to repair or replace any defective part of EQUIPMENT at site at its own costs. Replaced materials will be placed at CONTRACTOR'S disposal at site. All terms and conditions with regard to warranty for the original item will also held true for replaced items.

2.4 The warranty under this article covers also any part that has been replaced as per article 2.3 and will be valid in such cases for TWELVE (12) months from start-up of the replaced item.

2.5 On CONTRACTOR's request, OWNER will render assistance to CONTRACTOR in the operation of the plant and give CONTRACTOR an opportunity to inspect the deficiency and examine its causes.

2.6 OWNER shall have the option to use the EQUIPMENT until replacement is made, in case such replacement is necessary and use of the EQUIPMENT if possible, which will be determined in consultation with CONTRACTOR.

3.0 PERFORMANCE TEST RUN PROCEDURE

3.1 After the unit have been completed, put into operation and steady state operation is established, performance test of units shall be conducted. Before carrying out of the

performance test of units, CONTRACTOR shall develop a procedure/protocol and schedule in consultation with the OWNER/FEDO and submit to OWNER/FEDO for their approval. Among other things the procedure shall broadly include the following:

1. Test Conditions
2. Log Sheet for Recording Operating Data
3. Analytical Methods
4. Methods of Calculations
5. Pre-Test Run Period, if any
6. Methodology for Interpretation and Measurement of Tests
7. Methodology for Taking Operating Data and its Frequency
8. Methodology for Evaluating the Performance of the Unit, Fuel/Utilities/Energy Consumption at Unit's Battery Limits etc.

3.2 CONTRACTOR shall provide the services of his commissioning engineer during this performance test run period. CONTRACTOR shall be held responsible for any defects noted during performance test run and attributable to him and shall be dealt as per the relevant provision of the contract.

3.3 Measuring methods, tolerances, instructions for analysis and calculations shall be as per accepted practices and shall be mutually agreed upon before the start of performance test. Bidder/s shall furnish the measuring methods & tolerances in their offer.

3.4 If a performance test of unit has been carried out successfully for a period as specified and plant guarantees as per CONTRACTOR's bid are met, then the performance test shall be deemed to have been successfully completed.

3.5 After completion of a performance test, all relevant operating and production figures shall be recorded in a protocol to be signed by authorized representatives from CONTRACTOR and OWNER.

3.6 CONTRACTOR shall prepare test report and submit to OWNER/FEDO within FIFTEEN (15) days after the completion of performance test. A guarantee shall be deemed to have been met if OWNER/FEDO indicates that the performance test was successful and if OWNER within THIRTY (30) days after notification of the results of such performance test, do not specify in writing to CONTRACTOR in what respect, in OWNER's opinion, such guarantee has not been met.

4.0 FUNCTIONAL TESTS

4.1 The Functional Tests shall demonstrate that the safety and controls of the plant operate satisfactorily. The Functional Tests shall be part of CONTRACTOR's commissioning program. These tests shall be performed prior to offering the plant for Reliability Test and Performance Guarantee Tests. The Plant shall be ready in all respects prior to commencement of the Functional Tests. The individual Functional Tests to be demonstrated by the CONTRACTOR and witnessed by the OWNER/FEDO for each system under this package shall be mutually agreed upon during detail engineering phase.

4.2 Functional Tests shall broadly cover, but not be limited to, the demonstration of satisfactory functioning of the following:

4.3 General Functional Tests (applicable for all plants/ systems under this package)

1. Hydrostatic Test
2. Alarm, Trip, Remote/Manual Operation, Process and Safety Interlocks, Emergency Shutdown of the Systems/Equipments included in this package.
3. Automatic Operation of all System Controls, Bump Less Changeover of Auto/Manual Controls and Proper Maintenance of the Controlled Variables within the desired band.
4. Normal Start-up & Shutdown Sequence of the Refrigeration section.
5. Fail Safe Shutdown in the event of total Power Failure.

5.0 PERFORMANCE GUARANTEE TEST

The following performance guarantee shall have to be demonstrated by the CONTRACTOR:

5.1 Performance Guarantee:

a. **Ammonia Storage Tank Capacity:** Effective storage capacity of 10,000 MT of liquid ammonia at (-)33^{o}C & 500 mmWC(G) excluding the dead volume at bottom of the tank and vapor space including slosh height at the top. Bidder/s shall furnish methodology for fulfillment of capacity guarantee test.

b. **Unloading Cycle Time from 350 MT Barge Bullets:** Capacity of barge unloading/refrigeration system to unload liquid ammonia from the 350 MT barge bullets within the unloading cycle time of 6 hours while maintaining the storage tank temperature and pressure. This is subjected to the temperature of liquid ammonia in the bullet being at (-)26^{o}C maximum. The unloading cycle time shall include pressurizing, rampup &

depressurizing to 1 kg/cm^2(G), excluding the time for connection / disconnection. ***Note: In any case, the storage tank pressure shall not exceed 600 mmWC(G) at any time during the unloading operation.***

c. **Rate of Liquid Ammonia Transfer to User Plant/s:** Capacity of each ammonia transfer pump to deliver liquid ammonia at the rate of 40 m^3/h & 20 kg/cm^2(G) discharge pressure. ***Note: The transfer pump capacity & discharge pressure shall be finalized during detailed engineering by the CONTRACTOR in consultation & approval from OWNER considering the maximum ammonia demand & pressure by User Plant/s.***

d. **Tank Boil Off:** This test is to determine the heat ingress through insulation. Guaranteed figure shall be maximum 0.04% evaporation per day of the tank content when the tank is entirely full and it is maintained at (-)33ºC & 500 mmWC(G). Bidder/s to furnish methodology for fulfillment of boil off guarantee test.

e. **Noise Level Guarantee:** CONTRACTOR shall demonstrate the noise level below 85 dBa @ 1 m from the equipment.

f. **Utility Consumption:** CONTRACTOR guarantees fulfillment of consumption figure for utilities (Works Cost) during Unloading of liquid ammonia from Barge to Storage Tank along with Transfer of liquid ammonia from Storage Tank to User Plant/s, as submitted with bid in the below given tabular format. CONTRACTOR shall demonstrate separately the guaranteed power, make-up water & steam consumption, during performance guarantee test run of 72 hours. For evaluation purpose, the average power consumption during THREE (3) unloading cycles from 350 MT Barge and simultaneous Transfer of liquid ammonia to User Plant/s.

Parameter	**Rate (A) INR**	**Unit**	**Specific Consumption (Bidder/s to fill-up Guaranteed Figures) (B)**	**Amount (A X B)**
Power	6.378	kWh	---- kWh per **Unloading Cycle & Simultaneous Transfer of liquid ammonia**	
Raw Water (Cooling Tower Make-up)	17.89	m^3	----- m^3 per **Unloading Cycle**	
Total Guaranteed Utility Consumption per Unloading Cycle				

Loading towards utility consumption (Works Cost):

Bidder/s shall furnish the guaranteed consumption figures of utilities as defined in clause 5.1 f). Calculation of Works Cost shall be done as defined therein. The differential Works Cost (in comparison to Bidder quoting the lowest Works Cost) considering 365 stream days per year will be calculated and will be discounted at the discount rate of 10.0% p.a. for the period of 15 years of operation starting from Preliminary Acceptance. Such differential works costs shall be added to the Lump Sum price of respective CONTRACTORs to arrive at the Final Evaluated Price. The bidder with the Lowest (L-1) Final Evaluated Price shall be selected as the successful bidder.

5.2 The performance guarantee under 5.1 shall be carried out by CONTRACTOR in the presence of OWNER/FEDO and will be proved by a continuous test run of 72 hours. In case it is not possible due to limitation from availability of ammonia barge or user plant/s shutdown, it shall be carried out for individual plant sections separately. CONTRACTOR will notify OWNER, 72 hours before beginning of the guarantee test run. If the test run cannot be made within the period set forth above, a test run procedure will be proposed by CONTRACTOR and mutually agreed to between the parties.

5.3 The performance guarantee will be deemed to have been fulfilled if the average values obtained during the test run are not less favorable than those stipulated in clause 5.1. Immediately after successful proof of performance guarantee, OWNER will give written confirmation of plant acceptance to CONTRACTOR.

5.4 The guarantee test runs shall be undertaken, under CONTRACTOR's direct supervision and responsibility, under normal operating conditions.

5.5 All working data of the guarantee test runs which are required for the purpose of evaluating the results of such test runs shall be signed and confirmed both by OWNER's and CONTRACTOR's authorized representatives. Instruments for analysis and measurements shall be calibrated as per accepted international practices and their accuracy shall have to be mutually agreed upon before start of the guarantee test runs.

5.6 Fulfillment of performance guarantee according to 5.1 will be considered to be effected if the test run cannot be performed within TEWLVE (12) months after mechanical completion due to reason not attributable to CONTRACTOR. Beyond this period, for the performance of the plant, CONTRACTOR will render all necessary services at terms and conditions to be mutually agreed upon.

5.7 If the guarantee figures as signed and confirmed between OWNER and CONTRACTOR are not reached during the test run either completely or partially due to reasons for which CONTRACTOR is responsible, CONTRACTOR will make necessary alterations of the plant for fulfillment of performance guarantees.

5.8 CONTRACTOR shall carry out the modification at their cost within SIXTY (60) days.

5.9 In case guarantees are not reached even after modification, OWNER shall have the option to undertake modification addition to achieve the guarantee figure at the risk and cost of the CONTRACTOR.

5.10 The guarantee test runs shall deem to have been satisfactorily completed when the ammonia storage and dispatch facility has been established to have achieved guaranteed capacities and consumption of utilities.

6.0 PERFORMANCE DEFICIENCY DAMAGES

6.1 Ammonia Storage Tank Capacity:

Ammonia storage tank capacity of 10,000 MT shall be demonstrated by CONTRACTOR as per the methodology given by CONTRACTOR. There shall be no negative acceptable deviation for the ammonia storage tank capacity.

6.2 Rate of Liquid Ammonia Receipt From Barge Bullets: (Guaranteed Unloading Cycle Time of 5 hours)

There shall be no upper acceptable deviation for the guaranteed unloading cycle time from the 350 MT Barge Bullets.

6.3 Rate of Liquid Ammonia Transfer to User Plant/s: (Guaranteed 40 m^3/h for each pump)

There shall be no negative acceptable deviation for the guaranteed rate of transfer of liquid ammonia to user plants.

6.4 Tank "Boil Off": (Guaranteed maximum 0.04% evaporation rate per day)

There shall be no upper acceptable deviation for the guaranteed evaporation rate from tank.

6.5 Noise level: (Guaranteed maximum 85 dBa 1 m from equipment/process line)

CONTRACTOR shall demonstrate the noise level below 85 dBa @ 1 m from the equipment /process line with zero deviation on positive side.

6.6 Utility Consumption (Works Cost):

If and as stated in specifications mentioned at para 5.1 f) above, in the event that the consumption figures exceed the figures guaranteed by the CONTRACTOR, it is agreed that the OWNER shall be entitled to recover and/or the supplier shall pay to the OWNER, without prejudice to any other right or remedy available to the OWNER, the following amount as **damages**:

CONTRACTOR shall pay damages at the rate of 0.5% of basic Total Basic contract Order value for every 1% or part thereof increase in the total works cost, subject to a maximum of 2.5% of the Total Basic Contract Order Value.

For clauses 6.6 beyond tolerance limit, Make Good clause shall be applicable. For clauses 6.1 - 6.5 no tolerance is applicable.

6.7 Civil Works:

For any mistake in Civil Work arising due to incorrect civil jobs done by the CONTRACTOR shall rectify the same without any cost to OWNER.

6.8 Make Good Clause:

In case of any shortfall in the guaranteed performance within the limit, CONTRACTOR has the option to either replace or repair the PLANT to the extent required within a reasonable time from test run, or opt for levy of damages wherever applicable.

However, if the guaranteed performance beyond the tolerance provided as per clause 6.0 above, CONTRACTOR shall carry our corrective action at no extra cost to OWNER and demonstrate the guaranteed performance at least up to the limit where performance deficiency damages is applicable, within a reasonable time frame. However, if guarantees are not attained even after corrective action by CONTRACTOR, OWNER have option to undertake modifications/ additions for fulfillment of guarantees at the risk and cost of the CONTRACTOR and CONTRACTOR's liability in such case shall be unlimited.

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TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENTS	32686-11-PS-002-VDR	
		PAGE 1 OF 3	R0

TPS No.:	32686-11-PS-002
Item:	10,000 MT Ammonia Storage Facility Including Offsite & Utilities
Equipment No.:	
Status:	■ Enquiry ☐ Commitment — **P.O. No.:**

Sl. No.	Group Code	Description	Offer	After Commitment				Final**
			Qty.	Qty.	Lead Time in Weeks			Qty.
					Reqd.	Propd.*	Agrd.	
1.	B	Process Description of the System/Packages	1S+1P	1S+1P	2			1S +4P
2.	B	Process Design Basis - Refrigeration Requirements @ Various Operating Conditions, Specifications & Consumption Ratios of Raw Materials & Utilities (including startup & makeup), Effluent & Emission, etc.,	1S+1P	1S+1P	2			1S +4P
3.	B	Data/Information for Technical Evaluation of Tender as per Scope of Work 32686-11-PS-002-SW & Performance Guarantee Test 32686-11-PS-002-PGT	1S+1P					
4.	B	Equipment Design Margins & Standby Philosophy	1S+1P	1S+1P	2			1S +4P
5.	B	Process Control and/or ESD Philosophy including Critical Equipment Identification (Emergency Power) & VFD Requirements	1S+1P	1S+1P	2			1S +4P
6.	B	Process Flow Diagram (PFD) - Flow Rate, Composition, Temperature, Heat Duty, Power & Pressure Across Each Item/Equipment	1S+1P	1S+4P	4			1S +4P
7.	B	Utility Flow Diagram (UFD) - Flow Rate, Composition, Temperature & Pressure Across Each Item/Equipment		1S+2P	4			1S +4P
8.	B	Piping Material Specification (PMS) – Project		1S+2P	4			1S +4P
9.	B	List of Equipment & Instrument With Specifications - MOC, Capacities, Design Condition & Tolerance Level	1S+1P	1S+1P	4			1S +4P
10.	B	Overall Plot Plan	1S+1P	1S+1P	4			1S +4P
11.	B	Hazardous Area Classification Diagram		1S+4P	4			1S +4P

Legends:	Group Code: **A** – For Review & Detailed Engg. **B** – For Review **C** – For Information & Record Document Type: **P** – Print **S** – Editable Soft in AutoCAD / MS Word / ....
Notes:	* Vendor shall fill in proposed lead time if different from the required lead time ** Each set of final document shall be submitted in a folder. Two such folders shall be packed & despatched with the equipment

Rev	Details	By	Chkd.	Apprd.	Date
0	For Comments	AT	KVR	KVR	13/04/2021

Project: 10,000 MT Ammonia Storage Facility at CD

Client: M/s. FACT-CD

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

00FTxxx/15

Sl. No.	Group Code	Description	Offer	After Commitment				Final**
			Qty.	Qty.	Lead Time in Weeks			Qty.
					Reqd.	Propd.*	Agrd.	
12.	B	Piping & Instrumentation Diagram (P&ID) - Process	1S+1P	1S+4P	4			1S +4P
13.	B	Piping & Instrumentation Diagram (P&ID) - Utilities, Offsite & Yard Piping	1S+1P	1S+4P	4			1S +4P
14.	B	Interlock Logic Diagram (ILD)/Cause & Effect Diagram		1S+4P	4			1S +4P
15.	B	Engineering Design Calculations - Sizing & Pressure Drop, Heat & Mass Balance, Hydraulic & Surge Analysis, Relief/Flare Load etc.,		1S+1P	4			1S +4P
16.	B	HAZOP Report		1S+1P	5			1S +4P
17.	B	Line Schedule & Valve List		1S+1P	6			1S +4P
18.	B	Detailed Specification of Equipment, Piping, Instruments, Safety Relief Valves & Control Valves including package items with General Arrangement Drawings etc.,		1S+1P	6			1S +4P
19.	B	Quality Assurance Plan (QAP) and/or Performance Evaluation Procedures for Process/Package Items		1S+1P	6			1S +4P
20.	B	Pre-commissioning & Commissioning Procedure, Checklist etc.,		1S+1P	56			1S +4P
21.	C	OEM Manual for Individual Equipment & Package Items covering Start-up, Normal Operation, Troubleshooting, Shutdown, Interlock/Safety System & Repairs/Overhaul Procedure Catalyst/Tower Packings Loading/Unloading Procedure etc.,		1S+1P	56			1S +4P
22.	B	Safety & Technical Audit Report		1S+1P	60			1S +4P
23.	B	Performance Guarantee Test Report (as per Performance Guarantee Test 32686-11-PS-002-PGT (Within 5 days after Completion of Guarantee Tests)	1S+1P	1S+1P	81			1S +4P
24.	C	Detailed Operation & Maintenance Manual for the System with Information on Hazard & Safe Practices, Method & Frequency of Sampling/Analysis etc.,		1S+1P	80			1S +4P

Legends:	Group Code: **A** – For Review & Detailed Engg. **B** – For Review **C** – For Information & Record Document Type: **P** – Print **S** – Editable Soft in AutoCAD / MS Word / ....
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Rev	Details	By	Chkd.	Apprd.	Date	
						Project: 10,000 MT Ammonia Storage Facility at CD
0	For Comments	AT	KVR	KVR	13/04/2021	**Client:** M/s. FACT-CD

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

Sl. No.	Group Code	Description	Offer	After Commitment				Final**
			Qty.	Qty.	Lead Time in Weeks			Qty.
					Reqd.	Propd.*	Agrd.	
		Safety Relief Valves						
25.	C	Valve Catalogue		1S+1P	4			1S +4P
26.	B	Valve Data Sheet		1S+1P	4			1S +4P
27.	B	Valve Area Calculation		1S+1P	4			1S +4P
28.	B	Valve Drawings Within 15 days of TOI/LOI/Order for Approval Prior to Manufacture or Inspection indicating, Order No., Valve Tag No., Quantity, End Connection Details, Set Pressure, Valve Dimensions, Material of Construction, Wall Thickness, Hydrostatic Test Pressure etc.,		1S+1P	6			1S +4P
29.	C	Place & Address of premises where it is manufactured		1S+1P	6			1S +4P
30.	B	Test Certificates for Chemical Composition & Mechanical Properties of Valve Material. (Within 3 days after Completion of Testing & Inspection)		1S+1P	56			1S +4P
31.	B	Pressure Test Certificates as per Scope of Inspection 32686-11-PS-002-INS (Within 3 days after Completion of Testing & Inspection)		1S+1P	56			1S +4P

Legends:	Group Code: **A** – For Review & Detailed Engg. **B** – For Review **C** – For Information & Record Document Type: **P** – Print **S** – Editable Soft in AutoCAD / MS Word / ....
Notes:	* Vendor shall fill in proposed lead time if different from the required lead time ** Each set of final document shall be submitted in a folder. Two such folders shall be packed & despatched with the equipment

Rev	Details	By	Chkd.	Apprd.	Date
0	For Comments	AT	KVR	KVR	13/04/2021

Project: 10,000 MT Ammonia Storage Facility at CD

Client: M/s. FACT-CD

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

LEGENDS

- ISOLATION VALVE (GATE/BALL/PLUG)
- GLOBE VALVE
- CHECK VALVE
- PNEUMATIC OPERATED VALVE
- MASS FLOW METER
- ORIFICE FLOW METER
- BLIND FLANGE
- SAFETY RELIEF VALVE
- SPECTACLE BLIND
- ROTARY SCREW COMPRESSOR
- TIE IN POINT
- INSULATION
- BATTERY LIMIT
- VERTICAL CENTRIFUGAL PUMP
- AMMONIA VAPOUR(NHG)
- AMMONIA LIQUID(NHL)
- COOLING WATER(WCS)
- INSTRUMENT AIR(AI)
- GAS LINE(LPG/RLNG)
- STEAM TRAP
- AUTOMATIC RECIRCULATION VALVE

LETTER CODE FOR SERVICE

PPV	PRESSURE CONTROL VALVE
FPV	FLOW CONTROL VALVE
XPV	SHUT OFF VALVE
PI	PRESSURE INDICATOR
PG	PRESSURE GAUGE
PIC	PRESSURE INDICATOR CONTROLLER
PIA	PRESSURE INDICATOR ALARM
TE	TEMPERATURE
RO	RESTRICTION ORIFICE
MI	MOTOR RUNNING INDICATION
PG	PRESSURE GAUGE
LIA	LEVEL INDICATOR ALARM
FIC	FLOW INDICATOR CONTROLLER
FI	FLOW INDICATOR
HPV	HAND OPERATED CONTROL VALVE
I	INTER LOCK
SRV	SAFETY RELIEF VALVE
FC	FAIL CLOSE
FO	FAIL OPEN
LI	LEVEL INDICATOR
TI	TEMPERATURE INDICATOR
HIC	HAND INDICATOR CONTROLLER
M	ELECTRIC MOTOR
NO	NORMALLY OPEN
NC	NORMALLY CLOSE
ST	STEAM TRAP
LO	LOCKED OPEN
NG	NITROGEN GAS
VRV	VACUUM RELIEF VALVE

GENERAL NOTES:

1. INSTRUMENTATION & CONTROL SCHEMES INDICATED ARE MINIMUM PROCESS REQUIREMENT. BIDDER/S HOWEVER SHALL CONSIDER ALL NECESSARY INSTRUMENTS & CONTROL SYSTEM FOR SAFE & NORMAL OPERATION OF THE PLANT AS PER APPLICABLE ENGINEERING DESIGN STANDARDS/REGULATIONS.
2. SUFFICIENT NO. OF AMMONIA GAS DETECTORS SHALL BE PROVIDED.
3. RAW WATER & FIRE WATER WILL BE MADE AVAILABLE AT ONE LOCATION. BIDDER/S SHALL PROVIDE SUFFICIENT SERVICE WATER SUPPLY POINTS AT REFRIGERATION, STORAGE TANK,TRANSFER PUMP, BARGE JETTY & UTILITY LOCATIONS.
4. ALL LIQUID/VAPOR TIE-IN POINTS SHALL BE PROVIDED WITH BLOCK & BLEED ARRANGEMENT AND THE VENT LINES SHALL BE ROUTED TO FLARE HEADER.

NOTES:

1. THE INNER CUP OF STORAGE TANK SHALL BE PROVIDED WITH TWO (2) INDEPENDENT SERVO TYPE LEVEL TRANSMITTERS.
2. TANK SHALL BE PROVIDED TWO INDEPENDENT PRESSURE RELIEF VALVES.
3. THE INNER CUP OF STORAGE TANK SHALL BE PROVIDED WITH TWO MULTIPOINT TEMPERATURE ELEMENT MINIMUM AT SIX LEVELS OF TANK WITH ONE IN LOWEST LIQUID LEVEL & ONE IN VAPOR SPACE.
4. CONNECTION FROM PROPOSED TRANSFER PUMPS (P-201A/B/C) TO EXISTING LIQUID AMMONIA TRANSFER LINE TO NP PLANT.
5. NORMALLY TWO PUMPS WILL BE RUNNING OF WHICH ONE PUMP WILL BE CATERING TO NEW NPK PLANT & ANOTHER FOR EXISTING NP PLANT.
6. ALL TANK BODY FIRST ISOLATION VALVE SHALL BE BUTT WELDED ON TANK SIDE & FLANGED WITH RTJ ON OTHER SIDE.
7. INDIVIDUAL PUMP DISCHARGE LINES ARE TO BE PROVIDED WITH MINIMUM FLOW LINE WITH AUTOMATIC RE-CIRCULATION VALVE.
8. STARTUP/COMMISSIONING NOZZLES FOR NITROGEN PURGING.
9. SUITABLE LEAK DETECTION SYSTEM FOR INNER SHELL & BOTTOM PLATE TO BE PROVIDED.
10. TANK SHALL BE PROVIDED TWO INDEPENDENT VACUUM RELIEF VALVES.

FIRE WATER

RAW/SERVICE WATER

004 TO FLARE

003 NHG TO COMPRESSOR SUCTION

NHG TO STORAGE TANK T-201 002

NHL FROM ECONOMIZER 003

NHL FROM SEPARATOR S-201

004 TO FLARE

NHL FROM EXISTING TRANSFER PUMPS

NHL TO EXISTING NP PLANT

NHL TO AMMONIA VAPORIZER E-201

NHL TO NEW NPK PLANT

T-201
AMMONIA STORAGE TANK

P-201A
AMMONIA TRANSFER PUMP

P-201B
AMMONIA TRANSFER PUMP

P-201C
AMMONIA TRANSFER PUMP

<32686-11-PD-101_R1>

FOR TENDER PURPOSE ONLY

A2

CLIENTS: FACT-CD

DRAWING NO.	TITLE
	REFERENCE DRAWING

NO	ZONE	PARTICULARS	REVISED	CHECKED	APPROVED	DATE
1		AS MARKED (BATTERY LIMIT OF LSTK CONTRACTOR REVISED)	ST	AT	KVR	23/04/2021

REVISION

SCALE	NTS
DATE	13/04/2021
DRAWN	ST
CHECKED	AT
DESIGNED	AT
CHECKED	KVR
APPROVED	KVR

FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD
UDYOGAMANDAL KERALA

FEDO

PROJECT NAME 10,000 MT AMMONIA STORAGE FACILITY AT CD PROJECT No: 32686

TITLE P&ID OF PROPOSED 10,000 MT AMMONIA TANK & PUMPING SECTION

SHEET 1 OF 1 DRG. No. 32686-11-PD-101 REV. 1 0

00FT004/10

LEGENDS

- ISOLATION VALVE (GATE/BALL/PLUG)
- GLOBE VALVE
- CHECK VALVE
- PNEUMATIC OPERATED VALVE
- MASS FLOW METER
- ORIFICE FLOW METER
- BLIND FLANGE
- SPECTACLE BLIND
- SAFETY RELIEF VALVE
- ROTARY SCREW COMPRESSOR
- INSULATION
- TIE IN POINT
- BATTERY LIMIT
- STEAM TRAP
- VERTICAL CENTRIFUGAL PUMP
- AMMONIA VAPOUR(NHG)
- AMMONIA LIQUID(NHL)
- COOLING WATER(WCS)
- INSTRUMENT AIR(AI)
- GAS LINE(LPG/RLNG)

LETTER CODE FOR SERVICE

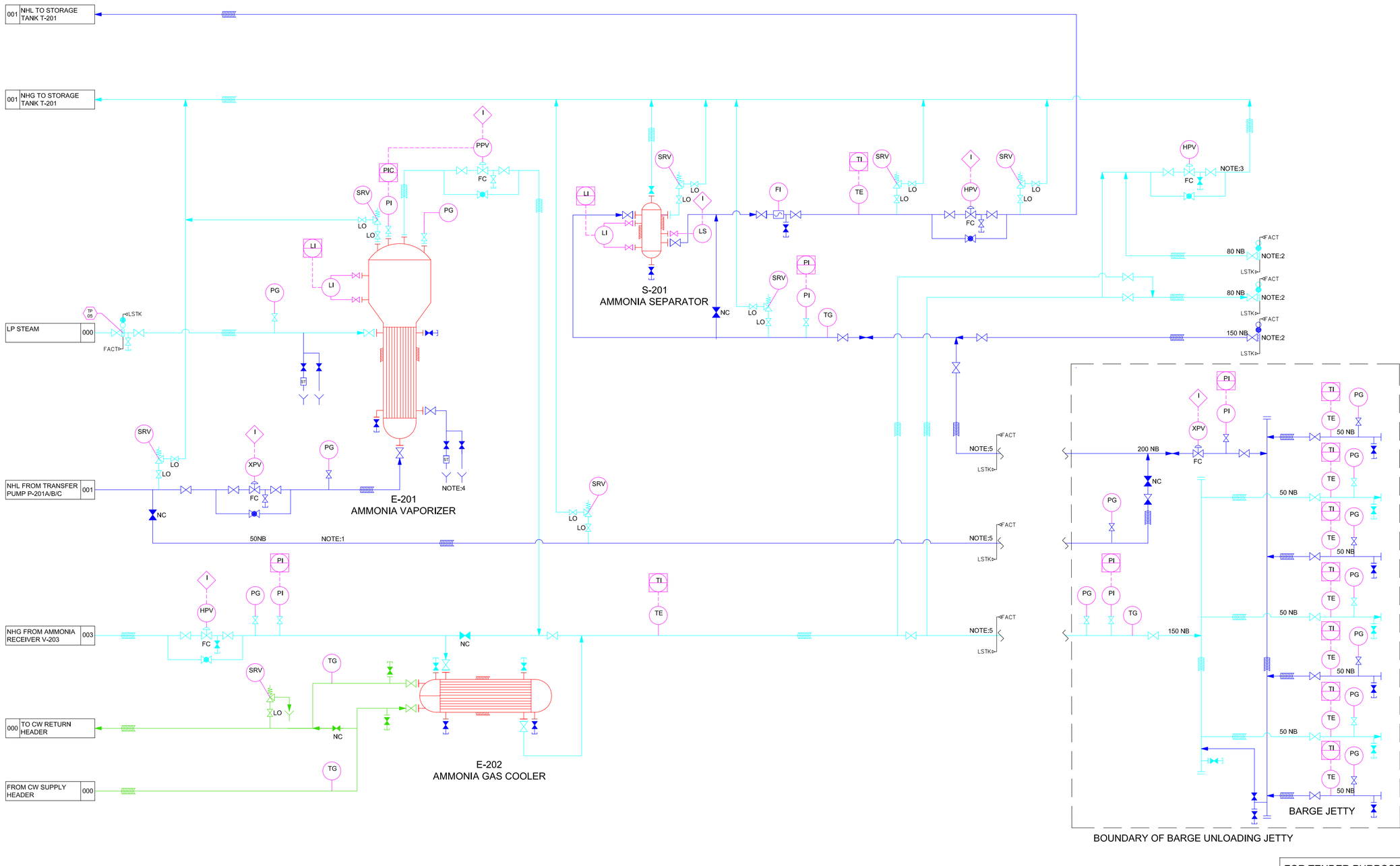
PPV	PRESSURE CONTROL VALVE	LI	LEVEL INDICATOR	HIC	HAND INDICATOR CONTROLLER
FPV	FLOW CONTROL VALVE	TE	TEMPERATURE	M	ELECTRIC MOTOR
XPV	SHUT OFF VALVE	RO	RESTRICTION ORIFICE	NO	NORMALLY OPEN
PI	PRESSURE INDICATOR	MI	MOTOR RUNNING INDICATION	NC	NORMALLY CLOSE
PG	PRESSURE GAUGE	PG	PRESSURE GAUGE	ST	STEAM TRAP
PIC	PRESSURE INDICATOR CONTROLLER	LIA	LEVEL INDICATOR ALARM	LO	LOCKED OPEN
PIA	PRESSURE INDICATOR ALARM	FIC	FLOW INDICATOR CONTROLLER	NG	NITROGEN GAS
TI	TEMPERATURE INDICATOR	FI	FLOW INDICATOR		
FO	FAIL OPEN	HPV	HAND OPERATED CONTROL VALVE		
FC	FAIL CLOSE	I	INTER LOCK		
		SRV	SAFETY RELIEF VALVE		

GENERAL NOTES:

1. INSTRUMENTATION & CONTROL SCHEMES INDICATED ARE MINIMUM PROCESS REQUIREMENT. BIDDER/S HOWEVER SHALL CONSIDER ALL NECESSARY INSTRUMENTS & CONTROL SYSTEM FOR SAFE & NORMAL OPERATION OF THE PLANT.
2. ALL LIQUID/VAPOR TIE-IN POINTS SHALL BE PROVIDED WITH BLOCK & BLEED ARRANGEMENT AND THE VENT LINES SHALL BE ROUTED TO FLARE HEADER.

NOTES:

1. BARGE BULLET PRECOOLING LINE.
2. FUTURE PROVISION FOR TANKER UNLOADING.
3. BARGE BULLET DEPRESSURIZING LINE.
4. CONDENSATE TO BE ROUTED TO NEARBY STORM WATER DRAIN.
5. LSTK CONTRACTOR SCOPE OF BARGE UNLOADING LINES SHALL BE LIMITED UPTO HIS BATTERY LIMIT. HOWEVER ENGINEERING, SUPERVISION & COMMISSIONING OF THE BARGE UNLOADING LINES SHALL BE IN LSTK CONTRACTOR'S SCOPE.



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<32686-11-PD-102_R1>

A2

CLIENTS: FACT–CD

DRAWING NO.	TITLE
REFERENCE DRAWING	

NO	ZONE	PARTICULARS	REVISED	CHECKED	APPROVED	DATE
1		AS MARKED (BATTERY LIMIT OF LSTK CONTRACTOR REVISED)	ST	AT	KVR	23/04/2021

REVISION

SCALE	NTS
DATE	13/04/2021
DRAWN	ST
CHECKED	AT
DESIGNED	AT
CHECKED	KVR
APPROVED	KVR

FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD
UDYOGAMANDAL KERALA

PROJECT NAME 10,000 MT AMMONIA STORAGE FACILITY AT CD PROJECT No: 32686

TITLE P&ID OF PROPOSED BARGE/TANKER UNLOADING SECTION

SHEET 1 OF 1 | DRG. No. 32686–11–PD–102 | REV. 1 0

00FT004/10

LEGENDS

- ISOLATION VALVE (GATE/BALL/PLUG)
- GLOBE VALVE
- CHECK VALVE
- PNEUMATIC OPERATED VALVE
- MASS FLOW METER
- ORIFICE FLOW METER
- BLIND FLANGE
- SPECTACLE BLIND
- SAFETY RELIEF VALVE
- ROTARY SCREW COMPRESSOR
- INSULATION
- TIE IN POINT
- BATTERY LIMIT
- STEAM TRAP
- VERTICAL CENTRIFUGAL PUMP
- AMMONIA VAPOUR(NHG)
- AMMONIA LIQUID(NHL)
- COOLING WATER(WCS)
- INSTRUMENT AIR(AI)
- GAS LINE(LPG/RLNG)

LETTER CODE FOR SERVICE

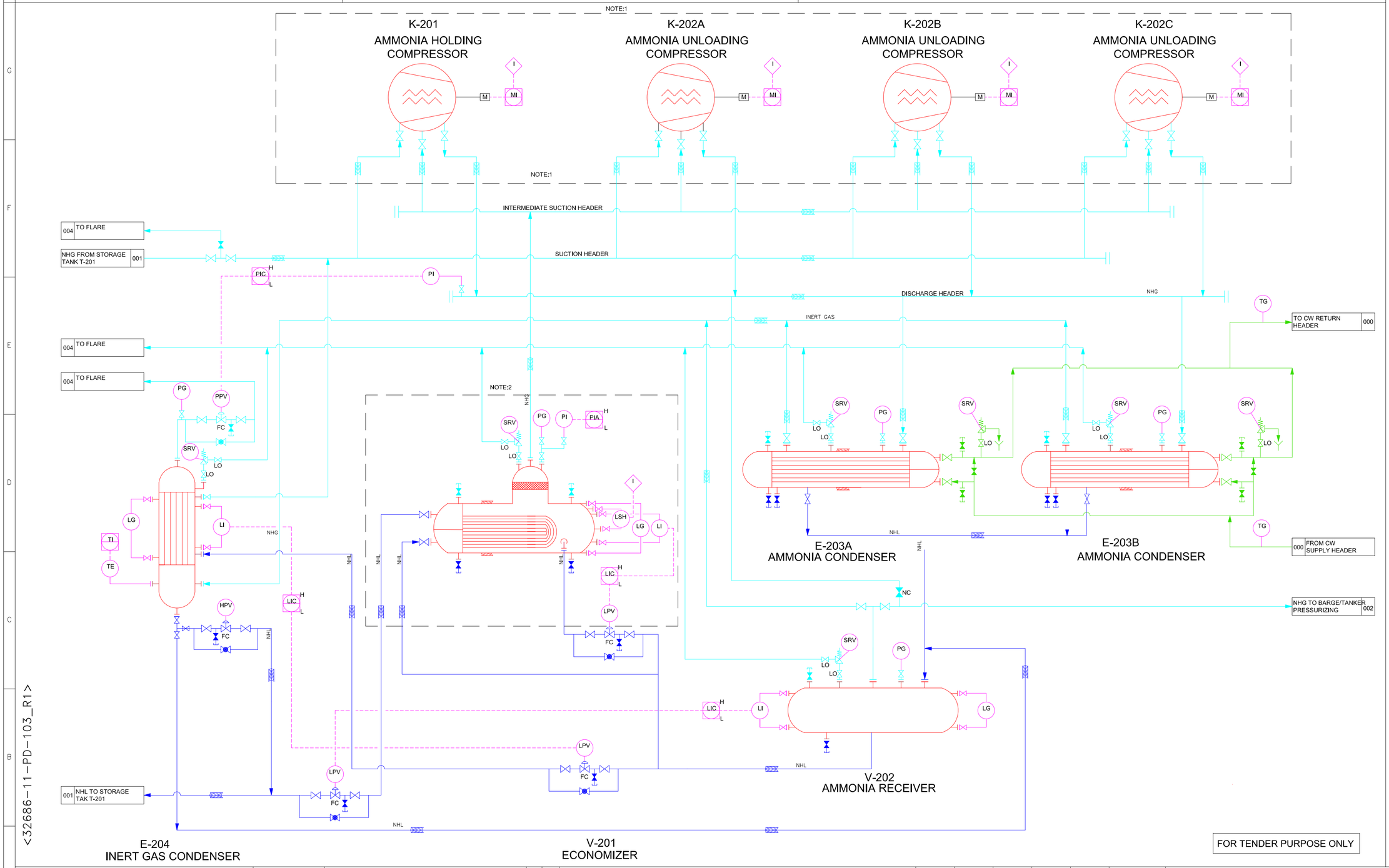
PPV	PRESSURE CONTROL VALVE	LI	LEVEL INDICATOR	HIC	HAND INDICATOR CONTROLLER
FPV	FLOW CONTROL VALVE	TE	TEMPERATURE	M	ELECTRIC MOTOR
XPV	SHUT OFF VALVE	RO	RESTRICTION ORIFICE	NO	NORMALLY OPEN
PI	PRESSURE INDICATOR	MI	MOTOR RUNNING INDICATION	NC	NORMALLY CLOSE
PG	PRESSURE GAUGE	PG	PRESSURE GAUGE	ST	STEAM TRAP
PIC	PRESSURE INDICATOR CONTROLLER	LIA	LEVEL INDICATOR ALARM	LO	LOCKED OPEN
PIA	PRESSURE INDICATOR ALARM	FIC	FLOW INDICATOR CONTROLLER	NG	NITROGEN GAS
TI	TEMPERATURE INDICATOR	FI	FLOW INDICATOR	LCV	LEVEL CONTROL VALVE
FO	FAIL OPEN	HPV	HAND OPERATED CONTROL VALVE		
FC	FAIL CLOSE	I	INTER LOCK		
		SRV	SAFETY RELIEF VALVE		

GENERAL NOTES:

1. INSTRUMENTATION & CONTROL SCHEMES INDICATED ARE MINIMUM PROCESS REQUIREMENT. BIDDER/S HOWEVER SHALL CONSIDER ALL NECESSARY INSTRUMENTS & CONTROL SYSTEM FOR SAFE & NORMAL OPERATION OF THE PLANT.
2. ALL LIQUID/VAPOR TIE-IN POINTS SHALL BE PROVIDED WITH BLOCK & BLEED ARRANGEMENT AND THE VENT LINES SHALL BE ROUTED TO FLARE HEADER.

NOTES:

1. COMPRESSORS SHALL BE PROVIDED WITH SUCTION/DISHCARGE DAMPERS, INTERCOOLERS, AFTER COOLERS, ALL NECESSARY CONTROLS & SAFETY INTERLOCKS.
2. ECONOMIZER VESSEL IS INDICATIVE BIDDER TO PROVIDE ACTUAL CONFIGURATION.



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CLIENTS: FACT–CD

DRAWING NO.	TITLE
REFERENCE DRAWING	

NO	ZONE	PARTICULARS	REVISED	CHECKED	APPROVED	DATE
1		AS MARKED (BATTERY LIMIT OF LSTK CONTRACTOR REVISED)	ST	AT	KVR	23/04/2021
REVISION						

SCALE	NTS
DATE	13/04/2021
DRAWN	ST
CHECKED	AT
DESIGNED	AT
CHECKED	KVR
APPROVED	KVR

FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD
UDYOGAMANDAL KERALA

PROJECT NAME 10,000 MT AMMONIA STORAGE FACILITY AT CD PROJECT No:32686

TITLE P & I DIGRAM OF PROPOSED REFRIGERATION SECTION

SHEET 1 OF 1 | DRG. No. 32686–11–PD–103 | REV. 1 0

00FT004/10

LEGENDS

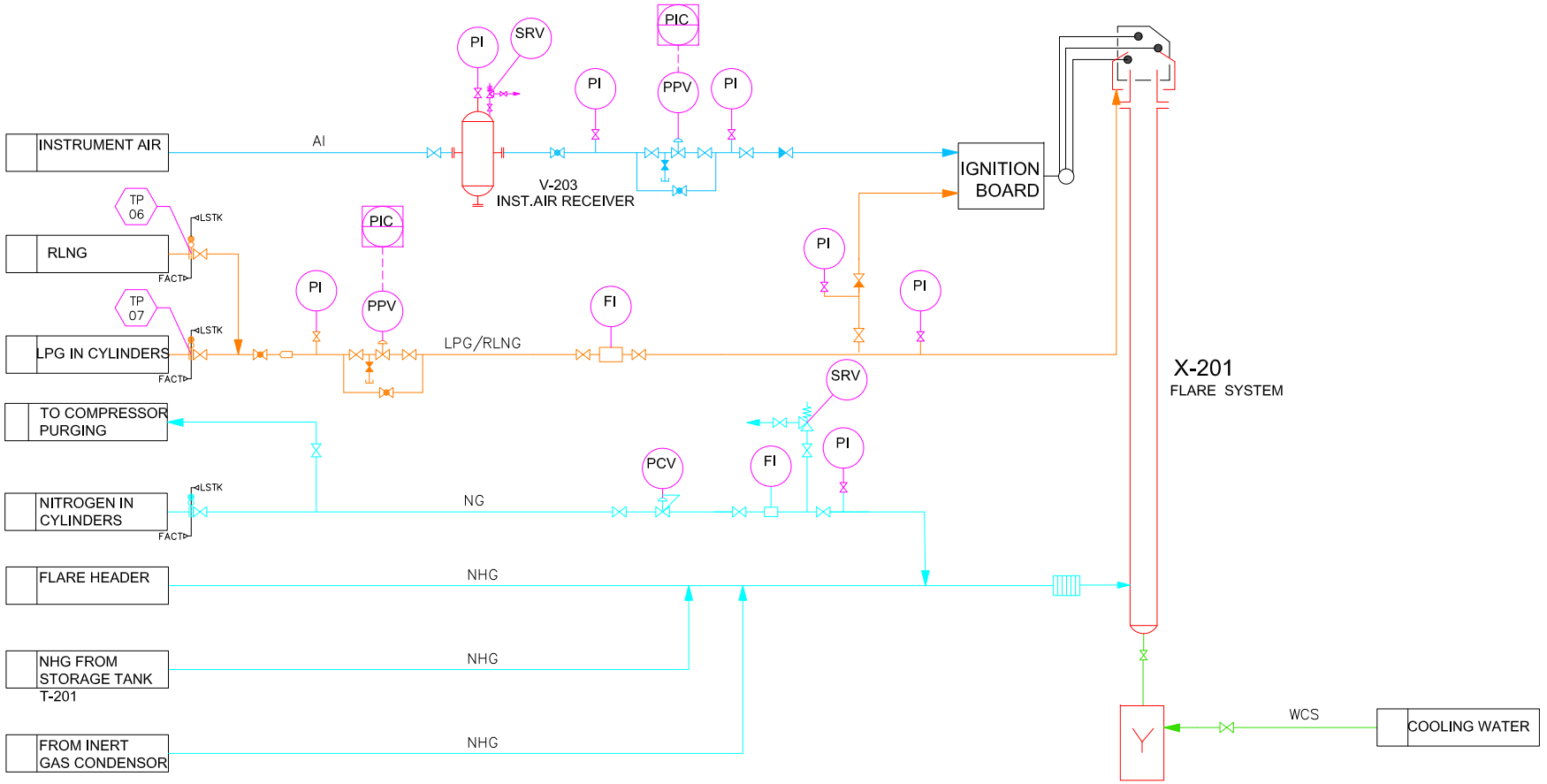
- ISOLATION VALVE (GATE/BALL/PLUG)
- GLOBE VALVE
- CHECK VALVE
- PNEUMATIC OPERATED VALVE
- MASS FLOW METER
- ORIFICE FLOW METER
- BLIND FLANGE
- SPECTACLE BLIND
- SAFETY RELIEF VALVE
- ROTARY SCREW COMPRESSOR
- INSULATION
- TIE IN POINT
- BATTERY LIMIT
- STEAM TRAP
- VERTICAL CENTRIFUGAL PUMP
- AMMONIA VAPOUR(NHG)
- AMMONIA LIQUID(NHL)
- COOLING WATER(WCS)
- INSTRUMENT AIR(AI)
- GAS LINE(LPG/RLNG)

LETTER CODE FOR SERVICE

PCV	PRESSURE REGULATING VALVE	LI	LEVEL INDICATOR	HIC	HAND INDICATOR CONTROLLER
PPV	PRESSURE CONTROL VALVE	TE	TEMPERATURE	M	ELECTRIC MOTOR
FPV	FLOW CONTROL VALVE	RO	RESTRICTION ORIFICE	NO	NORMALLY OPEN
XPV	SHUT OFF VALVE	MI	MOTOR RUNNING INDICATION	NC	NORMALLY CLOSE
PI	PRESSURE INDICATOR	PG	PRESSURE GAUGE	ST	STEAM TRAP
PG	PRESSURE GAUGE	LIA	LEVEL INDICATOR ALARM	LO	LOCKED OPEN
PIC	PRESSURE INDICATOR CONTROLLER	FIC	FLOW INDICATOR CONTROLLER	NG	NITROGEN GAS
PIA	PRESSURE INDICATOR ALARM	FI	FLOW INDICATOR		
TI	TEMPERATURE INDICATOR	HPV	HAND OPERATED CONTROL VALVE		
FO	FAIL OPEN	I	INTER LOCK		
FC	FAIL CLOSE	SRV	SAFETY RELIEF VALVE		

GENERAL NOTES:

1. INSTRUMENTATION & CONTROL SCHEMES INDICATED ARE MINIMUM PROCESS REQUIREMENT. BIDDER/S HOWEVER SHALL CONSIDER ALL NECESSARY INSTRUMENTS & CONTROL SYSTEM FOR SAFE & NORMAL OPERATION OF THE PLANT.



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A4

CLIENTS : FACT-CD

DRAWING No:	No	ZONE	PARTICULARS	REVISED	CHECKED	APPROVED	DATE
REFERENCE	REVISION						
	1		AS MARKED	ST	AT	KVR	23/04/2021

SCALE	NTS
DATE	13/04/2021
DRAWN	ST
CHECKED	AT
DESIGNED	AT
CHECKED	KVR
APPROVED	KVR

FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD
UDYOGAMANDAL KERALA

PROJECT NAME 10,000 MT AMMONIA STORAGE FACILITY AT CD PROJECT No: 32686

TITLE P&ID FOR PROPOSED FLARE SYSTEM

SHEET NO 1 OF 1 | DRG. No. 32686-11-PD-104 | REV. X 1 | X 0

00FT004/10

Sl. No.	Vendor Name	Location
A	**SAFETY VALVES & THERMAL RELIEF VALVES UPTO 2500#**	
1.	FAINGER LESER VALVES (P) LTD. (UPTO 600#, ½" TO 6")	INDIA
2.	INSTRUMENTATION LTD. (PALAKKAD)	INDIA
3.	TYCO SANMAR LTD.	INDIA
4.	BLISS ANAND PRIVATE LTD. (8" * 10" 300#, 6" * 8" 600# ,4 * 6" 1500#)	INDIA
5.	MEKASTER ENGG. LTD (UPTO 600# SAFETY – 4"* 6" , TH RELIEF ¾" * 1")	INDIA
6.	DRESSER VALVE & CONTROLS	CANADA
7.	PARCOL SPA	ITALY
8.	TAI MILANO S.P.A	ITALY
9.	ITOCHU CORPORATION (REP.KUBOTACORPN.)	JAPAN
10.	CROSSBY VALVE & ENGG. COMPANY LTD.	U.K
11.	FARRIS	U.K
12.	DRESSER INDUSTRIES INCORPORATED	U.S.A
13.	TELEDYNE FLUID SYSTEM	THAILAND
14.	SAPAG GEC ALSTHOM	FRANCE
15.	BOPP & REUTHER MESSTECHNIC GMBH	GERMANY
B	**VACCUM BREAKERS**	
1.	BRAUNSCHWEIGER FLAMMENFILTER GMBH	GERMANY
2.	PARCOL SPA	ITALY
3.	TAI MILANO S.P.A	ITALY
4.	ITOCHU CORPORATION	JAPAN

0	For Comments	13/04/2021	AT	KVR	KVR
Rev.	**Description**	**Date**	**Prpd. By**	**Chkd. By**	**Aprd. By**

5.	SAFETY SYSTEMS UK LTD.	U.K
6.	WHESSOEVAREC LTD.	U.K
C	**RUPTURE DISCS**	
1.	BS&B SAFETY SYSTEMS (INDIA) LTD.	INDIA
2.	FIKE EUROPE	BELGIUM
3.	SAPAG GEC ALSTHOM	FRANCE
4.	TELEDYNE FLUID SYSTEMS	THAILAND
5.	CONTINENTAL CONTROLS INC.	U.S.A
D	**PILOT RELIEF VALVES**	
1.	BLISS ANAND PRIVATE LTD. (SIZE 1"* 2" 2500#)	INDIA

Notes:

1. Make of the equipment not indicated and any other make for the specified equipment shall be subject to owner's / consultant's approval.
2. Bidder shall indicate make of various equipment offered by them.

0	For Comments	13/04/2021	AT	KVR	KVR
Rev.	**Description**	**Date**	**Prpd. By**	**Chkd. By**	**Aprd. By**

Sl. No.	Item	Quantity	Unit Price (Rs./Unit)	Total Price (Rs.)
1.	Safety Relief Valves / Pressure Relief Valves / Thermal Relief Valves/ Vacuum Relief Valves / Low Pressure Relief Valves / Pilot Operated Valves	10% of minimum one of each type & size for nozzle, disc insert, guide whichever is higher.		
2.	Rupture Disc	2 spare disc for each Tag.		

Notes:

1. The above indicated spares are loose items to be handed over to client at the end of project.
2. Commissioning spares are to be considered over and above the items mentioned above for immediate replacements if any during commissioning and startup and also to replace damaged instruments if any during erection activities.
3. Note that the list of spares is indicative and same philosophy shall be followed for every package in the plant. The spare supplied for one package shall not be counted as spare of the same instrument in any other package.
4. Next rounded figure to be considered wherever % is specified (i.e.,for example if a total of 11 items with 10% spares basis, 2 no. of spares shall be provided)
5. Wherever complete instrument/set is considered as spare, spare quantity shall never exceed ordered/ purchased quantity (for example, if ordered quantity is 1 and mandatory spare philosophy is 20% or min 2, in such cases mandatory spares quantity shall be 1 and not 2)
6. Above-mentioned mandatory spares list defines the minimum requirement. Additional items as recommended by manufacturer if any, shall also be considered.

Rev	Details	By	Chkd.	Apprd.	Date
0	For Comments	AT	KVR	KVR	13/04/2021

Project: 10,000 MT Ammonia Storage Facility at CD

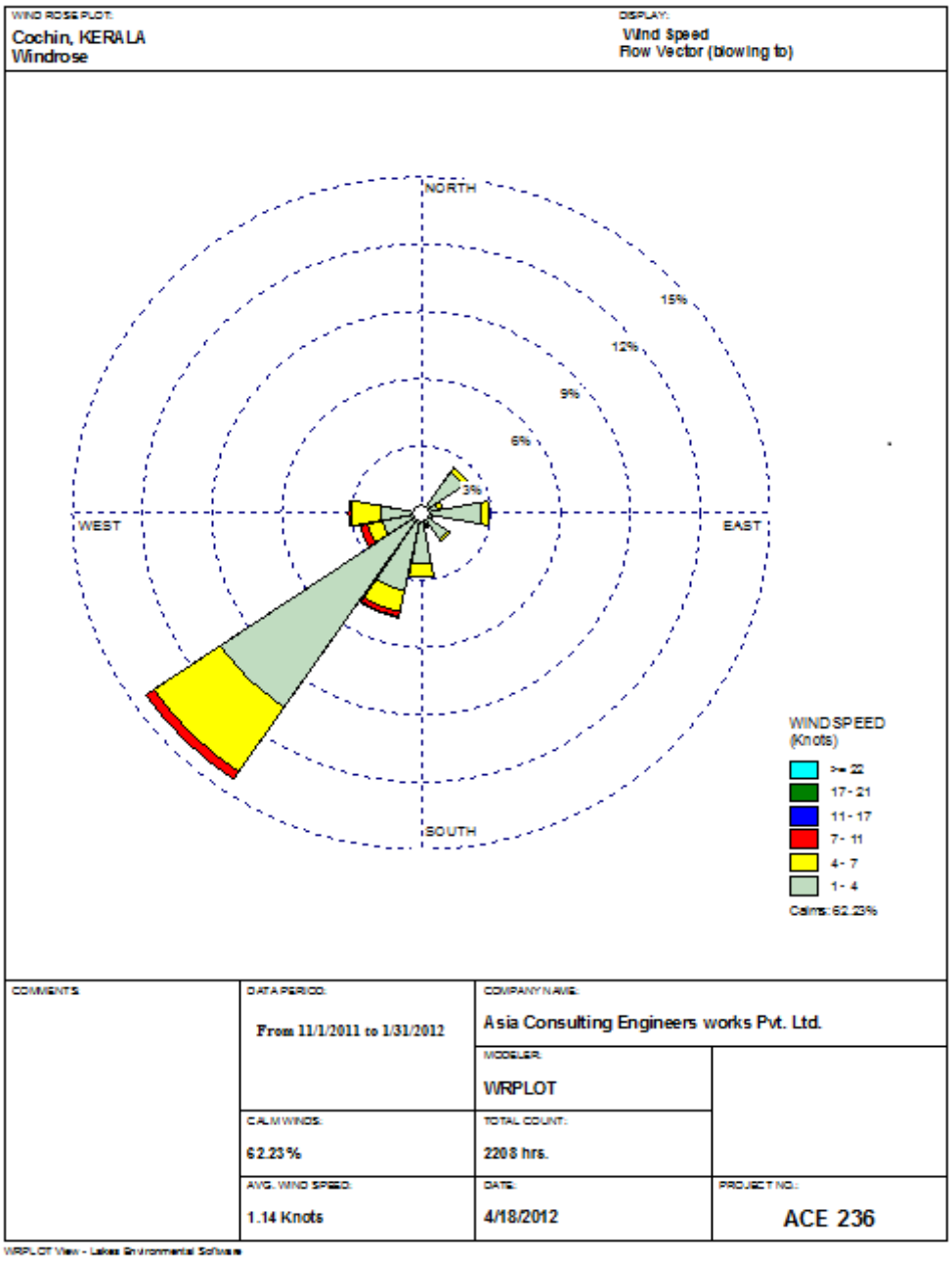
Client: M/s. FACT-CD

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

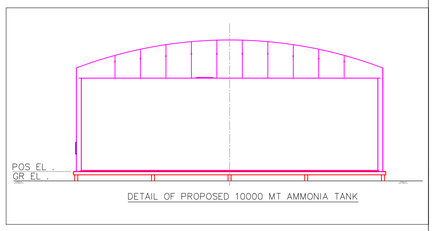
Utility Tie-In Points

Sl. No.	Tie-In Point	Tie-In Point Details	Fluid	Size, NB	Piping Specification (MOC & Rating)
1.	03	Existing Main Raw water line	Raw Water	150	150-RW-MS
2.	04	Existing Fire water lines in Ammonia Handling Section	Fire Water	250 & 200	250 & 200 IS3589 Gr.410 (Proposed Fire Water Layout)
3.	05	Existing LP steam line to Ammonia Vaporiser	Steam	50	50-STL-101-1A1B-IH50
4.	06	Existing RLNG line near Package Boiler	RLNG	50	150-NG-103-3A1S
5.	07	Existing LPG line to Flare system	LPG	25	25-LPG-A106



WINDROSE DIAGRAM FOR KOCHI
(Winter Season – November 2011 to January 2012)

THE FERTILISERS AND CHEMICALS TRAVANCORE Ltd.			
COCHIN DIVISION			
WATER ANALYSIS			
No	**Analysis Details**	**Unit**	**Raw Water**
1	pH		6.8
2	Conductivity	micro	42.00
3	Turbidity	NTU	3.0
4	Alkalinity	ppm	2
5	Chlorides as - Cl	"	35
6	Total Hardness	"	5
7	Ca Hardness	"	4
8	Mg.Hardness	"	1
9	Phosphate as P	"	0.44
10	Sulphate as SO_4	"	0.32
11	Free & Saline NH_3 as N	"	0.09
12	Ammonical Nitrogen	"	0.42
13	Nitrate as N	"	0.51
14	Total N	"	1.02
15	Total Solids	"	4.8
16	Total Dissolved Solids	"	4.0
17	Suspended Solids	"	0.8
18	Free CO_2	"	1.0
19	Arsenic as As	"	ND
20	Chromium as Cr	"	ND
21	Copper as Cu	"	ND
22	Zinc as Zn	"	ND
23	Iron as Fe	"	0.50
24	Fluoride as F	"	0.10
25	Silica as SiO_2	"	3.65
26	Oil	"	1.00
27	KMnO4 Value	"	0.40
28	C.O.D	"	1.2
29	Lead as Pb		ND
30	Cadmium as Cd		ND
31	Nickel as Ni		ND
32	Manganese as Mn		ND



DETAIL OF PROPOSED 10000 MT AMMONIA TANK

SL NO.	DESCRIPTION
1	NEW AMMONIA TANK
2	NEW COMPRESSOR HOUSE
3	NEW PUMP AREA
4	NEW REFRIGERATION UNIT
5	NEW COOLING TOWER
6	NEW FLARE STACK
7	NEW CONTROL ROOM
8	NEW SUB STATION & DG SET
9	NEW AIR COMPRESSOR HOUSE
10	NEW PIPE RACK
11	NEW ROAD
12	LOCATION OF UTILITY TIE-INS

NOTES:-

1. ALL DIMENSIONS ARE IN METER.
2. EXISTING FACILITIES WITH NOTE 2 TO BE DEMOLISHED.
3. HEAVY EQUIPMENT WORKSHOP TO BE RELOCATED AS SHOWN.
4. EXISTING ROAD TO JETTY TO BE MODIFIED AS SHOWN, ACCORDINGLY PIPE CROSSOVER TO BE RELOCATED.
5. GRADING IS REQUIRED TO MAINTAIN FINISHED GRADE LEVEL AT MSL +4.5 METER.
6. ALL EQUIPMENT LOCATIONS ARE INDICATIVE, BIDDER TO LOCATE THESE EQUIPMENT AT HATCH MARKED AREA CONSIDERING OPTIMUM DESIGN .

FLEXIBLE HOSE FOR AMMONIA UNLOADING FROM BARGE

Flexible Hose Type	: Corrugated Bellow type SS304/321 with SS304/321 wire over braiding
Size	: 50 mm x 3000 mm Long
Service	: For handling liquid Ammonia
Working Pressure	: 50 kg/cm^2
Working Temperature	: -33^oC
Test Pressure	: 1.5 x Design Pressure
End Connections	: SS304/321 flange with groove as per DIN 2512

Flange Details:

Outside Dia.	: 165 mm
PCD	: 125 mm
Bolt hole diameter	: 18 mm
No. of bolt holes	: 4
Flange thickness	: 18 mm
Groove ID	: 72 mm
Groove OD	: 88 mm

TECHNICAL PROCUREMENT SPECIFICATION	ATTACHMENTS	32686-01-PS-002AT
		PAGE 1 OF 1 R 0

Job No.: 32686

S.No.	Doc. No.	Description	No. of pages	Rev. No. with Issue				
				1	2	3	4	5
1.0	**DESIGN PHILOSOPHY**							
1.1	32686–02–PS–002 PH	Design Philosophy - Static	28	0				
1.2	32686–01–PS–002 PH1	Design Philosophy - Rotating Equipments	11	0				
1.3	32686–01–PS–002 PH2	Design Philosophy - Firefighting System	9	0				
2.0	**SPARES**							
2.1	32686-02-PS-002 SPR	Spares - Static	1	0				
2.2	32686-01-PS-002 SPR1	Spares - Rotary	2	0				
2.3	32686-01-PS-002 SPR2	Spares - Firefighting	1	0				
3.0	**VENDOR DATA REQUIREMENTS**							
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3.4	32686-01-PS-002 VDR1	VDR - Screw Compressor	1	0				
3.5	32686-01-PS-002 VDR2	VDR - Centrifugal Pump	1	0				
3.6	32686-01-PS-002 VDR3	VDR - Cooling Tower	2	0				
3.7	32686-01-PS-002 VDR4	VDR - EOT Crane	1	0				
3.8	32686-01-PS-002 VDR5	VDR - Fire Hydrant	1	0				
3.9	32686-01-PS-002 VDR6	VDR - CO_2 Extinguisher	1	0				
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6.1	02ES023/2010	FEDO Engineering Specification for Painting	13	-				
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7.0	**SPECIAL REQUIREMENTS**							
7.1	32686–01–PS–002 SPL	Special requirements for FRP Cooling Tower	7	0				

Note :
1. The receipt of all attachments shall be checked and ascertained.
2. All attachments of this TPS shall be retained since only revised sheets, if any, shall be issued.

REV.NO.	DATE	DESCRIPTION	PREPD	CHKD	APPRD
0	22.04.2021	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

Job No. : **32686**

Item : **STATIC EQUIPMENTS**

Item No. : **-**

Project : **NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS**

Client : **FACT-CD**

Location : **AMBALAMEDU, COCHIN**

CONTENTS

LIST OF ANNEXURES & ATTACHMENTS

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Attachment - 2	FEDO Engineering Specification for Hot Insulation (02ES029/2010)	35
Attachment - 3	FEDO Engineering Specification for Cold Insulation (02ES042/2010)	26
Attachment - 4	FEDO Design Standard for Anchor Bolts (02DS002/2010)	3
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1.0 GENERAL

1.1 SCOPE

1.1.1 This document defines the design philosophy to be applied to the design of various types of static equipment, i.e. Pressure Vessels, Heat Exchangers, Storage Tanks and Vessel Internals etc. for the New Ammonia Storage Tank for M/s. Fertilizers and Chemicals Travancore Limited (FACT), Ambalamedu.

1.1.2 The complete design, material for construction/fabrication (shop/site as applicable), inspection, testing, painting, supply, transportation and erection of equipment etc. at project site shall conform to the specifications, drawings and internationally accepted codes / standards listed below. In addition, all statutory rules & regulations shall be complied with.

1.2 STANDARD DEFINITIONS

COMPANY/Owner/Client	Fertilizers and Chemicals Travancore Limited (FACT)
Consultant	FACT Engineering and Design Organisation (FEDO)
Supplier/Bidder/Manufacturer	Is the party that manufactures or supplies equipment and services to perform the duties specified by the Contract
Sub Bidder/Sub Supplier	The manufacturer or supplier on whom purchase order is placed by the vendor for any part of material in accordance with the purchase order on the vendor.
TPIA	Third Party Inspection Agency
LSTK	Lump Sum Turn Key Contractor
CCE	Chief Controller of Explosives
IS	Indian Standards
NBC	National Building Code (India)

1.3 CODES AND STANDARDS

1.3.1 The equipment shall be designed & constructed as per the latest edition of the following codes and standards:

CODE	DESCRIPTION
ASME Section VIII Div 1 & 2	Rules for construction of Unfired Pressure Vessels
TEMA ‘R’/API 660	Standards of Tubular Exchangers Manufacturer's Association/API for Shell & Tube Heat Exchanger
HEI	Heat Exchanger Institute standards for steam surface condensers and steam jet ejectors
API 661	Air Cooled Heat Exchangers
API 662	Plate type Heat Exchangers
API 620	Design & Construction of Large, Welded, Low-pressure Storage Tank
API 625	Tank Systems For Refrigerated Liquefied Gas Storage
API 650	Welded Steel Tanks for Oil Storage
API Standard 2000	Venting Atmospheric and Low pressure storage Tanks

CODE	DESCRIPTION
API 2550	Method for measurement and calibration of upright cylindrical Tanks
API 941	Steels for Hydrogen Service at Elevated Temperature & Pressure
ASME Section II A&B/ASTM	Materials Specifications
ASME Section II PART C	Specification for welding rod, electrode & filler metal
ASME SEC II PART D	Properties
ASME Section V	Non-destructive Examination
ASME Section IX	Welding and Bracing Qualifications
ASME Section X	Fiber-Reinforced Plastic Pressure Vessels
EJMA *	Standard of Expansion Joint Manufacturers Association
NACE	National Association of Corrosion Engineers
ANSI B 16.20	Metallic Gaskets for Pipe Flanges
ASME B 16.5	Pipe Flanges and Flanged Fittings
ASME B 16.47	Large Diameter Steel Flanges
ANSI	Pipes, Flanges, Fittings and Valves
IS: 875/SITE DATA	For wind load consideration
IS: 1893 (Part 1, Part 2 & Part 4)	Criteria for Earthquake Resistant Design of Structures
BS EN ISO 12241	Thermal insulation for building equipment and industrial Installations.
BS 4994	Design & Construction of vessel & Tanks in Reinforced Plastics
BS EN 13923	Filament-wound FRP pressure vessels Materials, design, manufacturing and testing.
BS EN 13121-3	GRP tanks and vessels for use above ground Part 3: Design and workmanship
IS:4682 (Part-1) with Amendment No. 3	Code of Practice for Rubber Lining of Vessels & Equipment for Chemical Process
BS 6374-5	Lining of Equipment with Polymeric Materials for the Process Industries - Part 5: Lining with Rubbers

***** *Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA standard.*

NOTES:

1. LSTK Bidder may select DIN, BS or any other well-known international materials as substituted materials to ASTM/ASME, if they are equivalent or superior to ASTM/ ASME. The chemical & mechanical properties of such equivalent or superior offered materials, preferably comparison w.r.t. ASTM/ASME materials shall be furnished along with the bid for FACT/FEDO's approval. LSTK Bidder shall also submit the references

of past supplies of similar type of equipment w.r.t. the proposed materials offered by them in their bid.

2. Latest updated guidelines / standards may be adopted complying with the minimum requirements of this design philosophy for static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.
3. Specifications of all critical equipments shall be furnished in the technical bid.

***Any conflicts between documents, including specifications, regulations and codes, shall be brought to FACT / FEDO's attention for resolution.*

1.4 REGULATIONS

1.4.1 Besides codes & standards, LSTK Bidder shall follow National Laws and Regulations such as the Petroleum and Explosives Safety Organisation (PESO) rules together with Local bylaws for the state including statutory requirements as applicable. The Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with.

1.5 PUBLICATIONS

NACE MR 0103	Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments.
NACE MR 0175 / ISO 15156	Petroleum and natural gas industries - Materials for use in H_2S containing environments in oil and gas production.
NACE RP 0296	Guidelines for Detection, Repair and Mitigation of Cracking of Existing Petroleum Refinery Pressure Vessels in Wet H_2S Environment.
NACE TM 0284	Evaluation of Pipeline and Pressure Vessel Steel for Resistance to Hydrogen Induced Cracking.
NACE TM 0177	Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in Hydrogen Sulphide Environment
WRC Bulletin#537	Local Stresses in Spherical & Cylindrical Shells due to external Loadings

1.6 SITE CONDITIONS

1.6.1 Climatic and other site conditions as defined in the Process Design Basis of the technical bid.

1.7 OPERATING DUTY and DESIGN LIFE

1.7.1 Service shall be twenty-four (24) hours per day, seven (7) days per week, and fifty-two (52) weeks per year. The equipment design life shall be minimum 25 years.

1.8 DESIGN DOCUMENTATION

Detailed design calculations considering different loadings shall be made as per applicable code/standards and the additional requirements as mentioned below:-

1.8.1 Design of equipment inside the Ammonia storage facility shall be in accordance with the process licensor's data sheets and specifications.

1.8.2 LSTK bidder shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil/Structural Drawings
- P&ID"s

- Materials
- 3D-PDMS Model for Piping and Equipment Layout
- Hazardous Area Classification

1.8.3 LSTK bidder shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil/Structural Drawings
- P&ID"s
- Materials
- 3D-PDMS Model for Piping and Equipment Layout

1.8.4 Hazardous Area Classification

1.8.5 Design philosophy of other disciplines shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria

1.9 SAFETY

1.9.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable to this criterion. Job Hazard and Operability [HAZOP] as per ISO-18001 & Factory's Act shall be done during design stage of the project.

1.9.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

- Ladder cages
- Safety chain across platform access
- Step-off platforms with Hand Railing where necessary
- Platform grating with adequate thickness
- Toe plates

1.10 EQUIPMENT FABRICATION

1.10.1 Equipment design shall be based on maximizing shop fabrication and assembly where deemed practical. Fabrication in open yard shall be avoided.

1.10.2 The LSTK Bidder shall comply in all respects with the provision of the applicable codes / standards and specification during fabrication. For equipment fabricated in multiwall / multilayer construction, special fabrication requirements as per ASME Sec-VIII Div.2 Article 6.8 shall be complied with.

1.10.3 Impact test, when required as per code/specifications, shall be carried out on parent metal, weld and HAZ.

1.10.4 Production Control coupons, when required as per code / specifications, shall be subjected to all tests like impact, inter granular corrosion test etc., in addition to the mechanical test as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.

1.10.5 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

1.10.6 In case of equipment involving site assembly / fabrication the entire site job including loading & unloading at site, fabrication, radiography, heat treatment, Inspection & testing etc. shall be included in the scope of supply.

1.10.7 All nozzle connections up to NPS 10" size shall be made of seamless pipes. For sizes above NPS 10" nozzles connection may be rolled from plates with full radiography of welds.

1.10.8 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes / standards and approved by FACT / FEDO.

1.10.9 Flange facing and thread connection shall be protected against oxidation during Heat Treatment.

1.10.10 All welding shall be done by metal arc welding. For welding on thinner gauge sheets TIG welding is preferred.

1.10.11 Gas or Carbon arc welding shall not be used.

1.10.12 Welding electrodes of composition similar to Internals material shall be used except austenitic electrodes of higher chromium and nickel content such as AWS A5.4, ASME SFA 5.4 class E309 and E310 may be used for 12-Cr stainless steel. For dissimilar material welding, electrode composition shall be similar to nobler material being welded. Following electrodes shall be used unless specified otherwise:

E 7018	for all CS materials
E 7018-1	for all LTCS materials
E 308	for all SS 304 to SS 304
E 308L	for all SS 304L to SS 304L
E 309 MoL	For SS 410S to SS 410S, SS to CS, SS 410S to SS 304, 304L, 316, 316L
E 316	For all SS 316

1.10.13 Welding wherever specified, is to be done by qualified and approved welders using suitable fillers and fluxes recommended for the materials specified in the fabrication drawings. For welding the stud on tray decks and support beams, use of stud welding gun with suitable flux is acceptable. In manually welding of studs, care should be taken to minimize the weld spatter and the outside diameter of the weld so that it should not foul with tray deck or washer. For stud welding, proper welding procedure shall be established. Torque required for welding failure shall be higher than the torque required for failure of the stud.

1.10.14 A proposed Welding Procedure Specification (WPS) shall be submitted to owner / approved inspection agency for approval. On approval, a Procedure Qualification Test (PQT) shall be conducted which shall be witnessed by approved inspection agency. On acceptance of all tests as per ASME Section IX, a final WPS along with Procedure Qualification Record (PQR) shall be submitted. Production welding shall start only after approval of final WPS/PQR and qualification of welders as per ASME Section IX, approved inspection agency may accept previously qualified WPS/PQR at his sole discretion.

1.10.15 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.

1.10.16 MISCELLANEOUS

1. All parts fabricated shall be smooth, true, clean and free from burrs, grease and dents. Openings for passage of workman must have exposed edges rounded.
2. Seal welds shall have a throat thickness at least equal to the specified Corrosion allowance.
3. All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.

1.11 CONSTRUCTION & ERECTION

1.11.1 LSTK Bidder shall follow standard established procedures for handling storage, construction & erection. LSTK Bidder shall strictly follow Manufacturer's / Principal's instructions, approved drawings and procedures for construction & erection and satisfy Principal in all respects of storage, handling, construction & erection of Package. All erection work shall conform to the working / erection drawings (to be prepared by LSTK Bidder) and shall be in conformity with codes & standards as applicable. The LSTK Bidder shall supply & arrange all necessary construction & erection tools and tackles, machinery, scaffolding etc.

1.11.2 LSTK Bidder shall perform the following:

1. Before installing the equipment, the foundations shall be checked and wherever necessary, chipping shall be done by the LSTK Bidder. All grouting materials, packing plates/wedges required for the leveling and alignment of equipment, structures & pipelines etc. shall be provided.
2. Top of the foundations shall be thoroughly cleaned to the satisfaction of FACT / FEDO before placing base plates.
3. All equipment & structure etc. shall be checked and inspected for its proper leveling and granting (grouting) shall be done with suitable grouting material as required.
4. After tightening the foundation bolts, the final level / alignment shall be rechecked and redone, if required.
5. Installation of all supports and hangers, including concreting or welding as necessary.
6. To check correctness of the piping, instruments and other connecting points in the equipment and piping installed.
7. The welding joints shall be stress relieved wherever necessary as per applicable codes, standards & specifications.

1.11.3 The following shall be arranged and supplied by LSTK Bidder for completion of job. Any other item whatsoever required shall also be included by LSTK Bidder in their scope:

1. All construction & erection materials, equipment & machinery, scaffolding, consumable, and test equipment etc.
2. Cranes/Hydra, temporary lifting beams and spreaders etc.

3. Procedures for site assembly, construction & erection including lifting methodology for Owner/Third party approval.

1.11.4 As a minimum bidder shall comply the requirements indicated below:

1. Fabricate, erect and align the equipment & internals as per applicable codes, standards & specifications. All internals shall be inspected before and after installation.
2. Carry out all NDT's required. The Personnel performing NDT's should have a minimum qualification as "NDT LEVEL-II" in the relevant Technique, certified by American Society for Non-destructive Testing (ASNT).
3. Perform non-operating field pressure tests and leak tests on field fabricated equipment in accordance with the applicable codes, standards and specifications, ensuring disposal of test media in accordance with instruction/recommendations.
4. Notify Owner/Third party of the test schedules for witness the tests by concerned inspector.

1.12 MATERIAL OF CONSTRUCTION

1.12.1 The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under specific process design guidelines. However superior materials as per the recommendation of FACT / FEDO may be selected which shall be indicated in the Bid by the LSTK Bidder.

1.12.2 All materials, whatsoever, required to complete the supplies shall be procured by LSTK Bidder and all such materials shall be covered with due identifiable material test certificate.

1.12.3 Materials used in low temperature service must be impact tested (Charpy V) as per design code & specification. Impact test & energy value shall be in accordance with code requirement, unless specified otherwise.

1.12.4 For coarse grained & high tensile materials in carbon steels (UTS>45 Kg/mm^2) & low alloy steel, guaranteed impact strength shall be ensured at a temperature 15^0C below envisaged hydraulic test temperature as a precaution against brittle fracture during hydraulic test.

1.13 HEAT TREATMENT

1.13.1 Heat treatment of formed parts shall be carried out as per following:

For Carbon Steel:

1. Cold formed dished ends or knuckles up to 16 mm nominal thickness shall be stress relieved.
2. For Low alloy Steel:- Cold Formed Dish ends or Knuckles shall be stress relieved.
3. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalizing range in the final stages of manufacture shall be normalized.
4. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall be applicable.
5. All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment.

1.13.2 All CS & LAS materials including forging used for pressure parts shall be procured in fully killed and normalized condition. CS & LAS materials above 50 mm thickness shall be vacuum degassed except for plate ring flanges.

1.13.3 All SS plates shall be hot rolled & solution annealed and pickled as per SA 480.

1.13.4 All plates above 50 mm thickness shall be examined by UT as per ASTM-A435 at mills for both at surface & edges.

1.1.1 Cladded plates shall be supplied as per ASTM A264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A578 level S8.

1.1.2 The minimum thickness of 3 mm for cladding and 6 mm for lining / weld deposit (after machining) except clad or weld overlay tube sheets and gasket surfaces.

1.1.3 Cladded / Weld overlayed Tube sheets shall have a nominal clad or weld overlay thickness of 3/8 inch (10 mm) but not less than 5/16 inches (8 mm undiluted). Shell side claddings on tube sheets are not acceptable. The minimum thickness of clad or weld overlay at a pass partition groove shall be 1/8 inch (3 mm undiluted) minimum.

1.13.5 Weld overlayed nozzle and girth flange gasket faces shall have a minimum thickness of 3/16 inch (4.8 mm) after machining.

1.13.6 All forgings except for flanges as per ANSI shall be UT tested as per ASTM A 388 for the thickness greater than 100 mm and shall be procured in normalized / annealed condition. Acceptance standards shall be as per AM 203.2 of ASME Section VIII Div. 2. In case any defect is found, no repair by welding shall be allowed.

1.13.7 All forgings including nozzle flanges shall be examined for surface defects by MP / PT testing after machining as per ASTM A 275.

1.13.8 Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

1.13.9 Unless more restrictive prescription given by material specification the max. Content for carbon steel used for fabrication as shown by ladle analysis shall be 0.23% for plates, pipes & tubes, 0.25% for forging.

1.13.10 In order to minimize the effect of temper embrittlement for material to 2¼ Cr 1 Mo specifications in the temperature range of 375-575oC, the embrittlement factors 'X' & 'J' shall be limited to:

$X = (10P + 5Sb + 4Sn + AS) / 100 \leq 15$

The elements above are expressed as ppm

$J = (Si + Mn) (P + Sn) \times 104 < 160$

The elements above are expressed as percentages

A stimulated PWHT followed by step cooling shall be performed on a sample of material. Acceptable toughness shall be demonstrated by means of a Charpy V Impact Test.

1.13.11 Unless otherwise specified Copper & Copper alloys shall not be used.

1.13.12 Top portion of skirt (min. 500 mm height) welded to the bottom dished head shall be of same material as that of shell/head for LAS & SS materials.

1.13.13 All directly welded external / internal attachments shall be of same materials as that of equipment, unless specified otherwise.

1.13.14 Unless otherwise specified, all internal parts shall be removable type. Internal shall be designed in units as large as can be installed through the nearest upper manhole or opening. The weight of unit shall not generally exceed 40 Kg. except for support beams.

1.13.15 Trays, distributors, baffles and support beams shall be designed in such a way that deformation of shell due to operating pressure and thermal expansion does not occur. Bolts and nuts for fixing internals shall be 18 / 8 S.S and minimum size of bolts shall be M10. All internal bolts shall be provided with locking nuts.

1.13.16 PWHT of complete vessel shall be carried out in one go in a furnace. Local stress relieving of weld joint in piece meal shall be avoided as far as possible.

1.13.17 For SS 316 & 316L material Ferrite content for plate, pipe, tubes and forging shall be max. 2%.

1.13.18 For high pressure equipments, in shell & heads, the impurity limit shall be Copper ≤ 0.20% & Nickel ≤ 0.30% for Mo & Cr- Mo low alloy steels while Copper shall be ≤ 0.20% & Vanadium ≤ 0.15% for carbon steels.

1.13.19 Gaskets for all medium with flange rating ≤ 600 # class shall be SS spiral wound type with external & internal guide rings shall be used unless otherwise specified.

1.13.20 Gaskets used for high pressure shall be of the following type:

- Ring Joint
- Double conical with graphite tape
- Diaphragm gasket
- Lip seal Gasket

1.13.21 Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions. After testing, gaskets used during testing shall be replaced by new gaskets.

1.13.22 Inter granular corrosion test shall be carried out on all SS 316L materials, weld & HAZ as per ASTM A 262 practice E (Strauss test) unless otherwise specified.

1.13.23 Hydro testing of equipment shall be as per UG-99b. Design pressure for each nozzle shall be sum of maximum allowable working pressure and static head of corresponding nozzles.

1.14 QUALITY ASSURANCE & CONTROL

1.14.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Bidder to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests , measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.

1.14.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Bidder in order to assure that Equipment leaving LSTK Bidder's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

1.14.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Bidder's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

1.14.4 LSTK Bidder shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Bidder to develop and implement adequate QA/QC systems.

1.14.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Bidder.

2.0 EQUIPMENT DESIGN BASIS

2.1 GENERAL

2.1.1 Design pressure shall not be lower than 10% over the maximum anticipated operating pressure and design temperature should be 25^0C higher than the maximum anticipated operating temperature for all equipment unless otherwise specified.

2.1.2 Design pressure is normally specified at the top of vertical vessel or at the highest point of horizontal vessel. The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.

2.1.3 Forces and moments acting on nozzles shall be considered in the equipment design. The exact forces & moments shall be indicated after piping layout which shall be considered by equipment supplier without any commercial implication to Owner.

2.1.4 All Carbon Steel (CS) and Low-Alloy Steel (LAS) pressure parts shall have 3 mm corrosion allowance unless specified otherwise. All internal CS & LAS parts shall have at least 1.5 mm Corrosion Allowance on either side. No corrosion allowance shall be considered for SS.

2.1.5 Design of supports and anchor bolts considering soil and importance factors shall be performed for compressive and tensile loading. In no case shall diameter of anchor bolts be less than M24 for skirt support and M16 for other type of support.

2.1.6 Lifting lug, lifting trunion, tailing lug etc. shall be designed with shock factor 2.

2.1.7 Bolt of size M48 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner. The bolts shall have an extra threaded length at one end of approximately 1 bolt diameter, and shall be provided with threaded projection caps. Hex nuts shall have suitable holes for manual tightening. The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be supplied by LSTK Bidder as per mechanical design of the equipment.

2.1.8 When Equipment is under Hydrogen / Lethal service or design pressure is more than 600# class and/or shell thickness is 50 mm and above, self reinforced forged nozzle shall be provided. Nozzle size ≥ 3" NPS Shell to SR nozzle welding shall be set-in type welding.

2.1.9 In case of nozzle with butt-end construction, extra length shall be provided to facilitate hydraulic testing and subsequently cutting and edge preparation to suit piping welding at site.

2.1.10 Orientation of longitudinal seams and position of circumferential seams shall be clearly marked in the fabrication drawing. Nozzles, support and other attachments shall be located clear of welded joints.

2.1.11 LSTK Bidder shall mark tangent lines, the position of the main axis and the center of gravity for orientation in a clearly identifiable and permanent way on the vessel. Centre of gravity shall be clearly marked.

2.2 INSPECTION AND TESTING

2.2.1 Equipment shall be inspected by a TPIA approved by FACT. The Inspection and testing shall be in accordance with the specified codes, standards, specifications, including mandatory NDT requirements indicated under Inspection and Testing clause 2.2.3 & Inspection guidelines (Annexure-1). All equipment & bought -out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LSTK Bidder and shall duly approved by Owner or their authorized representative. In case of site fabricated/assembled

equipment, TPIA approved by FACT shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed in Annexure-1 & also defined under Inspection & Testing clause of the design philosophy.

2.2.2 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Bidder.

2.2.3 The following NDT requirements are mandatory in addition to code / specification requirements:

1. UT examination:-

- All butt-welds in thickness greater than 50 mm as supplement to radiography.
- FPW of nozzle attachments of thickness above 50 mm as supplement to radiography.
- Clad Plates and formed heads from clad plates in all thicknesses.

2. MP / PT Examination:-

- All edges of plates and opening in shell of CS having thk. Above 40mm and LAS / SS having thk. more than 25mm.
- Root and final layer of all butt welds.
- Fillet welds of 3.5% Ni & SS.
- Each layer of weld deposit in SS overlay.
- Knuckle surfaces of dished ends, expansion bellows and pipe bends.

3. Radiography:-

- All weld seams of formed head, if made in more than one segment shall be fully radiographed after forming.
- All the welded T- Joints shall be fully radiographed.
- When spot radiography is specified, all T-joints & min. 10% of total weld length excluding T-joints shall be radiographed.

2.2.4 Following are mandatory requirements in addition to codes / standards for Ammonia Storage Tank

1. Radiography:-

- All L weld seams of Tank and Cup shall be 100% radiographed.
- Circumferential weld seams of bottom most two courses (Tank & Cup) shall be 100% radiographed.
- All butt weld joints of annular plate (Tank & Cup) shall be 100% radiographed.
- All butt weld joints internal nozzles in vapor zone shall be 100& radiographed.
- All remaining T joints shall be 100% radiographed.
- Dish end cap weld joints for inner and outer shell manholes shall be 100% radiographed.

2. MP Examination before hydro testing:-

- Weld joint between shell & annular plate.
- Final layer of all Butt-welds.
- All lap joints of bottom & roof plates.
- All welds on connections/attachment after stress relieving, if any.

- All Butt-weld joint which are not Radiographed shall be examined inside & outside.

3. MP Examination after hydro testing:-

- Annular plate to shell
- L-seam of bottom most two courses
- Compression plate to roof plate
- All joints of annular plate bottom

4. DP Examination before hydro testing:-

- After back gauging of root run
- All lap joints in the bottom and roof plate
- Rafter splice joint

5. All bottom & annular plate joints shall be vacuum box tested.

NOTE: Hydro testing of Inner & Outer tank shall be in accordance with API 620 Annex. R requirements.

2.2.5 All completed equipment shall be tested hydraulically as per the requirements of Specification/codes in presence of the inspecting authority. Pneumatic test of completed Equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 20 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. In the case of vessels made of carbon steel or low-alloy steel, the test water shall contain a rust inhibitor like 0.2% sodium nitrite. Duration of test shall be 1 hour minimum. After hydro testing stainless steel vessels shall be dried thoroughly immediately after draining to prevent the possibility of evaporation & concentration of chlorides.

2.2.6 All process equipments shall be supplied with Nitrogen gas filled. In case of equipment assembled and welded at site, it shall be filled with N2 after testing at site. Dry Nitrogen shall be filled at a pressure of 0.5 Kg/cm^2g and equipment shall be fitted with a pressure gauge and valve along with nitrogen cylinder.

2.2.7 Special tools/tackles as recommended by equipment manufacturer shall be included in the scope of bidder.

2.2.8 Equipment under preview of statutory bodies shall be inspected during various stages of fabrication by their authorized inspecting agency. It is the responsibility of the LSTK Bidder to get the design calculations and fabrication drawings. approved by concerned statutory bodies before commencing fabrication.

2.2.9 All raw materials shall be inspected at source and test certificates to enable proper identification shall be submitted. Bidder shall provide EN 10204 Type 3.2 certification for all Critical/high pressure equipment except IBR equipments. Further, other than high pressure equipment, Bidder shall provide EN 10204 Type 3.1 certification. For non pressure parts EN 10204 Type 2.2 shall be provided.

2.2.10 Unless otherwise stated gasket during testing shall be same as specified for operating conditions. After testing, gaskets used during testing shall be replaced by new gaskets.

2.3 PAINTING

All shop fabricated equipment shall be painted at Vendor's shop. For guidelines of painting refer to FEDO Engineering Specification 02 ES 023/2010.

2.4 PICKLING AND PASSIVATION

All SS material shall be Pickled & Passivated as per following procedures:-

2.4.1 PICKLING

Aqueous pickling solution shall be as follows:-

Nitric acid (Tech grade) - 10 to 25% plus Hydrofluoric acid - 1 to 8% (to be used only for stabilized SS grades). Temperature 50 to 60° C for 10% Nitric acid and 20° C for 25% Nitric acid. When size and shape of product permit, total immersion in the pickling solution is preferred. Where immersion is impractical, pickling may be accomplished by wetting the surface by

- Swabbing or spraying
- Partial filling the item with pickling solution and rotating or rocking so that the entire surfaces receive the required chemical treatment.

The maximum period for which the pickling solution shall be allowed to remain on the surface is 30 minute. During pickling removal of oxides may be hastened by brushing with a hard fiber or SS wire brush. Over pickling shall be avoided.

The pickling agent shall be washed off with plenty of water so as to leave no trace behind.

2.4.2 PASSIVATION

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10% weight and KMnO4 4% weight shall be used for neutralizing pickling solution. This shall be followed by thorough water rinsing. Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

2.5 FIRE PROOFING

Fire proofing, if required shall be considered as per Bidder's recommendations.

2.6 INSULATION

The equipment shall be insulated as defined in FEDO Engineering Specifications for Hot & Cold Insulation respectively 02 ES 029 / 02 ES 042.

2.7 OPERABILITY AND MAINTENANCE

Equipment design and layout shall provide for ease of access, operability and maintenance.

2.8 DESPATCH

2.8.1 Equipment intended for ship transportation shall be transported in the hatch of the ship. Suitable seaworthy packing/painting shall be applied to avoid any damage during transportation.

2.8.2 The complete transport, packing & forwarding of equipment shall be the responsibility of LSTK bidder. In case of inland transportation, equipment shall be properly lashed / fixed on the wagon / trailer to avoid any damage due to shocks during transport. In case of ODC (Over Dimensional Consignment) movement, ODC sanction for movement either by rail / road shall be arranged by LSTK bidder from appropriate authorities.

2.8.3 All spares shall be properly packed, marked as per packing list & sent separately along with equipment.

2.8.4 Equipment shall be dispatched with filling of dry nitrogen gas at a pressure of above 0.5 kg/cm^2g and equipment shall be fitted with a pressure gauge.

2.9 GUARANTEES

2.9.1 MECHANICAL GUARANTEE

LSTK Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.

2.9.2 PERFORMANCE GUARANTEE

LSTK Contractor shall stand Guarantee of equipment as per respective technical specifications/Process Data sheets

3.0 TECHNICAL REQUIREMENTS

3.1 PRESSURE VESSEL

This specification covers the minimum requirements for the design, materials, fabrication, and inspection of welded pressure vessels which are defined in U-l of ASME Code Section VIII, Division 1 Latest Edition and Addenda.

3.1.1 REGULATIONS, CODES AND STANDARDS

3.1.1.1 Unless otherwise specified, the design, materials, fabrication and inspection of welded pressure vessels shall comply with ASME Code Section VIII, Division 1 latest edition.

3.1.1.2 Process licensors guidelines / standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

3.1.1.3 Unless specifically required, ASME Code stamp is not required for design code ASME Section-VIII Div 1. However, equipment designed with ASME Section VIII Div-2, ASME code stamp is mandatory.

3.1.1.4 Vessels will be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads. Minimum inside diameter shall be 500 mm. Top cover shall be flanged if the ID is equal or less than 900 mm.

3.1.1.5 Vessels shall conform to the requirements of ASME Section VIII Division 1 & 2 Pressure Vessels codes and Technical Specifications mentioned in the design criterion.

3.1.1.6 Design of vessel skirt shall be based on seismic / wind / thermal considerations and fireproofing / insulation requirements.

3.1.2 ALLOWABLE STRESS

3.1.2.1 Vessel stresses during hydrostatic tests shall not exceed 90% of the minimum yield strength of the material.

3.1.2.2 Vessels to be hydrostatically shop tested in the horizontal position shall be supported adequately to keep local stresses in the shell not exceeding 90% of the yield strength of the material.

3.1.3 CORROSION ALLOWANCE

3.1.3.1 For an intermediate head, corrosion allowances shall be added to both sides.

3.1.3.2 For the inside of shells, heads, nozzles and manholes, the specified corrosion allowances shall be added.

3.1.3.3 For non-removable internal parts, the specified corrosion allowances shall be added to both sides.

3.1.3.4 For removable internal parts, the specified corrosion allowances shall be added to one side only.

3.1.4 HEAD / DISHED ENDS

3.1.4.1 Dished ends shall be of seamless construction. However, dished ends with one chordal weld seam are acceptable. In such cases, the chordal seam shall preferably be in the middle one third of the blank. Intermediate heat treatment, if considered necessary, shall be carried out by the LSTK Bidder.

3.1.4.2 Whenever a dished end is made of more than two plates, it must have a crown plate. Whenever a nozzle or a manhole is positioned at the centre of the dished end, the crown plate should be larger than the nozzle / manhole reinforcing pad.

3.1.4.3 Torispherical heads shall be used for Pressures up to 6.86 bar (g). For torispherical heads, ratio of Knuckle to Inside Crown Radius shall not be less than 6 %.

3.1.4.4 Beyond 6.86 bar (g), heads shall be of ellipsoidal type having a ratio of major axis to minor axis 2:1 shall be used. Alternatively, Hemispherical Heads with minimum weld joints may also be used.

3.1.5 Vessel skirts for carbon steel vessels shall be designed from the same material as the shell or the head. Vessel skirts for other than carbon steel vessels shall be the same material as the shell or the head for the top 500mm.

3.1.6 Vessels with skirts having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be of box type (no annulus type) to avoid problem during final erection and installation. The template shall have adequate strength against deformation.

3.1.7 All nozzles above 24” NB shall comply with ASME B16.47 Series B.

3.1.8 Local vessel stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.

3.1.9 Design of supports and anchor bolts considering soil & importance factors shall be performed for compressive & tensile loading. In no case, diameter of anchor bolts shall be less than M24 for skirt support & M16 for other type of support.

3.1.10 The lifting lug, lifting trunion, tailing lug etc. shall be designed with shock factor of 2.

3.1.11 Maximum permissible deflection for tall vessels/columns when subjected to design wind loadings shall not exceed 0.005 x Vessel height.

3.1.12 For vessels, the minimum thickness of shell & heads, including corrosion allowance shall be as indicated below:

S. No.	Shell Diameter (mm)	Thickness (Min.) mm	
		CS / LAS	HAS
1	ID < 500	5	3
2	501 < ID < 1200	5	4
3	1201 < ID <2000	6	5
4	2001 < ID < 2600	8	6
5	ID > 2600	10	8

CS = Carbon Steel
LAS = Low-Alloy Steel
HAS = High-Alloy Steel

3.1.13 Use of structural steel shall be limited to non-pressure parts only.

3.1.14 Horizontal vessels of large size and thin wall shell on saddle supports shall be investigated for buckling, local circumferential bending and shear stress. The method of L. P. Zick (Supplement to Welding Research, 1971) may be used for this investigation.

3.1.15 Manhole / hand hole / blind holes covers shall be equipped with davits or hinges to facilitate handling.

3.1.16 Manhole size of 24” NPS is preferred. However for shell diameter more than 1000 mm, minimum size of manhole shall be 20" NB and for shell dia. 1000 mm & below 18" NB manhole size shall be minimum.

3.1.17 INTERNALS

3.1.17.1 All internal bolting shall be of corrosion resistant material.

3.1.17.2 All bolting size shall be minimum of M10. All nuts shall be hexagonal.

3.1.17.3 Allowable stress criterion for design of internals shall be as per ASME Section VIII Div. 1

3.1.17.4 All removable internals shall be designed so that they can pass through the vessel man-way internal diameter / shell flange if any.

3.1.17.5 For an intermediate head, corrosion allowances shall be added to both sides.

3.1.17.6 Internal distribution pipes shall have flanged connections with gaskets unless otherwise specified. Internal pipes shall be divided into suitable lengths to pass freely through the vessel manholes and internal man ways, and shall be suitably supported from shells or tray decks.

3.1.17.7 Demisters shall be securely fastened to support ring by bolting or clamping.

3.1.17.8 Internals (trays, distributors, support beams) shall be so designed that any expansion of it wouldn’t affect shell deformation.

3.1.18 ACCESSORIES

3.1.18.1 Clips for platforms, ladders and piping supports shall be furnished and attached to the vessel by the vessel manufacturer.

3.1.18.2 Top davits of vertical vessels shall be so designed and fabricated so that heavy valves around the vessels and internal parts of vessels can be removed and grounded without being interrupted by piping and steel structures.

3.1.19 INSULATION SUPPORT RINGS

3.1.19.1 Insulation support rings shall be suitably provided as per the specified insulation thickness.

3.1.19.2 Maximum longitudinal interval of insulation support rings shall be 3600 mm when preformed insulating material are used. Stiffening rings may be used as insulation support rings.

3.1.20 Lifting lugs of appropriate size shall be provided to ensure complete safety during erection of the Vessel.

3.1.21 Grounding lugs shall be attached to the vessel support for the ground connection.

3.1.22 TEMPLATES

3.1.22.1 Templates for vertical vessels with skirts shall be provided for lying out of anchor bolts at site.

3.1.22.2 The template shall have adequate strength against deformation. Template shall be identical to the Vessel Base Frame having double ring. It shall be confirmed that markings of the bolt hole orientation on the templates coincides with those shown on the approved drawings.

3.1.23 PLATE LAYOUT

3.1.23.1 Shell plate shall be laid out so that there will be minimum of welded seams.

3.1.23.2 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.

3.1.23.3 Longitudinal welded seams on adjacent shell segments shall be separated by at least 4 times the wall thickness of the thicker plate but not less than 100 mm.

3.1.24 CONNECTIONS

3.1.24.1 Unless shown in data sheets, nozzles, manholes, and hand holes shall be ground flush and smooth inside the vessel. The edges of internal projections for both nozzles and manholes shall be rounded to a radius of 2 mm minimum. Reinforcement pads shall be external.

3.1.24.2 Main vessel seams shall not pass through openings for connections as far as possible. When unavoidable, the portion of the weld seam covered by a reinforcing pad which shall be ground flush with the parent metal and 100% radio graphed prior to attachment of the pad.

3.1.24.3 All reinforcing pads shall be provided with at least one telltale hole of NPT 1/8".

3.1.25 HEAT TREATMENT

3.1.25.1 Fabricated vessels shall be post weld heat treated in accordance with ASME Code Section VIII, Division 1, and requirements specified in the data sheets.

3.1.25.2 The complete post weld heat treatment procedure including temperature and holding time shall be submitted to the owner for review.

3.1.25.3 All machined surfaces shall be protected against scaling during post weld heat treatment.

3.1.25.4 All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment.

3.1.25.5 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the owner.

3.1.25.6 Simulation Heat Treatment for the Alloy Steel Material shall be carried out as per the CODE Requirement.

3.1.26 PICKLING

3.1.26.1 When specified, all internal / external surfaces of stainless steel shall be cleaned by pickling before hydrostatic test.

1. Care shall be taken so that stainless steel surfaces shall not be subject to any scratch or damage during pickling.
2. Weld scale and other foreign material deposited on the surfaces shall be removed.
3. Pickled surfaces shall be completely neutralized, and washed by freshwater

3.1.27 FABRICATION TOLERANCE

Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.

3.1.28 PREPARATION FOR SHIPMENT

3.1.28.1 All vessels shall be drained, clean, and free of grease, oil, scale, weld spatter, and any other foreign substance.

3.1.28.2 All flange faces and other exposed machined surfaces shall be properly protected with substantial metal shields or covering against damage during shipment.

3.1.28.3 All inside surfaces and internal parts of carbon steel shall be coated with suitable rust preventive before shipment.

3.1.28.4 All openings shall be provided with metal closures.

3.1.28.5 Test holes of reinforcing pads for nozzles and manholes shall be plugged with steel or plastic plugs.

3.1.28.6 Vent holes of saddle pads shall be plugged with plastic sealant or hard grease prior to shipment.

3.1.28.7 All threaded connections shall be plugged with threaded round bars or covered with standard pipe caps of the same material as the equipment. Covers, flanges, gaskets, bolts, and nuts furnished by the fabricator shall be shipped in place.

3.1.28.8 Internals shall be tied or braced as necessary to avoid damage or dislodgment during Shipping and installation.

3.1.28.9 Baselines indicating four directions with figures of 0°, 90°, 180" and 270° shall be marked by paint on the shell. The paint colour shall be white for carbon steel and black for stainless Steel.

3.2 SHELL AND TUBE HEAT EXCHANGERS

3.2.1 This specification covers the minimum requirements for the design, materials, fabrication and Inspection of shell and tube type heat exchangers.

3.2.2 The Design Philosophy for the Shell & Tube Heat Exchangers shall be read in conjunction with the Design Philosophy for Pressure Vessels, as per Section 3.1 above.

3.2.3 Shell & Tube heat exchangers shall be designed, fabricated and tested in accordance with latest editions of ASME BPVC Section VIII, Division 1, TEMA & API 660.

3.2.4 The Exchanger shall be designed to allow for easy access for maintenance.

3.2.5 All tubular heat exchangers shall be of the type specified and shall be designed for the service and performance conditions given in the specification or data sheets.

3.2.6 Generally the design of the Shell & Tube Heat Exchangers shall be as per TEMA Class R. TEMA Class C shell and tube heat exchangers are acceptable for Lube oil service.

3.2.7 All the heat exchangers shall be of fixed tube sheet type only.

3.2.8 Tubular heat exchangers of auxiliary component for machine units such as lube oil coolers is to be designed, fabricated, inspected and tested in accordance with the manufacturer's standards and ASME Code Section VIII, Division 1, provided written approval is obtained from the owner.

3.2.9 Mean metal temperature of tube & shell be considered in the design of fixed tube sheet exchangers.

3.2.10 Parts such as tubes, tube sheets, floating heads etc. which simultaneously come in contact with both shell side and tube side fluids, shall be designed considering pressure acting on one side only or the combination of pressures, whichever results in higher thickness of parts.

3.2.11 Attachment of tube to tube sheet will be rolled and expanded (with seal welding), strength welded or seal welded as specified on data sheets. However, as a minimum following shall be adopted:

3.2.12 For tube sheet joint, tubes shall be expanded in grooved holes into the tube sheets. The expanding operation shall extend from the outer face of the tube sheets to a depth not < 90% of the tube sheet thickness. TIG welding (Preferably automatic) shall be done in downward position (i.e. keeping tube sheet in horizontal position) with minimum two passes and each pass shall be DP checked. For tube-to-tube sheet joint GTAW (Gas-Tungsten Arc Welding) welding is required.

3.2.13 Tubes shall be strength welded & expanded for any condition.

3.2.14 Procedure shall be qualified for tube-to-tube sheet joints. Mock-up test shall be carried out for all the heat exchangers as per applicable code.

3.2.15 The sample for tube sheet and tube for mock up test shall be drawn from the same heat Material from which the equipment shall be fabricated.

3.2.16 Process Shell and Tube Exchangers will comply with the requirements of ASME SEC VIII Div. I & TEMA Class 'R'.

3.2.17 ASME Section VIII, Div. I, Appendix 'S' shall be considered mandatory for bolted flange connections.

3.2.18 All tube sheet for the exchangers shall be designed as per ASME Sec VIII Div. I & also comply the requirement of section TEMA / UHX of ASME Code (thicker)

3.2.19 Shell side "hot" nozzles shall be located at the top of the shell at the channel end whenever possible.

3.2.20 Lifting lugs for heads or bonnets shall be specified where frequent dismantling is required.

3.2.21 Saddle wear plate material shall be the same as the shell material.

3.2.22 Tube sheets and Girth Flanges shall be of Forged Quality & Ultrasonically tested. It shall not have any segmental joint.

3.2.23 All heat exchanger tubes shall be seamless, cold drawn and formed from single length. CS tubes shall be normalized. LAS tubes shall be normalized and tempered.

3.2.24 Thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.

3.2.25 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm^2 G wherever specified leak testing with halogen shall be carried out.

3.2.26 Impingement plates shall be provided if required by TEMA or indicated as a part of process requirement.

3.2.27 Impingement baffles shall extend at least 1.1 times of the inside diameter of nozzles, or nozzle inside diameter plus 50 mm, whichever is the larger.

3.2.28 Flow induced vibration analysis shall be carried out for all heat exchangers.

3.2.29 Heat exchangers tubes shall be Eddy current tested at mill and the specified thickness of tube shall be minimum (and not average).

3.2.30 Tube sheets shall have the corrosion allowance on each side. Tube Sheets from plates shall not be used.

3.2.31 Slip-on flanges are not permitted for heat exchangers.

3.2.32 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

3.2.33 Dowels or match marks shall be provided to prevent misassemble head covers and channels with pass partitions, channel covers with grooves, and tube sheets to shell flange.

3.2.34 In horizontal exchanger cross baffles and support plates shall be provided with notches for draining and venting.

3.2.35 Minimum SS 304 as MOC for tubes shall be used for Heat Exchangers having Cooling Water. All tubes shall be seamless only.

3.2.36 All heat Exchanger Tubes shall be Eddy Current Tested in addition to Hydro testing.

3.2.37 Copper & Copper Alloy tubes shall not be used for any exchangers.

3.2.38 Corrosion allowance shall be added to the inside diameter of flanges. Gasket surfaces of flange shall have no corrosion allowance.

3.2.39 For all heat exchangers, thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.

3.2.40 Expansion joints shall be designed for the most severe conditions of differential expansion that can occur during normal operations, start up, shutdown, or upset conditions.

3.2.41 Expansion joints shall be of the single layer standard one-piece construction unless otherwise approved by owner. Length of the bellow and preset shall be specified on the manufacturer's drawings.

3.2.42 Expansion bellows shall be designed for min. 5000 cycle, as per TEMA.

3.2.43 All girth flanges joining two parts with different design conditions shall be designed for the severer condition.

3.2.44 All girth flanges for carbon and low-alloy steel exchangers shall be integrally forged welding necks, unless otherwise specified in the data sheets. i.e. Girth Flanges shall be WNRF / WNRTJ type only.

3.2.45 Lined Flanges shall not be used.

3.2.46 All flanges designed with bolts greater than M48 & above shall have sufficient clearance to permit the use of hydraulic bolt tensioning instrument. Bidder has to supply such hydraulic bolt tensioning instrument along with the supply of exchangers & its spares.

3.2.47 The Bidder shall guarantee tightness compatibility of closure designs. The differential thermal growth of gasketed joints of dissimilar materials (including gaskets) shall be considered.

3.2.48 All girth flanges shall be provided with jack screws to facilitate dismounting.

3.2.49 All pass partitions shall have a gasket contact surface of 9 mm width minimum, and shall be machined to a common plane at the gasket face.

3.2.50 The depth of pass partition grooves in tube sheets and flat cover plates shall be a minimum of 5 mm. For alloy cladding or facing, there shall be at least 3 mm of alloy after machining beneath the pass partition groove or gasket face.

3.2.51 When space permits, pass partitions shall be continuously welded from both sides. In cases where space is too small for both side welding, weld shall be continuous on one side in so far as possible.

3.2.52 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

3.2.53 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards.

3.2.54 The shell side test shall be performed in such a manner that the Tube-to- tube sheet joints can be adequately inspected during testing.

3.2.55 Hydro Testing sequence & procedure for testing Exchangers having Lip Seal Gasket shall be approved by the Owner.

3.2.56 Stacked units shall be hydraulically tested in the fully assembled condition.

3.2.57 Air leak test shall be performed for tube to tube sheet joint for all exchangers. However Helium leak test shall be performed for critical heat exchangers/ wherever specified by Process licensor.

3.2.58 After testing, all exchangers shall be completely dried.

3.2.59 Service bolts shall be used in all shop hydrostatic tests.

3.2.60 Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions. After testing, gaskets used during testing shall be replaced by new gaskets.

3.3 DOUBLE WALL AMMONIA STORAGE TANKS

3.3.1 For ammonia tanks below are the design codes/standards shall be followed as minimum in their latest edition:

1. API 620
2. API 625
3. EJMA
4. ASME B16.5 / B.16.47 , as applicable
5. EEMUA publication 147
6. Statutory regulations
7. Other referred codes.

3.3.2 Ammonia Storage Tank shall be designed as per API 620, Annex R, Latest edition and EN 1993-4-2 Latest for Roof structure design. Tank design will also comply with API 625 (as referred in Annex R of API 620) with following exceptions:

1. Provision of in-tank valve is not to be considered for pump suction line.
2. Provision of in-tank pump is not to be considered and side penetration of both shells is to be considered for ammonia pump suction line.
3. The pumps will be installed on outside of tank.

3.3.3 GENERAL

LSTK Bidder shall carry out the following:

1. Mechanical design Calculations showing adequacy (for all components: Shell / bottom / roof / nozzles / Anchor straps etc. for both inner & outer tanks) of ammonia Storage tanks for all the Design condition Including wind/ seismic, residual design etc.
2. Strength calculation for bottom insulation system.
3. Design calculation for Expansion bellows (for nozzles on Inner tank & coming out outer Tank)
4. The design of the tanks shall be in accordance with API 620 (including Annex R) / API 625 and the requirements specified here in. Minimum required thicknesses of various components shall be calculated based on design parameters considering different types of loadings conditions including effect of wind pressure, force of moment owing to connected piping & other attachments as platform etc. Ammonia Storage Tank shall also be designed for hydrostatic condition. Final thickness of tank shall be decided giving due consideration for corrosion allowance & thinning allowance.
5. All parent material (Primary & Secondary Components), weld and HAZ shall be Impact tested at Minimum Design Metal Temperature (i.e. minimum service temperature or the temperature to be computed as per applicable codes standards & specifications) by LSTK bidder and shall have impact energy values as per the applicable codes, standards & specifications.

3.3.4 Tanks shall be designed for the following conditions in accordance with API 620:

1. Erection condition.

2. Erection condition with combined loading (Wind/Seismic)
3. Normal operation with 20% safety valve accumulation.
4. Normal operation with combined loading (Wind / Seismic)-inner tank filled with Product, outer tank empty.
5. Normal operation with combined loading (Wind / Seismic)-inner tank failure i.e. both tank filled with product
6. Hydro test conditions with combined loading (Wind / Seismic)-outer tank empty.
7. Hydro test conditions with combined loading (Wind / Seismic)-both tank filled with test Water.

3.3.5 Corrosion allowance of Ammonia Storage Tank shall be as follows:
Inner Shell & Bottom: Nil
Outer Shell & Bottom: 1.5 mm
Dome Roof: 1.5 mm
Roof Support Structure: 1.5 mm
Suspended deck and related attachment: 1.0 mm

3.3.6 Design of Tank shall be checked in new as well as corroded condition.

3.3.7 A common base plate carrying both Shells should not be used.

3.3.8 Statutory approval from any authority as per statutory rules and regulation of state/ central government shall be LSTK bidder's responsibility. The application on behalf of Owner for submission to relevant authorities along with copies of required certificates complete in all respect shall be prepared by LSTK bidder well ahead of time so that the actual construction / commissioning of work is not delayed for want of approval/ inspection by concerned authorities.

3.3.9 All insulation shall be designed as per the applicable codes & standards taking into account the wind velocity, rainfall as per project site condition. The thickness of the insulation shall be sufficient to prevent condensation and ice formation on the surface of insulation. The insulation material shall have fire retardant properties. Polyurethane insulation (cast in-situ) required for outer tank shell must be capable to withstand wind loads and disbanding forces considering project site.

3.3.10 All workmen working at unsafe elevation during the insulation work shall have safe and adequate passage & should be properly instructed to take the necessary precautions & observe the safe practices to prevent accidental fall. Safety belt shall be used wherever necessary.

3.3.11 Passage nozzles in roof shall have pipe caps end (as end closures). Flat closure shall not be accepted.

3.3.12 A concentrated live load of 150 kg located at any position of the suspended deck shall be considered in suspended deck.

3.3.13 Nozzle on suspended deck through dome roof shall be provided with sleeve pipes (of sufficient Size) and to be insulated properly.

3.3.14 Shell seams shall be located to clear openings to the maximum extent possible in accordance with design code.

3.3.15 Bottom plates may be lap-welded with the lap toward the direction of drainage.

3.3.16 Circumferential Handrail for dome, Access Platforms & handrail for dome nozzles shall be provided.

3.3.17 Sufficient free board shall be provided in line with requirements of API 620 Annex. L.

3.3.18 Material requirement

1. All materials, whatsoever, required to complete the supplies shall be procured by the supplier and all such materials shall be covered with due identifiable material test certificates.
2. Material of construction of Ammonia Tank (LTCS) shall conform to ASTM A537 Cl.1 (as per API 620 Annex. R). Refer to Note 1 of Cl.1.3 for acceptance of alternate materials.
3. Unless otherwise specified all C.S and low alloy steel materials including forging used for pressure parts shall be fully killed and in normalized condition.
4. Unless more restrictive prescription given by material specification the maximum carbon content of carbon steel used for fabrication as shown by ladle analysis shall be:
   - 0.23% for plates, pipes & tubes
   - 0.25% for forging.
5. Additionally one of the requirements for carbon equivalent based on heat analysis shall be also satisfied :
   - $C + Mn/6 + (Cr+Mo+V)/5 + (Cu+Ni)/15 \leq 0.43$ %
   - $Ceq. = C + Mn/6 \leq 0.42$ %
6. Primary component materials including their impact requirements shall conform to API 620 Annex. R/ API 625 and impact requirements of ASTM A20 S5.
7. The use of copper on copper base alloys shall be completely avoided for Ammonia service.
8. Tolerance on thickness of plates shall be positive only.
9. All the carbon steel material exposed to the ammonia atmosphere (both liquid and vapour) shall be impact tested as per API 620/API 625 and the minimum energy value shall be as per API 620 (Annex. R) / API 625.
10. Anchor strap material shall be SS304, unless otherwise specified.

4.0 SPARE PARTS

4.1 MANDATORY SPARES

4.1.1 The mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project are listed in the attached Spare Parts List (Doc. No. 32686-02-PS-002 SPR). These spares shall be purely ware house spares. Bidder shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.

4.1.2 Bidders shall indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant

4.2 RECOMMENDED SPARES FOR 2 YEARS OPERATION

4.2.1 The Bidders shall submit the list including unit & quantity of recommended spares for two years normal operation & maintenance in un-priced part as per format attached and item wise price shall be submitted in priced part.

4.2.2 The Purchaser reserves the right to buy any or all recommended spares.

4.2.3 Prices of recommended spares will not be used for the evaluation of Bids. Prices of Spares shall remain valid for 12 months from the date of preliminary acceptance; Owner may order such spares any time during this period.

4.3 START-UP & COMMISSIONING SPARES

4.3.1 Start-up commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. All spares used until the system is handed over to the Purchaser shall come under this category. The Vendor shall procure and supply spare parts for start-up and commissioning and shall be included in his scope of work without any extra cost to purchaser. The Lump sum quoted price in the price bid (supply) shall be deemed to be inclusive of provision for such spares and additional spares

5.0 LSTK BIDDER/VENDOR DOCUMENTATION:

5.1 Bidder shall submit all documents related to quality and technical such as Calculations, Drawings, QAP, ITP, and Test procedures etc. as per attached Vendor Data Requirements (VDR), Doc. Nos. 32686-02-PS-002 VDR1/VDR2/VDR3 for review / approval. In addition to the attached VDR, any documents or drawing deemed necessary for the review/approval of the Client/Consultant shall be provided by the Bidder.

5.2 In addition to hard copies all final documents such as specifications, datasheets, drawings and manufacturers record book shall be provided in approved electronic software formats (Native files). Calculations shall be submitted in widely used software forms.

6.0 VENDORS LIST

6.1 All equipment shall be procured / fabricated as per approved vendor list (Doc. No. 32686-02-PS-002 VL).

6.2 Make of the equipment not indicated and any other make for the specified equipment shall be subjected to owner’s/consultant’s approval.

6.3 Bidder shall indicate make of various equipment offered by them in the bid.

ANNEXURE-1

1.0 INSPECTION GUIDELINES

1.1 GENERAL

The min. inspection to be carried out by Authorized approved Inspection agency:

1.2 VESSELS

1.2.1 All carbon steel plates shall be identified against mill-test certificates at the vendor's works before commencement of fabrication.

1.2.2 Establish that welding procedure and welders are qualified and welding electrodes are approved before commencement of fabrication.

1.2.3 Check fit-up and witness chipping-back of welded seams.

1.2.4 Wherever applicable, select spots for radiography, D.P and M.P Tests.

1.2.5 Witness any crack detection, hardness checks, ultrasonic tests etc. which may be specified. (Note 1)

1.2.6 Review radiographs and in case it is unsatisfactory re-radiograph. (Note 1)

1.2.7 Witness hydrostatic test.

1.2.8 Dimensionally check and carry out final internal and external inspection for quality of workmanship.

1.2.9 Check that all material test certificates and, where applicable, heat treatment charts are in order. Ensure that vendor is familiar with the requirements regarding data books and ensure that the documentation is submitted without any delay.

1.2.10 Check internal lining of reactors and vessels (if applicable) to specifications.

1.2.11 Witness any further test recommended by Process Licenser/Inspection agency and / or owner.

Note 1: X or Gamma rays

1.3 VESSEL INTERNALS

1.3.1 Final inspection only is required.

1.3.2 Spot check for interchangeability of parts, where applicable.

1.3.3 Where new designs and/or new vendor's are concerned, check that any applicable leakage tests have been carried out on prototype.

1.3.4 Check that materials including welding electrodes are in accordance with the requirements of the order and all applicable specifications and standards.

1.4 STORAGE TANKS

1.4.1 Shell plates to be dimensionally checked (including diagonals for squareness) before rolling to curvature.

1.4.2 All shell plates to be inspected and dimensionally checked after rolling to curvature.

1.4.3 Check material test certificates and ensure that all shell plates are clearly stamped with the cast and plate number, so that they can be identified against the relevant test certificates.

1.4.4 Check material test certificates for roof and bottom plates.

1.4.5 Select the spot radiographs, D.P & M.P test as per codes.

1.4.6 Review the radiographs. (Note 1)

1.4.7 On completion of inspection of shell plates ensure that vendor provides a chart giving all plate numbers, tier by tier.

1.4.8 Inspect fabrication of all fabricated fittings. This is to include checking of material test certificates also.

1.4.9 Inspect tank gauging equipment.

1.4.10 For shop fabricated tanks, witness hydrostatic tests to applicable standards.

1.4.11 Check welding material electrodes.

Note 1: X or Gamma rays

1.5 HEAT TRANSFER EQUIPMENT

SHELL AND TUBE EXCHANGERS

1.5.1 All carbon steel plates shall be identified against mill test certificates at the vendor's works before commencement of fabrication.

1.5.2 Establish that welding procedure and welders are qualified before commencement of fabrication.

1.5.3 Check fit-up and witness chipping-back of welded seams.

1.5.4 Wherever applicable, select spots for radiography.

1.5.5 Witness any crack detection, hardness checks, ultrasonic tests etc. which are specified in drawing, specification, data sheet etc.

1.5.6 Review radiographs. (Note 1)

1.5.7 Witness all hydrostatic tests on shell and tube sides.

1.5.8 Complete dimensional check for stacked units. This is to be carried out in the full assembly stage.

1.5.9 Check that all material test certificates and where applicable, heat treatment charts are in order. Ensure that vendor is familiar with the requirements regarding data books and see that the documentation is submitted without any delay.

1.5.10 Witness any further test recommended by Process Licensor / Inspection agency and / or owner.

Note 1: x or Gamma rays

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Job No.	**:**	**32686**
Item	**:**	**ROTATING EQUIPMENTS**
Item No.	**:**	**-**
Project	**:**	**NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS**
Client	**:**	**FACT-CD**
Location	**:**	**AMBALAMEDU**

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LIST OF ATTACHMENTS

1.0 SCOPE

1.1 GENERAL

1.1.1 This Philosophy states that LSTK bidder's scope of work shall include basic & detailed engineering, procurement, supply, manufacturing, fabrication, transportation, loading, unloading, insurance during transit, storage, construction, erection / installation of all Mechanical Rotating Equipment with allied electrical, instrumentation and civil works, obtaining all necessary statutory approvals from concerned government authorities as applicable, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs for New Ammonia Storage Tank for Fertilizers and Chemicals Travancore Limited (FACT), Ambalamedu.

1.1.2 In addition, all statutory rules & regulations shall also be complied with.

2.0 STANDARD DEFINITIONS

Company / Owner / Client	Fertilizers and Chemicals Travancore Limited (FACT)
Consultant	FACT Engineering and Design Organisation (FEDO)
Supplier / Bidder / Manufacturer	Is the party that manufactures or supplies equipment and services to perform the duties specified by the Contract
Sub Bidder / Sub Supplier	The manufacturer or supplier on whom purchase order is placed by the vendor for any part of material in accordance with the purchase order on the vendor.
TPIA	Third Party Inspection Agency

3.0 DESIGN PHILOSOPHY FOR MACHINERY

3.1 CODES AND STANDARDS

3.1.1 The Latest Edition of codes and standards as listed below shall be followed for design and manufacturing of different machinery items. Generally the manufacturer will comply with these codes and standards as indicated therein with minor deviations that are normally adopted by manufacturer and are reasonably accepted as per good engineering practice.

3.1.2 A list of such deviations, if any, shall be furnished by the LSTK Bidder along with offer.

Code	Description
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industry
ANSI / ASME B 73.1 M	Horizontal, End Suction centrifugal Pumps for Chemical Process
International Standard	Horizontal Centrifugal Pumps for Clear Cold Water
API 613	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services.
API 614	Lubrication, Shaft-Sealing, and Control Oil System for Petroleum, Chemical and Gas Industry Services.

API 619	Rotary Type Positive Displacement Compressors for General Refinery Services.
API 670	Vibration, Axial-Position, and Bearing-Temperature Monitoring Systems.
API 671	Special Purpose Coupling for Refinery Services, Petrochemical and Gas Industry.
API 675	Positive Displacement Pumps-Controlled Volume
API 676	Positive Displacement Pumps-Rotary.
API 678	Accelerometer and Vibration Systems.
API 682	Shaft sealing Systems for Centrifugal and Rotary Pumps.
ISO / DIN	Centrifugal Pumps for smaller size & Non Critical Services.
International Standard, ASHRAE / ISHRAE	HVAC
Performance Testing (ASME Codes)	
PTC 8.2	Centrifugal Pump
PTC 9	Displacement Compressors

3.2 DESIGN LIFE

All equipment shall be designed for a minimum service life of 20 years and at least 2 years of uninterrupted operation under normal operating conditions. This requirement excludes specialized components requiring periodic maintenance and replacement.

3.3 ESSENTIAL PROJECT REFERENCE DOCUMENTS

The following documents shall be observed, and relevant aspects incorporated into specifications and datasheets:

1. Process Description, Specifications and Data Sheets
2. Hazardous Area Classification
3. Electrical and Instrumentation Design Criteria

3.4 REGULATIONS

Besides codes & standards, LSTK Bidder shall follow National Laws and Regulations together with Local by Laws for the state including statutory requirements as applicable.

3.5 SITE CONDITIONS

Site conditions shall be as defined elsewhere in the bid document.

3.6 MATERIAL OF CONSTRUCTION

API guideline shall be adapted to the extent applicable. Use of equivalent &superior material may be selected & shall be furnished with the offer along with chemical composition.

3.7 QUALITY ASSURANCE & CONTROL

3.7.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Bidder to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests, measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments / unit / system.

3.7.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Bidder in order to assure that the machines & associated auxiliaries leaving LSTK Bidder's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

3.7.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Bidder's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

3.7.4 LSTK Bidder shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Bidder to develop and implement adequate QA/QC systems.

3.7.5 QA/QC system shall cover all products and services required for the complete machine unit as per scope of work including job sub contracted by the LSTK Bidder.

4.0 DESIGN REQUIREMENTS

4.1 GENERAL

4.1.1 All machines shall be directly coupled to their prime movers. Gears/any other forms of transmission shall be avoided. If not, specifically mentioned, the drivers shall have rated output at least 10% greater than the power requirement at design operating condition of the driven equipment.

4.1.2 Copper (Cu) or Cu-alloy shall not be used for ammonia services.

4.1.3 All process pumps shall have Mechanical Seals. Single seals will be used in most cases, however, for Ammonia service pumps, cartridge type double mechanical seal with tandem arrangement shall be used. Cooling water pumps, fire water pumps & effluent service pumps shall have gland packing arrangement.

4.1.4 Special tools and wrenches required for installation and maintenance shall be provided, if required.

4.1.5 LSTK Bidders have to submit the reference list for similar equipment's models (minimum 2 nos.) supplied in past for similar duty conditions. Reference list must contain at least the following: Fluid handled Capacity, Suction Pressure, Discharge Pressure, Model No., Power consumption, Client Name, Address and Year of supply.

4.1.6 All the flanges of rotating equipments shall confirm to raised face ends as per ANSI B16.5.

4.2 SCREW COMPRESSORS FOR INSTRUMENT AIR SERVICE

4.2.1 The screw compressors for Instrument Air service shall conform to manufacturer's standard. In addition to the above, the following shall be applicable:

4.2.2 Timing gears shall be made of forged steel and shall be a minimum of ISO/AGMA 1328 Quality 5. Timing gears shall be of the helical type. ISO/AGMA service factor shall be a minimum of 3.0

4.2.3 LSTK bidder shall provide the acoustic enclosure in case if the screw compressor is very noisy.

4.2.4 If required, LSTK bidder shall consider a separate moisture separator at discharge of compressor for moisture separation.

4.2.5 Shaft seals shall be provided to restrict the leakage of compressed air to atmosphere. Shaft seals should be easily accessible for inspection and replacement without dismantling the casing.

4.2.6 To minimize the need for heavy overhead pipe structures, suction and discharge piping to and from the knockout drums should run close to grade, supported on sleepers.

4.2.7 If required, frame lubrication system shall be provided with auxiliary pump driven by electric motor for initial lubrication.

4.2.8 Full flow twin oil filter (one in service & other as standby) shall be provided.

4.2.9 Oil cooler & inter-stage cooler (if required) shall be of fixed tube sheet shell-tube type heat exchanger with austenitic steel tubes.

4.3 SCREW COMPRESSOR FOR AMMONIA UNLOADING/HOLDING (BOIL-OFF) SERVICE

4.3.1 The Ammonia Unloading / Holding Compressor shall be designed as per API 619 4th edition or above. The compressor shall be of oil flooded screw type.

4.3.2 Compressor manufacturer standard deviations to API 619 standard shall be mutually agreed on case to case basis during detailed engineering stage without any additional cost impact to FACT.

4.3.3 Material of construction of compressor casing shall be LTCS, preferably ASTM A352 LCC.

4.3.4 The compressor shall be directly driven by motor (i.e. no gearbox shall be provided for power transmission from electric motor to compressor).

4.3.5 The tilting pad type hydrodynamic thrust & radial bearing shall be preferred for compressor.

4.3.6 Non contacting type vibration & axial position transducers shall be supplied, installed & calibrated in accordance with API 670.

4.3.7 A bearing temperature monitor shall be supplied & calibrated in accordance with API 670, if practically possible.

4.3.8 Oil content shall be of $\leq$ 10 ppm, after compressor discharge (i.e after oil separator). If required, LSTK bidder shall provide multiple separators for the same.

4.3.9 The demister pads provided for oil separation in oil separator shall be designed for easy removal for maintenance purpose.

4.3.10 Full flow twin oil filter (one in service & other as standby) shall be provided.

4.3.11 Oil cooler shall be of fixed tube sheet shell-tube type heat exchanger with austenitic steel tubes.

4.3.12 Dual lube oil pumps (one in service & other as standby) shall be provided for compressor.

4.3.13 Shaft seals shall be provided to restrict the leakage of vapour ammonia and oil to atmosphere. Shaft seals should be easily accessible for inspection and replacement without dismantling the casing.

4.3.14 Mechanical seal of John crane / Flowserve / Eagle-Burgmann make only shall be provided for compressor & lube oil pumps. Only balanced mechanical seal shall be used.

4.4 CENTRIFUGAL PUMPS

4.4.1 The process pumps shall be designed as per API 610 10th Edition or above. The pumps shall be of robust design to ensure long service life and minimum maintenance requirement. The pumps shall be designed for easy access for inspection and maintenance. All continuously running pumps shall have a spare pump.

4.4.2 In addition to codes & standards, following points shall also be applicable:

4.4.3 Ammonia Transfer pump shall be of VS-6 type centrifugal pump (ie., Double casing diffuser vertically suspended pump)

4.4.4 All pumps shall have continuously rising head curve from any specified operating point to shut off point. Pumps running in parallel shall have equal head rise to shut off point.

4.4.5 All pumps shall be designed for 20% overload.

4.4.6 The pumps should have stable operating characteristics. The pump head at shut off shall be approximately 110% of head at rated capacity and not exceeding 120%.

4.4.7 Best efficiency point shall be as close as possible to normal operating point.

4.4.8 Impellers of multistage pumps shall be secured positively against axial movement.

4.4.9 For multistage pumps, a lateral critical speed analysis shall be carried out.

4.4.10 The maximum calculated axial load shall not in any operating condition exceed 50% of bearing manufacturer's load rating.

4.4.11 Flexible coupling (metal spacer type) shall be provided. Coupling guard shall be non-sparking for pumps located in hazardous area.

4.4.12 Mechanical seal of John crane / Flowserve / Eagle-Burgmann make only shall be provided. Only balanced mechanical seal shall be used.

4.4.13 All continuously running pumps shall have a spare pump.

4.5 EOT CRANES

4.5.1 Design, detailed engineering, manufacturing, shop testing & inspection, painting, supply, transportation to site, unloading and storage at site, load testing at site, final painting and Erection & commissioning, requisite statutory approval of Electric Over head Travelling Crane along with runway rails and supply of spare parts for crane as per the technical specifications, terms and conditions mentioned in this Technical Specification.

4.5.2 LSTK Contractor to provide EOT Cranes of adequate capacity in Ammonia Compressor House for ease in operation and maintenance activities. Cranes to be provided in nearest multiple of 5 Metric Tonnes considering maximum weight to be lifted. Monorail with chain pulley block shall be provided for the Instrument air Compressor. Relevant Indian/ISO Standards shall be applicable for EOT Crane and Monorail facility. The main hook capacity of each hoist shall be minimum 25% over and above the heaviest component/equipment to be handled. 15 T and above EOT cranes shall have 5T auxiliary hoist. All statutory guidelines to be complied by the contractor/sub-contractor

4.6 HVAC SYSTEM

Air conditioning system & air flow ventilation rate shall be sufficient to satisfy not only air removal specification, but also to maintain over pressure and temperature specification. It shall also be capable to avoid wind penetration in order to meet the requirements of a conditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution shall be considered in design & selection of HVAC equipment. Emergency backup power shall be provided for the inside air pressurization system. Supply air for pressurization to the conditioned space shall be taken from a safe

distance perpendicular to the normal wind direction so that uncontaminated air can be made available in the conditioned space. Adequate HVAC requirement to be covered by LSTK vendor for control room. Eco-friendly refrigerant shall be used in HVAC equipment."

5.0 INSPECTION & TESTING

5.1 Machines shall be inspected by Third Party Inspection Agency approved by FACT. The Inspection and testing shall be in accordance with the all relevant codes, standards, specifications, including the minimum guide lines given in Annexure – 1 (attached).

5.2 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Bidder. DM water shall be used for hydro testing of the equipment which shall be supplied by client on chargeable basis.

5.3 In general, following tests shall be conducted for all rotating equipments:

1. Material test
2. Non-destructive test
3. Hydrostatic test for all the pressure containing parts
4. Dynamic balancing of rotor
5. Helium leak test of compressor casing (if required as per API Code)
6. Mechanical running test of compressor
7. NPSHR test for pumps
8. Performance Test
9. Disassembly Test

5.4 The tests required to be conducted and witnessed shall be specified in the equipment data sheet. Disassembly test for Compressors & Pumps can be waived off in case no problem occurs during mechanical / performance Test.

6.0 SPARES

6.1 MANDATORY SPARES

6.1.1 The mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project are listed in the attached Spare Parts List (Doc. No. 32686-01-PS-002 SPR1). These spares shall be purely ware house spares. Bidder shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.

6.1.2 Bidders shall be asked to indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant

6.2 RECOMMENDED SPARES FOR 2 YEARS OPERATION

6.2.1 The Bidders shall submit the list including unit & quantity of recommended spares for two years normal operation & maintenance in un-priced part as per format attached and item wise price shall be submitted in priced part.

6.2.2 The Purchaser reserves the right to buy any or all recommended spares.

6.2.3 Prices of recommended spares will not be used for the evaluation of Bids. Prices of Spares shall remain valid for 12 months from the date of preliminary acceptance; Owner may order such spares any time during this period.

6.3 START-UP & COMMISSIONING SPARES

6.3.1 Start-up commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. All spares used until the system is handed over to the Purchaser shall come under this category. The Vendor shall procure and supply spare parts for start-up and commissioning and shall be included in his scope of work without any extra cost to purchaser. The Lump sum quoted price in the price bid (supply) shall be deemed to be inclusive of provision for such spares and additional spares.

7.0 PAINTING

7.1 For guidelines of painting refer to attached FEDO Engineering Specification 02 ES 023/2010.

8.0 VENDORS LIST

8.1 All equipment shall be procured / fabricated as per approved vendor list (Doc. No. 32686-01-PS-002 VL1).

8.2 Make of the equipment not indicated and any other make for the specified equipment shall be subjected to owner's/consultant's approval.

8.3 Bidder shall indicate make of various equipment offered by them in the bid.

9.0 LSTK BIDDER/VENDOR DOCUMENTATION:

9.1 Bidder shall submit all documents related to quality and technical such as Calculations, Drawings, QAP, ITP, and Test procedures etc. as per attached Vendor Data Requirements (VDR) Doc No. 32686-01-PS-002 VDR1 to VDR4 for review / approval. In addition to the attached VDR, any documents or drawing deemed necessary for the review/approval of the Client/Consultant shall be provided by the Bidder.

9.2 In addition to hard copies all final documents such as specifications, datasheets, drawings and manufacturers record book shall be provided in approved electronic software formats (Native files). Calculations shall be submitted in widely used software forms.

ANNEXURE-1

INSPECTION & TESTING GUIDE LINES – ROTATING EQUIPMENT

1.0 SCOPE

1.1 This document covers the minimum guide lines for the Inspection & Testing for the rotating Equipments.

1.2 All rotating Equipments shall be inspected by Owner/approved Third Party Inspection Agency. The Inspection and testing shall be in accordance with the all relevant codes, standards, and specifications as specified in Specification sheet.

2.0 PUMPS AND DRIVERS

2.1 Pump casings to be identified against foundry test certificates and thickness checked to conform to approved drawings.

2.2 Witness hydrostatic test of casings.

2.3 Dynamic balancing of rotor.

2.4 Witness running tests on pumps including N.P.S.H. where applicable.

2.5 Non- destructive test.

2.6 Strip inspection of pumps on completion of running tests. Wearing surfaces to be checked and recorded. As a general principle, mechanical seals will not be dismantled after running tests. This necessity will be discussed on a case to case basis if abnormal noise or temperature has need records during testing. All materials to be checked against test certificates or VENDOR'S bill of materials.

2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).

2.8 Heat run or standard abbreviated tests, as specified, to be witnessed on electric motor drives.

2.9 Final inspection and dimensional check to be carried out on motor drivers.

2.10 Final inspection and dimensional check on steam turbines to be done.

2.11 Check all test certificates.

3.0 COMPRESSORS AND DRIVERS

3.1 Material of casings to be checked against test certificates.

3.2 Hydrostatic test on casings to be witnessed.

3.3 Dynamic balancing of rotor.

3.4 Non- destructive test.

3.5 Witness leakage test on lube oil tank and carry out internal and external inspection. Tank to be finally inspected after internal coating and / or painting.

3.6 Inspect prefabricated lube oil piping.

3.7 Witness performance tests shall be done and check all safety and alarm devices when contact instrumentation is fitted.

3.8 If spare rotating assembly is ordered, any running tests with spare fitted or the dropping of the spare into the casing, as may be specified, to be witnessed.

3.9 Strip inspection on completion of running tests. To include examination of all running surfaces, checking of critical clearances, and examination of lube oil filters in the tests.

3.10 Final inspection and dimensional check of compressors mounted on base plates.

3.11 Gearing, pinion forgings and main wheel forgings or castings to be inspected at forge shop or foundry.

3.12 Any dynamic balancing of gearing rotors to be witnessed.

Job No. : **32686**

Item : **FIRE FIGHTING SYSTEM**

Item No. : **-**

Project : **NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS**

Client : **FACT-CD**

Location : **AMBALAMEDU**

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LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS

1.0 SCOPE

Bidders' scope of work for firefighting system of New Ammonia Storage Tank. Package shall consist of following:

1. Fire fighting system for New Ammonia Storage Tank Package including Fire water network within the battery limit, hydrants, monitors & manually operated HVLRM, spray/sprinkler & water curtain system; Clean Agent Fire Extinguishing Systems, portable extinguishers, water/sand buckets and sign boards.
2. Manual call points, Smoke /heat detectors for Control room, MCC Room, UPS room, compressor house, and ammonia pump house area etc.
3. Approval from statutory authorities if required as per applicable standards.

1.1 FIRE FIGHTING SYSTEM FOR COMPLETE NEW AMMONIA STORAGE TANK PACKAGE

1.1.1 The scope of work shall include Design, engineering, manufacture/ fabrication, inspection & testing, supply, installation, commissioning, performance guarantee test run (PGTR), operation & general maintenance training, and submission of documents (including soft and hard copies of operation and maintenance manuals, as built documents etc) for the fire protection system for New Ammonia Storage Tank Package including Fire water network, Hydrants, monitors & manually operated HVLRM system; spray/sprinkler & water curtain system; Clean Agent Fire Extinguishing Systems, portable extinguishers, water/sand buckets and sign boards, Manual call points (MCP), Smoke /heat detectors for Control room, MCC Room, UPS room, compressor house, and ammonia pump house area etc. within the battery limit for the new Ammonia storage tank package.

1.1.2 Integration of the new systems such as fire water network, MCP, detection system etc with existing systems (FW ring main, control room, alarm/siren system etc.) outside the battery limit (OSBL) shall be under the scope of bidder.

1.1.3 The complete system shall be designed in compliance with TAC, NFPA standard and "Kerala Fire Prevention and Life Safety Measures Act and Rules" required for New Ammonia Storage Tank Package. Requirements as per latest edition of ANSI/CGA G-2.1 (Requirements for the Storage and Handling of Anhydrous Ammonia) shall be followed as applicable. Further, the design, engineering shall comply with the requirements of the latest editions of the codes & standards relevant to this specification.

1.1.4 Bidder shall prepare the relevant drawings (Flow scheme, piping, electrical) for all systems and get approved by Purchaser and statutory authorities under the "Kerala Fire Prevention and Life Safety Measures Act and Rules". The fire protection system shall be designed to perform satisfactorily & meet all requirements. Necessary design calculations such as pipe sizing and hydraulic calculations/ report, water demand calculations etc. shall be submitted for review.

1.1.5 The layout shall be strictly in compliance with TAC (Tariff Adv. Committee) and NFPA especially with regard to clearance of mains from buildings/ structures, spacing of hydrants, wet risers, Monitors, spray system etc.

1.1.6 Tools for satisfactory operation & maintenance of the items/equipment supplied shall be included in the scope of bidder.

1.1.7 Testing kit including procedure required for checking healthiness of the system shall also be in Bidder's scope

1.1.8 Vendor shall visit FERTILIZERS AND CHEMICALS TRAVANCORE LIMITED (FACT), Ambalamedu site before bidding to understand our existing Firefighting, detection and alarm/siren system.

2.0 FIRE WATER NETWORK, SPRAY SYSTEM AND EXTINGUISHERS

2.1 All items for the safe and smooth functioning and meeting the statutory requirements of the fire protection system within the battery limit shall be included in the vendor's scope.

2.2 The system shall comprise of but not limited to the following:

2.2.1 Fire water ring main, delivering water to the hydrant system, monitors, manually operated HVLRM and spray system for the new Ammonia storage tank package.

2.2.2 Hydrants, monitors, and manually operated HVLRM system.

2.2.3 Fire buckets and extinguishers.

2.2.4 Hydrant accessories, such as, hydrant stand pipes, Fire hose cabinet with delivery hoses, Hose coupling, branch pipes and nozzles, etc

2.3 Fire Hydrant system shall be provided as per statutory requirements, and standards specified in this document as part of the fire protection system.

2.4 Minimum **3 no.** of fixed type **Ground Water Monitor (Manually operated HVLR) 4 " minimum** size having minimum capacity of 1250 gpm capable of giving minimum water throw of 75-80 mtrs in still air at 7 Kg/cm2, inlet pressure with the provision of jet and spray pattern, with 360^{o} horizontal and 135^{o} vertical movement shall be provided around the New Ammonia storage tank at 120 degree apart. The material of construction of both monitor and nozzle shall be of SS for corrosion resistance. The monitor shall be of cast-in-turning vane type without any welding for reduced pressure loss and increased efficiency. The monitor nozzle also shall be of non-welded type and shall have the provision of giving a straight jet and spray pattern with mechanism to control the water flow from 500-1250 gpm, for avoiding water wastage. The monitor shall have the provision of locking mechanism to hold it in the desired position. The entire equipment shall have BIS or UL/FM marking/approval.

2.5 Yard hydrants shall be as per IS 13039: 1991

2.6 Fire hoses should be of sufficient length to, carry water from the nearest source of water supply to the. Most distant point in the area covered by a hydrant, by the normal route of travel. For each internal hydrant, there should be a total length of not less than 30 m, conforming to Type A of IS 636 or provided in two lengths of not more than 15 m each wire wound with coupling together with branch pipe conforming to IS 2871

2.7 Hoses and accessories should be kept in hose cabinet painted fire red and constructed of cast iron or sheet iron with glass front.

2.8 Water spray system to valve manifold on top of tank shall be provided.

2.9 Spray system shall be provided for the compressor house, and ammonia pump house area.

2.10 Water curtain shall be provided around the periphery of control room area.

2.11 Spray heads shall be as per latest revision of applicable IS/NFPA standards

2.12 All distribution piping and fittings shall confirm to relevant standards as mentioned in IS 15105

2.13 Pipe material of construction (MOC) for Fire water network and spray system shall be ASTM A106 Gr.B for line sizes starting from 15 NB to 200 NB. For pipe sizes above 200 NB, IS 3589 pipe MOC shall be used.

2.14 F.W. header / line shall be laid above ground wherever possible, however FW lines shall be laid underground at road crossings / pedestrian crossings and wherever necessitates with 1 meter earth cushion. Hume pipe shall be provided at road crossings to protect underground FW lines. Supply & Application of Coal tar primer, Coal tar enamel, Inner & Outer wraps and surface preparation prior to the application of the primer and all the works related to the wrapping coating for all underground lines shall be carried out with 1 meter earth cushion.

2.15 Fittings MOC shall be A234 Gr.WPB

2.16 Gaskets shall be SS SPW+ Graphite

2.17 Hydrants, monitor MOC shall be CS+HDG

2.18 Valve MOC shall be CS

2.19 Orifice MOC shall be marine bronze

2.20 Pressure reduction if required from the battery limit condition shall be achieved under vendor scope.

3.0 CLEAN AGENT FLOODING FIRE EXTINGUISHING SYSTEM

3.1 Clean Agent (Inergen or Argonite) System shall be provided to Ammonia Storage Tank Control Room.

3.2 Clean Agent System shall be in accordance with the requirements of NFPA 2001 standard

4.0 FIRE DETECTION AND ALARM SYSTEM FOR THE SECTION.

4.1 The system shall comprise of but not limited to the following:-

4.1.1 Intelligent, Addressable Push button type manual call points, distributed throughout the area. Wherever specified, it shall be Weather proof / flameproof type as per area class and the same shall be connected to the existing fire alarm panel in the Ammonia handling area.

4.1.2 Vendor shall provide sufficient number of line isolators as per the standards mentioned above and required for trouble-free operation of the system

4.1.3 Response Indicator

4.1.4 Cabling (including power & control) required for complete smoke detection and alarm system. All applicable cables shall be FRLS type. Control cables and power cables shall be laid in separate cable trays with TAG provision at specified distances for identification.

4.1.5 Lightening protection system shall be designed as per NFPA and to protect the total plant area with necessary documents.

4.1.6 Earthing of complete smoke detection and alarm system shall be provided as per Bidders' recommendation and good engineering practices.

4.1.7 Terminal boxes and junction boxes as required for complete fire alarm system is included in the scope and shall be explosion proof as per area classification.

4.1.8 Accessories for mounting and supporting all equipment covered by this specification is included in the scope.

4.1.9 Audio hooter (1 no.) to alert the people in that area during fire for evacuation. Addressable electronic hooter shall have a sound output not less than 80 dB with provision shall be made to make it available an alarm at proposed new Ammonia control room also. The

sounders shall be loop powered by fire panel with support voltage range from 17-28V DC. The operating temperature range shall be from 0^{o}C to 70^{o}C. maximum current consumption of the sounder shall be limited to 22mA.

4.1.10 Any other items which are required to make the system complete in all respects and not specifically mentioned is also included in the scope.

4.1.11 Fire alarm system shall be designed to provide continuous surveillance against fire in the areas covered by the system under all conditions. All the layouts shall be provided by the bidder during detailed engineering

4.1.12 Intelligent, addressable smoke /heat detectors shall be provided. The detectors shall be ceiling-mount and shall include a twist-lock base. The detectors shall be loop powered by fire panel with support voltage range from 17-28V DC. The operating temperature range shall be from 0^{o}C to 70^{o}C

4.1.13 The detectors shall provide an indication LED. The LED shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. The LED is placed into steady illumination by the control panel indicating that an alarm condition has been detected. The system shall continue to operate even if detectors removed from base. Discrimination between a false fire and real fire condition shall be provided.

4.1.14 The number of detectors, spacing and their locations shall comply with NFPA 72E/IS2189. The actual quantity of detectors required, taking into consideration of the required code and applicable area. The obstruction due to floor beams, etc., so as to obtain complete coverage, shall be worked out by the bidder based on the final drawings of the applicable plant during detailed engineering.

4.1.15 Intelligent type multi sensor detectors, probe type heat detectors, Manual call points etc. shall generally comply with standard requirements as per relevant code.

4.1.16 Any other area not specified but within the battery limit of this Bidder shall be included and necessary cabling shall be provided till existing fire alarm panel.

4.2 MANUAL CALL POINTS

4.2.1 Manual call points shall be provided as per the guidelines listed in NFPA 72E/IS 2189.

4.2.2 Each area shall be provided with a manual call point and hooter. Required number of response indicators and isolators shall be provided in each loop Manual call point shall be connected to the existing fire alarm panel in Ammonia handling area. All the manual call points for the outdoor installations shall be weather proof as per IP-65 or better; MCP's in the hazardous installations shall be flame proof. The Manual Call point shall be loop powered by fire panel with support voltage range from 17-28V DC. The operating temperature range shall be from 0^{o}C to 70^{o}C

4.3 JUNCTION BOXES (JB)

4.3.1 Junction boxes shall be fabricated out of 2.0mm thick CRCA sheet steel & shall be hot dip galvanized. For outdoor installation, they shall be of cast iron type and provided with a canopy at the top.

4.3.2 Junction boxes for indoor installation shall have degree of protection of IP 55. JBs for outdoor installation shall have a degree of protection of IP 65 & shall be provided with neoprene gasket. All the junction boxes shall have a weeping hole at the bottom plate and provided with necessary double compression aluminum cable glands. Two earthing

terminals suitable for terminating 8 SWG GI wire shall be provided. Al structures required for mounting the JBs shall be included in bidder's scope.

4.4 CABLING

4.4.1 Supply, laying, termination, testing and commissioning of the cables required for complete smoke detection and alarm system shall be in the scope of the Bidder.

4.4.2 The cable included in the scope shall confirm to specification indicated below : 1100V grade3 core annealed high conductivity stranded copper conductor of 1.5 sq.mm / 2.5 sq mm, extruded PVC insulated, laid up, PVC inner sheathed, armored and overall FRLS PVC sheathed confirming to IS 1554-part I.

4.4.3 The cable with the above mentioned details shall be suitable for the system offered by the bidder. In case any other type of cable is necessary, Bidder shall indicate and quote for the same.

4.4.4 Cable Installation and Accessories is included in the scope.

4.4.5 Cables for Manual call point smoke/heat detection and alarm system shall be routed in a convenient route acceptable to Purchaser and as per approved drawings. Cabling shall be done in a neat manner with clamps at regular intervals.

5.0 CIVIL WORKS

5.1 All civil works associated with the installation of Firewater network, spray, detection, alarm system equipment & cables laying and dressing shall be done by Bidder and made good. These civil works shall include pipe supports and sleepers, chipping, punching of holes, pockets, welding or any such work required for the neat and aesthetic installation of all equipment covered under this contract. TAG numbering for firefighting system equipment and safe operating procedures shall be written at the relevant locations.

6.0 CODES AND STANDARDS

6.1 Fire protection system for the New Ammonia Storage Tank Package system including fire water ring main, hydrants, monitors, manually operated HVLRM, spray system, fire extinguishers, Fire hose cabinet, hose reels, branch pipe and other accessories (ISBL) shall meet the requirements of TAC (Tariff Adv. Committee) and NFPA.

6.2 Fire hydrant equipment and accessories such as Monitors, Deluge Valves and Spay nozzles shall be Factory Mutual (FM) /Underwriters Laboratory (UL) approved. Other items such as Fire hydrants, manually operated HVLRM, Branch Pipes, Fire Hoses & couplings, Extinguishers etc shall be as per applicable Indian Standards or FM/UL approved.

6.3 Requirements as per latest edition of ANSI/CGA G-2.1 (Requirements for the Storage and Handling of Anhydrous Ammonia) shall be followed as applicable.

6.4 The fire protection and detection system shall be designed to perform satisfactorily & meet all requirements of relevant statutory authorities.

6.5 All detection and sensing devices forming an integral part of the microprocessor based, addressable, intelligent fire detection and alarm system shall be approved by any of the following bodies as applicable.

1. Underwriters Laboratories (UL) – USA.
2. Fire Officers Committee (FOC) – UK.

6.6 Any other internationally recognised body acceptable to the OWNER / ENGINEER Approval certificates shall be furnished with the bid.

7.0 DESIGN REQUIREMENTS

7.1 The equipment shall be designed and manufactured in accordance with the best engineering practice and shall have proven record for the services intended. The installation practices adopted and the design shall be as per relevant standards.

7.2 The Bidder shall be solely responsible for obtaining the required approval and clearances for the different components and systems of the firefighting, smoke detection and alarm system from the following authorities as applicable :

1. Local / state Fire Authorities
2. Any other Local / state Authority having jurisdiction. All approval / clearance certificates shall be furnished accordingly

8.0 BATTERY LIMIT

Fire Water ring main shall be made available at 5 m from project boundary of new ammonia storage tank (Near existing ammonia compressor house) with a residual pressure of minimum 7.5 Kg/cm^2.

9.0 EXCLUSIONS

Fire water pumps and ring main up to battery limit are excluded from the scope of bidder.

10.0 PAINTING

For guidelines of painting refer to attached FEDO Engineering Specification 02 ES 023/2010.

11.0 TESTS

11.1 Bidder shall furnish test certificates / approval certificates for the equipment / system offered from the Regulatory bodies - local and state level - indicated in the specification after the award of contract for Owner's Representative's review / approval.

11.2 Hydro-test for the FW network and spray, sprinkler and water curtain system shall be conducted as per relevant standards. Arrangements required for conducting hydro-test including nozzle plugs for the spray, sprinkler and water curtain system shall be arranged by the contractor.

11.3 Performance tests shall be conducted at site on the system to prove that the performance and guarantees indicated for the individual components shall completely satisfy all specific requirements. All tests required by the relevant standards shall be conducted.

12.0 SPARES

12.1 <u>MANDATORY SPARES</u>

12.1.1 The mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project are listed in the attached Spare List (Doc. No. 32686-01-PS-002 SPR2). These spares shall be purely ware house spares. Bidder shall supply spares as per attached list of spares. If any of the spares required for the offered equipment/item are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares shall be final and binding on the bidder.

12.1.2 Bidders shall be asked to indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant.

12.2 RECOMMENDED SPARES FOR 2 YEARS OPERATION

12.2.1 The Bidders shall submit the list including unit & quantity of recommended spares for two years normal operation & maintenance in un-priced part as per format attached and item wise price shall be submitted in priced part.

12.2.2 The Purchaser reserves the right to buy any or all recommended spares.

Prices of recommended spares will not be used for the evaluation of Bids. Prices of Spares shall remain valid for 12 months from the date of preliminary acceptance; Owner may order such spares any time during this period.

12.3 START-UP & COMMISSIONING SPARES

12.3.1 Start-up commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. All spares used until the system is handed over to the Purchaser shall come under this category. The Vendor shall procure and supply spare parts for start-up and commissioning and shall be included in his scope of work without any extra cost to purchaser. The Lump sum quoted price in the price bid (supply) shall be deemed to be inclusive of provision for such spares and additional spares.

13.0 VENDORS LIST

13.1 All equipment shall be procured / fabricated as per approved vendor list (Doc. No. 32686-01-PS-002 VL2).

13.2 Make of the equipment not indicated and any other make for the specified equipment shall be subjected to owner's/consultant's approval.

13.3 Bidder shall indicate make of various equipment offered by them in the bid.

14.0 LSTK BIDDER/VENDOR DOCUMENTATION:

14.1 Bidder shall submit all documents related to quality and technical such as Calculations, Drawings, QAP, ITP, and Test procedures etc. as per attached Vendor Data Requirements (VDR), Doc. Nos. 32686-01-PS-002 VDR5 & VDR6 for review / approval. In addition to the attached VDR, any documents or drawing deemed necessary for the review/approval of the Client/Consultant shall be provided by the Bidder.

14.2 In addition to hard copies all final documents such as specifications, datasheets, drawings and manufacturers record book shall be provided in approved electronic software formats (Native files). Calculations shall be submitted in widely used software forms.

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TECHNICAL PROCUREMENT SPECIFICATION	MANDATORY SPARES STATIC EQUIPMENT	32686-02-PS-002 SPR	
		PAGE 1 OF 1	R 0

Sl. No.	Description	Quantity	Unit Price	Total Price
1	GASKETS	200%		
2	BOLTS, NUTS, WASHERS, CLAMPS	10%		
	(MINIMUM 2 NOS OF EACH SIZE)			
	ABOVE SPARES SHALL BE APPLICABLE FOR ALL THE NOZZLES INCLUDING NOZZLES WITH BLIND FLANGES			
3	SIGHT GLASS (IF APPLICABLE)	100%		
4	TUBE PLUG FOR HEAT EXCHANGER (FOR EACH)	5% of Tube Holes		

Notes :

1.0 The above table shows mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project. These spares shall be purely ware house spares. Bidder shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.

Bidders shall be asked to indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant

2.0 LSTK Contractor shall submit their quote inclusive of cost all spare parts required during Pre-commissioning & Commissioning of the plant until the plant is handed over to the Owner after Performance Test.

3.0 List of 2 years operation spares with price shall be furnished by the bidder along with offer.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION

FEDO

SCREW COMPRESSOR

Sl No	Description	Suggested Quantity (%)	Quantity	Unit Price	Total Price
1.0	**Screw Compressor:**				
1.1	Complete spare coupling including distance piece and set of coupling bolts & nuts	1 set			
1.2	Complete Set of radial bearings (Both suction & discharge side)	1 set			
1.3	Complete Set of thrust bearings (both active & inactive sides), if applicable	1 Set			
1.4	Complete Set of Mechanical seal	1 Set			
1.5	Complete Set of oil seals	2 Set			
1.6	Complete Set of 'O' rings, gaskets, sealing rings for compressor	4 Set			
2.0	**Oil System:**				
2.1	Spares for oil pump				
	- Bearings	1 Set			
	- Oil seal	1 Set			
	- Gaskets & 'O' rings	2 Set			
	- Complete Set of Mechanical seal	1 Set			
	- Complete spare coupling including distance piece and set of coupling bolts & nuts	1 Set			
	- Suction strainer element	1 set			
2.2	Cartridge for discharge oil filter	4 Set			
2.3	Gaskets for Oil cooler	2 Set			
3.0	**Accessories**				
3.1	Spare elements for permanent filters in suction line	1 Set			

Notes:

1) The above table shows mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project. These spares shall be purely ware house spares. Bidder shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.
   Bidders shall be asked to indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant

2) LSTK Contractor shall submit their quote inclusive of cost all spare parts required during Pre-commissioning & Commissioning of the plant until the plant is handed over to the Owner after Performance Test.

3) List of 2 years operation spares with price shall be furnished by the bidder along with offer.

4) Set means complete replacement of particular part in one machine/equipment etc.

Sl No	Description	Suggested Quantity (%)	Quantity	Unit Price	Total Price
4.0	**Centrifugal Pump (Ammonia Transfer Pump / Cooling Water Pump / Effluent Pump & wherever applicable):**				
4.1	Wear Rings complete set	1 Set			
4.2	Shaft with keys	1 Set			
4.3	Shaft to shaft couplings in case of vertical pumps with multiple shafts	1 Set			
4.4	Set of all sleeves	1 Set			
4.5	Complete Set of Mech. Seal where applicable	1 Set			
4.6	Constant level Oiler	2 Set			
4.7	Deflectors	2 Set			
4.8	Complete set of coupling with element and fasteners	1 Set			
4.9	Complete set of all Bearings	1 Set			
4.10	Complete set of Gaskets & 'O' Rings	2 Sets			
4.11	Complete set of Oil Seals	2 Sets			
4.12	Leak-off valve-gaskets, 'O' Rings and springs	2 Sets			
4.13	Suction strainer element	1 Set			
5.0	**Cooling Tower:**				
5.1	Fan blades with clamp & fasteners	1 Set			

Notes:

1) The above table shows mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project. These spares shall be purely ware house spares. Bidder shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.
   Bidders shall be asked to indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant

2) LSTK Contractor shall submit their quote inclusive of cost all spare parts required during Pre-commissioning & Commissioning of the plant until the plant is handed over to the Owner after Performance Test.

3) List of 2 years operation spares with price shall be furnished by the bidder along with offer.

4) Set means complete replacement of particular part in one machine/equipment etc.

Sl No	Description	Suggested Quantity	Quantity	Unit Price	Total Price
1.0	**HYDRANT SYSTEM**				
1.1	Monitors	2 Nos			
1.2	Hydrant valve	2 Nos			
2.0	**M.V Spray System**				
2.1	Spray nozzles	10%			
3.0	**Orifice**				
3.1	Orifice Plate	20%			
4.0	**Gasket**				
4.1	Gasket	200%			
5.0	**Fastners**				
5.1	Fastners	10%			

Notes:

1) The above table shows mandatory spares required for satisfactory operation of equipment supplied under Ammonia Tank project. These spares shall be purely ware house spares. Bidder shall supply spares parts as per list of spares for satisfactory operation of Ammonia Tank Unit. If any of the spares required for the offered machines are not indicated in the list, bidder may include the same with appropriate justification. However owner's decision regarding inclusion / exclusion of the spares, shall be final and binding on the bidder.
   Bidders shall be asked to indicate the itemized price for each of the spares in the list. The price of spares in the list will be considered for evaluation and the same shall be supplied by bidder at the time of commissioning of the plant.

2) LSTK Contractor shall submit their quote inclusive of cost all spare parts required during Pre-commissioning & Commissioning of the plant until the plant is handed over to the Owner after Performance Test.

3) List of 2 years operation spares with price shall be furnished by the bidder along with offer.

4) Wherever suggested Quantity is less than 1 set or 1 No., minimum 1 set or 1 No: shall be provided

REV.NO.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	AAN

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENTS PRESSURE VESSELS	32686-02-PS-002 VDR1
		PAGE 1 OF 2 | R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS ITEM: PRESSURE VESSELS

CLIENT : FACT-CD Job No. 32686

STATUS ■ ENQUIRY ☐ COMMITMENT PO No.

Sl. No.	Grp Code	Description	Qty. with offer	After Commitment				Qty. of final **
				Qty.	Lead time in weeks			
					Reqd.	Propd *	Agrd	
1	B	Vendor data index		1S	4			1S+4P
2	A	Filled in Data Sheets	1S	1S	4			1S+4P
3	A	Dimensioned outline drawing	1S	1S	4			1S+4P
4	A	Foundation loading data (including Foundation details & Anchor bolts)		1S	4			1S+4P
5	A	Assembly drawing		1S	4			1S+4P
6	B	Design calculations for the following		1S	4			1S+4P
		a. Shell, heads and supports						
		b. Wind & earthquake analysis						
		c. Anchor bolts, Saddles supports and base plate						
		d. Nozzles and flanges						
		e. Internal & supports						
		f. Lifting provisions						
7	B	Detailed fabrication drawings		1S	4			1S+4P
		a. Equipment proper						
		b. Shell/heads, support						
		c. Nozzle and flanges						
		d. Internals						
		e External attachments						
		f. Saddle supports and base plate						
		g. Tower davits						
		h. Shell development dwg. With attachments						
		I. Lifting provisions						
		j. Name plate & bracket						
		k. Earthing boss						
		l. Miscellanious items						
8	B	Quality Assurance Plan		1S	6			1S+4P
9	B	WPS & PQR		1S	6			1S+4P
10	B	Manufacturing Procedure		1S	8			1S+4P
11	B	Inspection and testing procedure		1S	8			1S+4P
12	B	Heat treatment procedure		1S	10			1S+4P
13	A	Spare part list with sketch (For startup, commissioning and 2 years operational)	1S	1S	10			1S+4P
14	B	Pert chart of shop & site activities	1S	1S	4			
15	B	Packing/marking/forwarding instructions with sketched		1S	16			
16	B	Installation & maintenance procedure		1S	14			1S+4P
17	B	Packing list		1S	16			1S+4P

Legend : Group code : A - For review and detailed engineering, B- For review, C - For information and records

Document type : R - Reproducible, P - Print, M - Microfilm. F- floppy disc.

Notes : * Vendor shall fill in proposed lead time if different from the required lead time.

** Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Balance documents shall be forwarded to FEDO.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.03.2021	For Enquiry	IA	SK	ASN

00FT017/00

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

Sl. No.	Grp Code	Description	Qty. with offer	After Commitment				Qty. of final **
				Qty.	Lead time in weeks			
					Reqd.	Propd *	Agrd	
18	C	Data folder with the following documents						
		a. Vendor data index						1S+4P
		b. As built drawings						1S+4P
		c. Loading data						1S+4P
		d. Manufacturing records						1S+4P
		e. Material test reports						1S+4P
		f. WPS &PQR						1S+4P
		g. Heat treatment procedure/recods						1S+4P
		h. Inspection/test records						1S+4P
		I. Third party inspection records						1S+4P
		j. Design calculation		1S				1S+4P
		k. Equipment data						1S+4P
		k. O&M Manual						1S+4P

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENTS (HEAT EXCHANGERS)	32686-02-PS-002VDR2
		PAGE 1 OF 2 | R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS

ITEM: HEAT EXCHANGERS

CLIENT : FACT-CD

Job No. 32686

STATUS ☑ ENQUIRY ☐ COMMITMENT

PO No.

Sl. No.	Grp Code	Description	Qty. with offer	After Commitment				Qty. of final **
				Qty.	Lead time in weeks			
					Reqd.	Propd *	Agrd	
1	B	Vendor data index		1S	4			1S+4P
2	A	Dimensioned outline drawing		1S	4			1S+4P
3	A	Dimensioned outline drawing		1S	4			1S+4P
4	A	Foundation loading data (including foundation details & anchor bolts)		1S	4			1S+4P
5	A	Assembly drawing		1S	4			1S+4P
6	B	Design calculations for the following		1S	6			1S+4P
		a. Shell, Channel, heads & Body Flanges						
		b. Tube Sheet						
		c. Saddle Support design & stress analysis						
		d. Nozzle & Flanges						
		e. Stiffener Rings & Special attachments						
		f. Tube Vibration Analysis						
		g. Lifting provisions						
7	B	Detailed fabrication drawings		1S	6			1S+4P
		a. Equipment proper						
		b. Shell, Channel, heads & supports						
		c. Tube Sheet & Baffles						
		d. Tie Rods, Spacers Dummy Tubes, etc.						
		e Nozzles and Flanges						
		f. Other Internals						
		g. External attachments						
		h. Lifting provisions						
		i. Name plate & bracket						
		j. Earthing boss						
		k. Miscellanious items						
8	B	Quality Assurance Plan		1S	6			1S+4P
9	B	WPS & PQR		1S	6			1S+4P
10	B	Manufacturing Procedure		1S	6			1S+4P
11	B	Inspection and testing procedure		1S	6			1S+4P
12	B	Heat treatment procedure if applicable		1S	6			1S+4P
13	A	Spare part list with sketch		1S	6			1S+4P
14	B	Pert chart of shop activities		1S	4			
15	B	Packing/marking/forwarding instructions with sketches.		1S	16			
16	B	Installation & maintenance procedure		1S	14			1S+4P
17	B	Packing list		1S	16			1S+4P

Legend : Group code : A - For review and detailed engineering, B- For review, C- For information and Records

Document type : R - Reproducible, P - Print, M - Microfilm. F- floppy disc.

Notes : * Vendor shall fill in proposed lead time if different from the required lead time.

** Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Balance documents shall be forwarded to FEDO.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	IA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION

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Sl. No.	Grp Code	Description	Qty. with offer	After Commitment				Qty. of final **
				Qty.	Lead time in weeks			
					Reqd.	Propd *	Agrd	
18	C	Data folder in addition to the documents mentioned in sheet 1						
		a. As built drawings						1S+4P
		b. Manufacturing records						1S+4P
		c. Material test reports						1S+4P
		d. Inspection/test records						1S+4P
		e. Third party inspection records						1S+4P
		f. Rubbing of Name Plate						1S+4P

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENTS STORAGE TANK	32686-02-PS-002 VDR3
		PAGE 1 OF 2 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS ITEM : AMMONIA TANK

CLIENT : **FACT-CD** Job No. **32686**

STATUS [X] ENQUIRY [ ] COMMITMENT [ ] P.O No.

Sl. No.	Grp Code	Description	Qty. with offer	After Commitment				Qty. of final docs. (@@)
				Qty.	Lead time in weeks			
					Reqd.	Propd @	Agrd	
1	A	Reference List of similar jobs	1S	1S	4			
2	A	Drawing Index		1S	4			
3	A	General Arrangement drawing of Double wall Tank	1S	1S	4			
4	A	Foundation loading data / diagram	1S	1S	4			
5	B	Detailed fabrication drawing of the following		1S	4			1S+4P
		Inner Shell Detail						
		Outer Shell Details						
		Shell / Bottom / Deck Insulation Details						
		Nozzle Details						
		Suspended Deck Details						
		Roof Details						
		Roof & Deck Rafter Details						
		Wind Girder / Compression Bar Details						
		Platforms / Landing / Ladders / Earthing / Attachments						
		Still well for Instrument (Level, temp. etc.)						
		Anchor Straps, Anchor Box						
6	B	Design calculations for the following		1S	4			1S+4P
		Shell, & Bottom plate						
		Roof, & Roof Support Structure						
		Wind girder & Wind analysis						
		Earth quake analysis						
		Anchor design (if required)						
7	B	Quality Assurance Plan		1S	4			1S+4P
8	B	WPS & PQR		1S	4			1S+4P
9	B	List of Spares (Commissioning & 2 years operational)	1S	1S	4			1S+4P
10	A	Bar-chart for anticipated activities	1S					
11	A	Manpower allocation chart for the site work	1S					
12	A	Site erection / assembly procedure		1S	4			
13	B	Hydrostatic / Pneumatic Test Procedure		1S	6			1S+4P
14	B	Heat Treatment Procedure		1S	6			1S+4P
15	B	Radiography test procedure		1S	6			1S+4P
16	B	Painting scheme		1S	6			1S+4P
17	B	Information on all bought out items		1S	6			1S+4P
18	B	Completion Certificates						1S+4P
19	B	Approval certificate from statutory authority						1S+4P
20	B	Detailed Erection Scheme		1S	6			1S+4P

Legend : Group code : A - For review and detailed engineering, B - For review, C - For information and record

Document type : R - Reproducible, P - Print, M - Microfilm. or Floppies

S- Soft copy in Autocad/ MS word/Adobe Acrobat in TWO separate CD

Notes : @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment. Balance documents shall be forwarded to FEDO.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	AKN

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS ITEM : AMMONIA TANK

CLIENT : **FACT-CD** Job No. **32686**

STATUS [X] ENQUIRY [ ] COMMITMENT [ ] P.O No.

Sl. No.	Grp Code	Description	Qty. with offer	After Commitment				Qty. of final docs. (@@)
				Qty.	Lead time in weeks			
					Reqd.	Propd @	Agrd	
21	C	Data folder with the following documents						
		Drawing Index						1S+4P
		As-built drawings						1S+4P
		Quality Assurance Plan						1S+4P
		WPS / PQR						1S+4P
		Material test certificates						1S+4P
		Inspection test reports						1S+4P
		Hydrostatic test report						1S+4P
		Design calculations						1S+4P
		Rubbing of name plate						1S+4P

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENT SCREW COMPRESSOR	32686-01-PS-002 VDR1
		PAGE 1 OF 1 REV 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS

ITEM ; SCREW COMPRESSOR

CLIENT : FACT-CD

JOB NO : 32686

STATUS ■ ENQUIRY □ COMMITMEN

P.O NO :

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
1.0	A	Data sheets	1S	1S	4			1S + 4P
2.0	A	Predicted performance curves	1S	1S	4			1S + 4P
3.0	A	Dimensioned G.A. drawings	1S	1S	4			1S + 4P
4.0	A	Cross sectional drawings with material of construction of components	1S	1S	4			1S + 4P
5.0	A	Foundation drawings with load details		1S	4			1S + 4P
6.0	A	Calculation for						
		Shaft diameter						
		Bearing selection						
7.0	A	Dimensioned G.A. drawings	1S	1S	4			1S + 4P
		- Air filter /silencer						
		- Relief valves						
		- After cooler / Moisture separator						
8.0		Cross sectional drawings with material of construction of components	1S	1S	4			1S + 4P
		- Air filter / Silencer /Relief valves						
		- After cooler / Moisture separator						
9.0	A	Piping drawing	1S	1S	4			1S + 4P
10.0	B	Equipment lubrication data sheet	1S	1S	4			1S + 4P
11.0	C	Inspection and test procedure						1S + 4P
12.0	C	Material test certificates						1S + 4P
13.0	C	Test records						1S + 4P
14.0	C	Installation, operation and maintenance mant						1S + 4P
15.0	C	Referance list of previous supplies						1S + 4P
16.0	C	Techanical literature and catalogues						1S + 4P
17.0	B	Compliance statement	1S					

Legend : Group code **A** - For review and detailed engineering, **B** - For review, **C** - For information and record

Document type **R** - Reproducible, **P** - Print, **S** - Soft copy in Autocad/ MS word/Adobe Acrobat

Notes @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV. NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

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TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENTS CENTRIFUGAL PUMP	32686-01-PS-002 VDR2
		PAGE 1 OF 1 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS

ITEM : CENTRIFUGAL PUMP

CLIENT : FACT-CD

Job No : 32686

STATUS : [x] ENQUIRY [ ] COMMITMENT

Sl. No	Grp Code	Description	Offer	After Commitment				Final @@
			Qty	Qty	Lead time in weeks			Qty
					Reqd	Prop @	Agrd	
1.0	A	Data sheets	1S	1S	4			1S+4P
2.0	A	Predicted performance curves	1S	1S	4			1S+4P
3.0	A	Dimensioned G. A drawings	1S	1S	4			1S+4P
4.0	A	Foundation plan with load details		1S	4			1S+4P
5.0	A	Foundation bolt details		1S	4			
6.0	B	Cross section drawing with list of parts and	1S	1S	4			1S+4P
		material of construction						
7.0	B	Mechanical seal drawings		1S	4			1S+4P
8.0	B	Auxiliary piping drawing						
9.0	B & C	Inspection and test procedure		1S	4			
10.0	B	Spares list for commissioning Spares	1S	1S	4			
11.0	B	Spares list Mandatory Spares	1S	1S	6			1S+4P
12.0	B	Coupling drawings		1S	6			1S+4P
13.0	B	Base plate drawing	1S	1S	4			
14.0	A	Allowable nozzle forces and moments		1S	6			
15.0	A	Utility consumption list	1S					
16.0	C	Reference list of previous supplies	1S					
17.0	C	Technical literature and catalogues	1S					
18.0	C	Lube data sheet		1S	6			
19.0	C	Packing list						1S+4P
20.0	C	Inspection & test reports and material test certificates		1S	#			1S+4P
21.0	B & C	Installation, operation and maintenance manual						1S+4P
		(Routine and preventive)						
22.0	B	Compliance statement	1S					1S+4P

Legend :

Group code : A - For review and detailed Engineering , B - For review , C - For information and record

Document type : R - Reproducible , P - Print , S - Soft copy, # Before despatch

Notes :

' @ ' Vendor shall fill in proposed lead time if different from the required lead time

' @@ ' Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION

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01FT010B / 15

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENT COOLING TOWER	32686-01-PS-002 VDR3
		PAGE 1 OF 2 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS ITEM : COOLING TOWER

CLIENT : FACT-CD Job NO : - 32686

STATUS ■ ENQUIRY □ COMMITMENT P.O NO :

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
1	A	Dimensional GA Drawings	1S	1S	4			1S+4P
2	A	Piping forces and moments at battery limit		1S	4			1S+4P
3	A	Foundation loading diagram:		1S	4			1S+4P
		-- Weight & point load distribution						
		-- Base plate details and foundation bolt details						
4	A	GA drawing of fan assembly	1S	1S	4			1S+4P
5	A	Sectional drawing with parts list and MoC:		1S	4			1S+4P
		-- Fan						
		-- Gear box						
		--Drive shaft with coupling						
6	A	Predicted performance curve for 90, 100, 110% design water flow rate		1S	4			1S+4P
7	A	Tower data sheet	1S	1S	4			1S+4P
8	B	Inspection & Test procedure		1S	4			1S+4P
9	C	Test records		1S	4			1S+4P
		--Fan static balancing						
		-- Drive shaft static and dynamic balancing						
		-- Gear box shop test						
10	C	Installation, operation and maintenance manual		1S	4			1S+4P
11	B	Lubrication data sheet		1S	4			1S+4P

Legend : Group code : **A** - For review and detailed engineering, **B** - For review, **C** - For information and record

Document type : **R** - Reproducible, **P** - Print, **S** - Soft copy in Autocad/ MS word/Adobe Acrobat.

Notes : @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment

0	22.04.2021	For Enquiry	LA	SK	AAN
REV. NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
12	C	Spare parts list (Mandatory, commissioning and 2 years normal operational)	1S	1S	4			1S+4P
13	C	Inspection & Test procedure and records		1S	4			1S+4P
14	C	Mill test certificates		1S	4			1S+4P
15	C	Packing list		1S	4			1S+4P
16	C	Technical literature and catalogues		1S	4			1S+4P
17	C	Reference list of previous supplies	1S	1S	4			1S+4P
18	B	Compliance statement	1S					1S+4P

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENT EOT CRANE	32686-01-PS-002 VDR4 PAGE 1 OF 1 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS

ITEM : EOT CRANE

CLIENT : FACT-CD

Job NO : - 32686

STATUS ■ ENQUIRY □ COMMITMENT

P.O NO :

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
1	A	EOT Crane Data Sheets	1S	1S	4			1S+4P
2	A	Dimensional GA Drawings with load details	1S	1S	4			1S+4P
3	A	Rail layout, rail fixing, arrangement and end fixing arrangement		1S	4			1S+4P
4	A	Clearance diagrams		1S	4			1S+4P
5	B	C/S drawings with parts list		1S	4			1S+4P
6	B	Interlock diagram		1S	4			1S+4P
7	B	Inspection & test procedure		1S	4			1S+4P
8	B	Strength calculation for all load bearing memebers		1S	4			1S+4P
9	B	Detailed dwg of structural member, travel & hoist mechanism, end carriage & wheel assemblies, gear boxes, current collection system and control panel		1S	4			1S+4P
10	B	Erection and assembly drawings		1S	4			1S+4P
11	B	Lubrication data sheet		1S	4			1S+4P
12	C	Inspection & test procedure	1S	1S	4			1S+4P
13	C	Erection, operation and maintenance manual		1S	4			1S+4P
14	B	Spares list (Mandatory, commissioning and 2 years operational)	1S	1S	4			1S+4P
15	C	Reference list of previous supplies	1S	1S	4			1S+4P
16	C	Technical literature and catalogues	1S	1S	4			1S+4P
17	B	Compliance statement	1S					1S+4P

Legend : Group code : **A** - For review and detailed engineering, **B** - For review, **C** - For information and record

Document type : **R** - Reproducible, **P** - Print, **S** - Soft copy in Autocad/ MS word/Adobe Acrobat.

Notes : @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

0	22.04.2021	For Enquiry	LA	SK	ANN
REV. NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

01FT045B/94

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENT FIRE HYDRANT SYSTEM	32686-01-PS-002 VDR5
		PAGE 1 OF 1 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS

ITEM : FIRE HYDRANT SYSTEM

CLIENT : FACT-CD

Job NO : - 32686

STATUS ■ ENQUIRY □ COMMITMENT

P.O NO :

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
1	A	Data sheets	1S	1S	4			1S+4P
2	A	Block Plan (showing pipeline, layout, hydrants and monitors)		1S	4			1S+4P
3	A	Pressure drop calculation showing line dia and flow rate considered		1S	4			1S+4P
4	A	Pump house layout dwg. & civil scope dwg for pump house.		1S	4			1S+4P
5	A	Bar chart for schedule		1S	4			1S+4P
6	A	GA dwg for equipments	1S	1S	4			1S+4P
7	A	Details of hose stations		1S	4			1S+4P
8	C	Spare parts list (Start up & commissioning, mandatory and 2 years operational)	1S	1S	4			1S+4P
9	C	Lubrication Schedule		1S	4			1S+4P
10	C	Manufacturer's inspection & all test reports		1S	4			1S+4P
11	C	Installation, operation and maintenance manual		1S	4			1S+4P
12	C	Guarantee certificates		1S	4			1S+4P
13	A	Pumping rate calculation		1S	4			1S+4P
14	C	Reference list of previous supplies		1S	4			1S+4P
15	C	Technical literature and catalogues	1S	1S	4			1S+4P
16	B	Compliance statement	1S	1S	4			1S+4P

Legend : Group code : **A** - For review and detailed engineering, **B** - For review, **C** - For information and record

Document type : **R** - Reproducible, **P** - Print, **S** - Soft copy in Autocad/ MS word/Adobe Acrobat.

Notes : @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV. NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

01FT074B/94

TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENTS CO_2 FIRE EXTINGUISHER SYSTEM	32686-01-PS-002 VDR6 PAGE 1 OF 1 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK

ITEM : CO_2 FIRE EXTINGUISHER SYSTEM

CLIENT :

Job No. 32686

STATUS ■ ENQUIRY ☐ COMMITMENT ☐ P.O No.

Sl. No.	Grp Code	Description	Offer	After Commitment				Final@@
			Qty	Qty.	Lead time in weeks			Qty
					Reqd.	Propd @	Agrd	
1.0	A	Data sheets	1S	1S	4			1S+4P
2.0	A	System Layout showing pipe lengths, sizes		1S	4			1S+4P
		and pipe supports, nozzle sizes, location of CO_2						
		cylinders, nozzles and detectors.						
3.0	A	Calculation on CO_2 requirements and selection		1S	4			1S+4P
		of nozzles and detectors						
4.0	B	Drawings and details of CO_2 battery frame	1S	1S	4			1S+4P
		assembly, CO_2 valves, nozzles, smoke detectors,						
		main control panel and emergency push						
		button system.						
5.0	B	Cable layout		1S	4			1S+4P
6.0	B	Isometric piping drawing		1S	4			1S+4P
7.0	B	Functional test procedure		1S	4			1S+4P
8.0	C	UL / FM / TAC certificates and approval for the		1S	4			1S+4P
		components and system						
9.0	C	Inspection, test reports & test certificates		1S	4			1S+4P
10.0	B	Bill of materials		1S	4			1S+4P
11.0	C	Reference List of Previous supplies	1S	1S	4			1S+4P
12.0	C	Write up on the system	1S	1S	4			1S+4P
13.0	C	Installation, Operation & Maintenance Manual		1S	4			1S+4P
14.0	C	Technical Literature & catalogues	1S	1S	4			1S+4P
15.0	B	Spares list (mandatory, commissioning and 2 years operation)	1S	1S	4			1S+4P
16.0	C	Packing list		1S	4			1S+4P
17.0	B	Compliance statement	1S	1S	4			1S+4P

Legend : Group code : A - For review and detailed engineering, B - For review, C - For information and record

Document type : R - Reproducible, P - Print, M - Microfilm.

S- Soft copy in Autocad / MS word / Adobe Acrobat

Notes : @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	LA	SK	ANN

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

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TECHNICAL PROCUREMENT SPECIFICATION	VENDOR DATA REQUIREMENT AIR CONDITIONING SYSTEM	32686-01-PS-002 VDR7
		PAGE 1 OF 2 R 0

PROJECT : NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS

ITEM : AIR CONDITIONING SYSTEM

CLIENT : FACT-CD

Job NO : - 32686

STATUS ■ ENQUIRY □ COMMITMENT

P.O NO :

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
1	A	Schematic flow sheets	1S	1S	4			1S+4P
2	A	Air conditioning equipment room layout		1S	4			1S+4P
3	A	Data Sheets of:	1S	1S	4			1S+4P
		-- Compressor						
		-- Condenser						
		-- Evaporator						
4	A	Dimensional GA of:	1S	1S	4			1S+4P
		-- Compressor						
		-- Condenser						
		-- Evaporator						
5	A	C/S drawings with MoC f each part		1S	4			1S+4P
		-- Compressor						
		-- Condenser						
		-- Evaporator						
6	A	Foundation dwg. with load data	1S	1S	4			1S+4P
		-- Compressor						
		-- Condenser						
		-- Evaporator						
7	A	Duct work layout		1S	4			1S+4P
8	A	Duct support & insert details of duct work		1S	4			1S+4P

Legend : Group code : **A** - For review and detailed engineering, **B** - For review, **C** - For information and record

Document type : **R** - Reproducible, **P** - Print, **S** - Soft copy in Autocad/ MS word/Adobe Acrobat.

Notes : @ Vendor shall fill in proposed lead time if different from the required lead time.

@@ Each set of final documents shall be submitted in a folder. Two such folders shall be packed and despatched with the equipment.

REV. NO	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED
0	22.04.2021	For Enquiry	IA	SK	AAN

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

01FT056B/94

SI.NO	GRP CODE	DESCRIPTION	OFFER	After commitment				Final @@
			QTY.	QTY.	Lead time in weeks			QTY
					Reqd.	Prop @	Agrd	
9	A	Control Panel		1S	4			1S+4P
		-- Dimensional GA drawing						
		--Schematic wiring diagram						
10	A	Filter GA and C/S drawings		1S	4			1S+4P
11	A	Utility consumption	1S	1S	4			1S+4P
12	B	Equipment lubrication data sheets		1S	4			1S+4P
13	B	Inspection & Test procedure		1S	4			1S+4P
14	C	Material test certificates		1S	4			1S+4P
15	C	Test records		1S	4			1S+4P
16	C	Installation, erection & maintenance manual		1S	4			1S+4P
17	C	Technical literature & Catalogues		1S	4			1S+4P
18	C	Reference list of previous supplies	1S	1S	4			1S+4P
19	B	Compliance statement	1S					1S+4P
0								

DATA SHEET	ROTARY TYPE POSITIVE DISPLACEMENT COMPRESSOR	32686-01-DA-001 PAGE 1 OF 9 R 0

Job No : 32686 | Item no : | Tender No.

Applicable to ● Proposal ○ Purchase ○ As-built

Site Ambalamedu, Kochi | No.off

Unit FACT-CD | Type Rotary Screw

Service Ammonia | Size Nm^3/h

Driver Electric motor | Model ☐

Note: ○ Indicates information to be completed by purchaser ☐ By manufacturer

OPERATING CONDITIONS

(All data on per unit basis)	Normal	Normal	Other conditions			
			Design	Design	C	D
	All to storage		All to storage			
	Stream 1	Stream 2	Stream 1	Stream 2		
○ Gas handled (also see page)						
○ NM^3/h (760 mm HG & 0^oC) dry		-				
○ Weight flow, (kg/h) (wet) (dry)						
Inlet conditions						
○ Pressure (Kg/cm^2 G)						
○ Temperature (^0C) min./nor./max.		-				
○ Relative humidity (%)						
○ Molecular weight (M)						
☐ Cp/Cv (K_1) or (Kavg)						
☐ Compressibilty (Z_1) or (Z_{avg})						
☐ Inlet volume mn^3/h (wet)						
Discharge conditions						
○ Pressure (kg/cm^2 G) min./nor./max.						
☐ Temperature (^0C)						
☐ Cp/Cv (K_1) or (K_{avg})						
☐ Compressibilty (Z_2) or (Z_{avg})						
☐ KW required (All losses incl)						
☐ Speed (RPM)						
☐ Pressure ratio (R)						
☐ Volumetric efficiency (%)						
☐ Silencer P						
○ Total flow (kg/h)						
☐ Performance curve No.						

					PROJECT	NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS
					CLIENT	FACT-CD
					P.O No.	
0	22.04.2021	LA	SK	AAN	VENDOR	
Rev	DATE	PRPD.	CHKD.	APPRD.		

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

01FT026C/94

Process control		1
Method	○ By pass from To:-	2
	○ By pass ○ Manual ○ Auto	3
	○ Speed variation from To	4
	○ Other	5
Signal	○ Source	6
	○ Type	7
	○ Range for pneumatic control RPM @ (Kg/cm^2)& RPM@ (Kg/cm^2)	8
	○ Other	9
Service	● Continuous ○ Intermittent ○ Standby	10
Remarks		11
		12
		13

Gas analysis		Normal	Rated	Other conditions				Remarks	
○ Mol % ○				A	B	C	D		15
	M.W								16
Air									17
Oxygen									18
Nitrogen									19
Water vapour									20
Carbon monoxide									21
Carbon dioxide									22
Hydrogen sulphide									23
Hydrogen									24
Methane									25
Ethylene									26
Ethane									26
Propylene									28
Propane									29
i - Butane									30
n - Butane									31
i - Pentane									32
n - pentane									33
Hexane plus									34
									35
									36
									37
Total									38
Avg. mol. wt									39
									40

Location	Noise Specifications	1
● Indoor ○ Heated ● Under roof	○ Applicable to machine	2
○ Outdoor ○ Unheated ○ Partial sides	See specifcation ISO 2151 : 2004	3
○ Grade ○ Mezzanine ○	○ Applicable to neighborhood	4
○ Electrical area class Gr. Div.	See specifcation	5
○ Winterisation reqd. ○ Tropicalisation reqd.	Accoustic housing ● Yes ○ NO	6
Site data	Sound level dB@ 1 M PM	7
○ Elevation PM Barometer (Kg/cm^2)	dB Re 0.0002 Microbar	8
○ Range of ambient temps. Dry bulb Wet bulb	Applicable specification	9
Site rated ^{o}C	API 619 Positive displacement rotary compressors	10
Normal ^{o}C		11
Maximum ^{o}C		12
Minimum ^{o}C	Painting	13
Unusual conditions ○ Dust ○ Fumes	● Manufactures's std. (For Compressor only)	14
○ Others	○ Others	15
		16
	Shipment	17
	● Domestic ○ Export ○ Export boxing reqd.	18
	○ Long term storage for months	19
		20
		21
		22
☐ Speeds	☐ Shaft	23
max.cont. RPM Trip RPM	Material	24
Max.tip speeds m/s @ rated speed	diameter, mm: Rotors Coupling	
m/s @ max. const. speed	Shaft end ☐ Tapered ☐ Cylindrical	26
☐ Lateral critical speeds		27
First critical RPM	Shaft sleeves	28
Damped Undamped	○ At shaft seals Matl.	29
Mode shape	Material	30
Lateral critical speed - basis	☐ Timing gears	31
☐ Damped unbalance response analysis	Size, mm Type	32
☐ Shop test	Material	33
☐ Other type analysis (specify)	Shaft seals	34
☐ Torsional critical speed	☐ Type	35
First critical RPM	○ Seal system type	36
Second critical RPM	☐ Inner oil leakage guar.(lit/day/seal)	37
Third critical RPM	○ Type buffer gas	38
☐ Vibration	☐ Buffer gas flow / seal	39
Allowable level Test	Normal Kg/min.@ Kg/Cm^{2}G	40
(Peak to Peak) Site	Maximum Kg/min.@ Kg/Cm^{2}G	41
		42

☐ Rotation, viewed from driven end ☐ CW ☐ CCW	☐ Bearing housing construction	1
	Type (Separate, Integral) Split	2
	Material	3
☐ Casing	☐ Radial bearings :	4
Model	Type Span (mm)	5
Casing split	Area (mm^2)	6
Material	Loading (kg/mm^2) Act. Allow.	7
Operation ☐ Dry ☐ Flooded, with Liquid	Center pivot Offset pivot	8
Thickness (mm) Corr.allow.(mm)	% Offset from leading edge	9
Max. working pr. (kg/cm^2G)	No. pads Rotor on or between Pads	10
Relief valve setting (kg/cm^2G)	Pad material	11
Margin for accumulation (kg/cm^2G)	Type Babbit Thickness (mm)	12
Test pr.((kg/cm^2G) Helium Hydro		13
Max.allowable temp. ^oC Min.operating temp. ^oC		14
Max. Casing capacity (inlet M^3/hr)	☐ Thrust bearings	15
Radiography qlty. ○ Yes ○ No	Location Type	16
☐ Rotors	Mfr Area (mm^2)	17
Diameter (mm)	Loading (kg/mm^2) Act. Allow.	18
No.Lobes Male Female	Gas loading (kg) Cplg.slip load (kg)	19
Type	Cplg.coeff.of frict. Cplg.gear pitch dia. (mm)	20
Type fabrication	Bal.piston compensating load (kg)	21
Material	Center pivot Offset pivot	22
Max.Yield strength (kg)	% Offset from leading edge	23
Brinell hardness Max. Min.	Number of pads	24
Rotor length to diameter ratio (L/D)	Pad material	25
Rotor clearance (mm)	Type babbit Thickness (mm)	26
Max. deflection (mm)		27
Max. machine Mach No. @lobes		28
Internally cooled Uncooled		29
☐ Main connections	Axial position detector	30

	Size	ANSI rating	Facing	Position
Inlet				
Discharge				

○ In accordance with : API 670	31
Other (Specify)	32
○ Type ☐ Model	33
○ Mfr. ☐ No. reqd.	34
○ Oscillator detector supplied by	35
○ Mfr. ☐ Model	36
○ Monitor supplied by	37
○ Location Enclosure	38
○ Mfr. ☐ Model	39
☐ Scale range ○ Alarm ☐ Set@ µm	40
○ Shut down ☐ Set@ µm	41
○ Shut down ○ Time delay Sec	42

☐ Allowable piping forces and moments

	Inlet		Discharge			
	Force kg	Momt. Kg.M	Force kg	Momt. Kg.M	Force kg	Momt. Kg.M
Axial						
Vertical						
Horiz.90^0						

☐ Other connections					Couplings			1
Service	No	Size			○ In accordance with : API 671			2
Lube oil inlet					Other (Specify)			3
Lube oil outlet						Driver comp or driver	Gear-Comp	4
Seal oil inlet					○ Make			5
Seal oil outlet					☐ Model			6
Casing drains					○ Lubrication			7
Vents					○ Mount cplg.halves			8
Cooling water					○ Spacer required			9
Pressure					○ Limited end float reqd.			10
Temperature					○ Idling adapter reqd.			11
Purge for					☐ Cplg.rating (kw/100RPM)			12
Brg.housing					☐ Keyed (1) or (2) or hydr.fit			13
Between brg. & seal					Base plates & soleplates			14
Between seals & gas					Soleplates for ○ Comp. ○ Gear ○ Driver			15
					Baseplate			16
					○ Common for comp. gear & driver			17
Vibration detectors					○ Under compressor only			18
In accordance with ○ API 670 ○ API 678 ○ Others					○ Other			19
○ Type ☐ Model					○ Decked with nonskid deckplate ○ Open constr.			20
○ Mfr.					○ Drip rim ○ With open drain			21
○ No. at each shaft bearing Total no.					○ Horizantal adjusting screws for equipment			22
○ Oscillator detector supplied by:					○ Suitable for point support			23
○ Mfr. ☐ Model					○ Suitable for perimeter support			24
○ Monitor supplied by					Remarks :			25
○ Location Enclosure								26
○ Mfr. ☐ Model								27
☐ Scale range ○ Alarm ☐ Set @ µm								28
○ Shut down ☐ Set @ µm ○ Time delay Sec								29
○ Phase reference transducer								30
Utility conditions								31

Steam		Drivers		Heating			32
		Pressure kg/cm^2 G	Temp ^oC	Pressure kg/cm^2 G	Temp ^oC	☐ Weights (Kg)	33
Inlet	Min					Compr. Gear Driver Base	34
	Norm					Rotors Compr. Driver Gear	35
	Max					Compr. Upper case	36
Exhaust	Min					L.O Console S.O Console	37
	Norm					Max for maintenance (identify)	38
	Max					Total shipping weight	39
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							43
							44

DATA SHEET	ROTARY TYPE POSITIVE DISPLACEMENT COMPRESSOR	32686-01-DA-001
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Electricity :					☐ Space requirements (mm)				1
	Drivers	Heating	Control	Shut down	Complete unit	L	W	H	2
Voltage					L.O.Console	L	W	H	3
Hertz					S.O.Console	L	W	H	4
Phase					Miscellaneous				5
Cooling water :					☐ Recommended straight run of pipe dia.before suction				6
Temp. °C	Inlet		Max. return						7
Pressure Kg/cm²G	Normal Min.return		Design Max.allow. P		○ Vendor review & comments on purchaser's piping & foundation				8
Water source					○ Optical alignment flats required on compressor,gear & driver				9
Instrument air :					○ Provision for water washing before opening casing by				10
Pr.kg/cm²G	Maximum		Minimum						12
☐ Total utility consumption					● Torsional analysis report required				13
Cooling water :			M^3/h		○ Provision for torsional pick up on case condensate removal equipment required				14
Steam normal			Kg/h		○ Yes ○ No				15
Steam Max.			Kg/h		Silencers furnished by				16
Instrument air			nm^3/h		Reference specifications				17
KW (driver)			KW		API 614 ○ Yes ○ No				18
KW (Auxiliaries)			KW						19
Shop inspection and tests	Reqd.	Witness							20
Shop inspection	●	●			Area classification				21
Hydrostatic	●	●			Class	Group	Division		22
Hellium leak	○	○			Motor control & Instrument voltage				23
Mechanical run	●	●			Volts	Phase	Cycles		24
Mechanical run spare rotors	●	○			Alarm & shut down voltage				25
Fit in spare rotors	●	○			Volts	Phase	Cycles or	DC	25
Performance test (gas) (air)	●	○			Remarks				26
Comp. with driver	●	○			1.0 Performance test at site				27
Comp. less driver	○	○							28
Use shop lube & seal system	○	○							29
Use job lube & seal system	●	○							30
Use shop vibration probes, etc	●	○							31
Use job vib. & axial display probes,oscillator-detectors &	●	○							32
Pr.comp.to full oper. Press	●	○							33
Disassemble- reassemble comp,after test	○	○							34
Check brgs. & seals after test	●	○							35
Noise level test	●	○							36
									37
									38

Location control panel				1
Furnished by	■ Vendor	□ Purchaser	□ Others	2
□ Free standing	□ Weather proof	□ Totally enclosed	□ Extra cutouts	3
□ Vibration isolators	□ Strip heaters	□ Purge connections		4
□ Annunciator: Furnished by	■ Vendor	□ Purchaser	□ Others	5
Annunciator: Located on	□ Local panel	□ Main controler board		6
□ Customer connections brought out to terminal boxes by vendor				7
Instrument suppliers				8
Pressure gauges	Mfr.		Size & type	9
Temperature gauge	Mfr.		Size & type	10
Level gauge	Mfr.		Size & type	11
Diff. perssure gauge	Mfr.		Size & type	12
Pressure switches	Mfr.		Size & type	13
Diff. perssure switches	Mfr.		Size & type	14
Temperature switches	Mfr.		Size & type	15
Level switches	Mfr.		Size & type	16
Control valve	Mfr.		Size & type	17
Pressure relief valve	Mfr.		Size & type	18
Theramal relief valve	Mfr.		Size & type	19
Sight flow indicator	Mfr.		Size & type	20
Gas flow indicator	Mfr.		Size & type	21
Vibration equipment	Mfr.		Size & type	22
Tachometer	Mfr.		Range & type	23
Solenoid valves	Mfr.		Size & type	24
Annunciator	Mfr.		Model & No. points	25
	Mfr.		Size & type	26
	Mfr.		Size & type	27
Note: □ Supplied by vendor		○ Supplied by purchaser		28
Pressure gauge requirement				29

Function	Locally mounted	Local panel	Function	Locally mounted	Local panel	
Lube oil pump discharge	□ ○	□ ○	Gov.control oil	□ ○	□ ○	31
Lube oil filter P	□ ○	□ ○	Gov. control oil P	□ ○	□ ○	32
Lube oil supply	□ ○	□ ○	Coupling oil P	□ ○	□ ○	33
Seal oil pump discharge	□ ○	□ ○	Main stream in	□ ○	□ ○	34
Seal oil filter P	□ ○	□ ○	1st stage steam	□ ○	□ ○	33
Seal oil supply (each level)	□ ○	□ ○	Steam chest	□ ○	□ ○	34
Seal oil differential	□ ○	□ ○	Exhaust steam	□ ○	□ ○	35
Reference gas	□ ○	□ ○	Extraction steam	□ ○	□ ○	36
Balance line	□ ○	□ ○	Steam ejector	□ ○	□ ○	37
Seal eductor	□ ○	□ ○	Compressor suction	□ ○	□ ○	38
Buffer sael	□ ○	□ ○	Compressor discharge	□ ○	□ ○	39

Temperature gauge requirments

Function	Locally mounted	Local panel	Function	Locally mounted	Local panel
Lube oil discharge from EA	☐ ○	☐ ○	Cooler oil inlet & outlet	☐ ○	☐ ○
Compr.Journal bearing	☐ ○	☐ ○	Seal oil outlet	☐ ○	☐ ○
Driver journal bearing	☐ ○	☐ ○	Compressor suction	☐ ○	☐ ○
Gear journal bearing	☐ ○	☐ ○	Compressor discharge	☐ ○	☐ ○
Compressor thrust bearing	☐ ○	☐ ○	Lube oil reservoir	☐ ○	☐ ○
Driver thrust bearing	☐ ○	☐ ○			
Gear thrust bearing	☐ ○	☐ ○			

Miscellaneous instrumentation

☐ ○ Sign flow indicators, ecah journal & thrust bearing & each coupling oil return line

☐ ○ Sight flow indicators, each seal oil return line

☐ ○ Level guages, lube and / or seal oil reservoir, S.O. drain traps & S.O overhead tank

☐ ○ Vibration and shaft position probes & proximitors

☐ ○ Vibration and shaft position readout equipment

☐ ○ Vibration readout located on ☐ Local panel ☐ Separate panel ☐ Main board

☐ ○ Turbine speed pickup devices

☐ ○ Turbine speed indicators

☐ ○ Turbine speed indicators located on ☐ Local panel ☐ Main board

☐ ○ Remote hand speed changer - mounted on local panel

☐ ○ Alarm horn & acknowledement switch.

Alarm & shut down switches

Function	Press alarm	Trip	Function	Press alarm	Trip
○ ☐ Low lube oil pressure			○ ☐ High lube oil outlet temp. (cooler)		
○ ☐ High lube oil filter P			○ ☐ Compressor vibration		
○ ☐ High seal oil filter P			○ ☐ Compressor axial position		
○ ☐ Low lube oil reservoir level			○ ☐ Turbine vibration		
○ ☐ Low seal oil reservoir level			○ ☐ Turbine axial position		
○ ☐ High seal oil level			○ ☐ Gear vibration		
○ ☐ Low seal oil level			○ ☐ Gear axial position		
○ ☐ High seal oil level			○ ☐ Compressor motor shut down		
○ ☐ Low seal oil pressure			○ ☐ Trip & throttle value shut		
○ ☐ Aux. seal oil pump start			○ ☐ High turbine steam seal leakage		
○ ☐ Aux. lube oil pump start			○ ☐ High compr. Thrust brg. Temp		
○ ☐ High seal oil outlet temp. (cooler)			○ ☐ High driver thrust brg. Temp		
○ ☐ High liqud level suct.separator			○ ☐ Compr.balance drum P		
○ ☐ Compressor high disch. Temp.					

Switch closures	1
Alarm contacts shall ☐ Open ☐ Close to trip and be normally ☐ Energised ☐ De-energised	2
Shut down contacts shall ☐ Open ☐ Close to trip and be normally ☐ Energised ☐ De-energised	3
Note: Normal condition is when compressor in operation	4
Miscellaneous	5
○ Instrument tagging required	6
Pre-alarm and shut down switches shall be separate	7
Purchasers electrical and instruments connection with in the confines of the base and console shall be :	8
☐ Brought out to terminal boxes ☐ Made directly by the purchaser	9
Comments regarding instrumentation	10
	11
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Remarks	14
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	17
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DATA SHEET	CENTRIFUGAL PUMP	32686-01-DA-002 PAGE 1 OF 3 R 0

Job No	: 32686	**Tender No**	:
Applicable to : ■ Proposal ☐ Purchase ☐ As-built		No of electric motors reqd	:
Site	: Ambalamedu, Kochi	Motor item No.	: *
Unit	: FACT-CD	Motor provided by	:
Pump item No.	:	Motor mounted by	:
Service	: Ammonia	No. of turbines reqd	: -
No. of pumps reqd	:	Turbine item No.	: -
Pump mfr.	: *	Turbine provided by	: -
Pump size & type	:	Turbine mounted by	: -
Pump model No.	: *	Remarks :	
No. of stages	: *		

Notes :
1 Information to be completed : ■ By Purchaser ☐ By Manufacturer
2 Equipment shall conform to API Standard 610 Tenth Edition, along with FEDO spec.
3 Units of measurement ☐ SI System ☒ Metric System
4 * Vendor To Specify (VTS) 5. # Vendor To Confirm (VTC) 6. $ Vendor to advise (VTA)

OPERATING CONDITIONS (TO BE COMPLETED BY PURCHASER)

Liquid	:		NPSH available (NPSHA)	:		MLC
Pumping temperature	Normal	: ^{0}C	pH Value	:		
	Minimum	: ^{0}C	Capacity @ PT	Normal	:	M^3/Hr.
	Maximum	: ^{0}C		Minimum	: $	M^3/Hr.
Density @ PT	:	Kg/M^3		Maximum	:	M^3/Hr.
Vapor press. VP@ PT	:	Kg/cm^2 A	Discharge pressure(Max)	:		Kg/cm^2_G
Dynamic Viscosity (cP) @ PT	:	cP	Suct. pressure	Maximum	:	Kg/cm^2_G
Site temperature	Maximum	: ^{0}C		Minimum	:	Kg/cm^2_G
	Ambient	: ^{0}C		Normal	:	Kg/cm^2_G
	Minimum	: ^{0}C	Differential Pressure	:		Kg/cm^2
Solids in suspension	: Nil		Suction temperature	:		^{0}C
Un usual conditions	:		Differential head	:		MLC
Corrosion/erosion caused by	:		Hydraulic KW	:		
Duty	Continuous ■ Intermittent		Location	■ Indoor ■ Heated ■ With roof		
Remarks :	Priming - Flooded suction			■ Outdoor ■ Unheated ■ Without roof		

PERFORMANCE (TO BE COMPLETED BY MANUFACTURER)

Proposal curve No.	:		Minimum continuous flow	Thermal	: M^3/Hr
Speed	:	RPM		Stable	: M^3/Hr
NPSH reqd. (NPSHR) *note 1	:	M	Rotation (facing coupling end)	■ CW ☐ CCW	
Rated BHP	:	KW			
Max. BHP with rated impeller	:	KW	Suction sp. Speed	:	
Max. head with rated impeller	:	M	Efficiency (VTS)	:	%

Remarks :

CONSTRUCTION (TO BE COMPLETED BY PURCHASER & MANUFACTURER)

Casing mount	■ Centerline ■ Near centerline		Nozzles	Size*	Rating	Facing	Location
	■ Foot ■ Vertical ■ In line		Suction				
	■ Bracket ■ Vert. barrel ■ Sump pump		Discharge				
Casing split	☐ Axial ☐ Radial		Miscellaneous connections				
Casing type	■ Volute ■ Single ■ Staggered		Nozzles	Drain	Vent	Pressure gauge
	■ Diffuser ■ Double		Suction	■	■	■
Pressure balancing: Line and disc required			Discharge	■	■	■
Cooling water Inlet/outlet *			Casing Steam Jacket			

Note 1 : Margin between NPSHA and NPSHR should be minimum 0.6 meters.
2 : MLC - Meters of Liquid Column 3. Pump shall be provided with drive motor suitable for VFD operation.
4 : Suction pressure & NPSH available values indicated are at minimum operating level.
5 : Vendor to advise the pump type.

					PROJECT	NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS
					CLIENT	FACT-CD
					P.O No.	
0	22.04.2021	LA	SK	AAN	VENDOR	
Rev	DATE	PRPD.	CHKD.	APPRD.		

FACT ENGINEERING AND DESIGN ORGANISATION FEDO

01FT010C/15

DATA SHEET	CENTRIFUGAL PUMP	32686-01-DA-002 PAGE 2 OF 3 R 0	
☐ Maximum allowable pr.	* Kg/cm^2 G @15^{0}C * Kg/cm^2 G @ PT	Bearings* Type / No.	☐ Radial ☐ Thrust
☐ Hydro static test pr.	* Kg/cm^2 G	Lubrication* Type	☐ Ring oil ☐ Oil mist ☐ ☐ Flood ☐ Pressure ☐ Flinger
Impeller dia (mm)	☐ Rated * ☐ Maximum * ☐ Minimum *	Coupling *	☐ Manufacturer ☐ Type Flexible disc spacer ☐ Model
Impeller mount	☐ Between bearings ☐ Overhung	Driver half coupling to be supplied by	☐ Pump manufacturer
Impeller type*	☐ Closed ☐ Semi-open ☐ Open		☐ Driver manufacturer
Packing	Manufacturer Type Size/No.of rings		☐ Purchaser Gland plate taps reqd. ☐ Quench ☐ Flush ☐ Drain ☐ Vent
Mechanical seal	☐ Single ☐ Double ☐ Tandem ☐ Manufacturer ☐ Model ☐ Manufacturer code ☐ API class code ☐ Gland type / Material	Remarks :	
# Compatibility of Mechanical seal with respect to Seal Flush/Quench plan			
AUXILARY PIPING (TO BE COMPLETED BY MANUFACTURER)			
☐ Seal flush piping plan ☐ Tubing ☐ Carbon steel ☐ Piping ☐ Stainless steel		☐ Cooling water piping plan : ☐ Tubing ☐ Carbon steel ☐ Copper ☐ Piping ☐ Stainless steel	
Auxiliary flush plan ☐ Tubing ☐ Carbon steel ☐ Aux.flush liquid ☐ Piping ☐ Stainless steel		☐ Total cooling water reqd. : M^3/Hr. ☐ Sight flow indicators reqd. : ☐ Packing cooling injection reqd. :	
☐ Seal flush piping : ☐ Threaded ☐ Socket welded ☐ Flanged		☐ ` M^3/Hr. ☐ Kg/cm^2_G Remarks :	
☐ External seal flush fluid reqd. : ☐ M^3/Hr. ☐ Kg/cm^2_G			
All interface connection shall be terminated with Flanged Block Valves			
Lantern ring Inlet/Outlet Exit Seal Flush inlet/outlet Seal Quench Fluid Inlet		Size/Rating (ANSI)/Facing * * *	
☐ API 610 Tenth Edition Table H-1 Material Class #		☐ Base plate (material / type)	
☐ Barrel / case		☐ API 610 std. base plate No.	
☐ Impeller		☐ Base plate Drain Pan Type	
☐ Case/impeller wear rings		Base plate drain (Only flanged)*	
☐ Shaft / sleeve		Remarks :	
INSPECTION AND TESTS (TO BE COMPLETED BY PURCHASER)			
Tests	Non witnessed Witnessed Observed	☐ Inspection required for nozzle welds	
Performance	☐ ☐ ☐	☐ Magnetic Particle ☐ Dye penetrant	
Hydrostatic	☐ ☐ ☐	☐ Inspection required for castings	
NPSH	☐ ☐ ☐	☐ Radiographic ☐ Ultrasonic	
☐ Shop inspection ☐ Material certification		☐ Inspection required for	
☐ Dismantle and inspect after test		☐ Magnetic Particle ☐ Dye Penetrant	
☐ Casting repair procedure approval		☐ Radiographic ☐ Ultrasonic	
Remarks : ***As per scope inspection & tests attched***			
FACT ENGINEERING AND DESIGN ORGANISATION		FEDO	

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MOTOR DRIVER (TO BE COMPLETED BY PURCHASER & MANUFACTURER)

☐ * KW @ * RPM	☐ Manufacturer *
☐ Service factor *	☐ Type *
☐ Frame No. *	☐ Bearings *
☐ Volts / phase / hertz *	☐ Lube *
☐ Temperature rise * ^{0}C	☐ Insulation *
☐ Full load amps. *	☐ Enclosure *
☐ Parallel Operation required	
☐ Locked - rotor amps.*	Remarks:
Vertical shaft* ☐ Hollow ☐ Solid	
☐ Vertical thrust capacity, Kg*	
Up Down	

VERTICAL PUMPS (TO BE COMPLETED MANUFACTURER)

☐ Pit or sump depth	As per GA attached mm	Float & rod	☐ Carbon steel ☐ Stainless steel
☐ Pump length (mount plate to suction flange)	mm		☐ Bronze ☐ None
		☐ Float switch	
☐ Minimum submergence reqd.	mm	Pump thrust, Kg	☐ At min. flow
Column pipe	☐ Flanged ☐ Threaded		☐ At design flow
Line shaft	☐ Open ☐ Enclosed		☐ At run out ☐ Up
Guide bushings	☐ Bowl ☐ Line shaft		☐ Down
Guide bushing lube ☐ Water ☐ Oil ☐ Grease ☐		Remarks :	
		First dry critical speed of pump in vertical condition(rpm)*	
☐ Lube fluid Quantity	M^3/hr Pr Kg/cm^{2}G		

WEIGHTS (TO BE COMPLETED BY MANUFACTURER)

Weight of pump & base plate *	Kg	Remarks:
Weight of motor *	Kg	
Weight of coupling *	Kg	
Weight of turbine *	Kg	

PACKING AND SHIPPING

Packing type*	☐ Domestic	☐ Export		
Packing specs.*	☐ Mfr's standard	☐ Purchaser's specs.		
Packed weight*	Kg			
Packing size*	(LXBXH) mm			
Shipping by*	☐ Rail	☐ Road	☐ Ocean	☐

NOTES:

1. The scope of supply include the following items.
   a) Pumps, b) Drive Motors, c) Mechanical Seals /Gland packing, d) Minimum flow recirculation valve e) Couplings, f) Coupling Guards, g) Mounting flanges with gasket, h) Anchor Bolts with nuts, i) Piping confined to battery limit, j) Mating flanges for suction and discharge nozzles k) Mandatory spares, l) Commissioning spares - VTS, m) First-fill of lubricants - VTS, n) Balance device - VTS
2. Area classification: Hazardous Zone, Division 1 and Gas group IIA / IIB
3. Non sparking coupling guard to be provided.
4. Downstream design Pressure is 1.5 Times of Max operating pressure. Maximum Shutoff considering max suction pressure, including all tolerances shall not exceed this value.
5. Process min flow shall be equal to Pump MCF (Minimum Continuous flow)
6. Pump motor to be designed to start againt system pressure, and end of curve operation. Driver shall be suitable for pump starting with open disc valve condition & VFD operation.

S.No.	NAME OF THE VENDOR	ADDRESS
1.0	**VESSELS IN CS/AS/SS PRESSURE 11 TO 60 KG/CM^{2}G**	
1	BHEL (BHPV)	INDIA
2	GODREJ & BOYCE MFG. CO. LTD	INDIA
3	LARSEN & TOUBRO LTD	INDIA
4	ISGEC HITACHI ZOSEN LTD (DAHEJ)	INDIA
5	PATEL AIRTEMP (INDIA) LTD. (CS/SS)	INDIA
6	REYNOLDS ENGINEERING CORPORATION	INDIA
7	G.R. ENGINEERING	INDIA
8	TEMA EXCHANGERS	INDIA
9	GANSONS LIMITED	INDIA
10	GMM PFLAUDER	INDIA
11	TAS ENGINEERING CO. PVT. LTD.	INDIA
12	GRASIM INDUSTRIES	INDIA
13	ALTECH INFRASTRUCTURE (INDIA) PVT. LTD. (CS; UP TO 20 KG/CM^2)	INDIA
14	KAVERI ENGG. INDUSTRIES LTD.,	INDIA
15	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
16	LOYAL EQUIPMENTS PVT. LTD. (UP TO 11-30 KG/CM2,& NON IBR ONLY)	INDIA
17	MEENALKSHI ASSOCIATED PVT. LTD. (CS/ LTCS/ SS UP TO 30 KG/CM2)	INDIA
18	PHILS HEAVY ENGINEERING PVT. LTD. (UP TO 30 KG/CM2)	INDIA
19	PRECISION EQUIPMENT (CHENNAI) PVT LTD. (UPTO 30 KG/CM2 G)	INDIA
20	TECHNO PROCESS EQUIPMENT. PVT. LTD (CS/SS/AS)(P3 ONLY)	INDIA
21	THE ANUP ENGG. LTD.	INDIA
22	UNIVERSAL HEAT EXCHANGERS LIMITED (UP TO 30 KG/CM2 G ,CS/SS/LTCS ONLY)	INDIA
23	VIJAY TANKS & VESSEL LIMITED (11 TO 30 KG/CM2 G ,CS/SS/LTCS ONLY)	INDIA
24	PETROJET	EGYPT
25	OLMI SPA	ITALY

26	OFFICINE LUIGI RESTA	ITALY
27	SCHOLLER-BLECKMANN NOOTER APPARATETECHNK	AUSTRIA
28	BORSIG GMBH	GERMANY
29	BELLELI SPA	ITALY
30	FBM HUDSON ITALIANA	ITALY
31	GE POWER (NUOVO PIGNONE SPA)	ITALY
32	ROLLE S.P.A.	ITALY
33	WATER TOSTO SPA	ITALY
34	HITACHI ZOSEN	JAPAN
35	KOBE STEEL LTD	JAPAN
36	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
37	MITSUI ENGINEERING & SHIP BUILDING CO. LTD	JAPAN
38	MECANICA DE LA PENA S.A.	SPAIN
39	DOOSAN MECATEC CO. LTD	KOREA
40	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD	KOREA
41	DAEHAN CHEMICAL MACHINERY CO. LTD.	KOREA
42	HANJUNG DCM CO. LTD.	KOREA
43	HANTECH LIMITED	KOREA
44	HYOSUNG CORPORATION (CS/SS/LAS ONLY)	KOREA
45	SUNGJIN GEOTEC CO. LTD.	KOREA
46	HYUNDAI HEAVY INDUSTRIE	KOREA
47	SEMBAWANG ENGG.CO.	SINGAPORE
48	BEAIRD INDUSTRIES LOUISIANA	USA
2.0	**HEAT EXCHANGERS PRESSURE UPTO 30 KG/CM2G**	
1	BHPV	INDIA
2	BHARAT HEAVY ELECTRICALS LTD	INDIA
3	G R ENGG. WORKS LIMITED	INDIA
4	GODREJ & BOYCE MFG. CO. LTD.	INDIA
5	LARSEN & TOUBRO LTD.	INDIA
6	PATEL AIRTEMP INDIA LTD.	INDIA
7	TEMA INDIA LIMITED	INDIA
8	GRASIM INDUSTRIES	INDIA
9	ISGEC	INDIA
10	GMM PFLAUDER	INDIA
11	REYNOLD ENGINEERING CORPORATION	INDIA

12	THE ANUP ENGG. LTD.	INDIA
13	TITANIUM EQUIPMENT AND ANODE MANU. COMPANY LTD.	INDIA
14	GEMINI ENGINEERING – FAB PVT. LTD.	INDIA
15	LAXMI ENGINEERING INDUSTRIES PVT. LTD (CS/SS ONLY EXCEPT UREA SERVICE)	INDIA
16	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
17	PRECISION EQUIPMENTS (CHENNAI) PVT. LTD. (TUBESHEET THK. UPTO 150MM)	INDIA
18	REYNOLDS CHEMIQUIP PVT. LTD. (CS/SS ONLY)	INDIA
19	TITANIUM EQUIPMENT AND ANODE MANU. COMPANY LTD.	INDIA
20	TITANIUM TANTALUM PRODUCTS PVT. LTD. (CS/SS ONLY)	INDIA
21	UNIQUE CHEMO PLANT EQUIPMENTS	INDIA
22	UNIVERSAL HEAT EXCHANGERS LIMITED (CS/SS/LTCS ONLY)	INDIA
23	D,HONDT S.A.	BELGIUM
24	BORSIG GMBH	GERMANY
25	WATER TOSTO SPA	ITALY
26	BELLELI S.P.A.	ITALY
27	GE POWER NUOVO PIGNONE SPA	ITALY
28	OLMI SPA	ITALY
29	OFFICINE LUIGI RESTA	ITALY
30	BREMBANA	ITALY
31	HITACHI ZOSEN	JAPAN
32	MITSUI ENGG. & SHIPBUILDING	JAPAN
33	KOBE STEEL LTD.	JAPAN
34	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
35	HYUNDAI HEAVY INDUSTRIES	KOREA
36	DAEHAN CHEMICAL MACHINERY CO. LTD.	KOREA
37	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD	KOREA
38	HANJUNG DCM CO. LTD.	KOREA
39	HANTECH LIMITED	KOREA
40	SUNGJIN GEOTEC CO. LTD.	KOREA
41	MANNING & LEWIS ENGG. CO.	U.S.A.
42	APPARATEBAU SCHWEISSTECHNIK GMBH	AUSTRIA
43	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
3.0	**PLATE TYPE HEAT EXCHANGER**	

1	ALFA LAVAL INDIA LIMITED	INDIA
2	DOVER INDIA LTD (TRANTER PHE DIVN)	INDIA
3	GEA ECOFLEX INDIA PVT. LIMITED	INDIA
4	APV (PRAJ)	INDIA
5	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
6	TRANTER PHE, INC.	U.S.A.
7	TRANE CO.	U.S.A.
8	AIR LIQUE	FRANCE
9	APV INTERNATIONAL	U.K.
4.0	**AIR COOLED / FINNED TYPE EXCHANGERS**	
1	GEI INDUSTRIAL SYSTEMS LTD	INDIA
2	HITACHI ZOSEN	JAPAN
3	MITSUBIS HI HEAVY INDUSTRIES LTD.	JAPAN
4	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
5	HYUN DAI CORPORATION	KOREA
5.0	**TANKS & NON CODED VESSEL**	
1	G R ENGINEERING	INDIA
2	GODREJ & BOYCE	INDIA
3	VIJAY TANKS AND VESSELS	INDIA
4	INDUS ENGINEERING	INDIA
5	GMM PFLAUDER	INDIA
6	GRASIM INDUSTRIES	INDIA
7	SURENDRA ENGINEERING	INDIA
8	PHILS HEAVY ENGG. PVT LTD.	
6.0	**SCRUBBERS**	
1	ISGEC	INDIA
2	PHILS HEAVY ENGG. PVT. LTD.	INDIA
3	S.V.FABRICATORS	INDIA
4	NEWTON ENGG. & CONST. CO. LTD	INDIA
5	THERMAX LTD.	INDIA
7.0	**SOLUTION FILTERS**	
1	PENWALT	INDIA
2	GRAND PRIX	INDIA
3	GMM PFLAUDER)	INDIA
4	SUPERFLO FILTERS	INDIA

5	OTOKLIN	INDIA
8.0	**FRP/PVC TANKS/ VESSELS**	
1	UNC POLY VALVE	INDIA
2	K.K.NAG	INDIA
3	GANDHI & ASSOCIATES	INDIA
4	SONAL ENGG. PLASTIC FABRICATOR	INDIA
5	APPARATEBAU SCHWEISSTECHNIK GMBH (ACID TANK UP TO 3.8 IN DIA.)	AUSTRIA
9.0	**REFRACTORY**	
1	RHI DIDIER GMBH (EARLIER DIDIER GMBH)	GERMANY
2	INSULCON B.V.	HOLLAND
3	CALDERYS	HOLLAND
4	ACC	INDIA
5	TATA REFRACTORIES	INDIA
6	CARBORANDOM	INDIA
7	THERMAL CERAMICS – CIRIA DIVISION	ITALY
8	ISOLITE INSULATING PRODUCT	JAPAN
9	SHINAGAWA REFERACTRORIES CO.LTD	JAPAN
10	NICHIAS CORPORATION	JAPAN
11	PIBRICO, JAPAN	JAPAN
12	SAIN GOBAIN INDUSTRIAL CERAMICS (EARLIER CARBORUNDOM RESISTENT MATERIAL)	U.K.
13	THERMAL CERAMICS LTD.	U.K.
14	ANH REFRACTORIES CO.	U.S.A.
15	CHRISTY REFRACTORIES	U.S.A.
10.0	**RUBBER LINING**	
1	MIL IND. LTD	INDIA
11.0	**LTCS PLATE**	
1	ESSAR STEEL	INDIA
2	SAIL	INDIA
3	POSCO	KOREA
4	JSPL	INDIA
5	NLMK	BELGIUM
12.0	**FLARE SYSTEM**	
1	I.C.E. Srl	ITALY
2	AIROIL FLARE GAS (INDIA)	INDIA

3	JOHN ZINK COMPANY LTD.	INDIA
4	CALIDUS	UK / USA
5	ZEECO	UK / INDIA
6	NIPPON NATIONAL AIR OIL	JAPAN
13.0	**BURNER**	
1	AIROIL FLAREGAS (INDIA) PVT. LTD.	INDIA
2	JOHN ZINK COMPANY LTD.	INDIA
3	NIPPON NATIONAL AIR OIL	JAPAN
4	CALIDUS	U.K.

Note:

1) Make of the equipment not indicated and any other make for the specified equipment shall be subjected to owner's/consultant's approval.
2) Bidder shall indicate make of various equipment offered by them in the bid.

S.No.	NAME OF THE VENDOR	ADDRESS
1.0	**AGITATOR**	
1	SHIMAZAKI	JAPAN
2	CHEMA	GERMANY
3	NIPPON GEAR PTE LTD.	SINGAPORE, JAPAN
4	PHILADELPHIA MIXERS	U.S.A
5	PLENTY MIXERS	U.K
6	ACKI CO. LTD.	JAPAN
7	EKATO	GERMANY
8	ROBIN	FRANCE
9	JAPROTEK	FINLAND
10	EIMCO	
11	MERSEN	
2.0	**BLOWER & FAN**	
1	VENTI OELDE	GERMANY
2	TEXEL	JAPAN
3	HOWDEN FAN COMPANY PTE LTD.	AUSTRALIA
4	KOBE CAST IRON WORKS LTD.	JAPAN
5	FLAKT INDUSTRIES AB	SWEDEN
6	GREEN HECK	U.S.A
7	FAN & BLOWER LTD.	U.K
8	A.B.B SOLYVENT	U.K
9	ABB FLAKT INDIA LTD.	INDIA
10	AIR CONDITIONING CORPN. LTD.	INDIA
11	BHARAT HEAVY ELECTRICAL LTD.	INDIA
12	THERMAX BABCOCK & WILCOX LTD.	INDIA
13	ILLIONOIS BLOWERS INC.	U.S.A
14	KKK	GERMANY
15	ANDREW YULE	
16	GRUBBER HEMANOS	FRANCE

17	HAM WORTHY COMBUSTION	
18	BOLDROCHCHI	ITALY
3.0	**STEAM EJECTOR**	
1	GEA WIEGAND GMBH	GERMANY
2	KORTING HANNOVER AG	GERMANY
3	GRAHAM MANUFACTURING LTD.	U.K
4	MAZDA CONTROLS	INDIA
5	NEW FIELD INDUSTRIAL EQUPT	INDIA
6	H.S. EQUIPMENT	INDIA
4.0	**CENTRIFUGAL PUMPS**	
1	KSB PUMPS CO. LTD.	GERMANY/INDIA
2	TORISHIMA	JAPAN
3	INGERSOLL- DRESSER	INTERNATIONAL
4	SULZER	SWITZERLAND
5	GOULDS	U.S.A/SINGAPORE
6	DURCO	U.S.A
7	ENSIVAL ALTELIER DE CONSTRUCTION	BELGIUM
8	FRIATEC	GERMANY
9	A. R. WLIFLEY	U.S.A/INDIA
10	BUNGARTZ	GERMANY
11	MAZDA PUMPS	JAPAN
12	1ENVIROTECH PUMP SYSTEMS	U.K
13	RHEINHUTTE	U.S.A
14	PUMPEN FABRIK ERNST VOGEL	AUSTRIA
15	POMPE GABBIONETA SPA	ITALY
16	ARAI PUMP MFG. CO. LTD.	JAPAN
17	SANWA HYDROTECH CORPORATION	JAPAN
18	AKAY INDUSTRIES PVT. LTD.	INDIA
19	KIRLOSKAR BROTHERS LTD.	INDIA
20	KIRLOSKAR EBARA PUMPS LTD.	INDIA
21	WORHINGTON INDIA	INDIA
5.0	**AXIAL FLOW PUMP**	
1	ENSIVAL MORET	BELGIUM
2	LAWRENCE	U.S.A
3	EBARA	JAPAN

4	KESTNER	INDIA
5	A. R. WILFEY	U.S.A./INDIA
6	AKAY INDUSTRIES PVT. LTD.	INDIA
7	BEACON WIER LTD.	INDIA
8	KSB PUMPS LTD.	INDIA
9	SANWA HYDROTECH CORPORATION	JAPAN
6.0	**VACUUM PUMP**	
1	ENSIVAL MORET	BELGIUM
2	NASH	U.S.A/CANADA
3	SIEMENS AG	GERMANY/ SWITZERLAND
4	WEDAG	GERMANY
5	LEDERLE	GERMANY
6	HIBON	
7	SIHI	GERMANY
8	MAZDA LTD.	INDIA
9	SLM MANEKLAL	INDIA
10	USHA COMPRESSORS LTD.	INDIA
7.0	**COOLING WATER PUMPS**	
1	BEACON WIER. LTD.	INDIA
2	JYOTI LTD.	INDIA
3	KIRLOSKAR BROTHERS LTD.	INDIA
4	VOLTAS LTD.	INDIA
5	MATHER & PLATT (INDIA) LTD.	INDIA
6	KSB AG.	GERMANY
7	FLOWSERVE (IDP)	U.K.
8	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
9	SHIN NIPPON MACHINERY CO. LTD.	JAPAN
10	TORISHIMA PUMP MFG. CO. LTD.	JAPAN
8.0	**SUMP PUMP**	
1	KISHORE PUMPS PVT. LTD.	INDIA
2	BEACON WEIR LTD.	INDIA
3	TECHNO PUMPS	INDIA
9.0	**POLY PROPYLENE PUMPS/FRP PUMPS**	
1	A.R. WILFLEY INDIA PVT. LTD.	INDIA
2	BAKUBHAI AMBALAL	INDIA

3	MICROFINISH PUMPS PVT. LTD.	INDIA
10.0	**PUMPS FOR CHEMICAL DOSING/METERING**	
1	BRAN & LEUBE	U.K./INDIA
2	MILTON ROY INDIA (P) LTD.	INDIA
3	SWELORE ENGG. PVT. LTD.	INDIA
4	DOSAPRO MILTON ROY	FRANCE
5	LEWA HERBERT OTT GMBH & CO.	GERMANY
6	NIIGATA WORTHINGTON PUMPS	JAPAN
7	NIKKISO CO. LTD.	INDIA
11.0	**COMPRESSOR FOR INSTRUMENT AIR SERVICE**	
1	INGERSOLL RAND INDIA LTD.	INDIA
2	ATLAS COPCO ENERGAS GMBH	GERMANY
3	GHH BORSIG TURBOMASCHINEN GMBH	GERMANY
4	LINDE AG WERKSGRUPPE	GERMANY
5	MANNESMAN DEMAG AG	GERMANY
6	SIEMENS AG PGI	GERMANY
7	GE POWER (FORMERLY NUOVO PIGNONE SPA)	ITALY
8	EBARA CORPORATION	JAPAN
9	HITACHI LTD	JAPAN
10	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
11	KOBE STEEL LTD.	JAPAN
12	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
13	MITSUI ENGINEERING & SHIP BUILDING CO. LTD	JAPAN
14	SULZER TURBO LIMITED	SWITZERLAND
15	DRESSER-RAND CO.	SINGAPORE
16	ELLIOT OVERSEAS CORPORATION	U.S.A
17	MYCOM	INDIA/USA
12.0	**RECIPROCATING COMPRESSOR**	
1	ATLAS COPCO (FOR AIR SERVICE ONLY)	INDIA
2	BURCKHARDT COMPRESSION (INDIA) PVT. LTD.(CAPACITY UPTO 15520 M^3 /HR.PRESSURE UPTO 401 BAR ABS)	INDIA
3	DRESSER-RAND INDIA PVT LTD.	INDIA
4	INGERSOLL RAND INDIA LTD. (FOR AIR & N2)	INDIA
5	KIRLOSKAR PNEUMATIC CO. LTD	INDIA
6	BURTON CORBLIN	FRANCE

7	LINDE AG WERKSGRUPPE	GERMANY
8	GE POWER (FORMERLY NUOVO PIGNONE SPA)	ITALY
9	ISHIKAWAJIMA HARIMA HEAW INDS CO. LTD (IHI)	JAPAN
10	KOBE STEEL LTD.	JAPAN
11	MITSUI ENGINEERING & SHIP BUILDING CO. LTD	JAPAN
12	THOMASSEN TURBINE SYSTEMS B.V	NETHERLAND
13	BURCKHARDT COMPRESSION AG	SWITZERLAND
13.0	**SCREW COMPRESSOR**	
1	ATLAS COPCO KOMPRESSORTEKNIK AIS	DENMARK
2	BORSIG GMBH	GERMANY
3	MAN TURBOMASCHINEN AG GHH BORSIG	GERMANY
4	KOBE STEEL LTD.	JAPAN
5	SULZER TURBO LIMITED	SWITZERLAND
6	HOWDEN SIROCCO LIMITED	U.K
7	MYCOM	INDIA/USA
14.0	**GEAR REDUCER & GEAR BOXES**	
1	RADICON	INDIA
2	NEW ALLENBURY WORKS.	INDIA
3	FMG	INDIA
4	ELECON ENGG. CO. LTD.	INDIA
5	ROSSI	INDIA
6	FLENDER	INDIA
7	SHANTI	INDIA
8	TRIVENI	INDIA
15.0	**BEARINGS**	
1	SKF INDIA LTD.	INDIA
2	FAG BEARING INDIA LTD.	INDIA
3	NTN BEARINGS	INDIA
16.0	**COUPLINGS**	
1	FENNER	INDIA
2	NEW ALLENBURY WORKS	INDIA
3	FMCG	INDIA
4	ELECON ENGG. CO. LTD.	INDIA
5	EUROFLEX	INDIA
6	VOITH	INDIA

7	WELMAN BIBBY	INDIA
17.0	**ELECTRIC HOISTS**	
1	ELECON ENGG. CO. LTD	INDIA
2	GREAVES LTD.	INDIA
3	W.H. BRADY & CO. LTD	INDIA
4	HERCULES HOISTS LTD.	INDIA
18.0	**E.O.T CRANES**	
1	W.H. BRADY & CO. LTD	INDIA
2	THE ACME MANUFACTURING CO. LTD	INDIA
3	WMI CRANES	INDIA
4	SAMCO ENGINEERING PVT. LTD	INDIA
19.0	**WEIGH BRIDGE**	
1	AVERY INDIA LTD.	INDIA
2	METTLER TOLLEDO INDIA PVT. LTD.	INDIA
3	ASHBEE SYSTEMS PVT. LTD.	INDIA
4	HYDERABAD TULAMEN LTD.	INDIA
20.0	**ROTARY DRYER**	
1	L & T LTD	INDIA
2	KILBURN ENGG.	INDIA
21.0	**ROTARYCOOLER**	
1	KILBURN ENGG	INDIA
2	LARSEN & TOUBRO LTD.	INDIA
22.0	**GRANULATORS**	
1	KILBURN ENGG	INDIA
2	LARSEN & TOUBRO	INDIA
23.0	**DRYER AND FUMES FANS**	
1	DAVIDSON & CO;	USA
2	TLT ENGG. INDIA PVT.LTD.	INDIA
24.0	**PHOSPHORIC ACID / SCRUBBER LIQUOR / SLURRY PUMPS**	
1	WILFLEY	USA
2	GOULDS	USA
3	SULZER	FRANCE
4.	RUHRPUMPENINC	
25.0	**SULPHURIC ACID PUMPS**	
1	FLOWSERVE	INDIA

2	ARAI	INDIA
3	SULZER	FRANCE
4.	RUHRPUMPENINC	
26.0	**AMMONIA PUMPS**	
1	WORTHINGTON	GERMANY
2	KSB	GERMANY
3	SULZER	FRANCE
4	KIRLOSKAR EBARA	INDIA
5	RUHRPUMPENINC	
27.0	**LIFT**	
1	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
2	OTIS ELEVATORS CO. (I) LTD.	INDIA
3	SCHINDLER AG	SWITZERLAND
4	THYSSENKRUPP	INDIA
28.0	**AIR PRESSURIZATION / VENTILATION SYSTEM**	
1	AIR CONDITIONING CORPN. LTD.	INDIA
2	BLUE STAR LTD.	INDIA
3	VOLTAS LTD.	INDIA
29.0	**AIR CONDITIONING SYSTEM**	
1	AIR CONDITIONING CORP. LTD	INDIA
2	BLUE STAR LTD.	INDIA
3	KIRLOSKAR ELECTRIC COMPANY LTD.	INDIA
4	PATELS AIR TEMP INDIA LTD.	INDIA
5	VOLTAS LTD.	INDIA
30.0	**COOLING TOWER**	
1.	PAHARPUR COOLING TOWER	INDIA
2.	GACTEL TURNKEY PROJECTS LTD.	INDIA
3.	BLAKE DURR	GERMANY
4.	MARLEY C.T	U.K
5.	TOWER TECH.	U.S.A

Note:

1) Make of the equipment not indicated and any other make for the specified equipment shall be subjected to owner's/consultant's approval.
2) Bidder shall indicate make of various equipment offered by them in the bid.

S.No.	NAME OF THE VENDOR	ADDRESS
1.0	**FIRE FIGHTING SYSTEM**	
1	AGNICE FIRE PROTECTION LTD.	INDIA
2	BHARTIYA CACCIALANZA FIRE SYSTEMS LTD	INDIA
3	BLUE STAR LTD.	INDIA
4	DE'S TECHNICO	INDIA
5	DE'S TECHNICO PVT. LTD.	INDIA
6	FUTECH CONSULTANTS PVT. LTD.	INDIA
7	GENERAL MECHANICAL WORKS	INDIA
8	HD FIRE PROTECTION COMPANY	INDIA
9	LAL ENTERPRISES	INDIA
10	MATHER & PLATT (INDIA) LTD. (A SUBSIDIARY OF WILO SE GERMAN)	INDIA
11	MX SYSTEMS INTERNATIONAL PVT. LTD.	INDIA
12	NEWFIRE ENGINEERS SERVICES	INDIA
13	PRAGATI ENGG. (PVT.) LTD.	INDIA
14	PYROTEK INDUSTRIES (INDIA) PVT. LTD.	INDIA
15	RADIANT FIRE PROTECTION ENGINEERS	INDIA
16	STEELAGE INDUSTRIES LTD.	INDIA
17	TECHNOFAB ENGG.	INDIA
18	TRI-PARULEX FIRE PROTECTION SYSTEMS	INDIA
19	UNITECH MACHINES LTD	INDIA
20	VIJAY FIRE PROTECTION SYSTEM LTD.	INDIA
2.0	**HOSE PIPE (METALLIC) & CAM LOCK COUPLING**	
1	AEROFLEX INDUSTRIES LIMITED (SIZE 6MM TO 250MM DIA. (SS CORRG. FLEX. HOSE WITH BRAID,BRAID & ASSEMBLY)	INDIA
2	CHHATARIA RUBBER CHEMICALS INDUSTRIES	INDIA
3	D. WREN & CO.	INDIA
4	FLEXATHERM EXPANLLOW PVT. LTD. (1/2” TO 6”)	INDIA
5	GAYATRI INDUSTRIES	INDIA

6	GAYATRI INDUSTRIAL CORPORATION (UPTO 6” ID)	INDIA
7	HELIFEX HYDRAULICS & ENGG CO. LTD.	INDIA
8	SENIOR INDIA PVT. LTD.	INDIA
3.0	**HOSE PIPE (NON-METALLIC) & CAM LOCK COUPLING**	
1	CHHATARIA RUBBER CHEMICALS INDUSTRIES	INDIA
2	D. WREN & CO.	INDIA
3	GAYATRI INDUSTRIES	INDIA
4	GAYATRI INDUSTRIAL CORPORATION (UPTO 8” ID)	INDIA
5	HELIFEX HYDRAULICS & ENGG CO. LTD.	INDIA
6	SENIOR INDIA PVT. LTD.	INDIA
7	PADMINI INDUSTRIES LIMITED	INDIA
8	PYROTEK INDUSTRIES (INDIA) PVT. LTD.	INDIA

Note:

1) Make of the equipment not indicated and any other make for the specified equipment shall be subjected to owner’s/consultant’s approval.
2) Bidder shall indicate make of various equipment offered by them in the bid.

CONTENTS:

1.0.0. **SCOPE**

1.1.0. This specification covers the requirements for surface preparation, painting and painting materials for equipment, structures and piping (including those painted/primed at shop and those painted at Field/Site.

1.2.0. Requirement of painting for any item shall be as specified in any of the following documents.

a) Equipment Data Sheet
b) Piping line schedule
c) Design Basis for package items
d) Painting schedule

1.3.0. The purpose of painting described in this specification is generally for protection against corrosion.

1.4.0. Painting for other reasons shall be as indicated in the respective equipment data sheets or painting schedule.

1.5.0. The following surfaces exposed to atmosphere are covered by this specification, which are not provided by any other form of covering/coating.

a) Pressure vessels, Tanks, Heat Exchangers and other process equipment with Carbon steel and low alloy steel as material of construction.
b) Machinery items including motors.
c) Steel structures
d) Carbon and low alloy steel piping

1.6.0. The following items shall not be painted unless otherwise specifically required by respective equipment Data Sheets/Painting schedule

a) Non ferrous surfaces, stainless steel and High Alloy steel surfaces.
b) Glass, tile or ceramic surfaces
c) Name plates and identification tags
d) Valve stems
e) Machined contact surfaces
f) Galvanised surfaces
g) Insulation covers
h) Plastics
i) Underground / buried piping and equipments which are provided with special type of protective coatings.
j) Surfaces / Items which are excluded from painting due to specific reasons.

1.7.0. This specification also covers painting of “Markings” and color-coding of carbon steel, low/high alloy steel, stainless steel, galvanized iron and insulated pipes.

2.0.0. MATERIALS

2.1.0. All painting materials shall be of good quality as covered by respective IS or other international specifications

2.2.0. Special paints and painting materials shall have proven quality and shall meet the requirements laid down in the respective data sheets for equipment and piping.

2.3.0. All painting materials shall not have passed the date of expiry or shelf life as recommended by manufacturer.

3.0.0 SURFACE PREPARATION

3.1.0 All surfaces to be painted shall be free from rust, oil, grease, dust, stain, moisture or any other foreign material/contamination, as per IS 1477 Part I.

3.2.0 Surfaces to be painted shall be completely dry.

3.3.0 Oil, grease, stains and other similar contaminants shall be completely removed by using proper solvents and removers, After cleaning, the surfaces shall be free from even traces of contaminants and solvents/removers.

3.4.0 Dust shall be removed by air blowing or vacuum cleaning.

3.5.0 Hard and caked dust, mud, mill scale and rust shall be removed by mechanical means like wire brushing, sand blasting , shot blasting or grit blasting.

3.6.0 Wet surfaces shall be dried by blowing warm air.

3.7.0 All surfaces cleaned by different methods shall be painted immediately with out allowing the clean surfaces togather dust, rust and other external substances.

3.8.0 During the course of painting if it is found that the surfaces are contaminated due to any reason, the same shall be cleaned by any of the methods described earlier, before further proceeding with painting.

3.9.0 All surfaces to be painted after sand, grit or shot blasting shall exhibit almost clean white metal and shall have surface finish of SA 2 ½ as per IS 9954.

3.9.1 Blast cleaned surfaces shall be primed within 2 hrs, after blasting, before re-rusting starts and before contamination.

3.9.2. Blast cleaning shall not be carried out when temperatures are less than 20°C or when the relative humidity of air exceeds 90%.

3.9.3. Blasting operations shall not be carried out during rain, snow, or strong winds.

3.9.4. Blasting medium viz. Slag, grit, or shot shall be completely dry and shall be free from any sort of contaminants like dust, oil, grease etc.

3.9.5. Blasting air shall be completely dry and shall have minimum pressure of 3.5 kg/cm^2.

3.10.0 Surfaces which are not suitable for blast-cleaning or could not be blast-cleaned due to practical reasons shall be thoroughly wire brushed to exhibit a pronounced metallic sheen, equivalent to St 3 as per IS 9954.

3.10.1 Absence of compressed air, slag/shot/grit and/or blasting equipment and accessories shall not be a reason for not carrying out blast cleaning.

4.0.0. STORAGE OF PAINTING MATERAILS

4.1.0. Paints, varnishes, thinner, additives and other volatile substances shall be stored in a flame proof enclosure, away from heat.

4.2.0. Fire extinguishers or sand and water for emergency fire fighting operations shall be provided near storage area at easily accessible place for use, in case of fire.

4.3.0. Warning Boards and signs shall be exhibited around the storage area.

5.0.0. MIXING AND THINNING

5.1.0 Mixing and thinning of paints shall be carried out as per manufacturer's recommendations.

5.2.0 Mixing and thinning operations shall be carried out in well ventilated rooms.

5.3.0 Only that quantity of paint which is sufficient to cover the required area within the specified painting time, shall be mixed at a time.

5.4.0 Mixed paints shall be used with in the time span as recommended by manufacturer. Mixed paints, for which standing time specified has elapsed, shall not be used.

5.5.0 Ready-mixed paints containers shall be opened only at the time of painting. Containers shall be closed air tight after drawing paint from it.

5.6.0 Ready-mixed paints shall be stirred well before drawing from the storage container as well as during painting operations.

5.7.0 Ready-mixed paints shall be thinned only if absolutely necessary by using thinners commended by manufacturer.

5.8.0 Balance of ready-mixed paints shall not be poured back into the main container after use, but shall be kept in a separate air tight container.

6.0.0 PAINTING

6.1.0 General Requirements.

6.1.1 Painting of equipment, piping and structurals shall be carried out at shop or site as prescribed in the respective eqpt. data sheets, piping line schedule or structural detail drawing.

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6.1.2 Painting shall not be carried out on surfaces not prepared and not meeting the requirements of clause 3.0.0.

6.1.3 Painting shall be carried out only under favourable conditions. Painting shall not be carried out in dusty and draught conditions in damp areas and during rainy seasons or cold atmosphere.

6.1.4 During painting, adjacent equipments or surfaces shall be protected from paint sprays, splashes or drips.

6.1.5 Painting shall be carried out only by using brushes, rollers, air/airless spray.

6.1.6 Caution boards indicating 'wet paint' shall be posted after painting is over and kept till the curing time is completed.

6.1.7 For painting of multiple coating, each coat shall be applied only after sufficient curing time has elapsed after the previous coat, as recommended by manufacturer.

6.1.8 All painted surfaces shall have a uniform and smooth regular finish. The surfaces shall be free from foreign particles, brush marks, bristles, ridges, waves, laps wrinkles etc. If such surface defects occur, the same shall be removed by using abrasive paper/cloth and re-painted.

6.1.9 Surfaces inaccessible after assembly shall be painted to requirement before assembly.

6.1.10 Any imperfect or damaged layer/coat shall be repaired before subsequent coating.

6.1.11 At places where welding is to be carried out at field after assembly, a space of 100 to 200 mm width shall be left unpainted on both sides of the welding joint.

6.1.12 Field welded areas shall be thoroughly cleaned as required in clause 3.0.0 and painted in the same manner as the remaining area.

6.2.0 Shop Painting/Priming.

6.2.1 Shop painting/priming shall be carried out as specified in the respective data sheets/line schedule etc. and shall meet all the requirements of this specification.

6.3.0 Painting at Field /Site.

6.3.1 Field/site painting shall be carried out as specified in the data sheets/painting schedule and shall meet all the requirements of this specification for painting.

6.3.2 Where equipments/piping/structures have already received shop painting/priming, the painted/primed surfaces shall be thoroughly cleaned and inspected for any damage or defects. Such damages or defects shall be repaired before starting the filed/site painting.

7.0.0. SAFETY

7.1.0. Sufficient safety precautions shall be taken to ensure protection of Personnel, equipments, piping structures and buildings in the vicinity, where painting materials are stored and painting and blasting operations are carried out.

7.2.0. Open flames and exposed elements or sources of ignition of any kind shall be prohibited in the area where painting materials are stored and painting operations are carried out.

7.3.0. 'Warning' or 'Caution' boards indicating chances of fire shall be displaced around the paint storage and painting areas.

7.4.0 Electrical fittings and appliances shall be spark proof and shall not cause a fire in the painting storage and painting areas.

7.5.0 Cleaning agents with flash point less than 40^0C shall be used.

7.6.0 Adequate ventilation shall be ensured during painting and storage of paints.

7.7.0 Painting workmen shall wear face masks, gloves and protective clothing during painting and mixing operations. In addition, workmen engaged in blasting operations shall be earmuffs also.

7.8.0 Area where painting is carried out, as well as materials are stored shall be clean, After work, the areas shall be cleared of all scaffoldings, balance materials etc. in order to prevent fire hazards and hinder fire fighting operations.

7.9.0 Painting materials shall be stored and painting and blasting operations shall be carried out only in areas where fire fighting equipments/vehicles and personnel evacuation vehicles can have easy access. In areas where such easy access is not available suitable precautions are to be ensured.

8.0.0 INSPECTION

8.1.0. All painting materials and related items shall be inspected to check the suitability of the same for the specified purposes.

8.2.0. Painting surfaces are to be inspected after cleaning operation, to ensure that the surfaces are fit for painting.

8.3.0. Finished surfaces shall be checked for uniformity in colour, finish and appearance as well as for defects.

8.4.0. Thickness of each coat of paint shall be checked after curing time. The total thickness of multiple coats shall be as specified in the data sheets/piping line schedules/painting schedules.

8.5.0. Paint thickness gauge shall be either mechanical or electronic. The gauges

shall be calibrated regularly. Defective gauges shall not be used.

8.6.0. Absence of paint thickness gauge shall not be made for each eqpt/line/structure separately.

8.7.0. A detailed quality / inspection report shall be made for each eqpt / line / structure separately

9.0.0. GUARANTEE

Guarantee shall cover materials and workmanship.

10.0.0. CODIFICATION OF PAINTING MATERIALS

10.1.0. Primers

- A.01 Synthetic Zinc Phosphate Primer
- A.02 Epoxy based Zinc Phosphate Primer
- A.03 Epoxy based Zinc Rich Primer
- A.04 Alkyd High Build Zinc Phosphate Primer
- A.05 Inorganic Zinc Silicate Primer
- A.06 Chlorinated Rubber based High Build Zinc Phosphate Primer

10.2.0. Finish Paints

- B.01 Epoxy Resin based Enamel
- B.02 Epoxy Resin based Micaceous Iron Oxide Paint
- B.03 Epoxy Resin based High Build Paint
- B.04 Coal Tar Epoxy Resin based Paint
- B.05 Chlorinated Rubber Paint

10.3.0. Bituminous Coating

- C.01 Nontoxic Inert Coating for drinking water tanks
- C.02 Acid Alkali and Heat Resisting Coating

10.4.0. Heat Resistant Paints

- D.01 Dual Pack Aluminium Paint (upto 250^{o}C)
- D.02 Single Pack High Temperature Silicon Aluminium Paint (upto 600^{o}C)

10.5.0. Polyurethane Coating. (For low temp. application)

- E.01 Two-Pack Polyurethane Holding Primer
- E.02 High Build Polyurethane Coating

10.6.0. General Purpose Paints

- F.01 Synthetic Resin based Enamel
- F.02 Chemical Resistant Enamel
- F.03 Alkyd, Antiskid Abrasion Resistant Synthetic Floor Paint

10.7.0. Special Applications

- G.01 Bituminous Mastic Coating
- G.02 Asphalt doping as per IS 10987 App-B
- G.03 Thermocolour Paint

10.8.0 As an alternative, in place of one coat of E.01 – Two pack Polyurethane Holding Primer, one coat of Epoxy Zinc Phosphate Primer A02 (20 microns) followed by one coat of High Build Epoxy containing Micaceous Iron oxide-Bo2 (20 microns) shall be applied before applying finish paint E-02-High build Polyurethane coating.

11.0.0 SCHEME OF PAINTING

11.1.0. Scheme of painting of equipment, piping, structures and other items shall conform to class 1, class II or class III as specified in the equipment data sheet/ piping line schedule/ painting schedule/ structural drawings.

11.2.0 Representation of painting

Requirement of painting of an item shall be indicated in respective drawings/ data sheets/ line schedule/ painting schedule as follows. Indicate primer or finish or both as required followed by subclass indicated in Table 1, Table 2 or table 3 as the case may be.

Eg

Primer	Class I	(1)L
Finish	Class I	(1)L
Primer & Finish	Class I	(2)M
Primer	Class II	(2)O
Primer & finish	Class II	(3)O/P
Primer	Class III	(1)
Finish	Class III	(1)
Primer & Finish	Class III	(3)

12.0.0 COLOUR CODING AND MARKING FOR PIPING

12.1.0 In addition to the requirements of painting as per 11.0 the finish painting of the piping shall have the specified colors as per Table 4 – Color coding for pipes, for purposes of identification of service.

12.2.0 All pipes and pipe lines covered under 1.7 shall be provided with “Markings” such as color bands, hazard markings, line identification markings, flow arrow markings etc. at specified locations/intervals and dimensions as indicated in Table 5 – Marking of pipes.

TABLE 1 – CLASS I – Pressure Vessels, Heat Exchangers, Reactors, Towers, Tanks and Piping

Sl. No.	SERVICE CONDITIONS	OPERATING TEMP.	PAINT SUB-CLASS	PRIMER			FINISH		
				Type	No.of coats	*DFT	Type	No.of coats	*DFT
1	UN INSULATED NON CORROSSIVE ATMOSPHERE	=/< 15	(1) L	E.01	1	30	E.02	2	30
		=/< 65	(1) N	A.01	2	20	F.01	2	20
		=/< 125	(1) M	D.01	2	20	D.01	2	20
		=/< 400	(1) H	D.02	2	20	D.02	2	20
2	UN INSULATED CORROSSIVE ATMOSPHERE	=/< 15	(2) L	E.1	1	30	E.02	2	20
		=/< 65	(2) N	A.06	2	20	B.05	2	20
		=/< 125	(2) M	A.02	2	20	B.02	2	20
		=/< 400	(2) H	D.02	2	20	D.02	2	20
3	INSULATED NON CORROSSIVE ATMOSPHERE	=/< 15	(3) L	E.01	1	30	-	-	-
		=/< 65	(3) N	A.04	2	25	-	-	-
		=/< 125	(3) M	D.01	2	20	-	-	-
		=/< 400	(3) H	D.02	2	20	-	-	-
4	INSULATED CORROSSIVE ATMOSPHERE	=/< 15	(4) L	E.01	1	30	-	-	-
		=/< 65	(4) N	A.06	1	30	-	-	-
		=/< 125	(4) M	D.01	1	30	-	-	-
		=/< 400	(4) H	D.02	1	30	-	-	-
5	SUPPORTS FOR ALL EQPTS.(INSULATED/UN INSULATED)	=/< 15	(5) L	E.01	1	30	E.02	2	30
		=/< 65	(5) N	A.01	2	20	F.01	2	20
		=/< 125	(5) M	D.01	2	20	D.01	2	20
		=/< 400	(5) H	D.02	2	20	D.02	2	20
6	EQPT. AND STRUCTRURES SUBJECTED TO SALINE ATMOSPHERE UN INSULATED	=/< 15	(6) L	E.01	1	30	E.02	2	30
		=/< 65	(6) N	A.06	2	20	B.05	2	30
		=/< 125	(6) M	A.02	2	20	B.01	2	30
		=/< 400	(6) H	D.02	2	20	D.02	2	20

***** DFT – Dry film Thickness per coat microns

Notation:

L – Low Temperature
N – Normal Temperature
M – Moderate Temperature
H – High Temperature

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TABLE 2 – CLASS II – OTHER EQUIPMENTS

Sl. No.	TYPE OF ITEM		PAINT SUB CLASS	PRIMER			FINISH		
				Type	No.of coats	*DFT	Type	No.of coats	*DFT
1	Chimneys,Stacks, Furnaces,heaters (fired and unfired)operating Temp upto450^{o}C	Outside	(1)	A.05	2	25	D.02	2	20
2	D.M.Water Storage Tanks	Outside	(2)O	A.01	2	20	F.01	2	25
		Inside	(2)P	A.03	2	35	B.03	2	35
3	Fresh Water/fire Water Storage Tanks	Outside	(3)O	A.01	2	20	F.01	2	25
		Inside	(3)P	A.03	2	35	B.04	2	75
4	Drinking Water Storage Tanks	Outside	(4)O	A.01	2	20	F.01	2	25
		Outside	(4)P	A.01	2	20	C.01	3	20
5	Acid/alkali Storage Tanks	Outside	(5)	A.04	2	30	C.02	3	25
6	Storage Tanks/Vessels for Petroleum Products	Outside	(6)O	A.04	2	50	D.01	2	25
		Inside	(6)P	A.02	2	30	B.03	2	75
7	Floating Roof Tanks:Inside of shell, top of bottom plate,topside and underside of deck, inside of pontoon	Outside	(7)O	A.04	2	50	D.01	2	25
			(7)P	A.02	2	30	B.03	2	75
			(7)Q	A.01	2	25			
8	Underside of Bottom Plate of Tanks		(8)	A.01	1	20	G.01	1	80
9	Underground Tanks (buried)	Outside	(9)	A.01	1	20	G.02		
10	Below Ground (submersible) Tanks	Outside	(10)	A.06	2	35	B.05	3	35
11	Secondary Reformer& Similar Eqpt.(Thermo colour paint)		(11)	G.03	2	**	G.03	1	**

*DFT : Dry Film Thickness per coat microns
** : As per Manufacturer's recommendations
Notation: O- Outside P-Product Side Q-Specified Side

TABLE 3 – CLASS III – MISCELLANEOUS

Sl. No.	TYPE OF ITEM	PAINTING SUB CLASS	PRIMER			FINISH		
			Type	No. of coats	*DFT	Type	No.of coats	*DFT
1	Steel structures, Platform Supports	(1)	A.04	2	20	B.01	2	25
2	Chequered Plate,Floorplanks&Gang ways	(2)	A.04	2	20	F.03	2	25
3	Handrails Posts,Railings,Ladders and Stairways	(3)	A.04	2	20	B.01	2	25

* DFT – Dry Film Thickness per coat microns

TABLE 4 – COLOUR CODING FOR PIPES

Sl. No.	Service	Identification Ground / Finish Colour	Colour Band - 1	Colour Band - 2
1	Instrument Air0	Sky Blue	White	-
2	Service Air	Sky Blue	Light Brown	-
3	Plant Air	Sky Blue	French Blue	-
4	Cooling Water	Sea Green	French Blue	-
5	Service Water	Sea Green	French Blue	Signal Red
6	Demineralised Water	Sea Green	Light Orange	French Blue
7	Boiler Feed Water	Sea Green	-	-
8	Steam Condensate	Sea Green	Light Brown	-
9	Boiler Blow Down	Sea Green	White	Signal red
10	Turbine condensate	Sea Green	White	-
11	Process Condensate	Sea Green	Black	-
12	Low Pressure Steam	Silver Grey	Light Orange	-
13	Medium Pressure Steam	Silver Grey	Light Brown	-
14	High Pressure Steam	Silver Grey	Signal Red	-
15	Very High Pressure Steam	Silver Grey	Signal Red	French Blue
16	Naphta Liquid	Light Brown	French Blue	-
17	Naphta Vapour	Light Brown	French Blue	White
18	Fuel Oil	Light Brown	White	-
19	Antifoam Solution	Black	Sea Green	-
20	Phosphate	Black	Signal Red	-
21	Hydrazinc	Black	Signal Red	Sea Green
22	Waste Water	Black	Sea Green	Signal Red
23	Oily Water	Black	White	-
24	Ammonia Liquid	Dark Violet	French Blue	-
25	Ammonia Water	Dark Violet	French Blue	Sea Green
26	Ammonia gas	Dark Violet	French Blue	Canary Yellow
27	MDEA Solution	Dark Violet	Black	White
28	Process Vent	Canary Yellow	Light Grey	Signal Red
29	Carbondioxide	Canary Yellow	Light Grey	-
30	Hydrogen	Canary Yellow	Signal Red	-
31	Nitrogen	Canary Yellow	Black	-
32	LPG	Canary Yellow	French Blue	-
33	Fuel gas	Canary Yellow	Light Brown	-
34	Process Gas	Canary Yellow	Sea green	-
35	Synthesis Gas	Canary Yellow	White	-
36	Effluent	Black	Sea Green	Signal Red
37	Drinking Water	Sea Green	Light Orange	-

TABLE 5 – MARKING FOR PIPES

1.0.	**GROUND COLOUR**		**UNIT OF MEASUREMENT**
	Insulated Line – all (excludes buried line)		
1.1.	Un-insulated Lines–Stainless Steel,GI ,Alloy steels & Other non-ferrous pipelines (excludes buried line)	: Ground colour for a length of 2 meters	Per Marking as per para 6.0 below including pipe supports
1.2.	Un-insulated carbon steel Lines (excluded buried Lines)	: Ground colour applied throughout entire length	Run length in Meters along centreline including Markings as per Para 6.0 below & pipe supports

2.0. COLOUR BANDS MARKINGS

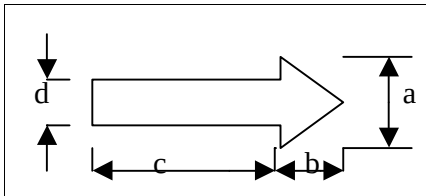
2.1 Colour band(s)and its width,Band 2 downstream of Band 1(ie.after band 1 along the direction of flow)

Pipe size NB (D-pipe size in inches)	Band 1 mm	B and 2 mm
80 NB and below	75	¼ of Band 1 (Rounded to the nearest mm)
Above 80 NB(3”) up to 100 NB(4””)	D x 25	
Above 100 NB(4”) up to 300 NB(12”)	D X 20	
Above 300 NB(12”)	D x 15	

3.0 HAZARD MARKINGS Diagonal strips of Black and golden Yellow as per IS2379 superimposed on the ground color. If color bands exists, the hazard marking shall be painted downstream of the bands (ie. after bands in the direction of flow)

4.0 LINE IDENTIFICATION MARKINGS Color shall be Black or White to contrast with the color on which they are painted. It shall consist of Line No., Line size, Fluid code & Pipeline Spec. No. The lettering dimensions shall be as per IS2379.

5.0 FLOW ARROW MARKINGS Color shall be Black or White to contrast with the color on which they are painted. The dimension of the arrow shall be as follows and is based on the size of the pipeline.



	150NB & below	200NB & above
a	65	90
b	30	50
c	95	125
d	20	30

6.0 LOCATION OF MARKINGS

Marking includes 2M long ground color, color band(s), hazardous marking, Line No. & flow direction arrow which shall be located at the following points with proper visibility as per IS2379.

a. Battery Limit Points
b. Either side of walls & dyke walls
c. For long yard piping – at 30M interval
d. Inter-section on pipe bridge
e. Any other location indicated by the Engineer-in-charge at site

7.0 PIPE SUPPORTS

7.1 This includes base springs, hanger springs, shoes and trunnions etc. and excludes pipe bridge structures, platform, equipment support structures and such structures which do not actually support the pipeline.

7.2 The painting of pipe supports forms part of the pipelines and a separate rate will not operate.

7.3 The painting specification for pipe supports shall be same as that for pipe ground colour.

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CONTENTS

1.1.0 SCOPE

1.1.1 This specification covers the requirement for the supply and application of external thermal insulation to equipments and piping for hot service conditions.

1.2.0 REQUIREMENT OF INSULATION

Requirement of insulation for any item shall be as specified in any of the following documents.

a. Equipment data sheet
b. Piping line schedule
c. Design basis for package items
d Insulation schedule

1.3.0 PURPOSE OF INSULATION

1.3.1 The insulation described in this specification is for the following purposes:

a. Maintenance of process temperatures.
b. Conservation of energy when a loss of heat is not desired.
c. Protection of personnel from heat.
d. Noise control.

1.3.2 Insulation for process reasons shall be as in the documents referred to in 1.2.0.

1.3.3 Insulation for conservation of heat energy shall be applied for all equipments operating above 80 deg.C.

1.3.4 Insulation for personnel protection shall be provided for areas of equipments and surfaces where there is a chance of human occupation and the surface temperature is above 60 deg.C.

1.3.5 Insulation for noise control shall be provided for items as specified in the respective eqpt. data sheet.

1.4.0 LIMIT OF APPLICATION

1.4.1 The following items shall not be insulated, unless otherwise specified.

a. Valves including safety valves and their flanges in hot process lines.
b. Special items like filters, strainers etc.
c. Body flanges on exchangers. Wherever it is not possible to exclude the. flanges for some channel construction, the flanges shall be insulated along with the channel but with removable box as approved by Engineer in Charge.
d. Steam traps and trap discharge lines to atmosphere.
e. Flanges and covers of manholes / hand-holes.
f. Drain and vent piping on insulated equipment and piping from downstream of the first block valve.
g. Nameplates and data plates.

1.4.2 Insulation for personnel protection shall be applied to a minimum 2 metres above and 0.3 metres horizontally from any operating walkway or platform. The method of application is the same as for heat insulation.

1.4.3 2 mm DIA. x 50 mm Sq wire mesh may be provided at a distance of 50mm away from the vessel surface with 6mm dia support rods (at800mm square pitch) instead of insulation as personnel protection, if so specified in the eqpt. data sheet or as approved by the FEDO site engineer.

1.4.4 Seal vent chambers and drip pots in pipelines shall be insulated to protect against solidification of high viscosity materials. Drain and vent lines in insulated lines shall be insulated up to the first block valve.

2.0.0 INSULATION MATERIALS

The material of insulation for individual items shall be as specified in the

respective eqpt. data sheet or insulation schedule. For package items the following guidelines shall be used for selecting the material.

2.1.0 MINERAL WOOL INSULATION

The mineral wool material to be used for insulation of pipes, vessels, heat exchangers, equipment, etc. shall be in the form of preformed pipe sections or mattresses subject to the limitations described below.

2.1.1 Pipes and Fittings

Preformed resin bonded pipe sections up to 350 NB size and for sizes above 350 NB, factory made, machine laid and machine stitched, lightly resin bonded or unbonded mattresses shall be used.

2.1.2 Vessels and Equipment

Preformed resin bonded pipe sections upto 350 NB size and for sizes above 350 NB. factory made, machine laid and machine stitched, lightly resin bonded or unbonded mattresses shall be used.

2.1.3 Insulated surfaces subjected to Foot Traffic

Preformed resin bonded pipe sections with craft paper jacketing shall be used for piping and equipment surfaces where there is chance of foot traffic.

2.2.0 MATERIAL SPECIFICATION FOR MINERAL WOOL

2.2.1 Unbonded mineral wool mattresses shall be in accordance with IS 3677 Type 2 or ASTM 592 Type 2.

2.2.2 Lightly resin bonded mineral wool mattresses shall meet the requirements of IS 8183. The amount of resin added shall be between 1% to 3% by weight.

2.2.3 Preformed pipe sections shall conform to the requirements given in ASTM C.547.

2.2.4 The insulation material shall be made from rock or slag processed from molten state into fibrous form. The fibres shall be ductile, tough, non-hygyroscopic and extremely fine with fibre diameter varying from 3 to 5 microns. There shall be no settling of the fibres over an extended period of use.

2.2.5 The applied density of mineral wool shall be as given below:

a. Operating temperatures from 250 °C to 500 °C

Machine made and machine stitched unbonded mineral wool mattresses	120 kg/m3
Machine made and machine Stitched lightly resin bonded mineral wool mattresses and preformed pipe sections	100 g/m3

b. Operating temperatures from 501 to 700 °C

Machine made and machine stitched unbounded mineral wool mattresses	200 kg/m3

c. Piping subjected to foot traffic/insulation on the roof of Storage Tanks

Preformed resin bonded pipe sections/slabs	150 kg/m3

2.2.6 Thermal Conductivity

a. Thermal conductivity of unbonded mineral wool mattresses of densities 120 kg/m^3 and 200 kg/m^3 shall be in accordance with IS 3677 and determined in accordance with IS 3346.

b. Thermal conductivity of lightly resin bonded mineral wool and preformed resin bonded pipe sections of densities 100 kg/m^3 shall be in accordance with Group 3 and Group 4 respectively of IS 8183.

c. The thermal conductivity shall be furnished at mean test temperature ranging from 50 deg C to 400 deg C in

steps of 50/100 deg C at different applied densities.

2.2.7 Noncombustibility

a. The insulation material shall be rated as non-combustible and shall be tested in accordance with IS 3677 & IS 8183 or IS 3114 as applicable.

a. The shot content, sulphur content, moisture content and moisture absorption of unbonded mineral wool mattresses as well as lightly resin bonded mineral mattresses and preformed pipe sections shall be in accordance with IS 3677 and IS 8183 respectively.

c. The finished mineral wool mattresses or pipe, sections shall not contain more than 10 ppm of leachable chlorides.

d. The insulation material shall be chemically inert and shall not decay during storage and shall be vermin proof. The insulation material shall retain their form under ordinary handling conditions.

e. The mineral wool (bonded and unbonded mattresses shall be of uniform density and thickness. The mattresses shall then be machine stitched along with the backing of specified wire netting. For double and multi layer insulation, the second and subsequent layer blankets shall have only one side wire netting. The lightly resin bonded mineral wool mattresses shall have wire netting on one side only.

2.3.0 CALCIUM SILICATE BLOCKS

2.3.1 Calcium silicate blocks shall be used for high temperature insulation on vessels and piping as specified in the eqpt. data sheet or insulation schedule.

2.3.2 Calcium silicate blocks shall conform to ASTM C-5S2Type1.

3.0.0 ANCILLARY MATERIALS

3.1.0 WIRE NETTING

3.1.1 Wire netting of machine-stitched mattresses shall be by Gl 20mm x 24 SWG. Lacing and stitching wires shall be 20 SWG and 22 SWG, Gl wire respectively.

3.1.2 For stainless steel piping, vessels, eqpt. etc.only stainless steel wire netting, stitching and lacing wires of the gauge described above shall be used. For multilayer insulation, the first layer of insulation shall have only stainless steel wire netting stitched and laced with stainless steel wire. Subsequent layers of insulation may employ Gl wire netting, stitching and lacing wires.

3.2.0 ALUMINIUM BANDS

3.2.1 Aluminium bands used for securing the insulation material on vessels/eqpt. Shall be of dimensions 20mm width and 24 SWG.

3.3.0 SELF TAPPING SCREWS

3.3.1 Self-tapping screws to be used with aluminium sheeting shall be 6 mm dia. cadmium plated or galvanized of best quality.

3.4.0 METAL CLADDING

3.4.1 Commercial quality aluminium jacketing in accordance with IS 737 shall be used for all piping, vessel and equipment. The thickness of cladding sheets shall be as given below:

Item	Size (mm) Or Dia	Type of aluminium sheeting	
		Vertical	Other portions
Equipment	</= 350 mm > 350 mm	24 SWG plain 22 SWG Corrugated	24 SWG plain 22 SWG plain
Tanks		22 SWG Corrugated	22 SWG plain for roof and other parts
Piping	</= 350 NB > 350 NB	24 SWG plain 22 SWG plain	24 SWG plain 22 SWG plain
Valves, flanges etc.		22 SWG plain	22 SWG plain

3.4.2 The metal cladding shall be bent true to shape, grooved and properly screwed on.

3.4.3 Corrugated metal cladding used for the vertical shells of the equipment shall be 10/75 General-purpose corrugated aluminium sheet of 22 SWG, in accordance with IS 1254.

3.5.0 SEALING COMPOUND

3.5.1 To ensure perfect waterproofing, sheet metal joints shall be packed with sealing materials which may either be in the form of bituminous mastic sealing compound or fibre based bituminous felt strips.

3.5.2 Sealing compound shall be suitable to withstand the temperature of insulation to seal the joints.

3.6.0 BITUMINOUS MASTIC

Bituminous mastic to be applied as a weatherproof coating shall be an emulsified bitumen product containing asbestos fibres. It shall give a joint less surface over the insulation and prevent ingress of moisture into it.

3.7.0 SPACER RINGS

3.7.1 Spacer rings shall be provided with mattress insulation to provide framework on which metal sheeting for protecting the insulation, is cladded. These rings shall be fabricated from 25 x 3 mm CS flats. The outside dia of these rings shall be equivalent to the diameter of the pipes/vessels measured over the insulation. Spacer rings are not required when insulation in the form of preformed pipe sections is used.

3.7.2 Spacer rings shall be provided with 'Z shaped stays fabricated from same size CS flats. Stays shall be provided at intervals of not more than 300 mm along the circumference of the insulation, subject to a minimum of 3 stays. Spacer rings shall be provided on the pipes at a pitch of not more than 900 mm.

3.7.3 A packing of 2 sheets of 3 mm thick asbestos mill board shall be provided at the joints of the stays and pipes, while the joints of stays and MS rings shall be riveted by 6 mm dia CS rivets with 2 sheets of 3 mm thick asbestos mill board in between.

3.7.4 On piping - 150 NB and above - vessels and equipment. 10 SWG GI wire rings shall be tightly tied circumferentially at 300 mm longitudinal pitch and 18 SWG Gl wire loop shall then be secured at 300 mm circumferential pitch to these rings. After placement of blankets in position, the 18 SWG wire shall be drawn out from the blankets and its ends tightly tied together. For pipe sections, this is not required.

3.8.0 HARD SETTING PLASTER

3.8.1 Hard setting plaster mixture of sand and cement/asbestos and cement shall be applied over wire netting on piping subjected to foot traffic.

3.9.0 BITUMINISED SELF FINISHING ROOFING FELT

3.9.1 Bituminised self-finishing roofing felt shall conform to IS 1322. type 3 grade 1.

3.10.0 ALUMINIUM FOIL

3.10.1 Aluminium foil used for wrapping stainless steel surfaces shall be of 0.1 mm thick and without any puncture or pinholes.

4.0.0 INSULATION THICKNESS

4.1.0 Insulation thickness shall be as specified in the equipment data sheets / piping line schedule / insulation schedule.

4.1.1 If insulation schedule/eqpt data sheet/piping schedule does not indicate insulation thickness and is required for personnel protection, it shall be as per Table 2 and as approved by the Engineer In Charge.

4.1.2 For package items, the insulation thickness tables 1 & 2 may be used as guidance for selecting the minimum thickness of insulation required. However the vendor shall check the same for process adequacy.

5.0.0 APPLICATION

5.1.0 GENERAL

5.1.1 The surfaces to be insulated shall be thoroughly cleaned by wire brushing to remove dirt and loose scale. However, if painting is required before application of insulation due to specific reasons, the painting as done is retained before laying the insulation. In such cases no harsh cleaning shall be done on surfaces, so that painting remains undisturbed.

5.1.2 Individual vessel and tank drawings indicate the location of insulation supports. However, the insulation contractor shall recommend, furnish and install, with the approval of Engineer concerned, any additional supports and anchorage that may be required to adequately support the insulation. The field welding of clips and other additional insulation supports shall be carried out only with the prior approval of the Engineer concerned.

5.1.3 All insulation materials to be used for insulation, fixing and protection shall be new and unused and shall be free from asbestos and starch. All insulating materials shall be non-corrosive to the surfaces insulated.

5.1.4 Insulation materials shall be protected against the weather at all times from delivery to finish cladding, and the materials shall at no time be stocked directly on the ground. Insulation materials shall be stored in covered storage as directed by the Engineer concerned. Insulation material showing any evidence of moisture shall not be used.

5.1.5 If insulation work proceeds in advance of hydrostatic testing and inspection, welded and mechanical joints shall be left uninsulated for a length of at least 300mm on either side and such joints shall be insulated after the testing and inspection is over. The insulation of flanges shall not be done until pipelines and/or vessels have reached the operating temperature and the flanged joints have been proved to be leak tight.

5.2.0 MULTILAYER INSULATION

5.2.1 When insulation thickness exceeds 75 mm, the insulation shall be applied in multilayer with all joints staggered. Each layer shall be secured with metallic bands. Number of layers to be employed shall be determined as given below.

Insulation thickness (mm)	No. of layers
</= 75	1
76 to 150	2
> 150	3

5.2.2 Filling

All Cracks and voids in the insulation shall be completely packed with loose mineral wool.

5.3.0 EXPANSION JOINTS

5.3.1 When expansion of pipe or vessel is required without producing random cracking of insulation, expansion joints shall be provided in the insulation. Expansion of insulation and covering can be neglected. The following steps shall be taken while providing the expansion joints.

a. Joints in insulation shall be staggered.

b. Expansion joints in horizontal vessel insulation shall be close to fixed support saddles.

c. At the expansion joint, there shall be a complete cut through of the insulation.

d. The cut out insulation shall be at least 25 mm wide and dry filled with loose insulation and its density shall be equal to that of the blanket.

e. Expansion joints shall be as per Fig 5 & 6. In case of vertical piping, the upper insulation sheeting shall be overlapped over the lower metal sheeting to allow shedding of rainwater.

5.4.0 INSULATION OF STAINLESS STEEL ITEMS

5.4.1 To avoid stress corrosion cracking of stainless steel, mineral wool insulation shall never come in contact with stainless steel surfaces.

5 4.2 For operating temperatures up to 500 deg. C. The stainless steel surfaces shall be wrapped with 0.1 mm thick aluminium foil with 50 mm overlap at longitudinal and circumferential joints before application of the insulation. All joints of the aluminium foil shall have Barium Chromate primer interposed.

5.4.3 Aluminium foil shall be firmly secured on to the stainless steel surfaces by 20mm x 24G aluminium pads at a pitch of 450mm.

5.4.4 For operating temperatures from 501 deg.C to 600 deg.C. the stainless steel surfaces shall be painted with two coats of heat resistant paint before application of insulation. Heat resistant paint shall be single pack, silicone resin based with aluminium flakes as pigment. 2 coats of such paint with a minimum of 20 microns per coat shall be applied on the surface in accordance with paint manufacturer's recommendation to obtain a defect free surface.

5.5.0 VERTICAL VESSELS

5.5.1 Insulation mattresses shall rest on the supports with joints tightly butted and laced together with lacing wire. In addition, mattresses shall be secured with tightly tensioned circumferential bands at approximately 450 mm pitch.

5.5.2 Where more than one layer is used, each layer shall be separately banded with the bands of successive layers not coinciding with each other. All mattress joints shall be staggered.

5.5.3 Top Heads

The mattresses shall be properly shaped and tightly wrapped on the top head. The blankets shall be held in position by

lacing them with 20 SWG GI wire to 2 or 3 loops of 10 SWG wire around the nozzle. Another ring shall be formed at

the nozzle with 25 mm x 1.5 mm aluminium band and same size aluminium bands shall be stretched between this ring and the first spacer ring on the shell after the tangent line as shown in Fig 1. Wire loops shall not be installed if no nozzle exists at the apex of the top head. The joints between adjacent mattresses shall be tightly butted and the edges of the wire mesh shall be tightly laced in.

5.5.4 Bottom Heads

In all skirt supported vessels insulation supports are provided inside the skirt. Floating rings or wire loops around the nozzle and bands may be used to support downward face of the insulation. Such a floating ring may be supported from the lagging support ring fixed inside the skirt. Blanket shall be shaped and secured onto the head by means of bands stretched across the floating ring and insulation support rings. The insulation shall be covered with galvanized wire netting firmly laced together and secured in place. Insulation details shall be as per Fig 15. All wire ends shall be cut short and turned into the insulation.

5.6.0 HORIZONTAL VESSELS

5.6.1 The mattresses shall be wrapped round the vessels and held in close contact with the faces to be insulated by tensioned bands at approximately 600 mm pitch.

5.6.2 Where more than one layer is required, each layer shall be banded separately. The bands for successive layers shall not coincide with each other. In any case, joints between adjacent blankets shall be closely butted and the edges of wire mesh shall be laced with lacing wire.

5.7.0 METAL CLADDING

5.7.1 The insulation shall be covered with aluminium cladding as indicated in this specification. All joints shall have minimum 50 mm overlap arranged in such a way as to shed water. Joints shall be offset between pieces.

5.7.2 Flat aluminium cladding

The metal sheeting shall be secured to the spacer rings and to itself by self tapping screws at a pitch of 150 mm. Jacketing for dished heads shall be fabricated in form with the radial overlapped joint (with adequate overlap) secured by self tapping screws spaced at 150mm pitch. Suitable metal bands shall be provided wherever screws are not possible as approved by Engineer concerned. The ends shall be secured to the vessel sheeting (Cylindrical shell) by circumferentially tensioned bands and reinforced by self-tapping screws set at 150 mm pitch.

5.7.3 Corrugated aluminium cladding

Corrugated aluminium sheeting shall. be adequately rolled and installed with corrugations parallel to the axis of the vessel and shall be secured to the insulation supports available on the vessel or they shall be secured to themselves and rings provided by the contractor by self tapping screws at a pitch not exceeding 150mm. All individual sheets shall be overlapped by at least 50mm on longitudinal joints and 1½ corrugations on circumferential joints, to shed water, wherever possible. Where it is not possible, suitable metal cladding shall be provided as approved by Engg. in Charge. Joints shall be offset between the adjacent pieces as given in Fig 26.

5.7.4 Top Heads

Insulation shall be covered with flat aluminium jacket fabricated in segmental form with lapped joints

secured by self-tapping screws set at a pitch of 150 mm. The ends shall be secured to the vessel sheeting by a tightly tensioned circumferential band and reinforced by self tapping screws at 150 mm. Aluminium sheet shall be secured by self tapping screws with aluminium straps underneath the cladding and over the mattress on head as shown in Fig 1, 2 & 3.

5.7.5 Bottom Head

Flat aluminium sheeting shall be used for weatherproofing and they shall be installed exactly in the same manner as indicated for top head. When removable covers are required they shall be fabricated with lapped joint secured by screws. No heavy gauge angles shall be used and they shall be of the push on type secured with quick release toggles.

5.7.6 Openings

Openings in metal jacket for nozzles, manholes, brackets, etc. shall be cut as close as possible for a snug fit.

5.7.7 Flashing

All openings through insulation finish shall be flashed weather tight by an approved sealant, particularly where connections are not insulated. Flashing shall be carried out as per detail given in Fig 20. Skirt supported vessels shall have the skirt insulated inside and outside for at least 600 mm below the tangent line. Unless otherwise specified, no insulation shall be applied to the inside of skirts that will be externally fire proofed. For leg supported vessels, continue the leg insulation to a length of minimum of 5 times the thickness of the insulation.

5.8.0 SPHERICAL VESSELS

5.8.1 For spherical vessels to be hot insulated, the details of support shall generally conform to FEDO Engineering Specification 02DS012.The size of floating angle iron rings shall however, be matching the insulation thickness. Extra supports, if required, shall be provided by insulation contractor with prior approval of Engineer concerned.

5.8.2 The insulation mattresses shall be properly shaped and lightly wrapped on spheres**.** The adjacent mattresses shall be tightly butted against each other and the edges of wire mesh shall be tightly laced in. The blanket shall be held in position by lacing with GI wire mesh and bands. The insulation shall be covered with minimum sheet cladding.

5.8.3 Where the spheres are located in coastal or high wind velocity areas, aluminium bands 20 SWG x 25 mm shall be provided between the two floating rings of top and bottom. These bands shall be so spread as to fall around the middle of each sheeting panel.

5.8.4 The contractor shall furnish the schematic drgs. showing various insulation details for approval of the Engg: in charge before commencement of any insulation work on spherical vessels.

5.9.0 HEAT EXCHANGER INSULATION

5.9.1 Exchanger shell with size above 350NB shall be insulated with insulation mattresses as specified for vessels and covered with flat aluminium sheet secured with screws. Sizes below 350 NB shall be provided with preformed pipe coverings.

5.9.2 Exchanger channels and channel covers shall be insulated with removable aluminium covers lined with mineral wool mattresses. Flange bolting shall be left uninsulated unless otherwise specified. Refer Fig 4.

5.10.0 STORAGE TANKS

5.10.1 Tank shell portion

a. Metal surfaces shall be cleaned by wire brushing, to make it free from dust and loose scale.

b. Where insulation angle rings and 40 mm x 4mm vertical flats at 2.5 metres interval are provided by Tank fabricator, the insulation contractor shall provide additional spacer rings at a pitch of not more than 900 mm. These spacer rings shall be tack welded or riveted to vertical flats. No welding shall be permitted on the tank surface.

c. Lightly resin bonded mineral wool mattresses faced with 20 mm x 24 SWG galvanized iron wire netting shall be pressed onto the supporting pins of 8 SWG Gl wire. All joints shall be closely butted as shown in Fig 22, 23 & 24.

d. Over the insulation and CS spacer rings, corrugated aluminium cladding shall be fixed with the help of suitable size pop rivets. Sheet to sheet joints shall also be sealed only with pop rivets and no self-tapping screws shall be used. Circumferential joints need not be riveted.

e. Insulation of manholes shall be carried out in accordance with Fig 25.

5.10.2 Tank Roof

The following steps shall be adopted where angle supports or wire lugs are not provided. Refer Fig 27 & 28.

a. Laying of central and peripheral rings.

b. Welding M5 studs length T + 6 mm (where T=Thickness of insulation) at 300 mm pitch to CS flats (15x6 mm) on ground. The flats shall then be laid on the tank top connecting the central and peripheral rings riveted/welded at both ends.

c. Fix the 15 x 6 mm flat cross stiffeners with welded studs.

d. Fix resin bonded mineral wool slabs of required thickness by pressing on to the studs.

e. Stretch 20 SWG chain link mesh, anchoring it to the CS studs by means of speed washers.

f. Apply approx. 20mm thick hard setting, non-conductive compound made from asbestos fluff and Portland cement trowel led to a smooth and even finish.

g. When hard setting compound is completely dried, apply a standard four course Bitumen felt water proof treatment as per IS 1346.

h. Fix a 'shed water' shroud constructed from 20 SWG galvanized iron plain sheet at the periphery of the tank. This shall be fitted prior to the application of the hard setting compound.

i. Aluminium cladding on rooftop of tanks shall be 22 SWG plain sheet and a minimum of 100 mm overlap shall be provided.

5.11.0 INSPECTION WINDOWS

5.11.1 All the heads shall be provided with one inspection window each.

5.11.2 Minimum two inspection windows shall be provided on the shell side.

5.11.3 One inspection window shall be provided at every platform level.

5.11.4 For storage tanks and spheres, one inspection window shall be provided at each course of the eqpt. and one at the top.

5.11.5 The size of inspection windows shall be 120mm dia. And the position of the window shall be indicated by the Engineer in Charge.

6.0.0 PIPING INSULATION

6.1.0 GENERAL

6.1.1 Refer Fig 18 & 19 for details of piping insulation.

6.1.2 External surfaces of pipes to be insulated shall be cleaned by wire

brushing to remove dirt and loose scale. However if painting is required before application of insulation due to specific reasons, the insulating contractor shall ensure that painting as done by painting contractor is retained before laying the insulation. In such cases, no harsh cleaning shall be done on surfaces, to ensure painting to remain undisturbed.

6.1.3 All pipes and supports shall be permanently set before insulation is started. Disturbed pipes and supports shall be restored to their original location and alignment when insulation is complete. Generally all insulation shall be applied with piping being at ambient temperature.

6.1.4 All piping specified on the piping line schedule to 'be insulated shall be covered with insulation. Inspection plugs to assess corrosion shall be provided as given in this specification or as directed by Engineer in Charge. Spacer rings for supporting the metal sheeting shall be installed by the contractor as in 3.7.0.

6.1.5 Insulation in the form of preformed pipe sections shall be applied over the pipe without the use of spacer rings. When mineral wool mattresses are used, they shall be wrapped around the pipes without any under layer. On top of each layer wire netting shall be applied and tightly butted against each other so that the fibres interlock both along the longitudinal and circumferential joints. The joints shall be stitched with 20 SWG soft galvanized iron wire for pipes up to 150 NB dia. For all pipes over 150 NB, the mattresses shall be further secured with 10 SWG GI wire tightly tied circumferentially at 300 mm intervals. (Ref Fig 13 & 14.)

6.1.6 At uninsulated flanges, insulation shall be stopped off at a suitable distance from the flange so that flange bolts can be withdrawn without disturbing the insulation.

6.1.7 When insulation thickness exceeds 75 mm. The insulation shall be applied in multiple layers with all joints staggered. The application details shall be exactly the same as described in 5.2.0.

6.1.8 In the case of mattress insulation on vertical piping, insulation supports shall be installed by the contractor. These shall consist of spacer rings at 4 metres intervals, clamped to the pipes as shown in Fig 11 & 12. On straight runs of pipe, the insulation shall be tightly wrapped with galvanized wire netting, the ends of which shall be laced together along the longitudinal joints. All wire ends shall be cut short and turned into the insulation.

6.1.9 For pipe sizes below 80 mm NB with higher than 50mm insulation thickness, spacer rings as well as insulation supports, if required, shall be provided by the contractor, on horizontal as well as vertical lines.

6.1.10 Insulation at Pipe Supports

During application of insulation around pipe supports, guides, anchors etc., care shall be taken to ensure that the insulation does not interfere with respective functions. The insulation around such components shall be sealed water tight as in 5.5.7

6.2.0 METAL SHEET FINISH

6.2.1 All pipes shall be covered with the specified sheeting on the outside of the insulation with 25mm circumferential and longitudinal overlaps. The overlapping shall be grooved so as to prevent ingress of water into the insulation. The longitudinal joints shall have single grooves while the circumferential joints shall be arranged at an angle of

30 - 45 deg. from the horizontal so as to shed rainwater. Contractor shall install spacer rings as required for securing the metal cladding. The sheeting shall be secured to themselves by self-tapping screws at a pitch not exceeding 150mm. Sheeting joints need not necessary. occur at spacer rings. In any case securing of sheeting shall be accomplished by the self-tapping screws.

6.3.0 FLANGES AND VALVES

6.3.1 Insulation of flanges and valves shall be provided only when specifically mentioned in the line schedule / insulation schedule-work order. When specified, removable covers shall be provided over all flanges and valves. wherever they are required to be insulated. The insulation shall be performed as per details in Fig 16 & 17. Aluminium sheet boxes filled with mineral wool insulation shall be used. These covers over the valves and flanges shall be fitted with quick release clips.

6.4.0 STEAM TRACED LINES

6.4.1 The lines to be steam traced shall be-indicated in the line list and also shall be shown in layout drawings and isometrics.

6.4.2 When lines are traced with one or more tracers, insulation shall be of sufficient size to house the assembly without distortion or damage to the insulation.

6.4.3 The steam traced line shall first be wrapped with 20 SWG x 20 mm hexagonal mesh GI wire netting so that it passes round the supporting hooks for the tracer line or lines, thus ensuring tracer pipe bearing tightly against the line which is steam traced. This prevents the insulating material from entering the air jacket formed between the insulation and the pipes. The details shall be as per Fig 10.

6.4.4 Application of insulation shall be exactly the same as for the piping described earlier. Expansion bellows and union couplings used in the tracer pipes shall not be insulated. The details shall be as per Fig 7, 8, & 9.

6.4.5 The insulation finish with aluminium sheeting shall also be the same as for pipes described in 6.2.0.

6.4.6 For stainless steel main lines having steam tracer, the method of application and insulation shall be the same as described above, except that an aluminium foil shall be wrapped round the main pipe and tracer pipe as per the procedure described in 5.4.0.

6.5.0 INSULATION OF PIPING WITH FOOT TRAFFIC

6.5.1 Apply mineral wool moulded "snap-on" pipe sections with ends closely butted. The sections are to be held together with 20mm wide hoop iron bands at 300 mm centres.

6.5.2 Wrap bituminised self-finishing roofing felt over the insulation with an overlap of minimum 50mm both on longitudinal and circumferential joints.

6.5.3 The roofing felt shall be secured with 24 SWG x 20 mm mesh galvanized iron wire having netting and all joints laced with 20 SWG bonding wire.

6.5.4 Apply 3 mm thick bituminous emulsion mastic compound for water and weather proofing.

6.5.5 When bitumen emulsion has completely dried, the surfaces shall be painted with bitumen based aluminium paint.

6.6.0 PIPING INSPECTION WINDOWS

6.6.1 Plug type inspection windows shall be provided on all insulated pipelines having diameter 50NB and above.

6.6.2 One inspection window at a distance of every 20 metres of the straight length of pipelines shall be provided.

6.6.3 Inspection windows shall be provided at the bottom, i.e. at 4, 6 or 8 O'clock positions which ever is convenient.

6.6.4 There must be at least one inspection window between bends, which are apart by 10 metres or more.

6.6.5 At least 50 % of the bends shall be provided with inspection windows. In case of critical pipelines more number of bends may be provided with inspection windows at the discretion of the Engineer in Charge.

6.6.6 On piping, inspection windows shall be provided at the bends by removal of the middle segment of the sheet metal covering, which shall be fixed by male grooving to the adjacent segments for easy removal. On the mineral wool lagging a hole of the required dia shall be cut and the same shall be fitted with a removable plug of mineral wool with both side wire netting and laced properly.

6.6.7 The sheet metal of the inspection windows shall be of the same gauge as that of the sheet metal cladding on insulation.

6.6.8 The size of the inspection windows shall be as follows:

Pipe Dia. (NB)	Window Dia (mm)
50	35
80	45
100	75
150	100
200	100
>200	200

7.0.0 MACHINERY ITEMS

In general, mineral wool filled removable (sheet metal) boxes of prefabricated type shall be adopted 2for insulation of machinery items. The contractor shall submit insulation details of individual pieces of equipment depending on the nature of item to be insulated, for the approval of Engineer in Charge.

8.0.0 INSTRUMENTS AND MISCELLANEOUS ITEMS

8.1.0 Drain and vent piping up to the first valve on insulated equipment shall be insulated with similar type of insulation and finish as the equipment to which it is attached.

8.1.1 Steam supply headers, listed in piping schedule, tracer lines used for steam tracing of instruments and steam trap hook-ups shall be insulated with similar type of insulation and finish as the connected piping.

8.1.2 All instruments which are steam traced shall be insulated for heat conservation.

8.1.3 Instrument connections shall be insulated if the lines or eqpts. are insulated. Instrument leads connected to hot insulated line or eqpt. other than steam containing eqpt. and lines, shall be insulated for personnel protection from the take off points to measuring instruments, provided this temperature is above 60 deg.C.

8.1.4 All sample connections and drains on steam lines shall be insulated.

8.1.5 The thickness of insulation for all items mentioned above shall be determined from piping line schedule for corresponding temperature and pipe sizes. Thickness for parts other than those specified shall be as directed by Engineer in Charge.

9.0.0 SAFETY

9.1.0 The insulation contractor shall provide adequate protective appliances like hand gloves, masks, glasses etc. to the workmen carrying out the insulation work, to protect them from insulation fibres.

10.0.0 GUARANTEE

10.1.0 The insulation contractor shall submit authentic test certificates to confirm that the insulation materials offered shall conform to the requirements of this specification and the standards mentioned therein.

10.2.0 All insulation works shall be guaranteed against faulty insulation and ancillary materials and bad workmanship for a period specified in the enquiry/order.

11.0.0 APPLICATION DETAILS

11.1.0 Refer the following details attached to this specification for application of insulation for various parts.

Table1 Equipment and Piping insulation thickness

Table 2 Thickness of insulation for personnel protection

Fiig 1 Vertical vessel - insulation with metal cladding on shell, top and bottom heads

Fig 2 Support for blanket insulation with metal cladding

Fig 3 Clips on heads & inside of skirt for blanket insulation

Fig 4 Insulation of heat exchanger

Fig 5 Expansion joints for blanket insulation

Fig 6 Expansion joint for rigid insulation

Fig 7 Steam tracing single tracer detail

Fig 8 Steam tracing double tracer detail

Fig 9 Steam tracing triple tracer detail

Fig 10 Steam traced pipe

Fig 11 Spacer ring

Fig 12 Insulation support for vertical piping

Fig 13 Elbow insulation

Fig 14 Tee insulation

Fig 15 Bottom head insulation of vessel

Fig 16 Flange insulation

Fig 17 Valve insulation

Fig 18 Single layer insulation for piping

Fig 19 Multilayer insulation for piping

Fig 20 Flashing at nozzles

Fig 21 Uninsulated flange

Fig 22 Tank shell insulation

Fig 23 Wire nails for holding insulation blankets

Fig 24 Support for metal covering of insulation

Fig 25 Manhole insulation

Fig26 Corrugated sheet overlapping

Fig 27 Tank roof insulation

Fig 28 Tank top setting of plaster finish

TABLE –1 EQUIPMENT AND PIPING INSULATION THICKNESS (MM)

NOM DIA (MM) </=	TEMP (°C)													
	20 to 150	151 to 200	201 to 250	251 to 300	301 to 350	351 to 400	401 to 450	451 to 500	501 to 550	551 to 600	601 to 650	651 to 700	701 to 750	751 to 800
50	40	40	50	50	75	75	100	100	100	100	100	100	125	125
80	40	50	65	65	100	100	100	100	100	100	100	125	125	150
100	40	50	65	65	100	100	100	100	100	100	125	125	150	150
150	50	50	75	75	100	100	100	100	125	125	125	125	150	150
250	50	65	75	75	100	100	125	125	125	125	150	150	150	175
300	50	65	100	100	100	100	125	125	150	150	150	150	175	175
350	50	65	100	100	125	125	125	125	150	150	150	150	175	175
400	50	65	100	100	125	125	125	125	150	150	150	150	175	200
500	65	75	100	100	125	125	150	150	150	150	150	150	175	200
750	65	75	100	100	125	125	150	150	150	150	150	175	175	200
900	65	75	100	100	125	125	150	150	150	150	150	175	200	200
> 900	65	75	100	100	125	125	150	150	175	175	175	175	200	200

TABLE – 2 THICKNESS OF INSULATION FOR PERSONNEL PROTECTION (MM)

NOM DIA (MM) </=	TEMP (°C)													
	61 to 150	151 to 200	201 to 250	251 to 300	301 to 350	351 to 400	401 to 450	451 to 500	501 to 550	551 to 600	601 to 650	651 to 700	701 to 750	751 to 800
50	25	25	50	50	65	65	75	75	100	100	100	100	125	125
80	25	25	50	50	65	65	100	100	100	100	100	125	125	150
100	25	25	50	50	65	65	100	100	100	100	125	125	125	150
150	25	40	50	50	75	75	100	100	100	100	125	125	150	150
300	25	40	50	50	75	75	100	100	125	125	125	150	175	175
350	25	40	50	50	75	75	100	100	125	125	150	150	175	175
400	25	40	65	65	75	75	125	125	125	125	150	150	175	200
500	25	40	65	65	100	100	125	125	125	125	150	150	175	200
750	25	40	65	65	100	100	125	125	125	125	150	175	175	200
> 900	25	40	65	65	100	100	125	125	150	150	150	175	200	200

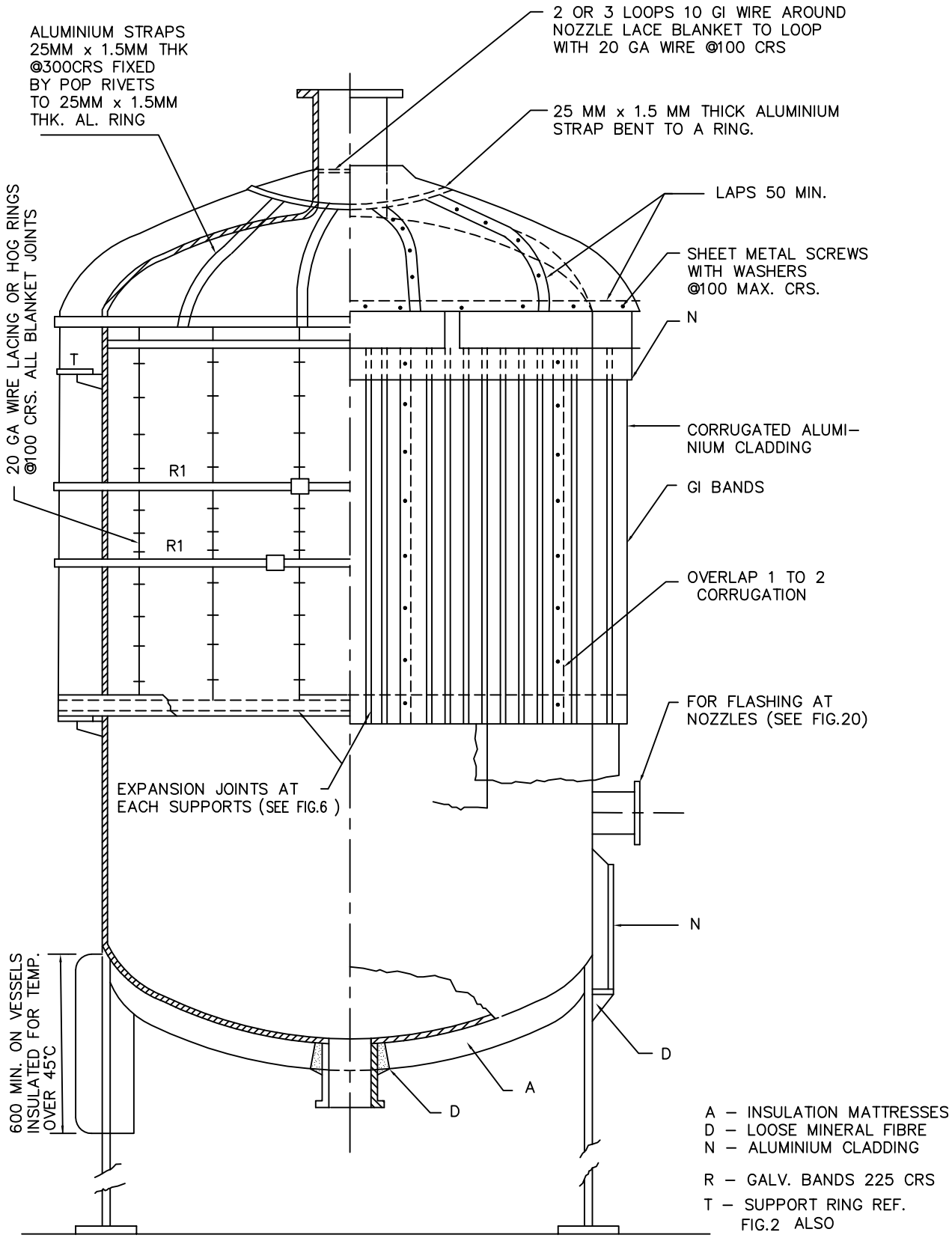
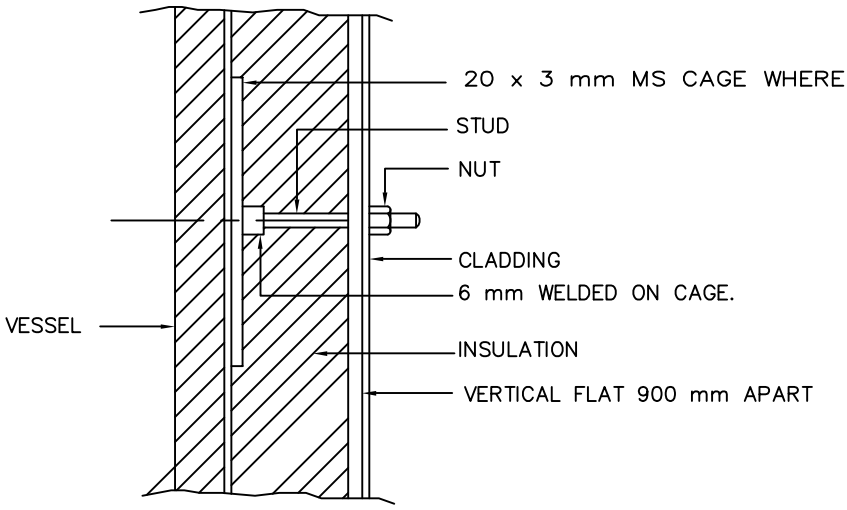
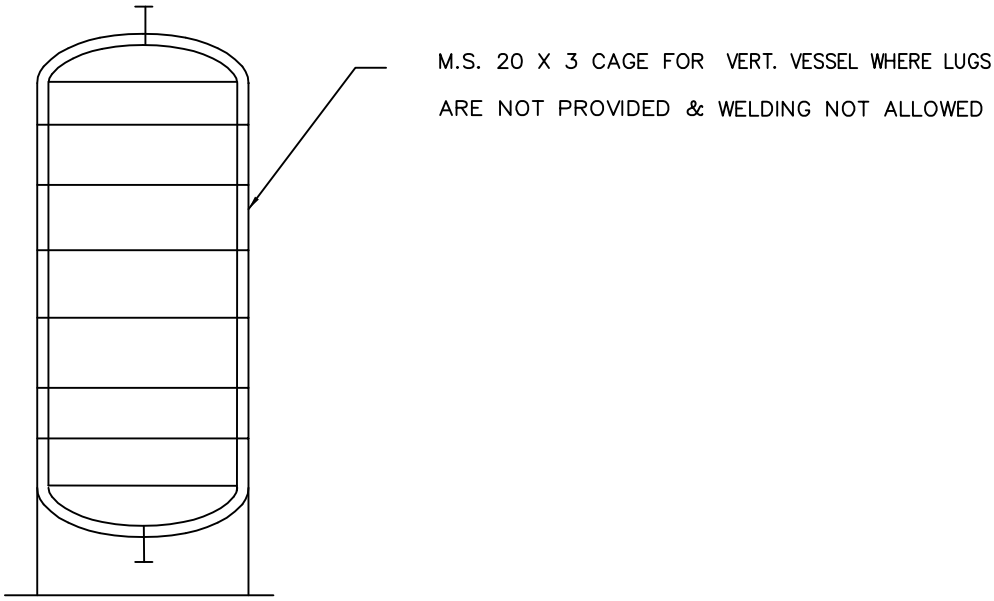


FIG. 1– INSULATION OF VERTICAL VESSELS





NOTE

THE BOTTOM OF ANY ANGLE RING SHOULD CLEAR THE TOP OF ANY NOZZLE" OR OTHER PROJECTION BY ABOUT 150 MM ADD SPACING MAY BE USED TO ACCOMPLISH THIS

FIG. – 2 SUPPORTS FOR BLANKET INSULATION WITH METAL CLADDING

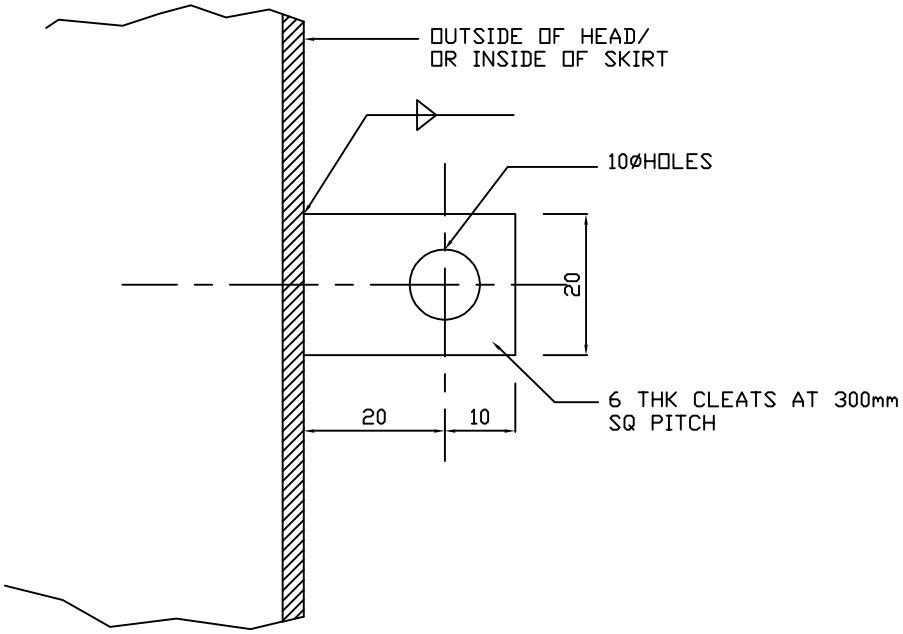


FIG. 3 - CLIPS ON HEADS AND INSIDE OF SKIRT FOR BLANKET INSULATION.

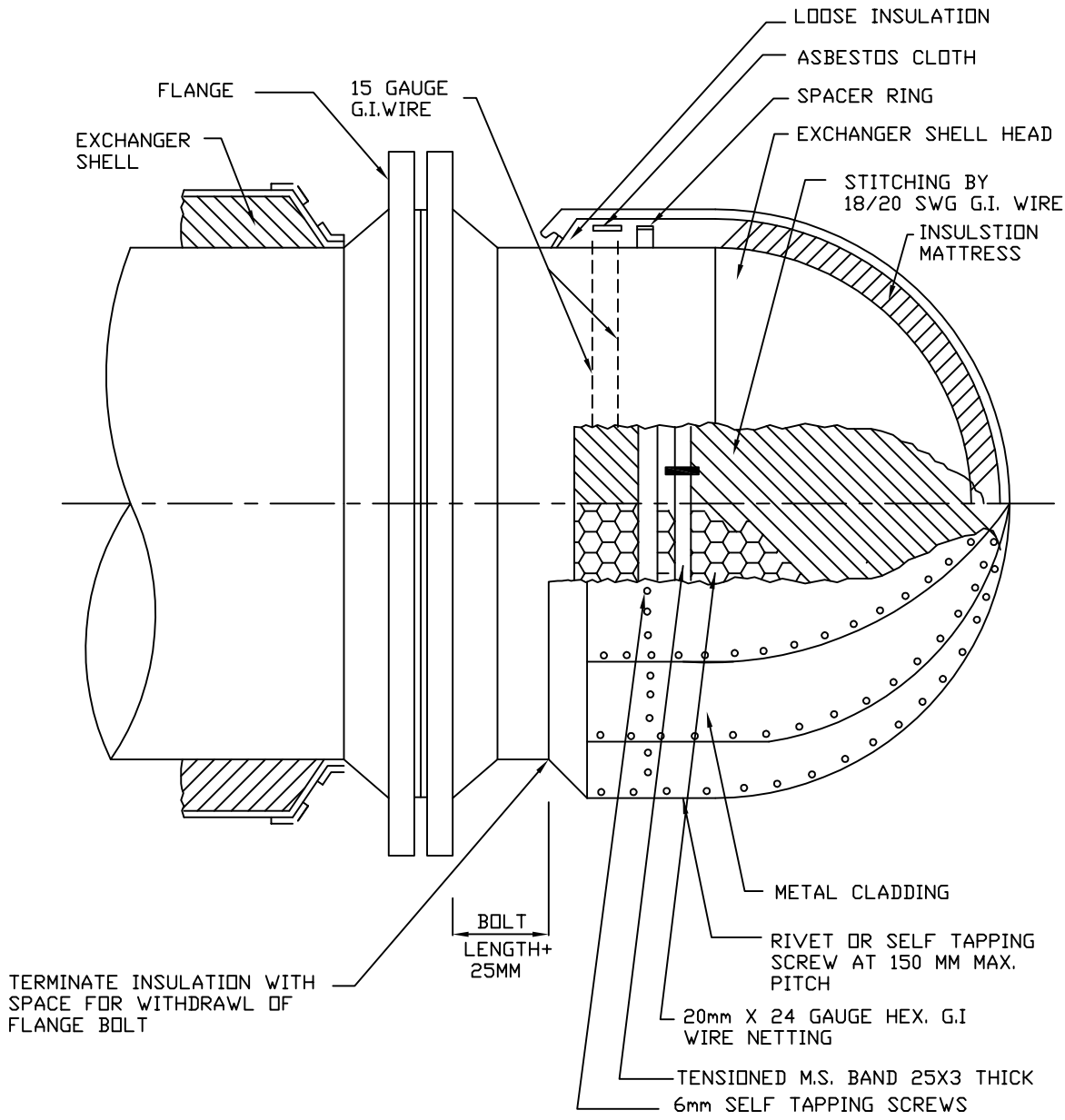


FIG.4 - INSULATION OF EXCHANGER SHELL & HEAD

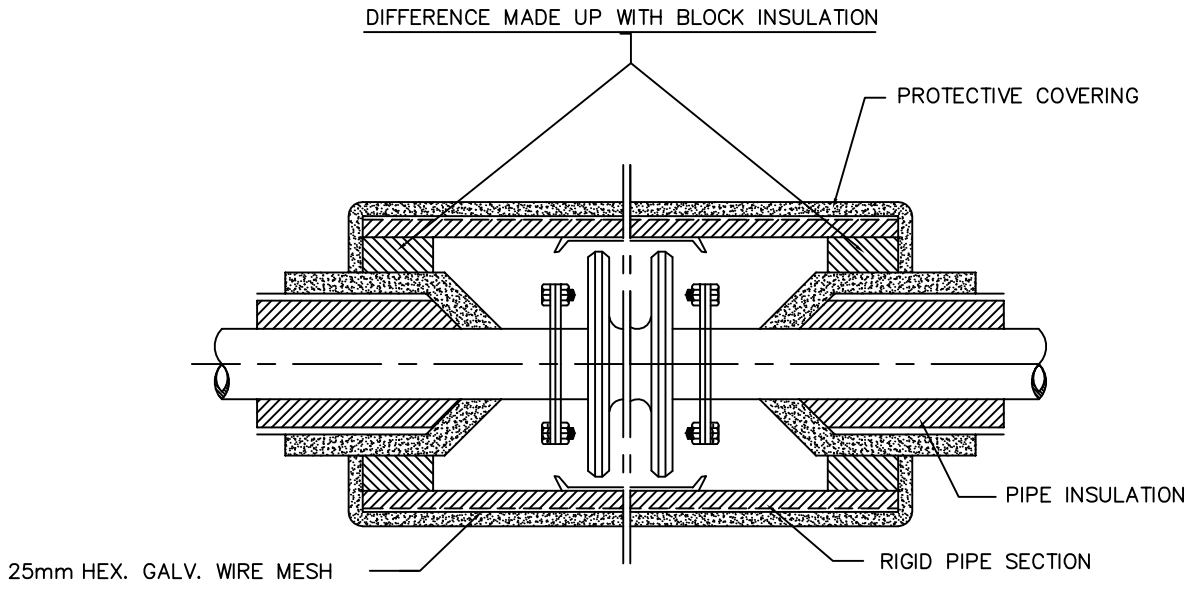


FIG.5 – EXPANSION JOINTS FOR BLANKET INSULATION

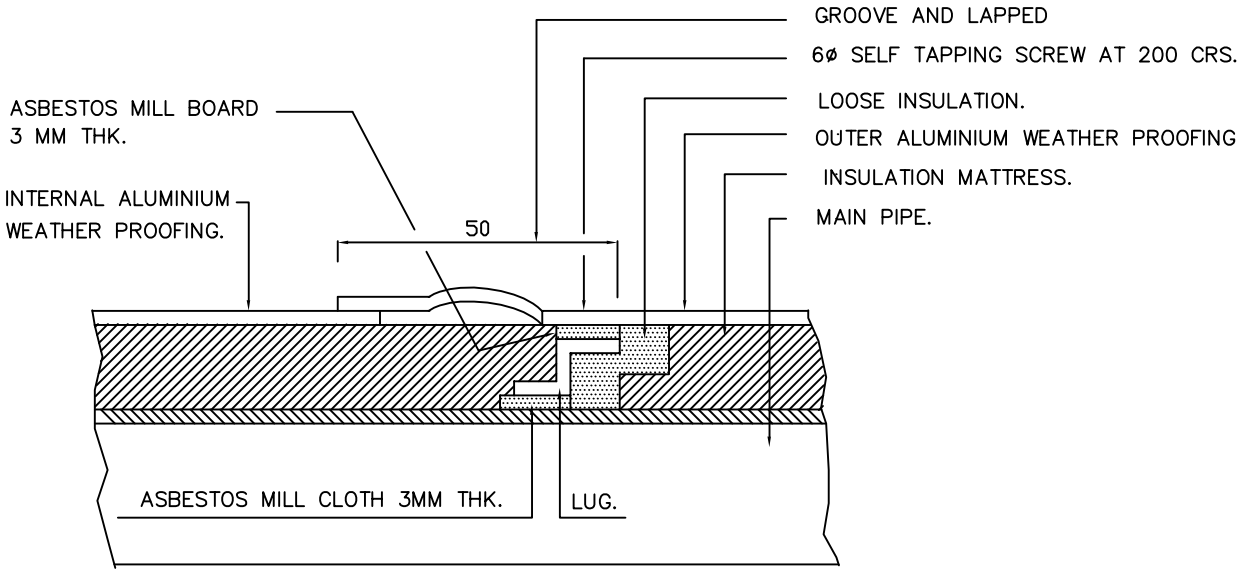


FIG.6 – EXPANSION JOINT FOR RIGID INSULATION.

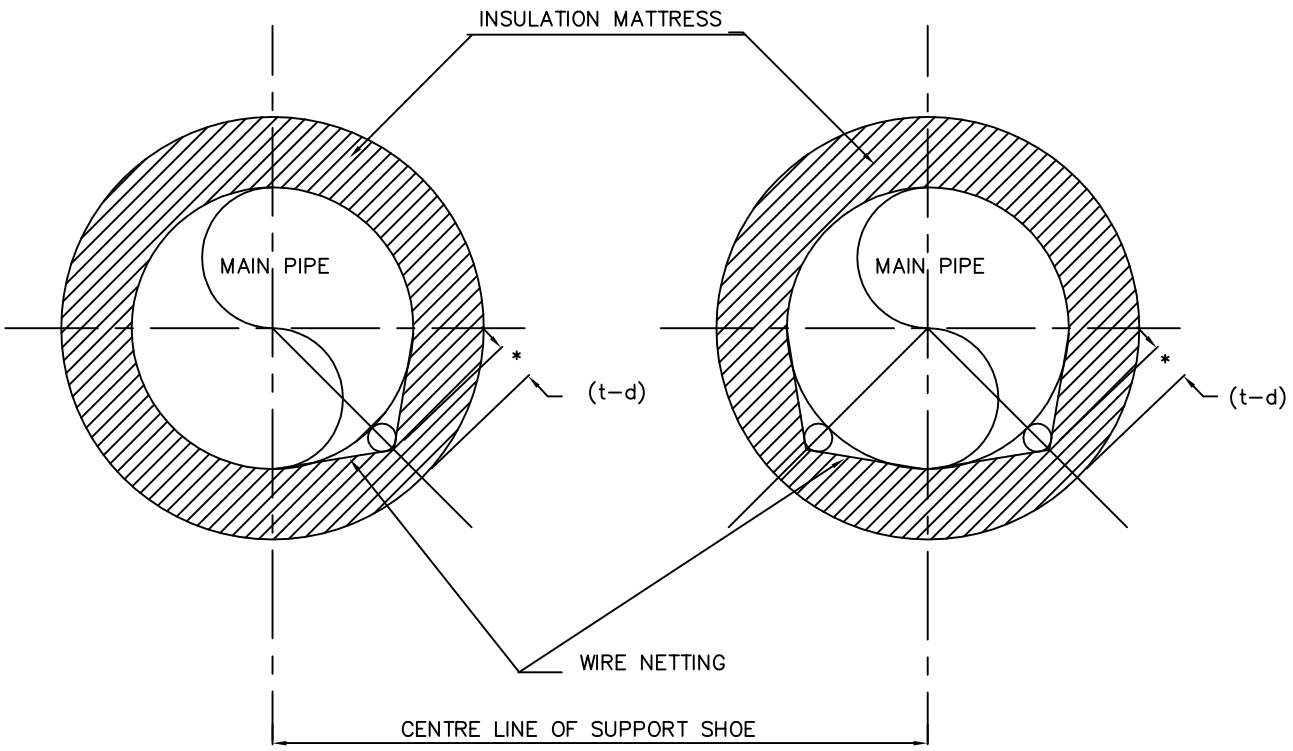
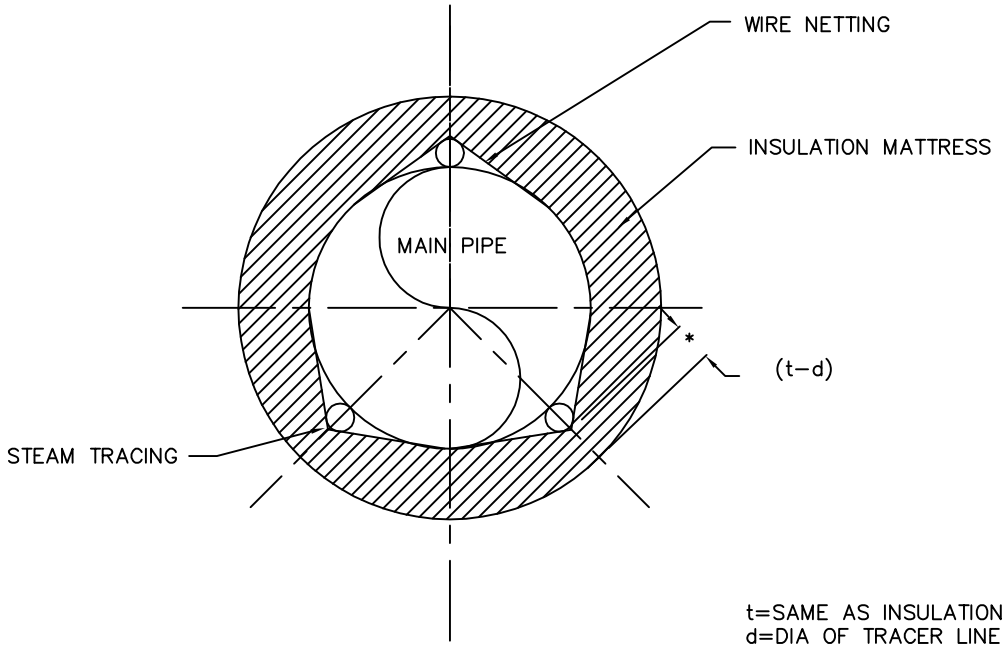


FIG.7 – SINGLE TRACER DETAIL

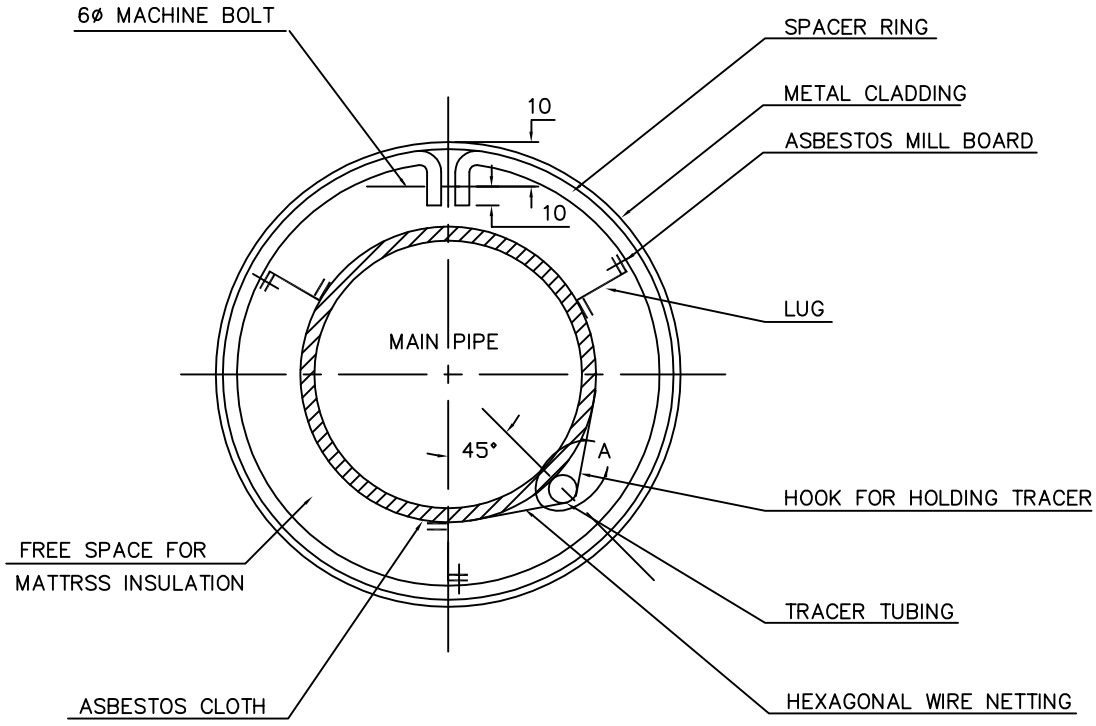
FIG.8 – DOUBLE TRACER DETAIL

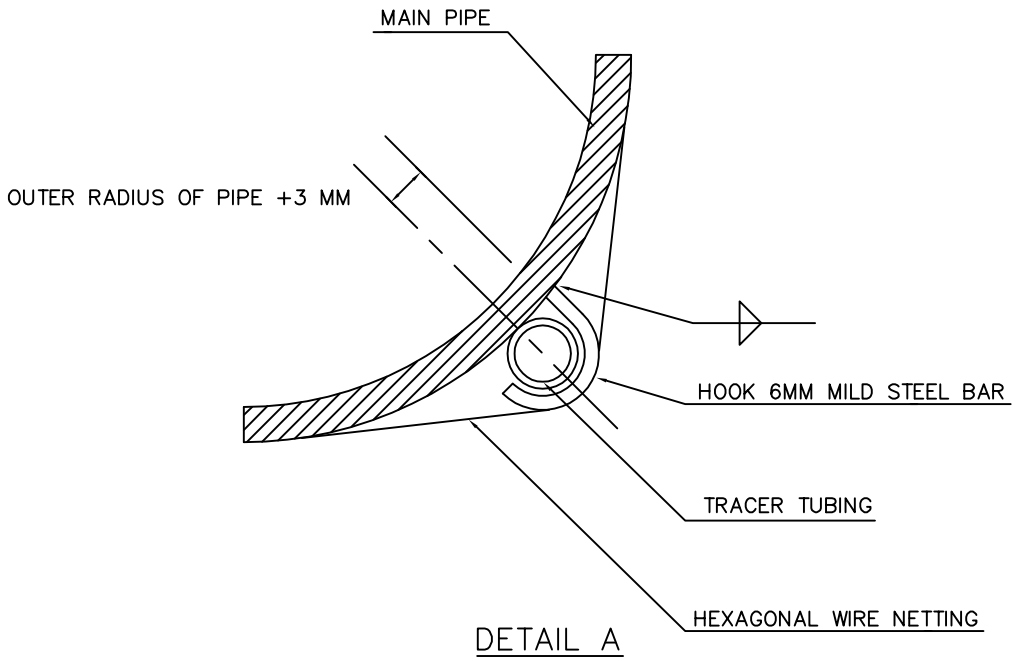


t=SAME AS INSULATION THICKNESS
d=DIA OF TRACER LINE

FIG.9 - TRIPLE TRACER DETAIL

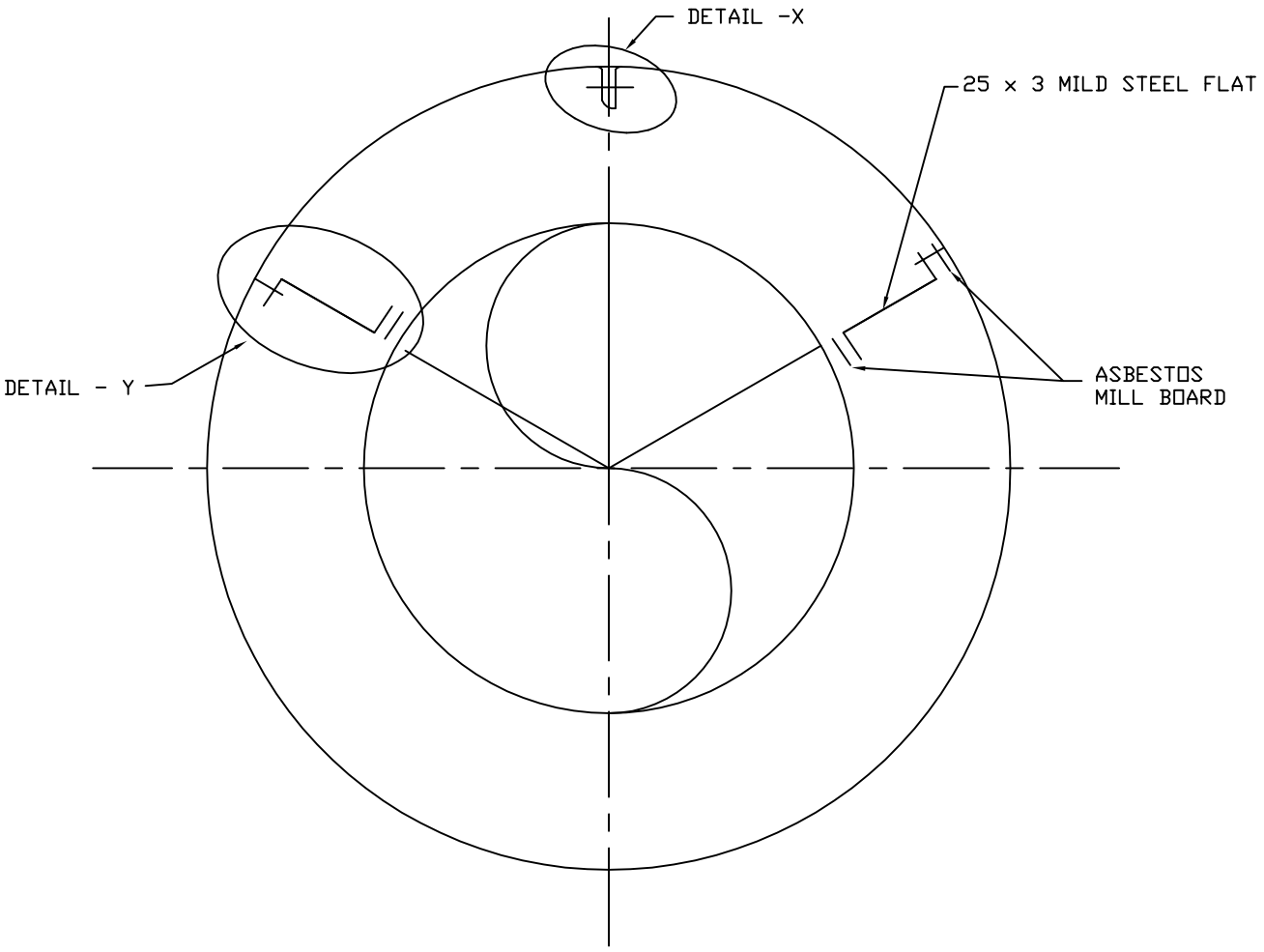
NOTE: * INSULATION SHALL BE COMPRESSED TO RETAIN CLADDING SHAPE

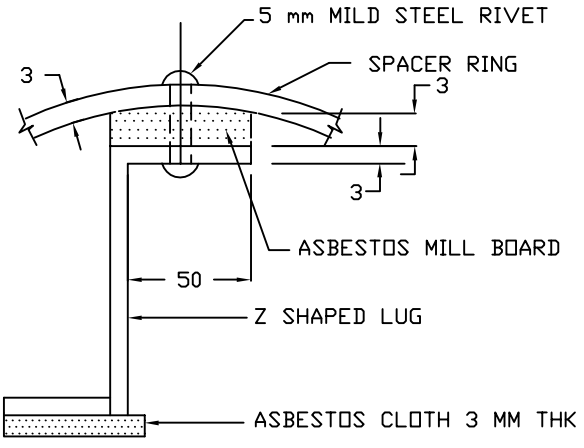




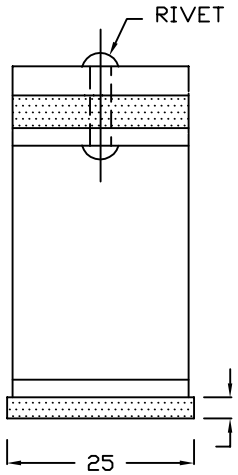
DETAIL A

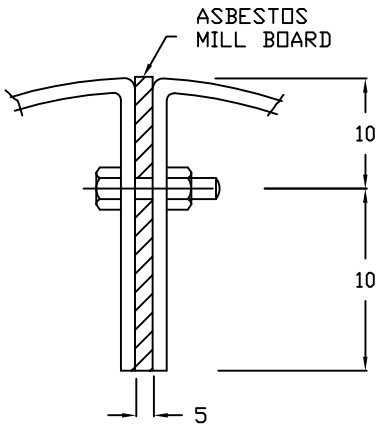
FIG.10 – DETAILS OF INSULATION ON STEAM TRACED PIPES





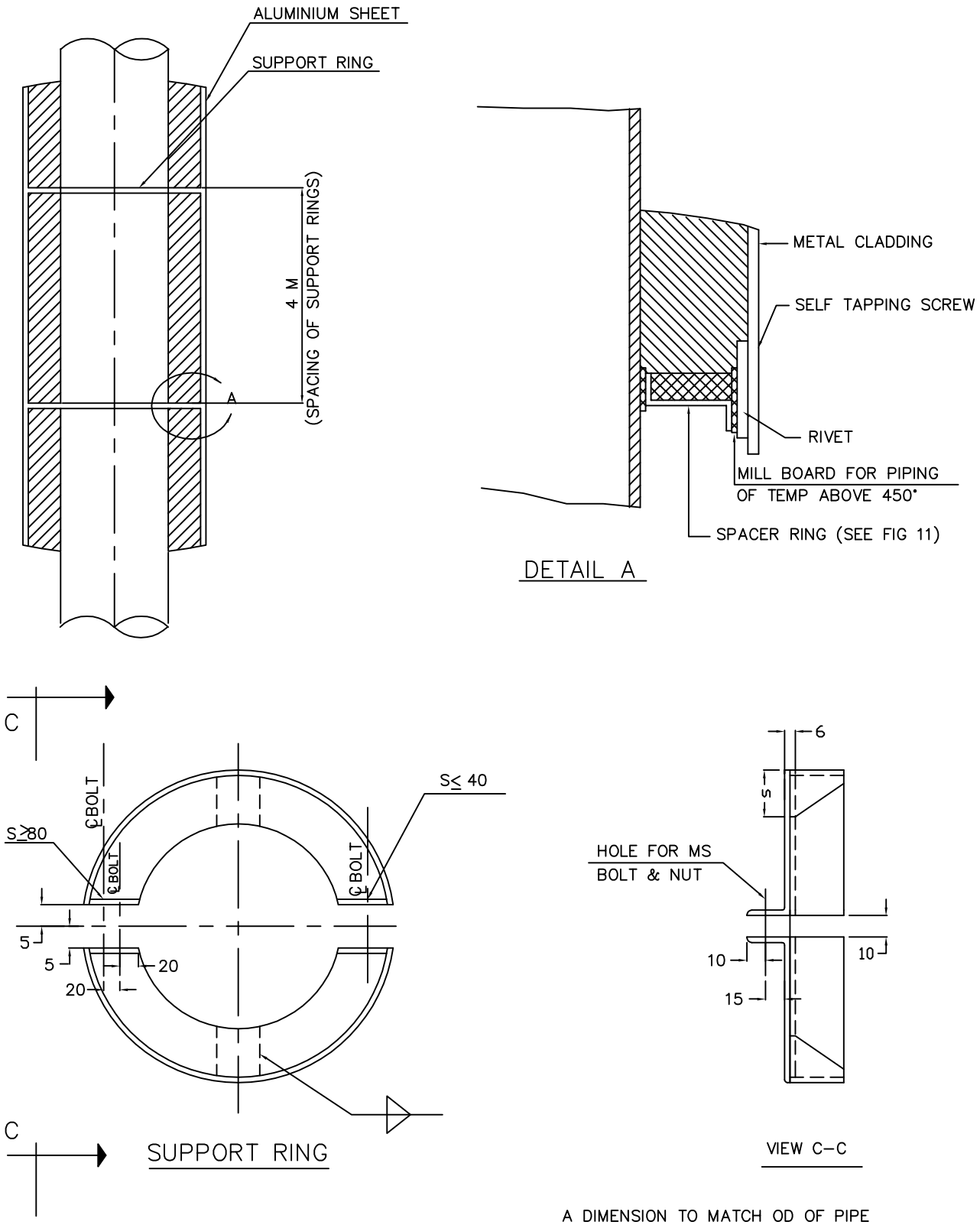
DETAIL - Y





DETAIL - X

FIG. 11 - SPACER RING DETAILS



A DIMENSION TO MATCH OD OF PIPE OR OD OF VESSEL.

S INSULATION THICKNESS.

FIG.12 – SUPPORT FOR VERTICAL INSULATED PIPING

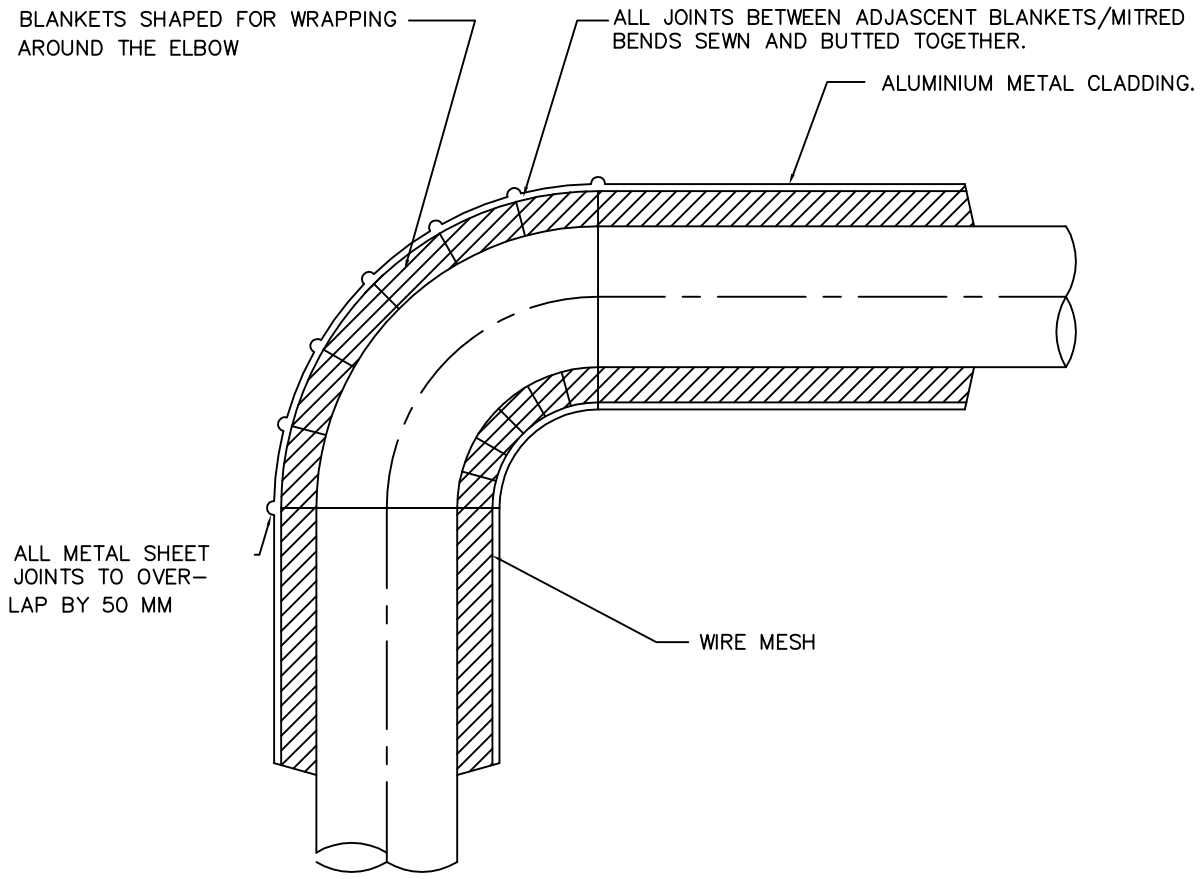


FIG 13 WELDED ELBOW INSULATION

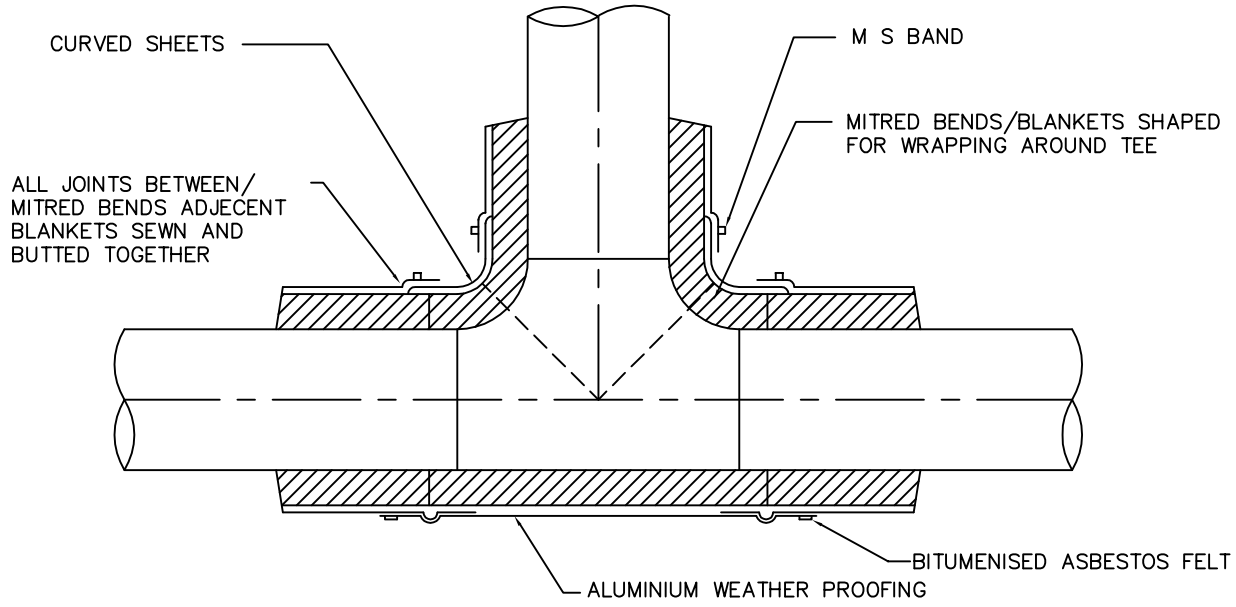


FIG 14 – TEE INSULATION

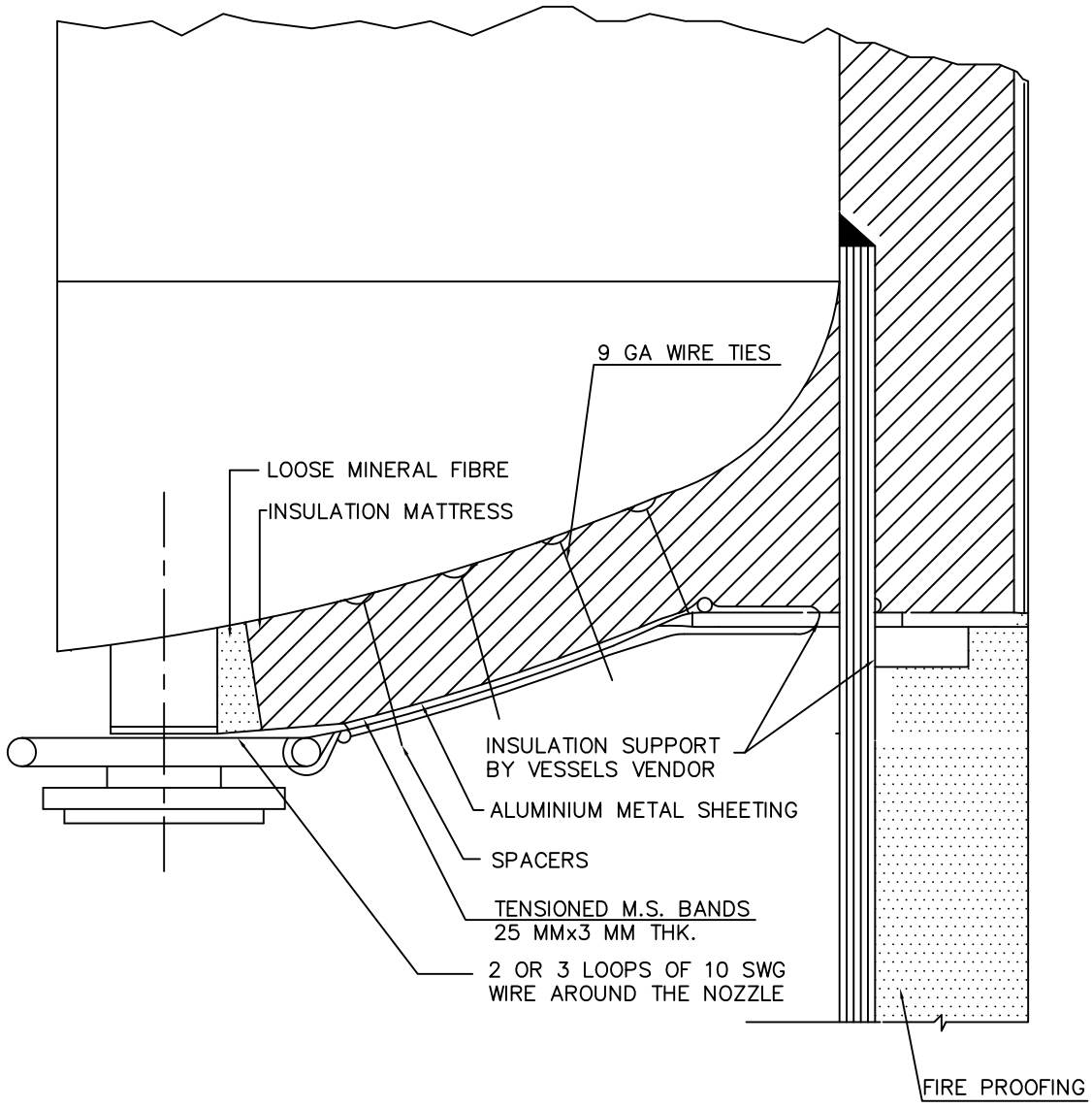


FIG. 15 – BOTTOM HEAD INSULATION FOR VERTICAL VESSELS

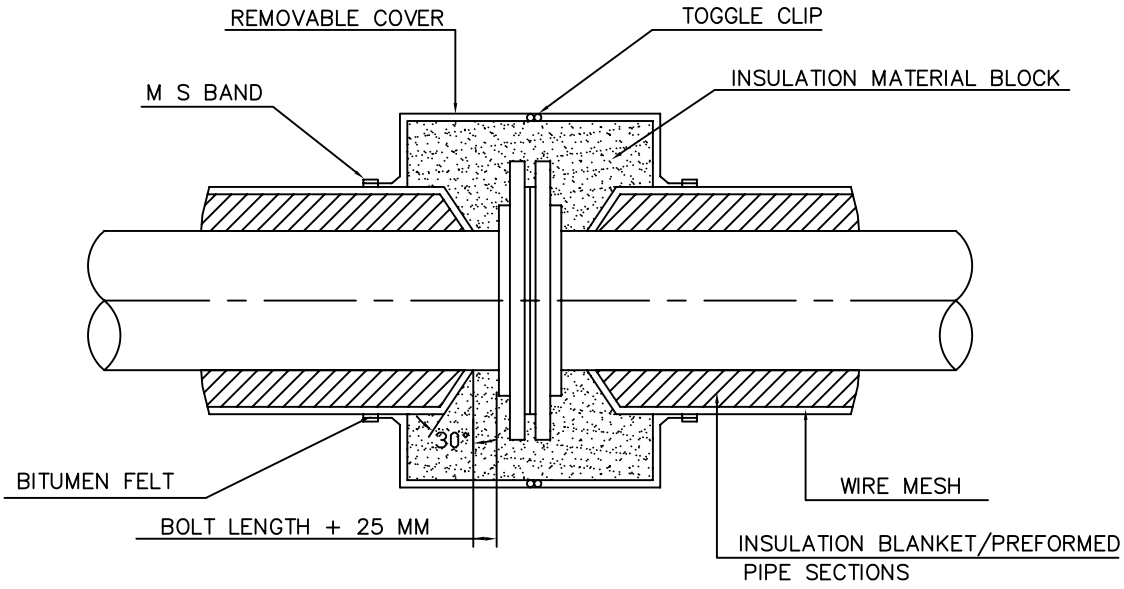


FIG 16 – FLANGE INSULATION

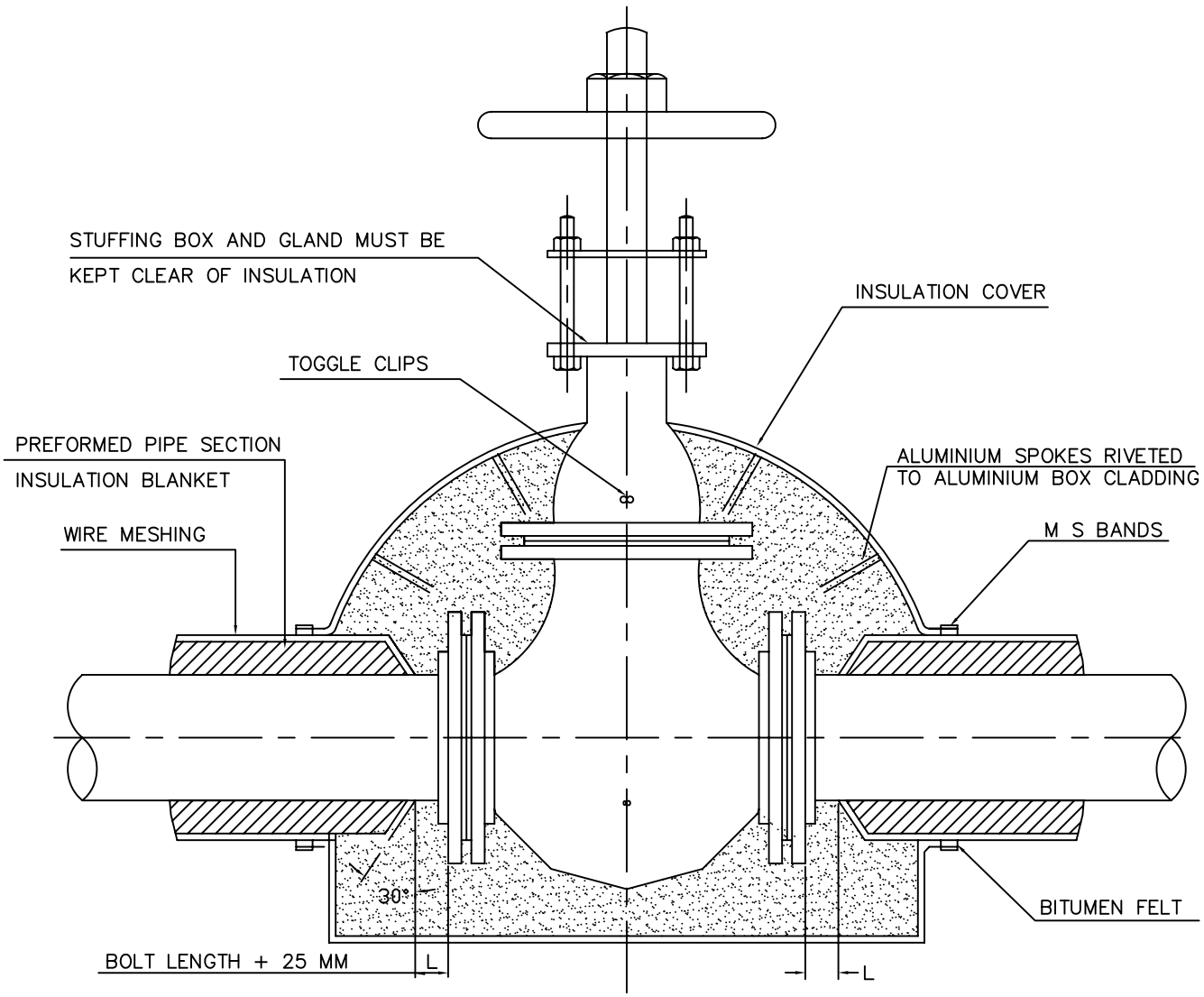


FIG 17 – VALVE INSULATION

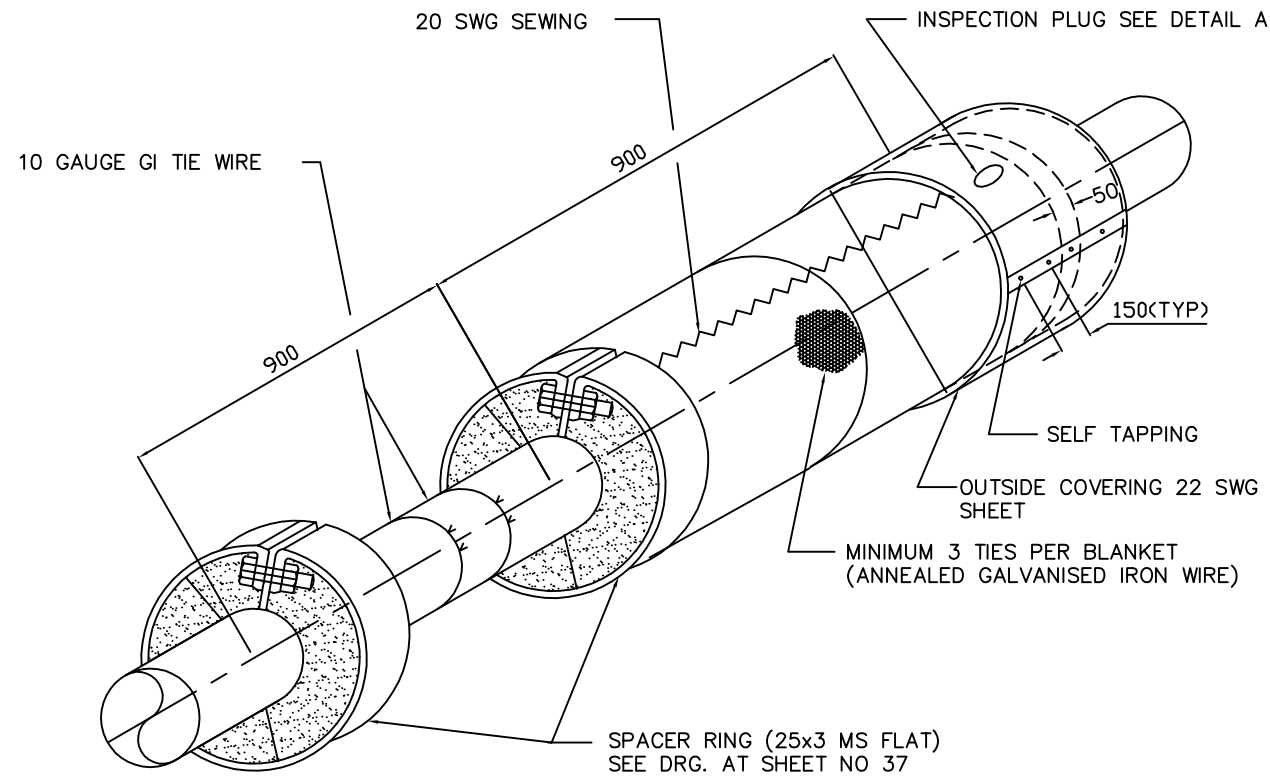


FIG.18 – SINGLE LAYER BLANKET INSULATION WITH ALUMINIUM SHEET FINISH

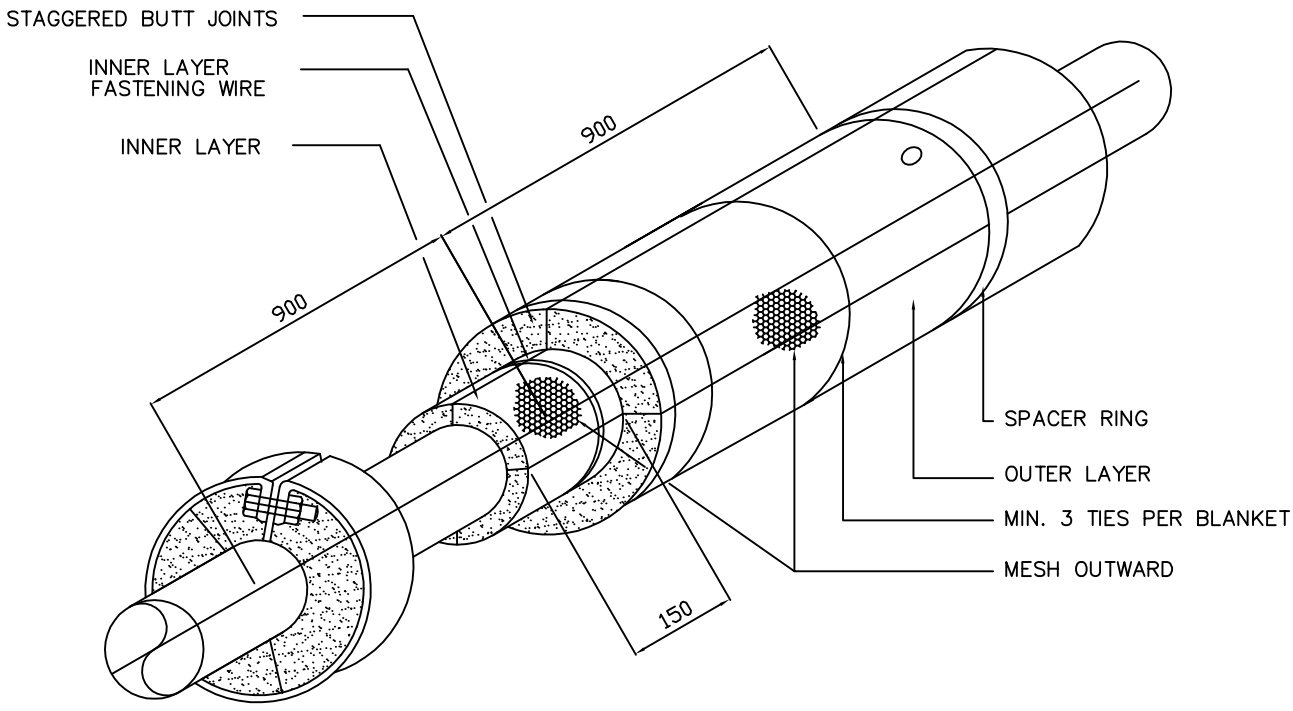


FIG.19 – MULTIPLE LAYER BLANKET INSULATION WITH ALUMINIUM SHEET FINISH

NOTE

FOR FIG 18 & FIG 19 SPACER RING AND WIRE MESH NOT REQUIRED IN CASE OF PREFORMED WIRE SECTION INSULATION.

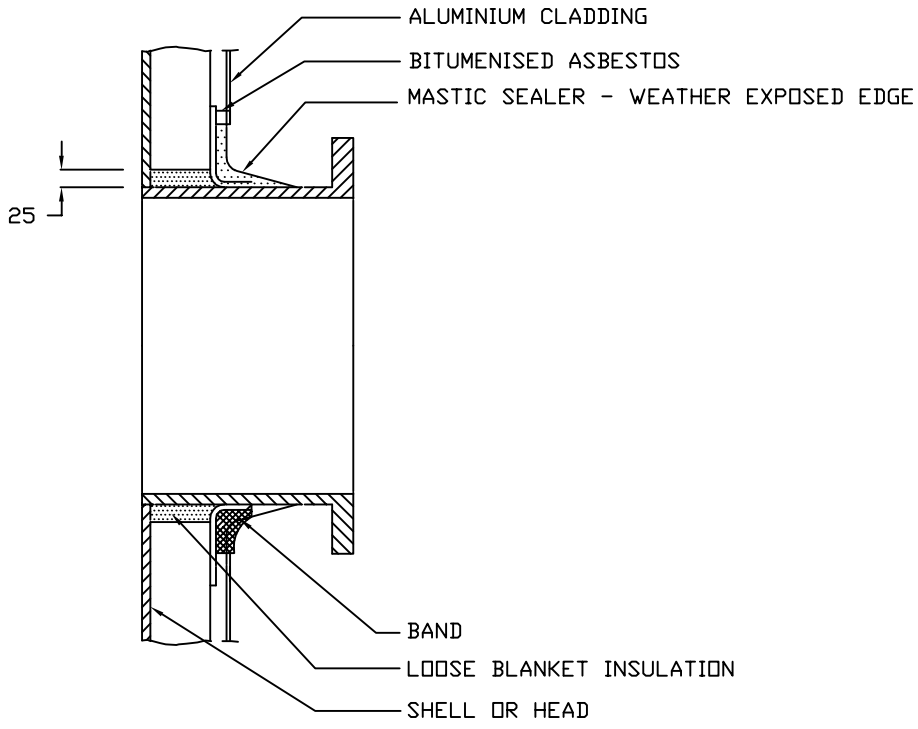


FIG. 20 FLASHING AT NOZZLES OR OTHER PROJECTIONS WITH METAL WEATHERPROOFING

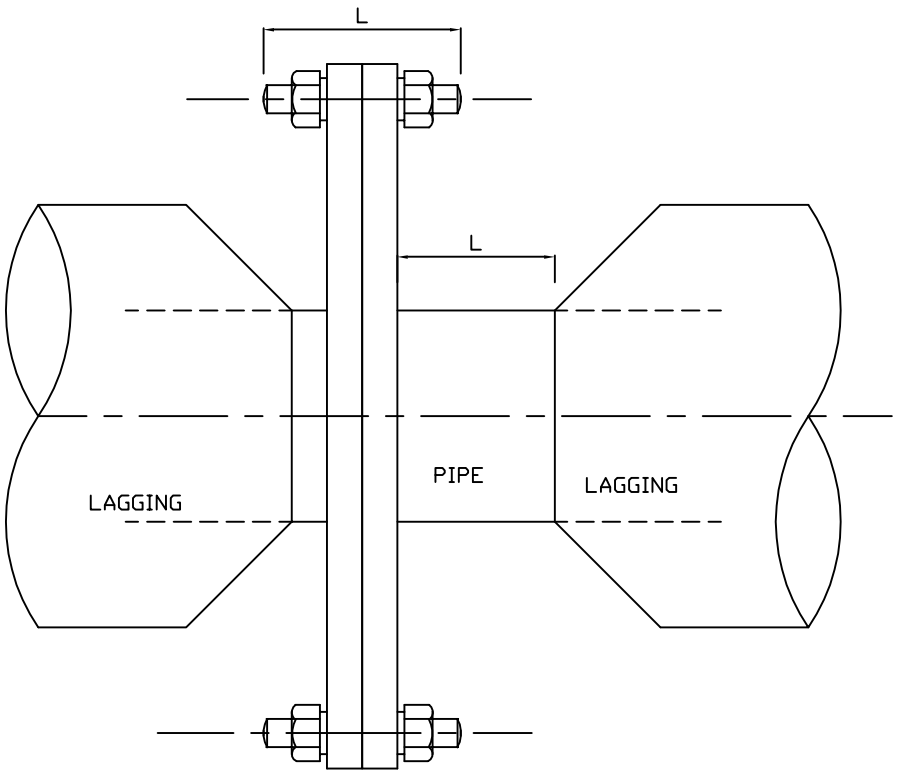


FIG. 21 UNINSULATED FLANGE

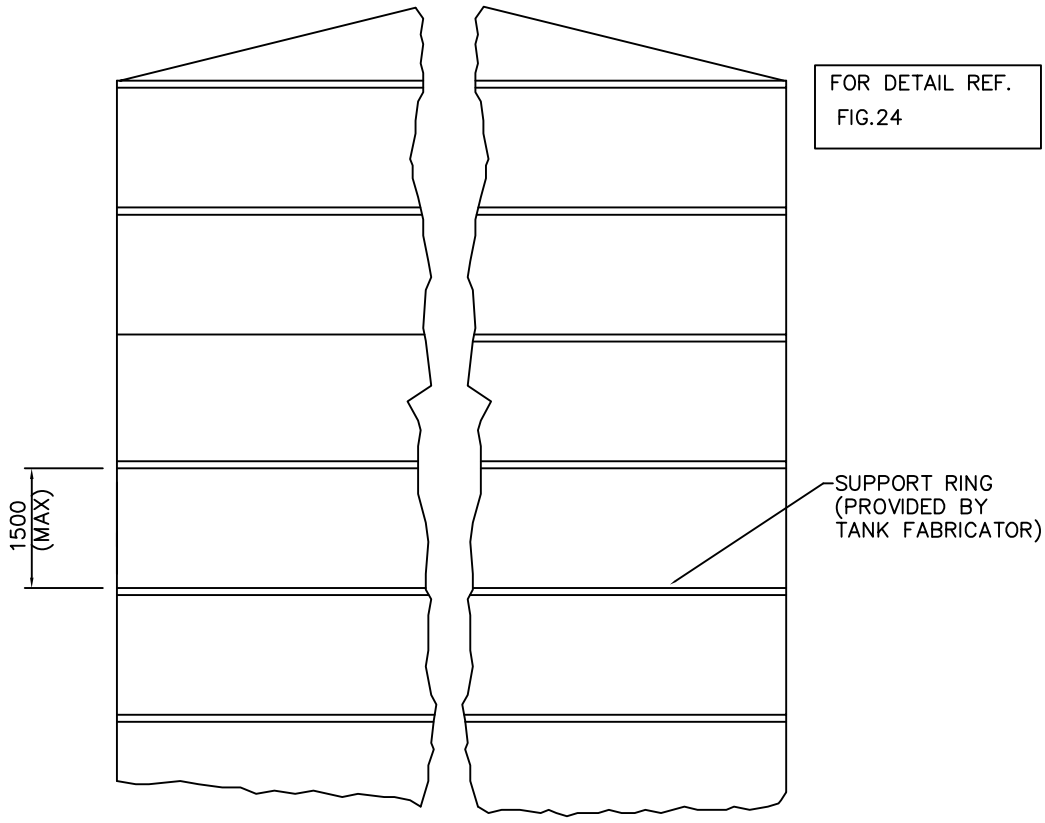


FIG. 22 – TANK SHELL INSULATION – DETAILS

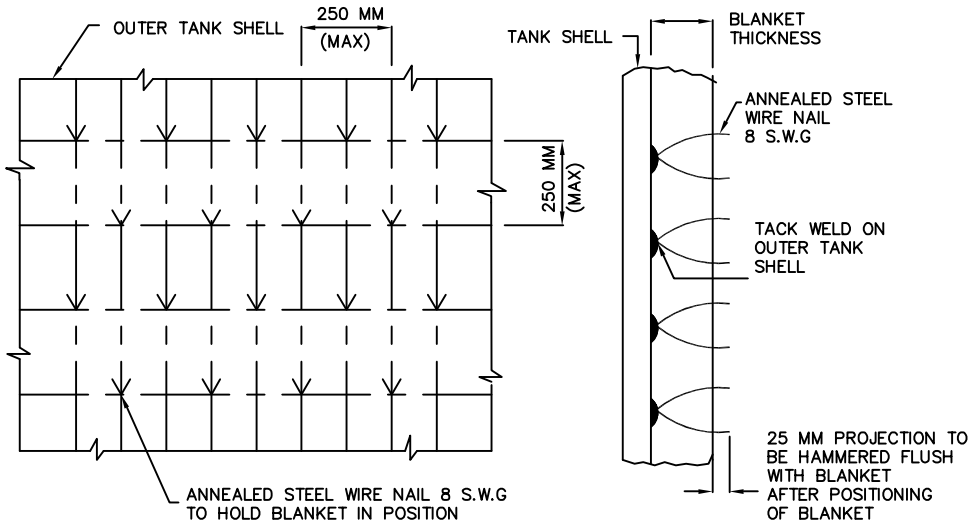


FIG. 23 – DETAIL FOR FIXING OF WIRENAILS FOR HOLDING INSULATION BLANKETS

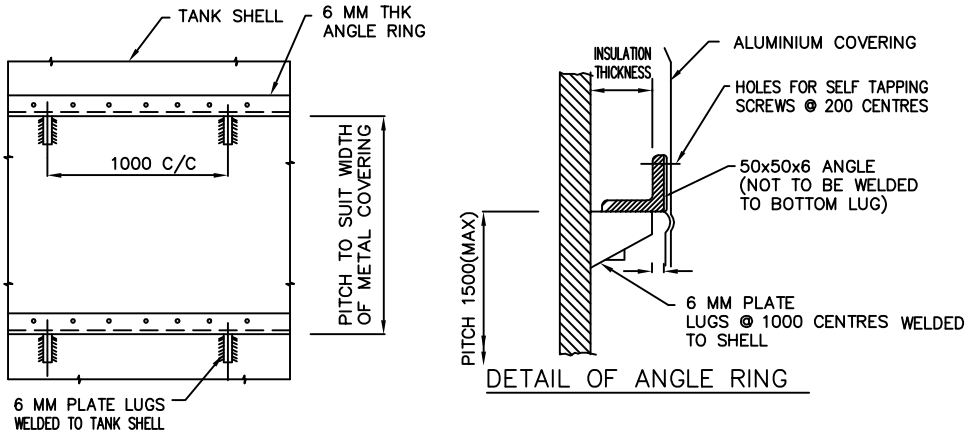


FIG.24 – SUPPORT DETAIL FOR METAL COVERING OF INSULATION

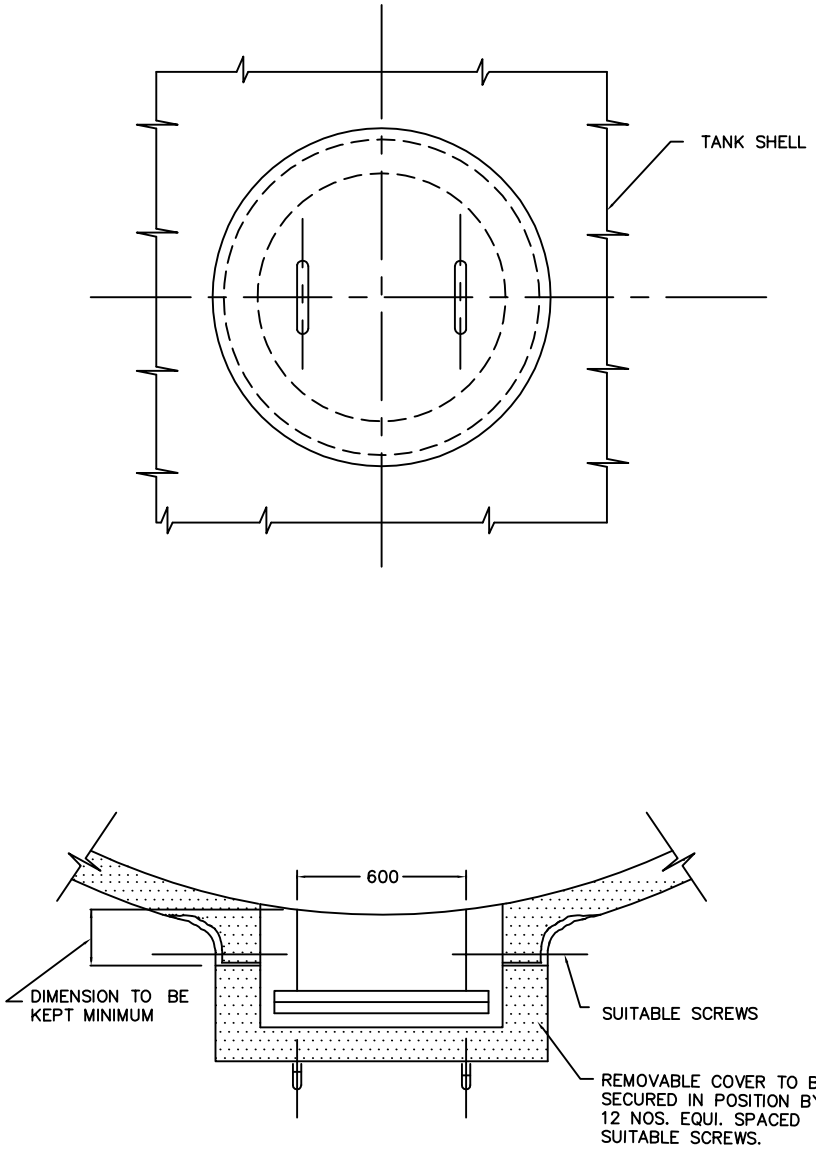


FIG. 25 – DETAIL OF MANHOLE INSULATION

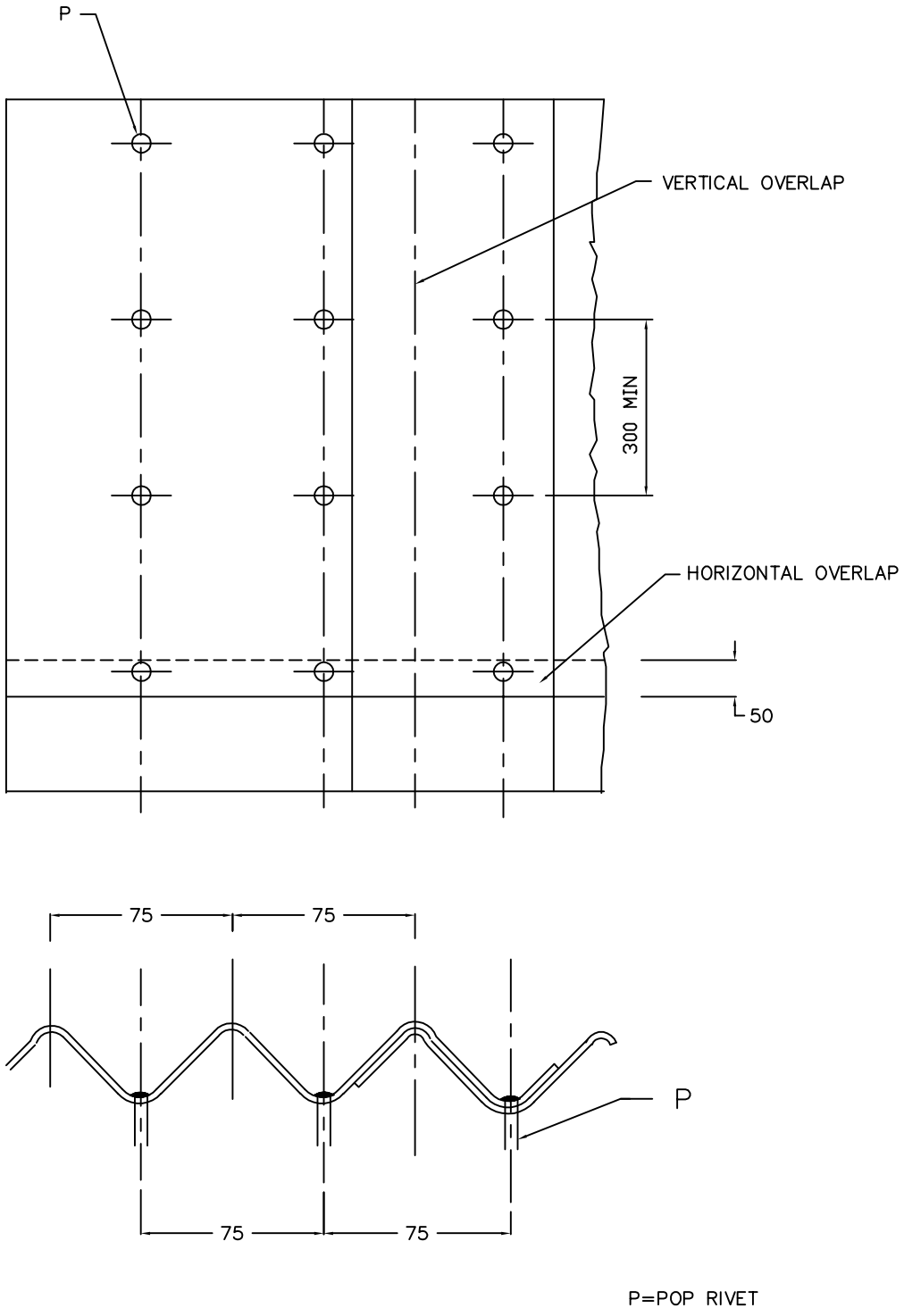
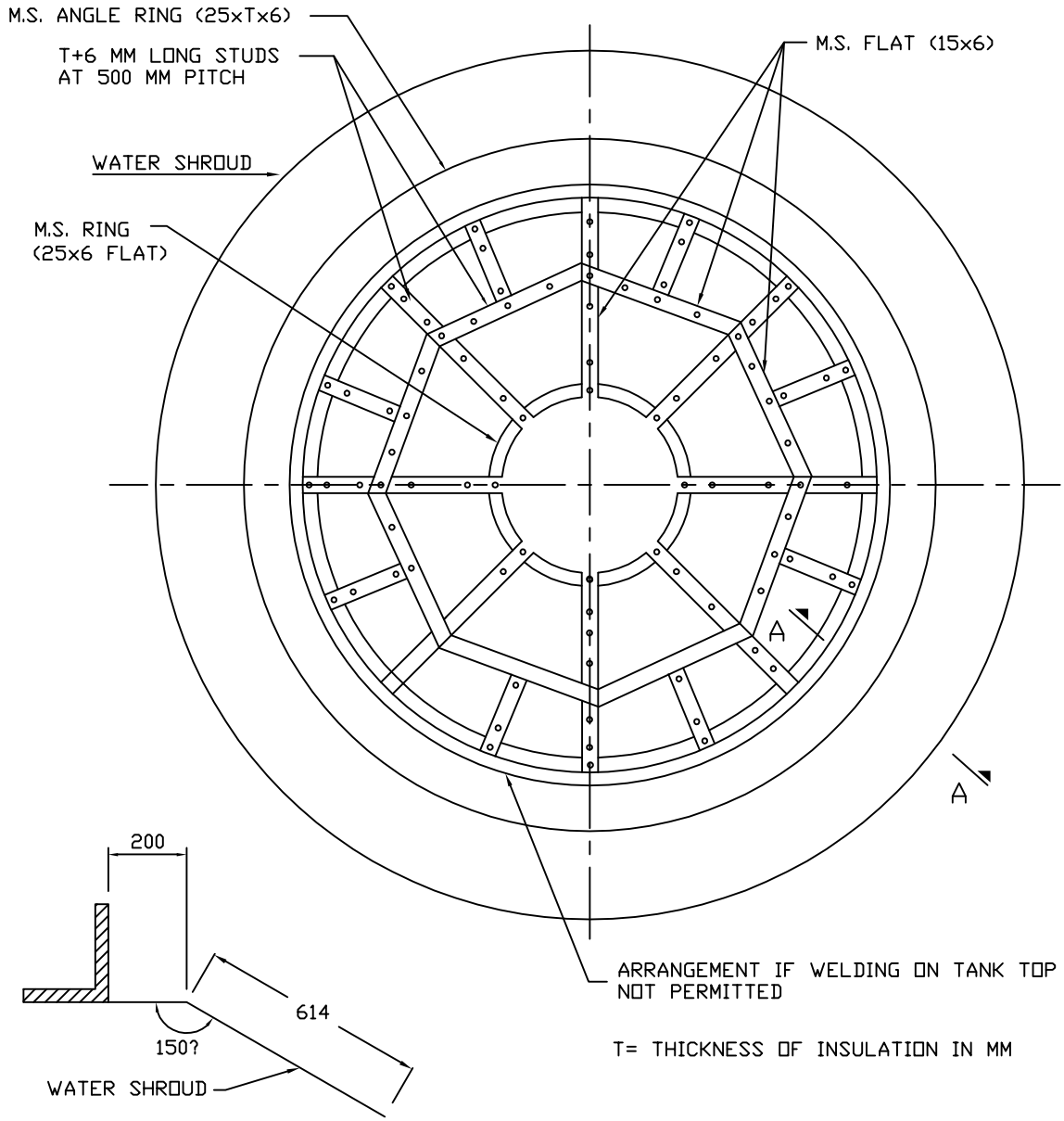


FIG. 26 – DETAILS OF CORRUGATED SHEET OVERLAPPING



SECTION A-A

FIG.27 - DETAILS OF TANK ROOF INSULATION SUPPORTS

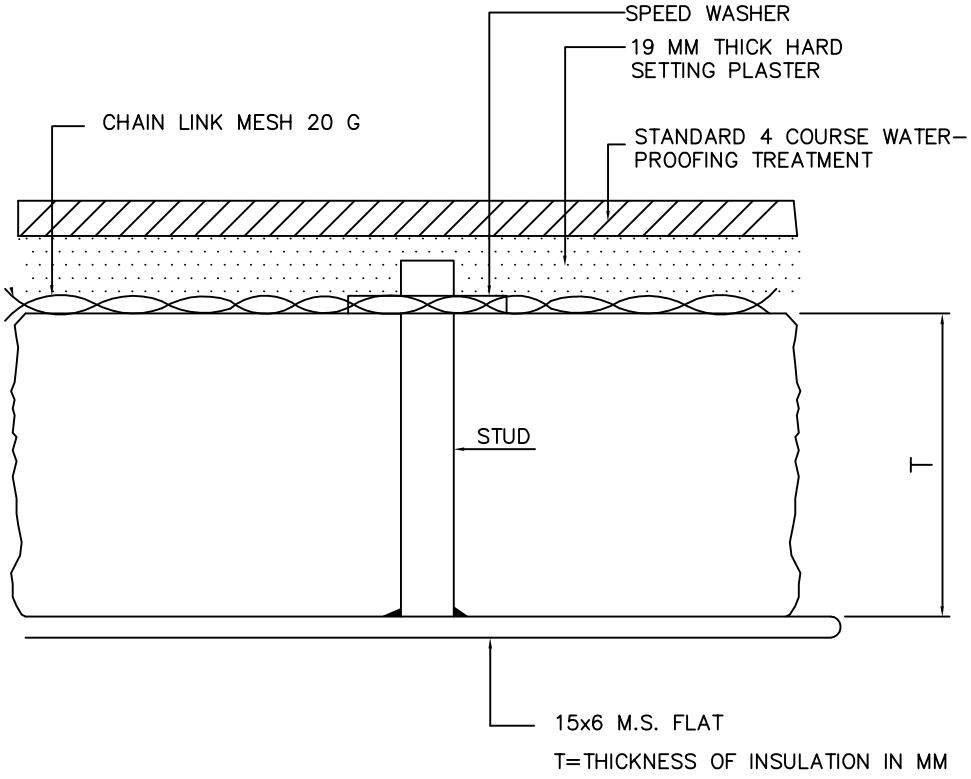


FIG. 28 – DETAILS OF TANK TOP SETTING PLASTER FINISH

CONTENTS

1.1.0 SCOPE

This specification covers the requirements for the supply and application of external, self extinguishing type thermal insulation of equipment and piping for cold service conditions.

1.1.0 REQUIREMENT OF COLD INSULATION

1.1.1 Requirement of cold insulation of any equipment or piping shall be as specified in any of the following documents.

a. Equipment data sheets / drawings
b. Piping line schedule
c. Design basis for package items
d Insulation schedule

1.1.2 Cold insulation is required to be provided on Pressure vessels, Heat Exchangers, Columns, Tanks other process equipment and Piping to meet the following requirements.

a.. To maintain process / operating temperature.

b. To prevent ingress of heat from external source/atmosphere.

c. To avoid surface condensation.

1.1.3 Insulation requirement to maintain process/operating temperature shall be as indicated in documents referred to in 1.1.1.

1.1.4 Insulation for preventing ingress of heat from external source/atmosphere and to avoid surface condensation shall be provided on all equipment and piping operating below 20^{o} C.

1.2.0 Limits of Application.

1.2.1 The following items shall not be insulated unless otherwise specified.

a. Bonnets of valves above packing glands

b. Nameplates and data plates of equipment.

1.2.2 All attachments and projections such as supports, structures attached to equipment pipe hanger supports, Instrument lead lines, branch lines like vents and drains and instrument connections connected directly to cold insulated equipment and piping shall be cold insulated up to a distance of 5 times the adjoining insulation thickness.

2.0.0 INSULATION MATERIALS

2.1.0 The material of insulation shall be as specified in the documents indicated in 1.1.1 and shall be one of the following.

a. Polyurethane foam

b. Expanded Polystyrene

2.2.0 Material of insulation shall be non-absorbent with a closed cell structure to ensure non-permeability of moisture / water vapour.

2.3.0 Material of insulation shall be fungus and vermin proof.

2.4.0 Insulation material shall not contain chemicals, which may be harmful to the equipment or piping or to the protective coating at ambient or service temperatures in wet or dry condition.

2.5.0 Insulation material used for austenitic steel equipment and piping shall be free from water-soluble chlorides and other harmful chemicals.

2.6.0 POLYURETHANE FOAM (PUF)

2.6.1 Polyurethane foam (PUF) may be used for insulation of equipment and piping either as preformed sections or cast-in-situ.

2.6.2 Polyurethane foam shall be of rigid preformed cellular urethane foam and self-extinguishable type in accordance with ASTM-C 591, Type II, Gr.2.

2.6.3 The foam shall be formulated in such a way that it shall be of self-extinguishing quality which shall not cause fire to spread under any circumstances.

2.6.4 The finished foam, in the form of sections, slabs or cast-in-situ, shall be of uniform closed cell structure, free from unreacted material, shrinkage and distortion.

2.6.5 Density of finished foam shall be approximately 45 Kg/m^3.

2.6.6 Thermal conductivity of the finished polyurethane foam shall not exceed 15 Kcl/hr deg C at 10 deg C mean temperature after ageing.

2.6.7 Closed cell content of finished PUF shall be at least 95% by volume.

2.6.8 Maximum permeance of finished PUF shall be 4.0 gms/m. 24h.mm Hg.

2.6.9 Resistance of 10% compression of finished PUF at ambient temperature shall be 1.5 Kg/cm

2.7.0 EXPANDED PLYSTYRENE (EPS)

2.7.1 Expanded polystyrene (EPS) may be used for insulation of equipment and piping in the form of preformed sections or slabs.

2.7.2 Expanded polystyrene shall be of self-extinguishing type with closed cell structure in accordance with IS-4671 type 2.

2.7.3 Finished EPS shall be free from shrinkage distortion and unreacted materials.

2.7.4 Density of finished EPS shall be given below:

Preformed sections	20 to 22 Kg/m^3
Slabs	18 to 20 Kg/m^3

2.7.5 Thermal conductivity of finished EPS shall be as given below:

Density	Thermal conductivity Kcal/m.hr. ^oC	
	0^oC	10^oC
18	0.028	0.031
20	0.027	0.030
22	0.026	0.029

2.7.6 Maximum permeance of finished EPS shall not be more than 4.0 gms/m. 24 hr.mm.Hg.

2.7.7 Finished EPS shall be free from leachable chlorides.

3.0.0 ANCILLARY MATERIALS

3.1.0 Wire netting; Lacing & Stitching

Wire netting of preformed sections and slabs shall be of 24 swg x 20 mm GI. Lacing and stitching wires shall be of 20 swg and 22 swg GI respectively.

3.2.0 BANDS

Aluminium bands of size 20mm width x 24 swg shall be used for securing insulation sections and slabs in place.

3.3.0 METAL CLADDING

Commercial quality aluminium jacketing conforming to IS 737 shall be used for all equipment and piping. Thickness of cladding sheets shall be as indicated in table. 1.

3.4.0 SELF TAPING SCREWS

Self tapping screws to be used for securing the metal cladding shall be 6mm dia cadmium plated or galvanised, and best quality.

3.5.0 SEALING COMPOUND

3.5.1 To ensure perfect water proofing, cladding joints shall be packed with sealing materials, which may either be in the form of bituminous mastic sealing compound or fibre based bituminous felt strips.

3.5.2 Sealing compound shall be suitable to withstand the temperature of insulation to seal the joints.

3.6.0 MASTIC BEDDING

Insulating sections and slabs shall be bedded in non-setting mastic to eliminate air pockets. The same mastic shall be used for ensuring vapour tight joints between adjacent sections/slabs.

3.7.0 HARD SETTING PLASTER

Hard setting plaster (mixture of sand & cement or asbestos & cement shall be applied over wire netting on piping subjected to foot traffic.

3.8.0 BITUMINISED SELF-FINISHING ROOFING FELT.

Bituminised self-finishing roofing felt shall conform to IS 1322 Type 3 Gr. 1.

3.9.0 VAPOR BARRIER

3.9.1 Sealing mastic for the vapour barrier shall be fire retardant mastic, bituminous emulsion mastic or elastomeric polymer mastic.

3.9.2 Instead of sealing mastic, aluminium foil of about 0.025mm (25 microns) thick glued to craft paper using polyethylene glue or aluminium foil (.025mm thick) coated with polyester may also be applied as vapour barrier.

4.0.0 INSULATION THICKNESS

4.1.0 Insulation thickness shall be as specified in the equipment data sheet/piping line schedule/insulation schedule.

4.2.0 For package items, the insulation thickness as per table 2 may be used as a guidance for selecting the minimum thickness of insulation required. The vendor shall check the same for process adequacy.

5.0.0 APPLICATION

5.1.0 GENERAL

5.1.1 The surfaces to be insulated shall be thoroughly cleaned by wire brushing to remove dirt and loose scale. Equipment and piping which have received primer / painting shall be cleaned well, without disturbing the surface treatment already received.

5.1.2 Unprimed carbon and low alloy steel surfaces shall be thoroughly cleaned by wire brush and one coat (30 microns) of epoxy based zinc phosphate primer shall be applied before starting cold insulation. Sufficient curing time shall be allowed for surface treatment.

5.1.3 Stainless steel and other non-ferrous surfaces shall not be primed.

5.1.4 The equipment drawings indicate the extend of insulation and location of insulation supports. However, the insulation contractor shall recommend, furnish and install any additional supports and anchorage that may be required to adequately support the insulation. Field welding of clips and supports shall be carried out only with the prior approval of the Engineer-in-charge.

5.1.5 All insulating and ancillary materials shall be new and unused and shall be free from contaminating materials, dust and dirt.

5.1.6 All insulation materials shall be stored in covered areas protected from moisture and dust. Insulation materials shall not be stacked directly on ground. Insulation materials showing any evidence of absorption of moisture shall not be used.

5.1.7 Insulation work shall be carried out only after hydrostatic testing of equipment / piping have been completed.

5.1.8 Insulation of flange joints shall be come only after they have been proved to be leak tight.

5.2.0 MULTILAYER INSULATION

5.2.1 When thickness of insulation exceeds 60mm, the insulation may be applied with multi layers, with all joints staggered. Each layer of insulation shall be secured by metallic banding.

5.2.2 All cracks and voids in the insulation shall be completely sealed by using the mastic bedding indicated in 3.6.0.

5.2.3 No. of layers to be employed shall determined as given below:

Insulation thickness	No. of layers
Up to 60 mm	1
Up to 120 mm	2
Above 120mm	3

5.3.0 VAPOR BARRIER

5.3.1 Vapour barrier shall be applied on insulation of all equipments at the outermost layer before metal cladding is applied.

5.3.2 Polyurethane foam and expanded polystyrene insulation shall be completely covered with a continuous vapour tight layer to prevent permeation of vapour into the insulating material.

5.3.3 A layer of sealing mastic shall be applied over the entire surface of the insulation, to obtain a thickness of 2 to 2.5 mm when completely dry. Over this coat while it is still wet a layer of open weave glass fibre cloth of 10 mesh size and 0.125 mm thick stretched with out any wrinkles or air pockets shall be laced with glass fibre threads. A final coat of sealing mastic shall be applied over the glass fibre mesh to obtain a thickness of 2.5 mm when dry.

5.3.4 Alternative type of vapour barrier as described in 3.9.2 may be applied instead of that given in 5.3.3, in which case all joints shall be completely sealed and shall leave an overlap of at least 100 mm. Sealing of joints shall be done by using airtight and waterproof adhesive tape.

5.4.0 WIRE NETTING & BANDING

5.4.1 Aluminium bands as specified in 3.2.0 shall be fixed over insulation blocks at an interval of 300 mm.

5.4.2 Before application of vapour barrier, the insulation sections and slabs shall be completely covered by wire netting, laced and stitched by using wire nets, lacing and stitching wire specified in 3.1.0. The bands shall be sufficiently tightened to keep the insulation sections/slabs firmly in place without deforming the insulation.

5.4.3 Protruding ends of the bands shall be cut off or turned down so as not to damage vapour barrier.

5.5.0 FILLING OF VOIDS

5.5.1 Polyurethane dust mixed with specified adhesive shall be packed tightly so as to fill voids and contractions on PUF insulation.

5.5.2 Blown bitumen mixed with polystyrene beads shall be used to fill voids and contractions in EPS insulation.

5.6.0 ALUMINIUM CLADDING

5.6.1 Vapour barrier of PUF or EPS insulation shall be protected by aluminium cladding specified in 3.3.0.

5.6.2 Aluminium cladding shall be bent to shape grooved & properly riveted by using pop rivets.

5.6.3 All joints of the cladding shall overlap aluminium of 50 mm and shall be arranged in such a way as to shed

water. Joints shall be offset between pieces.

5.6.4 Cladding shall be secured to aluminium bands of size 20 x 3 mm. Which are provided at a gap or 450 mm along the circumference.

5.6.5 All joints in the cladding shall sealed water tight by using seating compound or tapes as described in 3.5.0.

5.6.6 Jacketing for dished heads shall be fabricated radial segments with an overlap of 50mm. The sheeting shall be secured in position by radial tensioned metallic bands stretched over the heads. One end of each band is anchored to the circumferential band with shell, while the other is fastened to a floating ring fabricated in the form of a ring. The sheet metal bands may be held in place by using pop rivets.

5.7.0 FLASHING

5.7.1 Openings in metal jackets for nozzles, manholes, brackets shall be cut as close as possible for a smug fit.

5.7.2 All openings through insulation finish shall be flashed weather tight by an approved sealant particularly where connections are not insulated.

5.7.3 Skirt supported vessels shall have the skirt insulated inside and outside for at least 600 mm below the tan gent line.

5.7.4 Unless otherwise specified no insulation shall be applied to the inside of the skirt, which are externally, fire proofed.

5.7.5 For leg-supported vessels, insulation shall be provided to a length of at least 5 times the insulation thickness minimum.

5.8.0 VERTICAL VESSELS

5.8.1 Cylindrical Shell

1. Slabs/sections in handy sizes shall be applied resting on to the supports with joints tightly butted, staggered and adhering to each other with specified adhesives.
2. The slabs/sections are to be secured in position by circumferential metallic bands at an interval of 300mm. When multi layer insulation is applied each layer shall be banded separately.

5.8.2 Top Heads

1. Insulating material shall be properly shaped and tightly pressed on the top head.
2. The insulation shall be held in position by using metallic bands one end of which shall be fastened to the floating ring and the other end shall be anchored to the circumferential band laced on shell near the head.
3. Radial bands shall be spaced at 300 mm gap measured along the circumference of the vessel.
4. The final layer of insulation shall be held in position by metallic wire net laced at the top vortex nozzle by about two to three loop of 10 swg galvanised iron wire and the wire net over the insulation of the shell close to the head.
5. When there are no top vertex nozzles, the insulation shall be held in position by wire netting and metallic bands stretched over the head and anchored on the cylindrical section close to the head by circumferential metallic band on the shell near the head.

5.8.3 Bottom Heads

1. Preformed and shaped insulation sections shall be used for insulating the bottom head.
2. Preformed and shaped insulation sections shall be held in place in the same manner as for top heads.
3. While one end of the metallic bands shall be fastened to floating ring if a bottom vortex nozzle is present, the other end shall be anchored to the

insulation support ring provided inside the skirt support.

4. Radial bands shall be spaced at 300mm pitch measured along the circumference.
5. In case of absence of a bottom vortex nozzle, the metallic bands shall be stretched across the bottom head and anchored at the ring inside the skirt.

5.9.0 HORIZONTAL VESSELS

5.9.1 Insulation of horizontal vessels shall be carried out by using preformed and shaped insulation blocks/sections.

5.9.2 Insulation material shall be held in place by using metallic bands a spacing of 300 mm.

5.9.3 Final layer of insulation shall be provided with netting, laced and stitched.

5.9.4 Each layer of insulation shall be banded separately and bands of successive layers shall be staggered.

5.9.5 Insulation blocks/sections shall be held in position by metallic bands at radial pitch of 300mm on the heads and anchored to the circumferential metallic bands on shell near the head.

5.10.0 HEAT EXCHANGERS

5.10.1 Insulation of vertical heat exchangers shall be carried out in the same manner as in 6.0.0.

5.10.2 Insulation of horizontal heat exchangers shall be carried in the same manner as in 7.0.0.

5.10.3 Exchanger channels and channel covers including bolting flanges shall be insulated with removable aluminium covers lined with insulation sections/blocks of specified thickness.

5.11.0 SPHERICAL VESSEL

5.11.1 Shaped insulation block shall be used for spherical vessels.

5.11.2 All joints shall be sealed well by approved joint sealant.

5.11.3 Inner layers of insulation shall be held separately in place by metallic bands at 300 mm pitch at equator.

5.11.4 The bands shall be tied up with floating rings of 20mm O/D made of 15 SS rod at the poles of the sphere.

5.11.5 The bands on the successive layers shall be staggered and the clip ends are to be bent and recessed in to the insulation.

5.11.6 Outer layer of insulation shall be secured in place by wire netting, laced and stitched together.

5.12.0 STORAGE TANKS

5.12.1 Insulation of storage tank shell shall be carried out in the same manner as described in 6.0

5.12.2 Where tank fabricator has provided support rings and vertical flats on the tank shell, the insulation contractor shall provide additional rings at a pitch of 900 mm. These additional rings shall be tack welded only to the support rings and vertical flats. No welding shall be permitted on the tank surface.

5.12.3 Metal cladding of tank shell shall be with 22 swg corrugated aluminium sheet. All points shall be staggered by 300mm and shall be sealed water proof with approved sealing material.

5.12.4 Tank Roof

1. Tank roof shall be thoroughly cleaned of all dirt and rust and other contaminants.
2. Preformed insulation sections/slabs shall be laid over one coat of adhesive mastic and pressed well. All joints shall be sealed with adhesive mastic to make it airtight.
3. When multi layer insulation is applied of successive layers shall be staggered and sealed with adhesive mastic.
4. Each lay of insulation shall be secured with bands and wire netting laced and stitched as detailed in 5.8.2.

5. Vapour barrier shall be applied as specified in 5.3.0.
6. Fix a shed water shroud constructed from 20 swg GI plain sheets at the periphery of the tank.
7. Apply a 20mm thk hard setting non-conductive plaster made from asbestos fluff and Portland cement troweled to a smooth and even finish.
8. When hard setting plaster is completely dry apply a standard 4 course bitumen felt as per IS 1346. Aluminium cladding shall be applied over this.

6.0.0 PIPING INSULATION

6.1.0 GENERAL

6.1.1 External surfaces of pipes shall be cleaned well with wire brush (CS brush for CS pipes and SS brush for SS pipes) to remove all dirt rust and contaminating material and wiped well.

6.1.2 If painting is provided for specific reasons the insulation contractor shall not carry out any harsh cleaning and shall ensure that painting is undisturbed.

6.1.3 All pipes and supports shall be permanently set before commencement of insulation. Disturbed pipes and supports shall be restored to their original location and alignment when insulation is complete.

6.1.4 All insulation shall be applied when piping is at ambient temperature.

6.1.5 Spacer rings for supporting metal cladding shall be installed by the contractor.

6.1.6 Insulation in the form of preformed pipe sections shall be applied over the pipe without spacer rings. On top of each layer wire netting shall be applied and tightly butted against each other so that the wires interlock both longitudinally and circumferentially. The wire net joints shall be stitched with 20 swg soft galvanised iron wire.

6.1.7 At un-insulated flanges, insulation shall be terminated at suitable distance from the flange so that the flange bolts can be withdrawn without disturbing the insulation.

6.1.8 In case of vertical piping, insulation supports shall be installed by the insulation contractor. These shall consist of spacer rings at 4 metres intervals clamped to the pipes.

6.1.9 Insulation of piping shall be complete with mastic bedding, sealing compound, vapour barrier, filling of voids and metal cladding as described earlier in the specification.

6.1.10 Insulation of flanges and valves shall be provided only when specifically mentioned in the line schedule/work order. When specified, removable covers shall be provided over all flanges and valves. The insulation shall be preformed, filled in aluminium sheet boxes, and fitted with quick release clips.

6.2.0 INSULATION OF PIPING FOR FOOT TRAFFIC

6.2.1 After application of insulation including vapour barrier the insulation sections are to be held together with GI wire netting and joints laced with GI wire.

6.2.2 Wire netting shall be held together with 20mm wired hoop iron bands at 300mm spacing.

6.2.3 Apply hard setting plaster as per 3.7.0 of 20mm thick-troweled smooth.

6.2.4 After the hard setting plaster has dried wrap bituminised self-finishing roofing felt over the plaster with an overlap of 50mm both longitudinally and circumferentially.

6.2.5 The roofing felt shall be secured with 24 swg x 20mm GI wire netting and all joints are to be laced with 20 swg GI wire.

6.2.6 Apply 3mm thick bituminous emulsion mastic compound for water and weather proofing.

6.2.7 When bitumen emulsion has completely dried the surfaces shall be painted with bitumen based aluminium paint.

6.3.0 PIPING INSPECTION WINDOWS

6.3.1 Plug type inspection windows shall be provided on all insulated pipelines having size 50 mm and above.

6.3.2 The size of the inspection windows shall be as indicated below:

Pipe dia (mm)	Window dia (mm)
50	35
80	45
100	75
150 and above	100

6.3.3 Inspection windows shall be provided at the bottom of the pipelines.

6.3.4 There must be at least one inspection window within a span of 10m.

6.3.5 At least 50% of the bends shall be provided with inspection windows.

6.3.6 In case of critical pipelines, more number of inspection windows may be provided at the discretion of the Engineer-in-charge.

6.3.7 Sheet metal covering of inspection windows shall be of the same gauge as that of insulation cladding. These covers are to be fixed on with 6 mm self-tapping screws.

6.3.8 The plug shall be of perfect fit into the inspection window and shall ensure leak tightness.

7.0.0 MACHINERY ITEMS

in general PUF/EPS filled removable prefabricated sheet metal boxes shall be adopted for insulation of machinery items. The contractor shall submit insulation details of individual items of equipment depending on the nature of item to be insulated for the approval of Engineer-in-charge.

8.0.0 INSTRUMENTATION & MISCELLANEOUS ITEMS

8.1.0 Drain and vent piping up to the first valve on insulated equipment shall be insulated with similar type of insulation and finish as the equipment to which it is attached.

8.2.0 Headers, branch lines sample connections and pipelines to instruments shall be insulated with similar type of insulation and finish as the connected piping.

8.3.0 The thickness and type of insulation for all lines mentioned before shall be determined from piping like schedule for corresponding temperature and pipe sizes. Thickness of insulation for the parts not mentioned shall be as specified by Engineer-in-charge.

9.0.0 INSULATION CAST-IN-SITU

9.1.0 Large vessels and equipment may be insulated using polyurethane foam, foamed in situ.

9.2.0 Before commencement of foaming-in-situ, the contractor shall demonstrate the foaming procedure to the approval of Engineer-in-charge to check for the presence of voids after formation.

9.3.0 3 samples of PUF per shift shall be foamed in transparent polyethylene bags in presence Engineer-in-charge. Insulation work shall commence only after the approval of samples by the Engineer-in-charge.

9.4.0 Both the surface of equipment to be insulated and the cladding shall be free of rust, dirt and other contaminating matters.

9.5.0 The sheet metal cladding shall be adequately strapped and braced to withstand pressures developed during foaming, without distortion or failure. All joints of cladding shall be made leak

proof by using impermeable mastic sealing compound.

9.6.0 Air escape holes provided in the cladding shall be sealed well after foaming.

9.7.0 The annular space between the equipment and the cladding shall not be less than the thickness of insulation specified and shall be maintained uniform throughout by use of performed Polyurethane spacers, which will remain embedded in foam.

10.0.0 SAFETY

The insulation contractor shall provide adequate protective appliances, like gloves, masks, glasses and clothing to workmen carrying out the insulation work for protection against any hazardous / toxic chemicals and gases. Sufficient for protection methods / gadgets shall also be deployed at the place of insulation.

11.0.0 GUARANTEE

11.1.0 The insulation contractor shall furnish authentic test certificates to confirm that all materials offered conform to the requirements of this specification and standards mentioned therein.

11.2.0 All insulation works shall be guaranteed against defective materials and bad workmanship for the period specified in enquiry / order.

12.0.0 APPLICATION DETAILS

Refer the following details attached this specification for application of insulation of various parts.

****

TABLE 1 – THICKNESS OF ALUMINIUM CLADDING SHEETS

Item	Size (mm) Or Dia	Type of aluminium sheeting	
		Vertical	Other portions
Equipment	< / = 350 NB	24 SWG plain	24 SWG plain
	>350 NB	22 SWG Corrugated	24SWG plain
	Tanks	22 SWG Corrugated	22 SWG plain for roof and 24SWG plain for other parts
Piping	< / = 350 NB	24 SWG plain	22 SWG plain
	> 350 NB	24 SWG plain	24 SWG plain
	Valves, flanges etc.	24 SWG plain	22 SWG plain

TABLE 2 – THICKNESS OF COLD INSULATION

Nom: Dia < / =	Insulation Thickness (mm) for Temperature Deg.C						
	-40	-30	-20	-10	0	10	20
20	60	60	60	50	50	40	40
65	70	70	70	60	60	50	50
80	80	80	80	70	70	50	50
150	90	90	90	80	80	50	50
400	100	100	100	80	80	50	50
500	110	110	110	80	80	50	50
900	120	120	120	80	80	50	50
Above 900	130	130	130	80	80	50	50

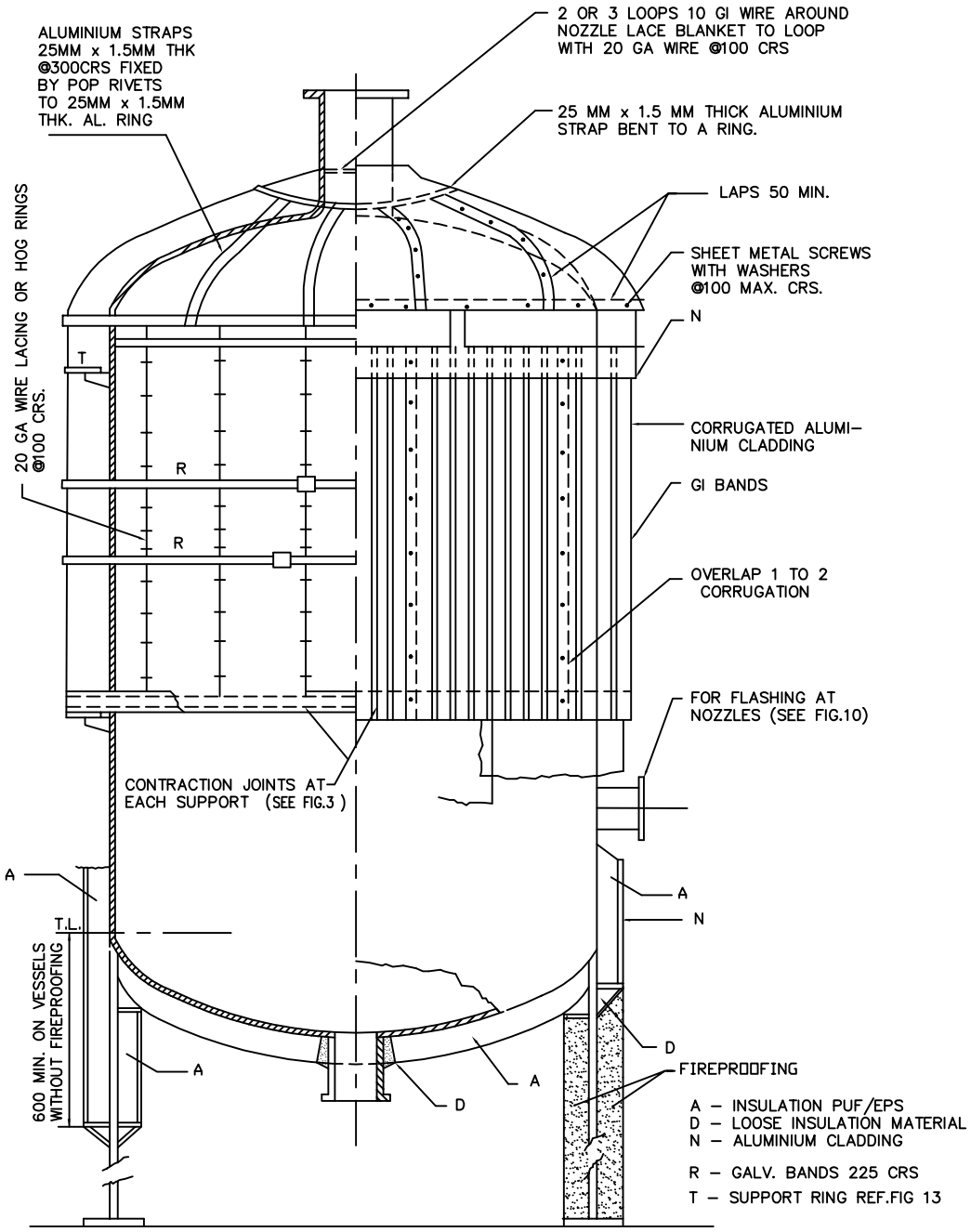


FIG. 1– INSULATION OF VERTICAL VESSELS

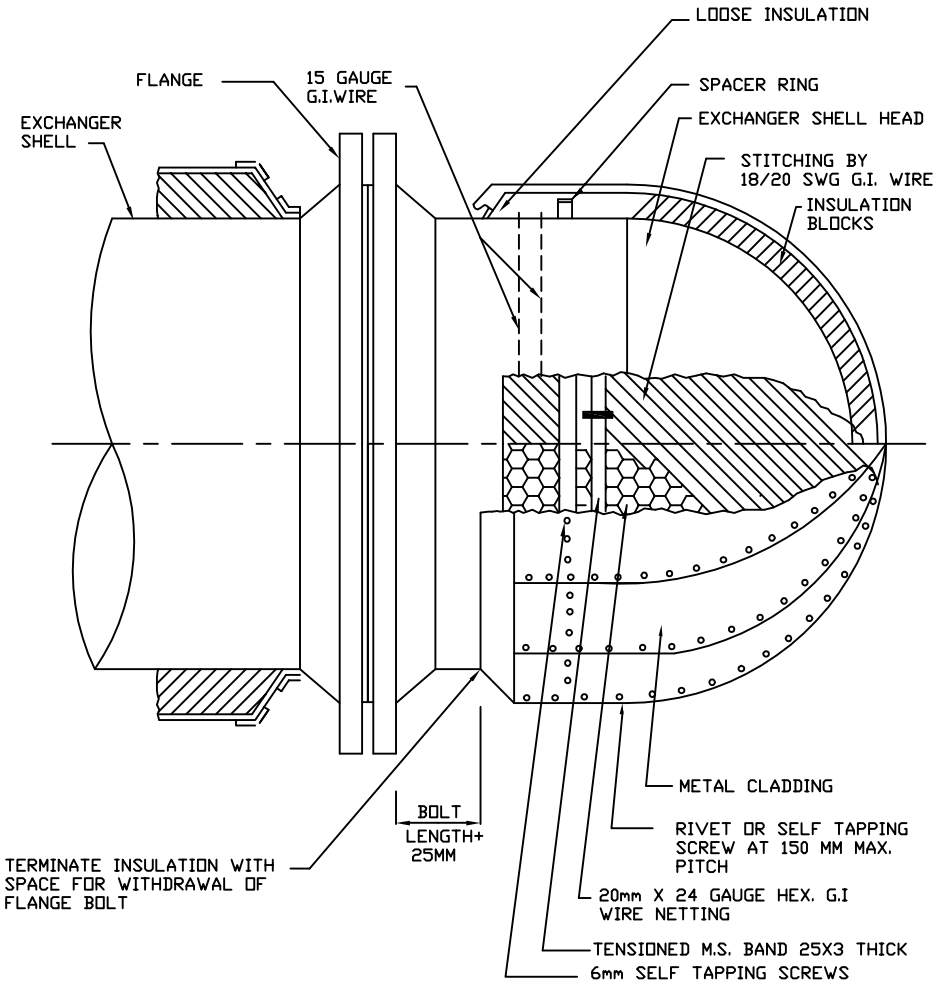


FIG.1 INSULSTION OF VERTICAL VESSELS

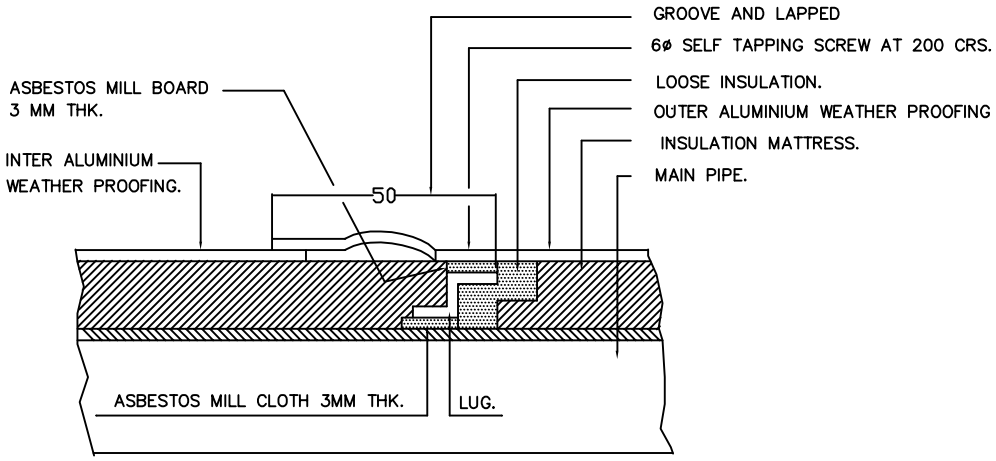


FIG.3 – EXPANSION JOINT FOR RIGID INSULATION.

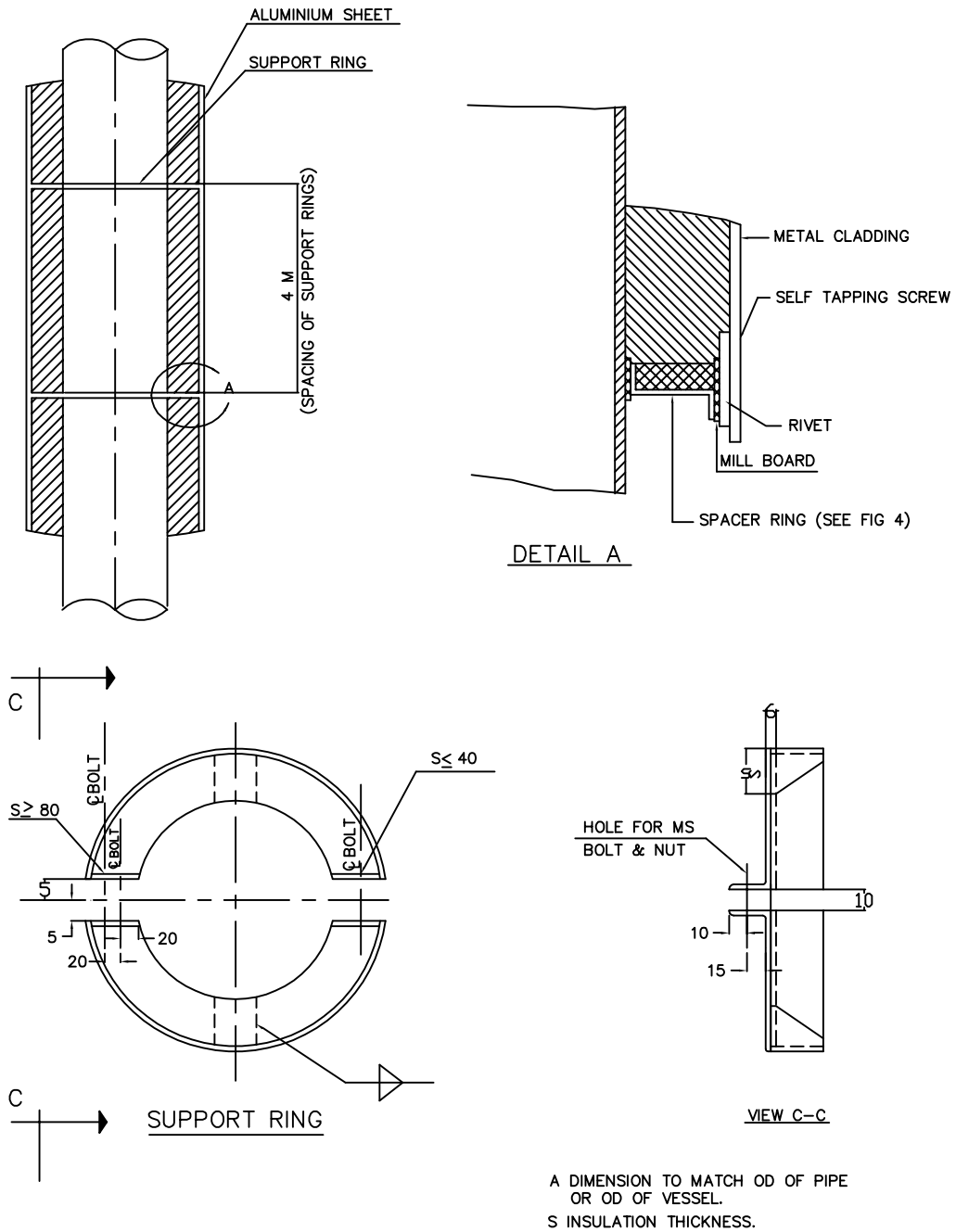


FIG.4 – SUPPORT FOR VERTICAL INSULATED PIPING

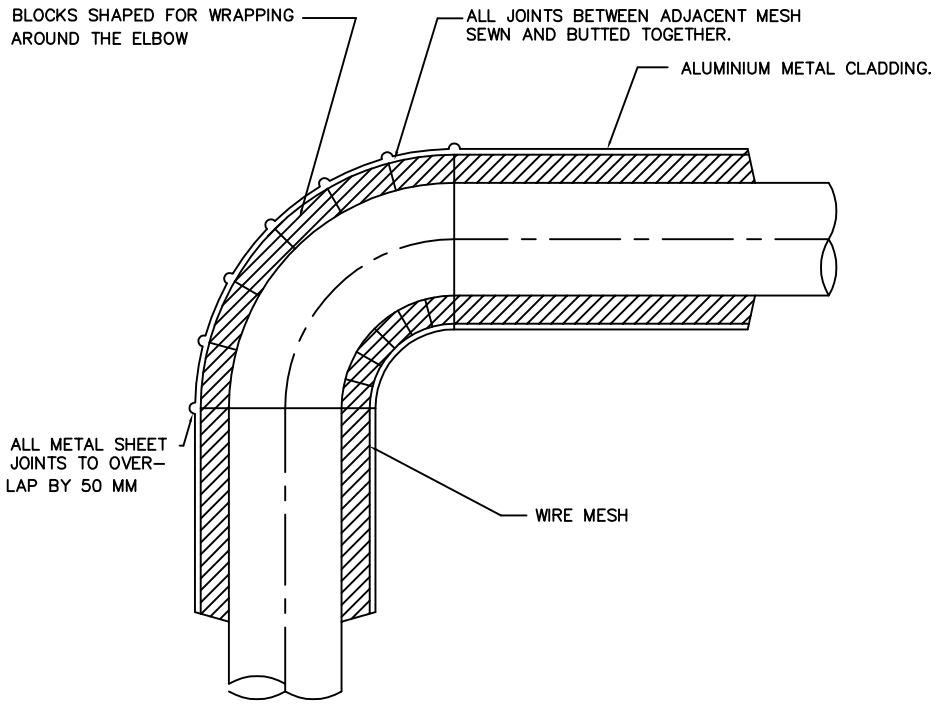


FIG 5 WELDED ELBOW INSULATION

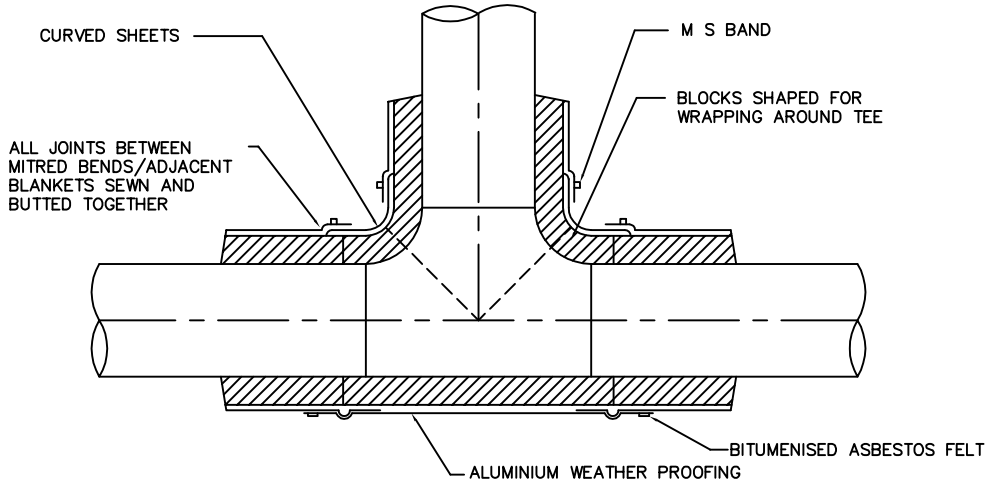


FIG 6 – TEE INSULATION

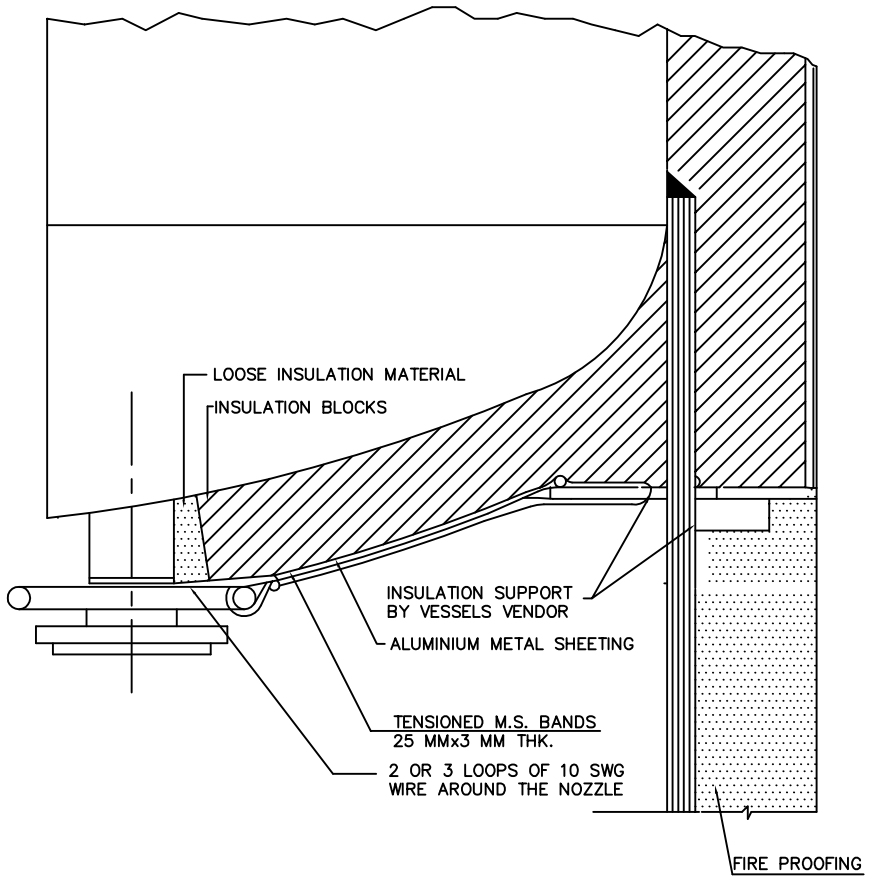


FIG. 7 – BOTTOM HEAD INSULATION FOR VERTICAL VESSELS

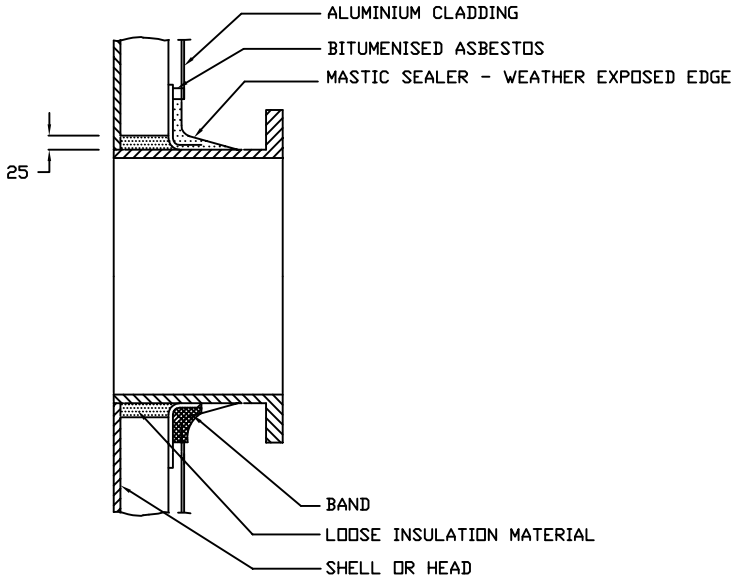


FIG. 10 FLASHING AT NOZZLES & OTHER PROJECTIONS

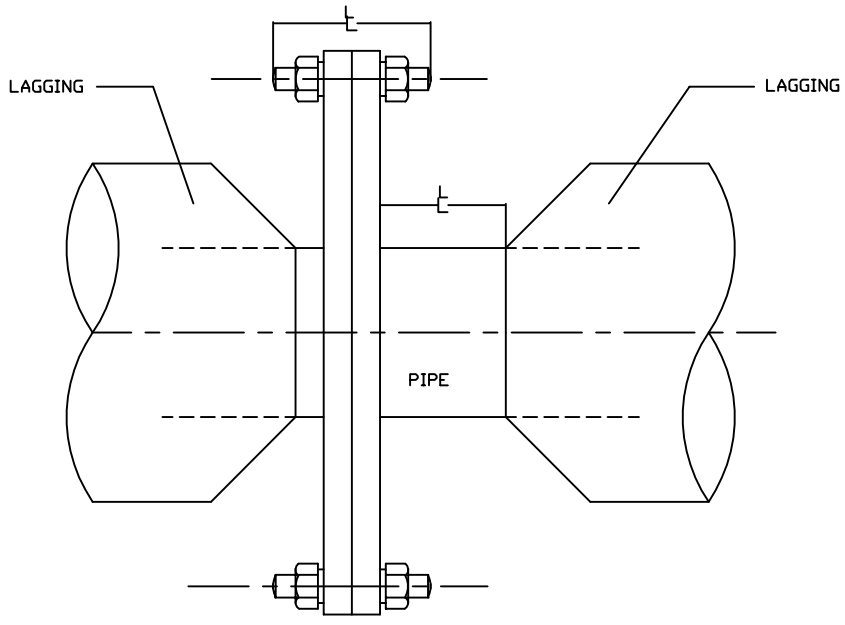


FIG. 11 UNINSULATED FLANGE

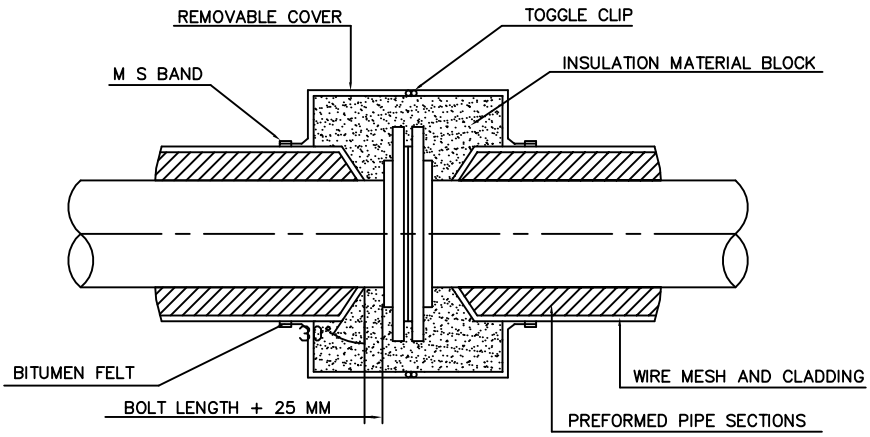


FIG 8 – FLANGE INSULATION

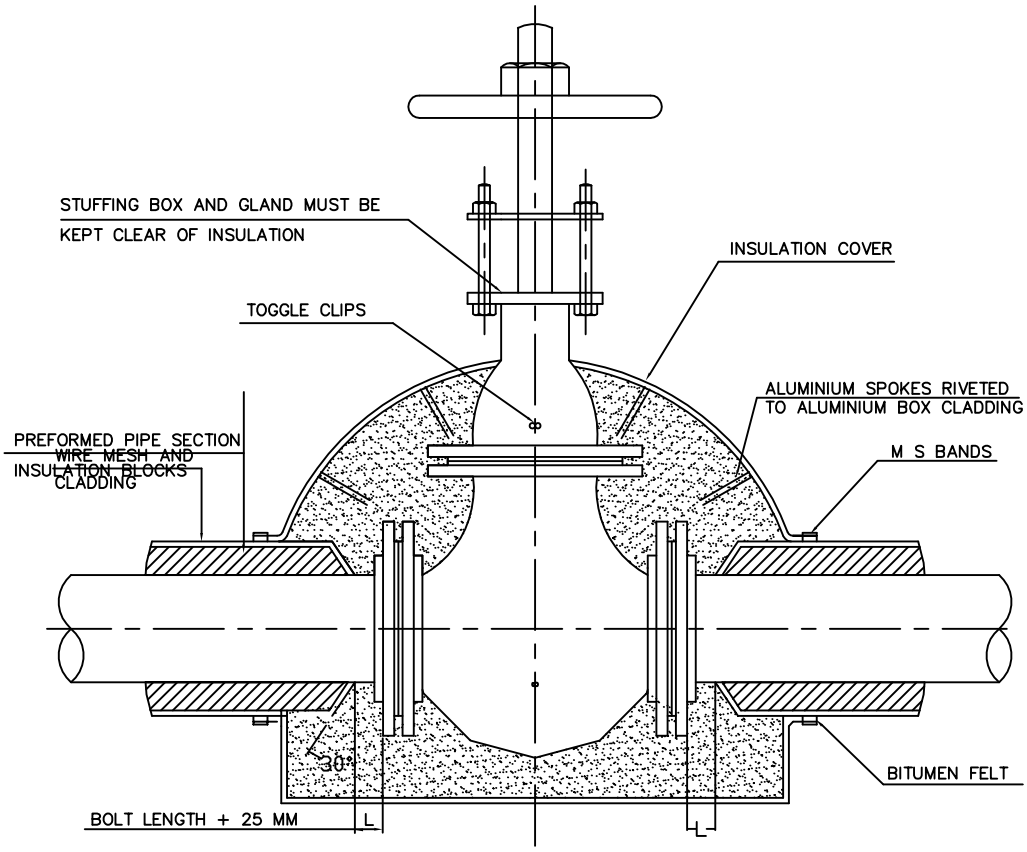


FIG 9 – VALVE INSULATION

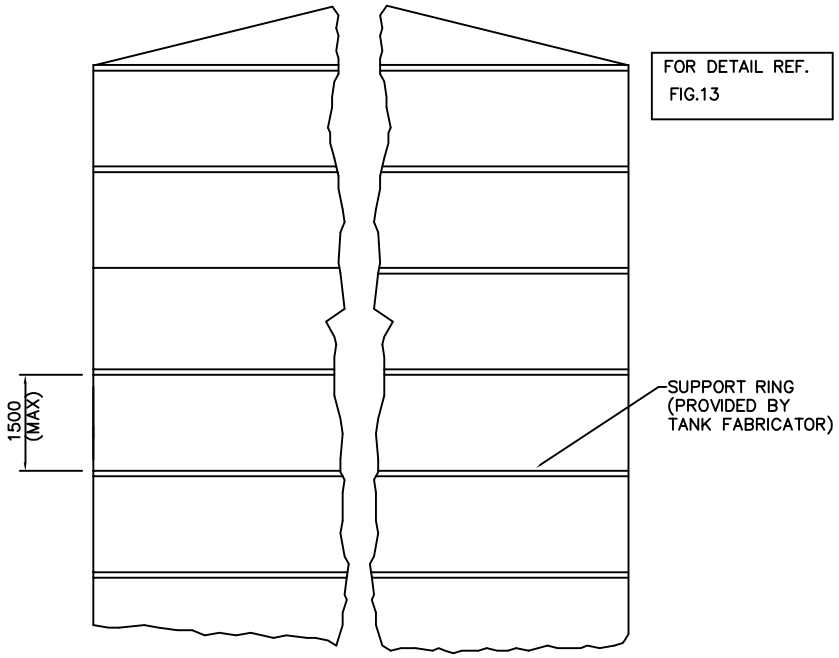


FIG. 12 – TANK SHELL INSULATION – DETAILS

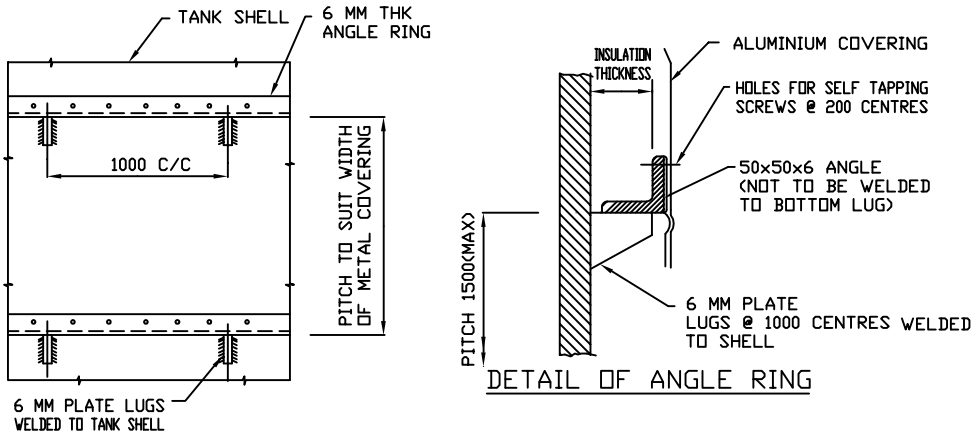


FIG.13 — SUPPORT DETAIL FOR METAL COVERING OF INSULATION

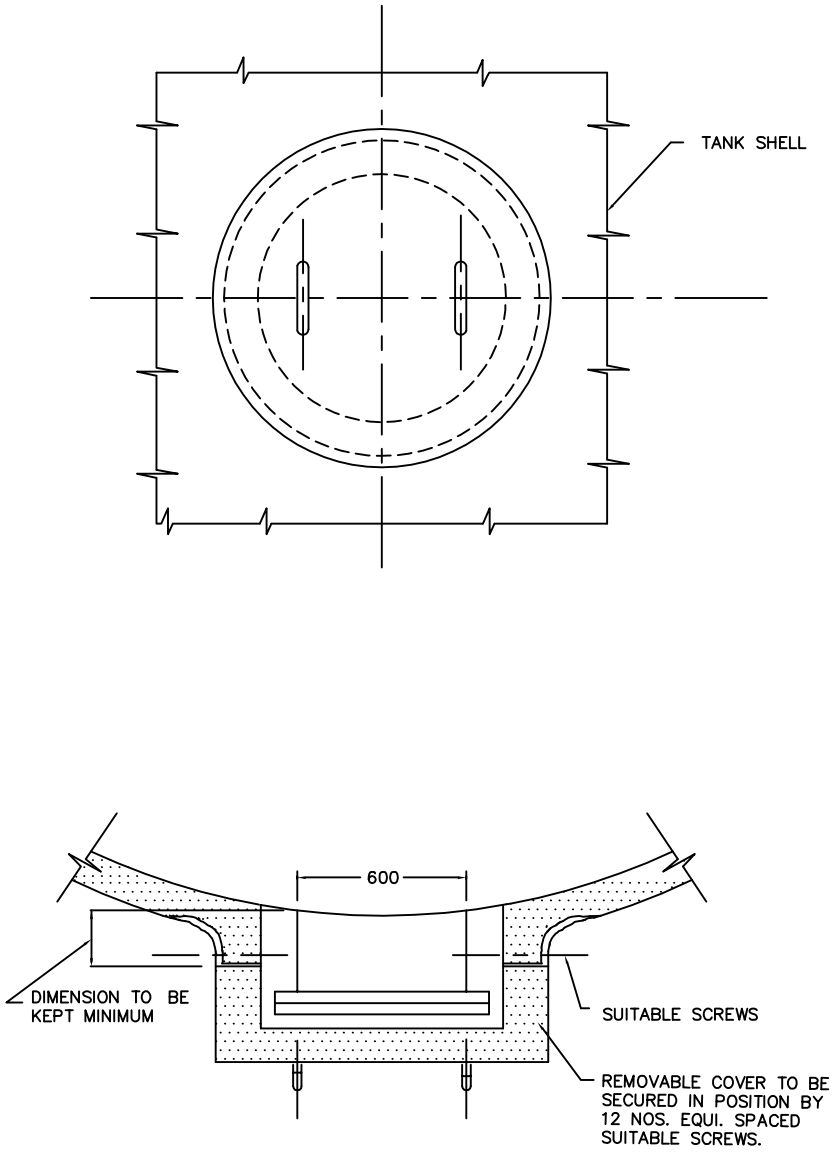


FIG. 14 – MANHOLE INSULATION

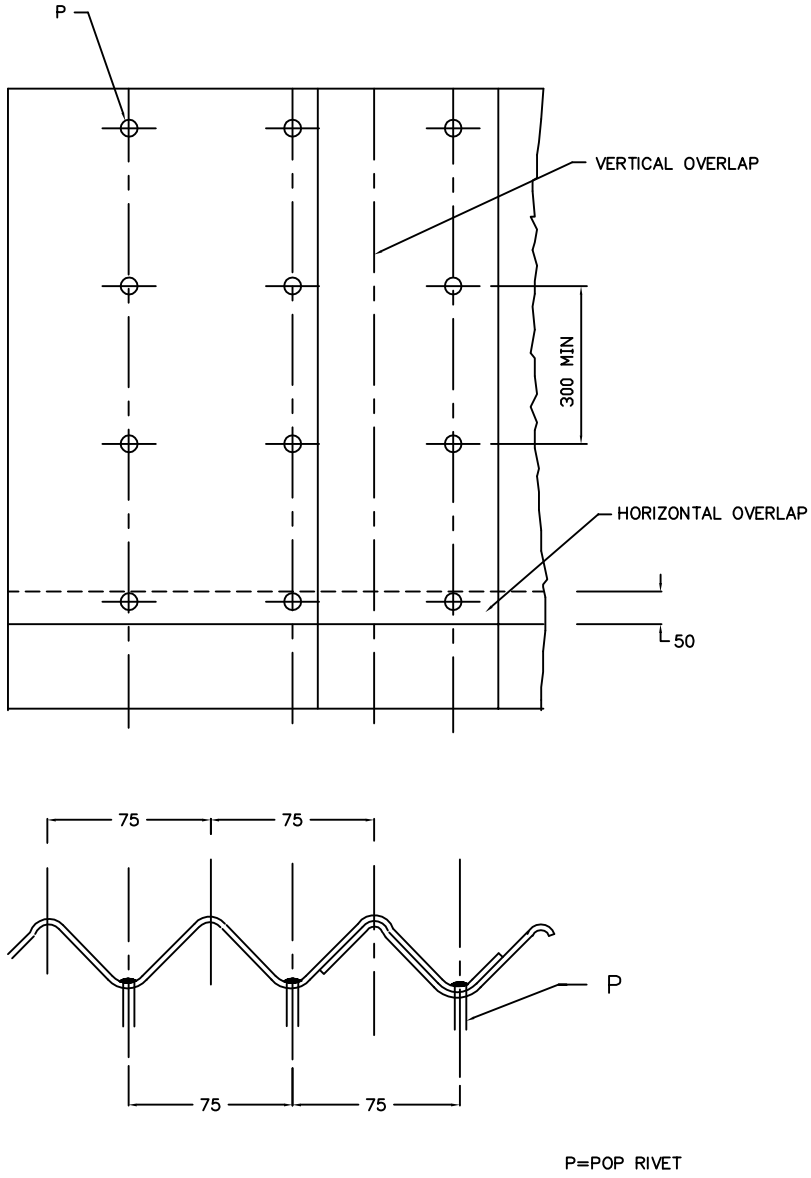


FIG. 15 – DETAILS OF CORRUGATED SHEET OVERLAPPING

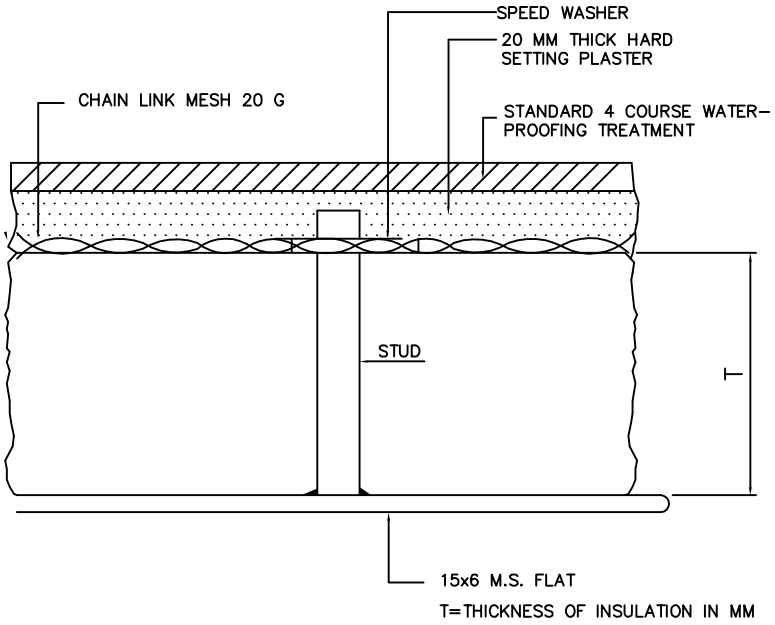


FIG. 17 – DETAILS OF TANK TOP SETTING PLASTER FINISH

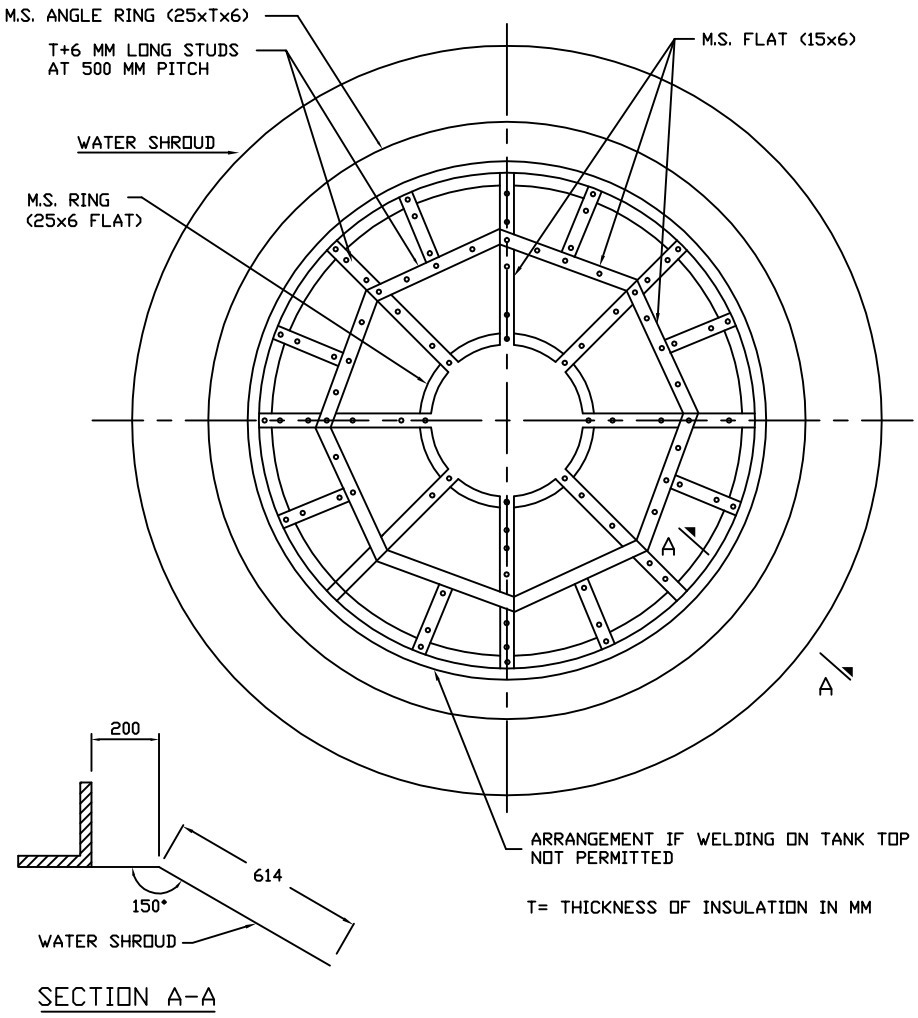


FIG.16 - DETAILS OF TANK ROOF INSULATION SUPPORTS

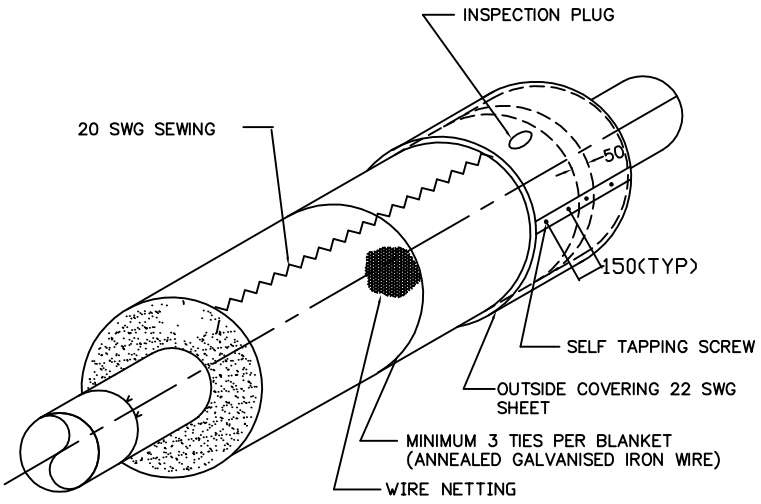


FIG.18 – SINGLE LAYER INSULATION FOR PIPING

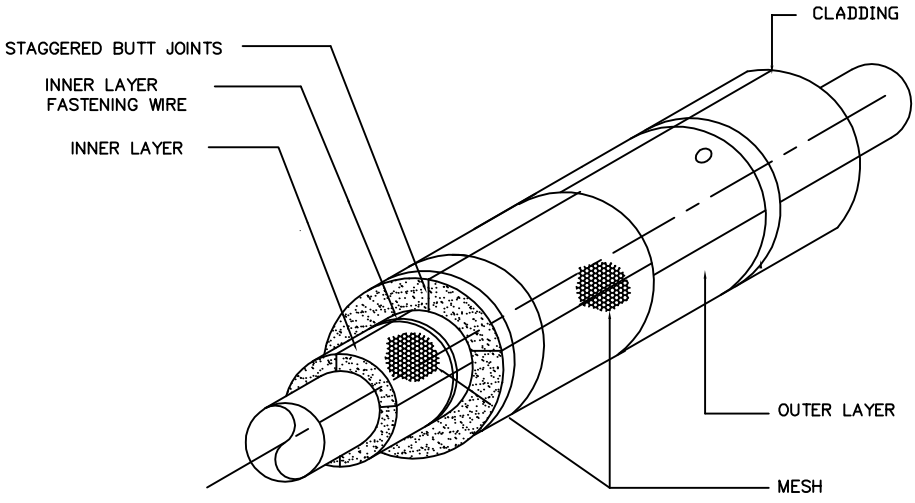
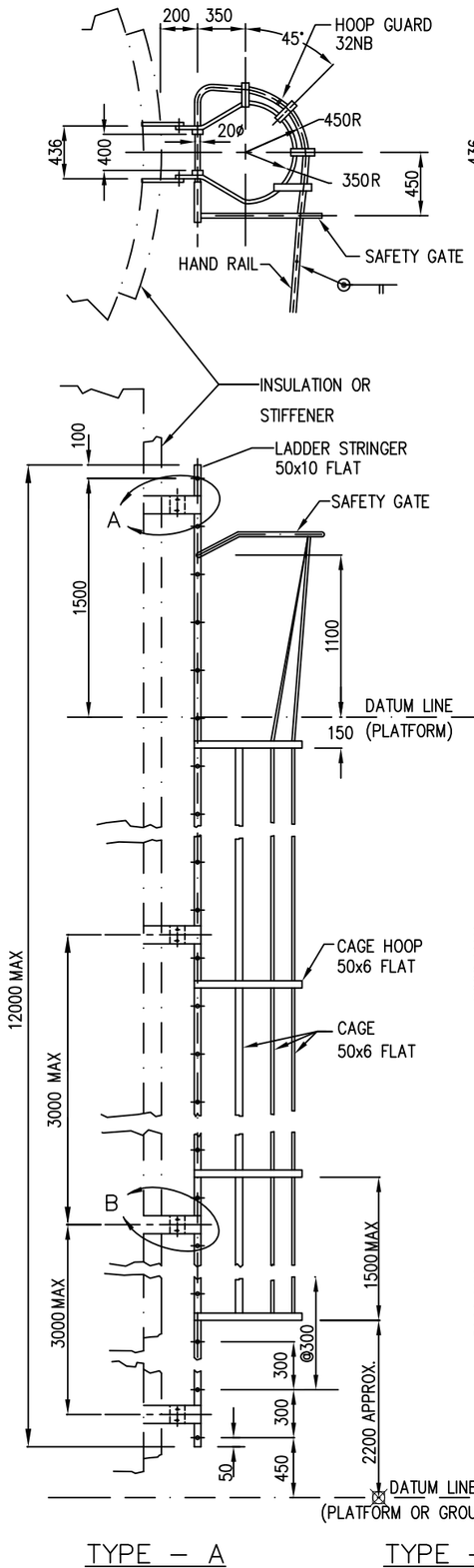


FIG.19 – MULTIPLE LAYER INSULATION FOR PIPING



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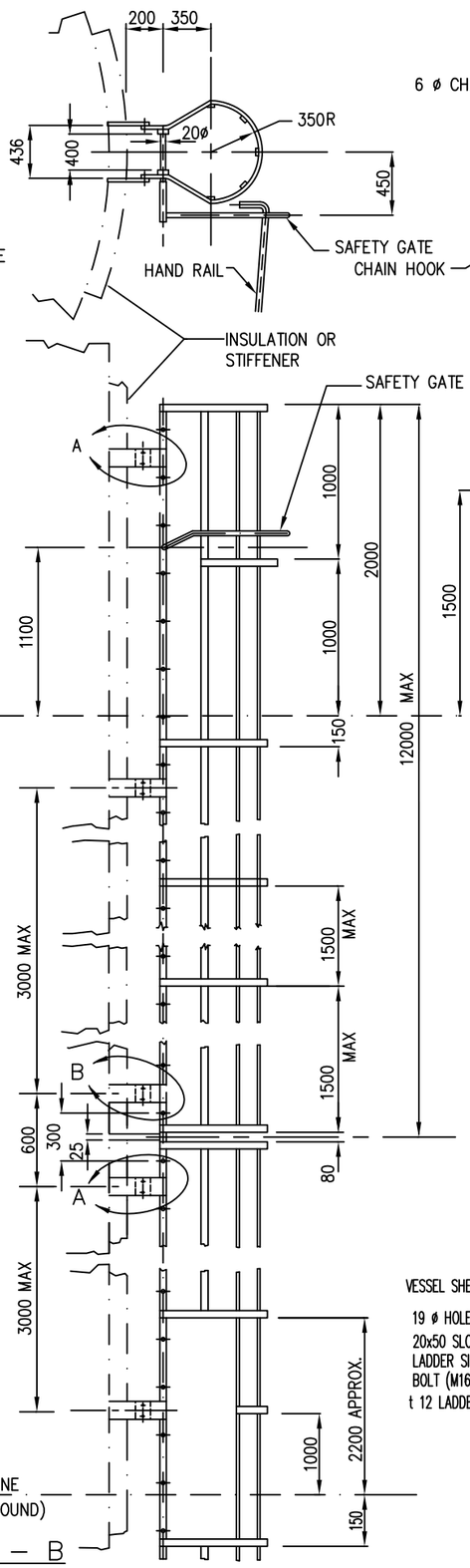

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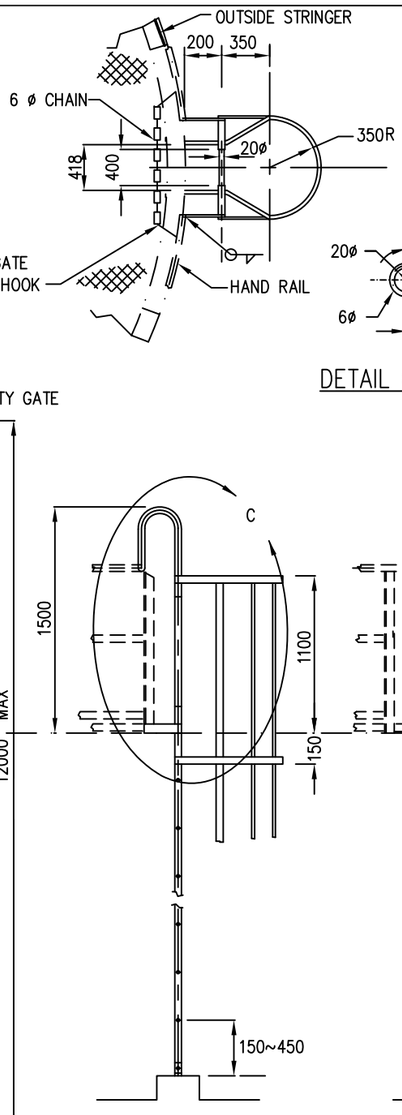

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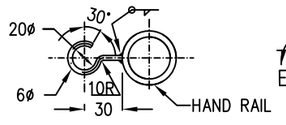
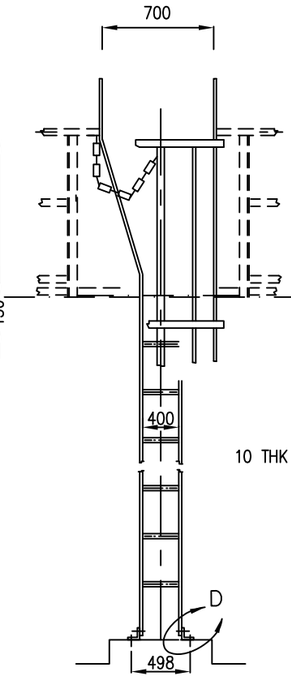
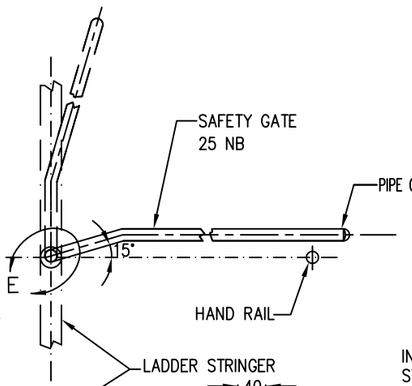
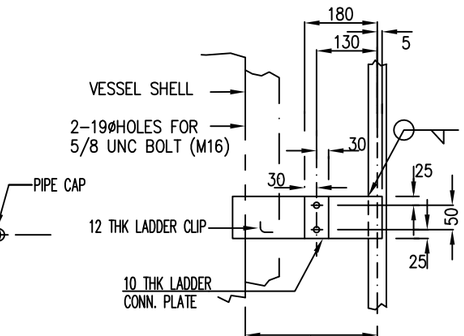


DETAIL OF CHAIN HOOK

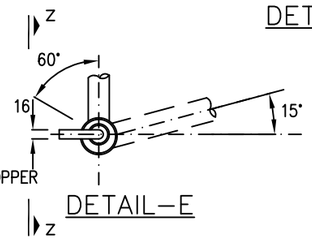




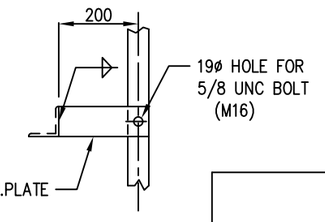
VIEW–ZZ



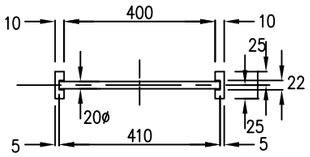
DETAIL–A



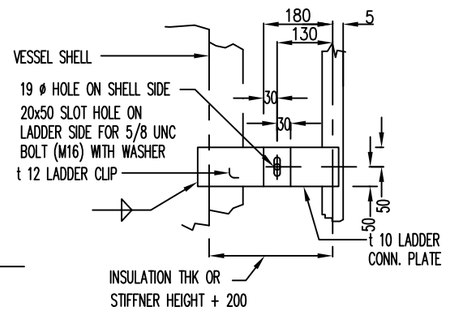
DETAIL–E



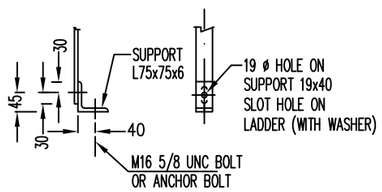
DETAIL–C



DETAIL OF LADDER



DETAIL – B



DETAIL – D

NOTES

1. MATERIAL : STUCTURAL : IS 226 (SEE NOTE.3)
   BOLT / NUT : IS 1353
   PIPE : IS 1239 (HEAVY)
2. FOR HIGH TEMPERATURE COLUMN / DRUM, LENGTH OF 20x50 SLOT HOLE ON LADDER SIDE SHALL BE CHECKED IN CONSIDERATION OF THE DIFFERENCE OF THERMAL EXPANSION BETWEEN SHELL & LADDER.
3. THE PADPLATE FOR LADDER CLIP (DETAIL A & B) SHALL BE ON THE SAME MATERIAL THAT OF EQUIPMENT CONNECTION PART.
4. ALL DIMENSIONS ARE IN MM UNLESS NOTED OTHERWISE.

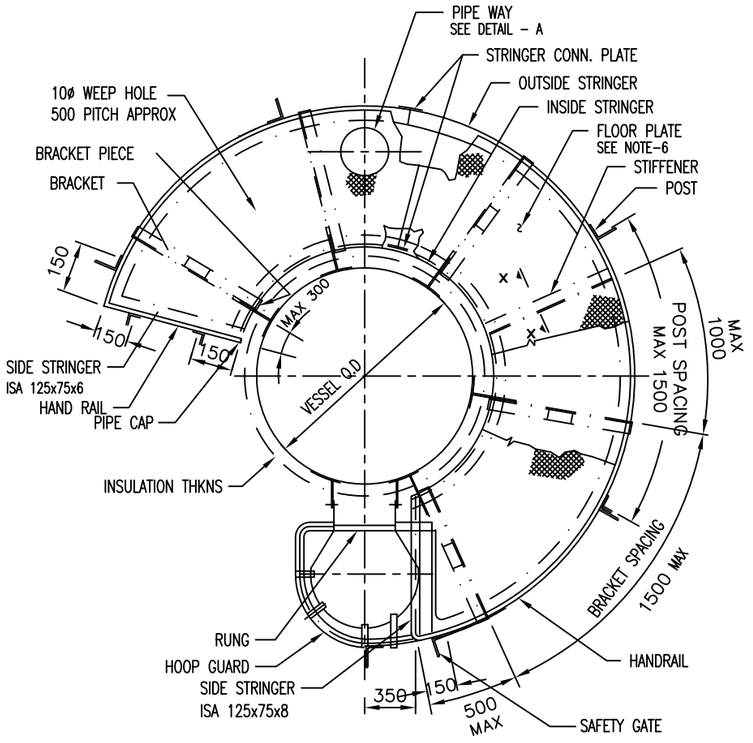
DATE	3.8.2010	3.8.2010	3.8.2010	3.8.2010	3.8.2010
BY	JC	CK	CK	CK	JK
	DRAWN	CHKD.	DSIGED.	CHKD.	APPD.

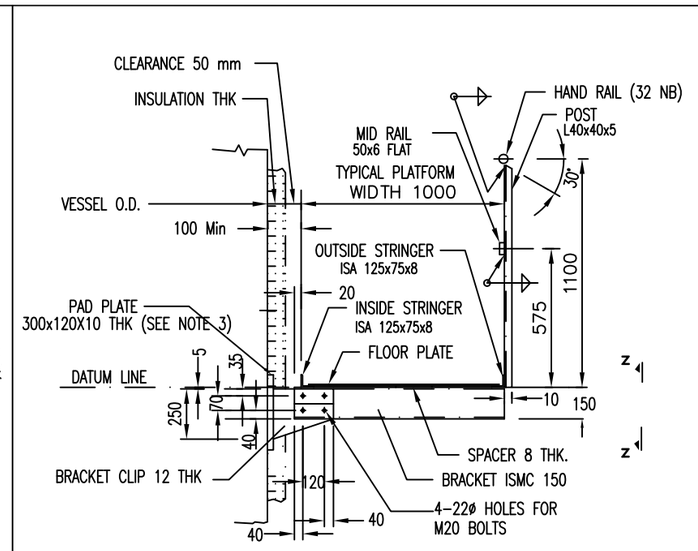
SCALE

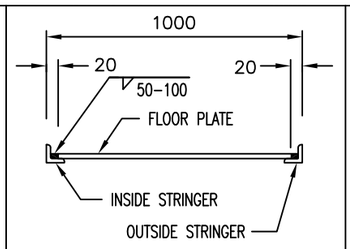
FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD.
UDYOGAMANDAL KERALA

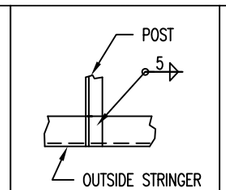
FEDO

TITLE	LADDERS	0
SHEET NO 1 OF 1	DRG.No. 02DS016/2010	REV

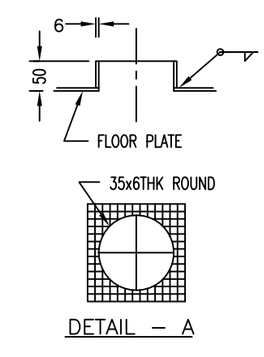




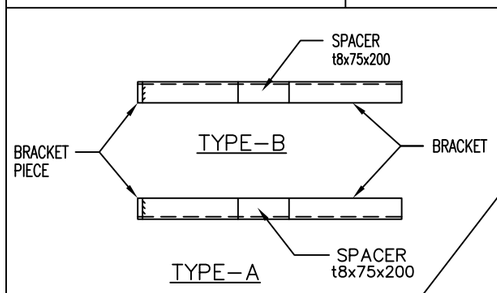




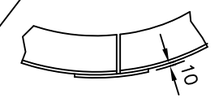
VIEW – ZZ

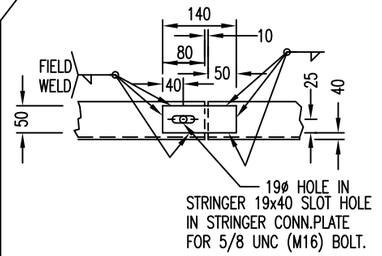


DETAIL – A

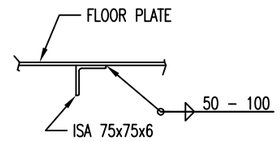


TYPE–A

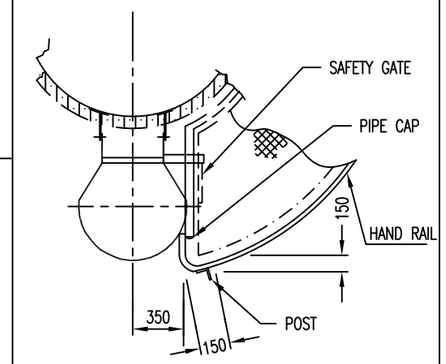


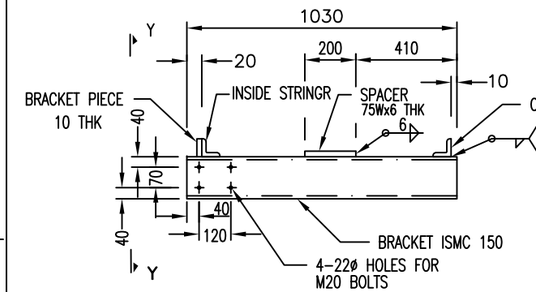


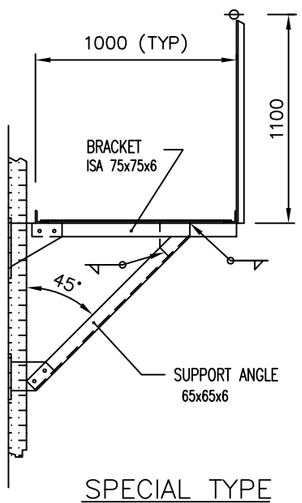
DETAIL OF STRINGER
CONN. PLATE



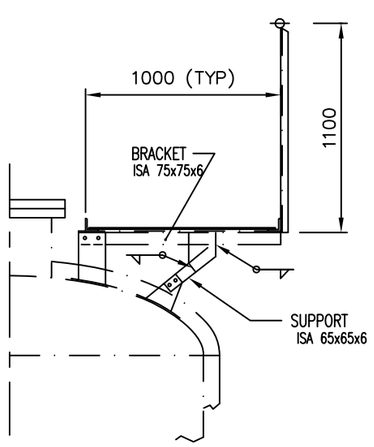
STIFFENER VIEW – XX
WHERE PLATFORM WIDTH IS OVER
1000 TO 5000



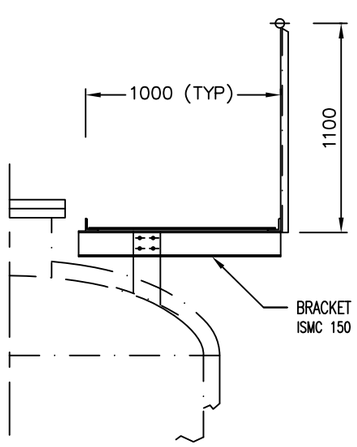




SPECIAL TYPE

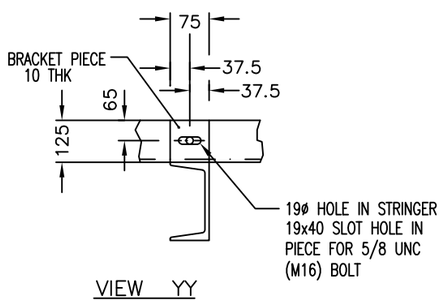


TYPE – 1



TYPE – 2

FOR TOP HEAD



VIEW YY

NOTES

1. ALL DIMENSIONS ARE IN MM UNLESS NOTED OTHERWISE.
2. MATERIAL : STRUCTURALS : IS 226 (SEE NOTE.4)
   BOLT / NUT : IS 1363
   PIPE : IS 1239 HEAVY
3. PLAT FORM LOADING WEIGHT 300 KGF / M^2
4. THE PAD PLATE FOR PLAT FORM BRACKET CLIP SHALL BE OF THE SAME MATL. THAT OF EQPT. CONN. PART.
5. WIDTH OF THE PLAT FORM IS 1000 mm (TYP) UNLESS SPECIFICALLY MENTIONED OTHERWISE IN DRG.
6. FLOOR PLATE SHALL BE OF GRATING. (AS PER TYPICAL DETAILS ATTACHED) UNLESS OTHERWISE SPECIFIED.

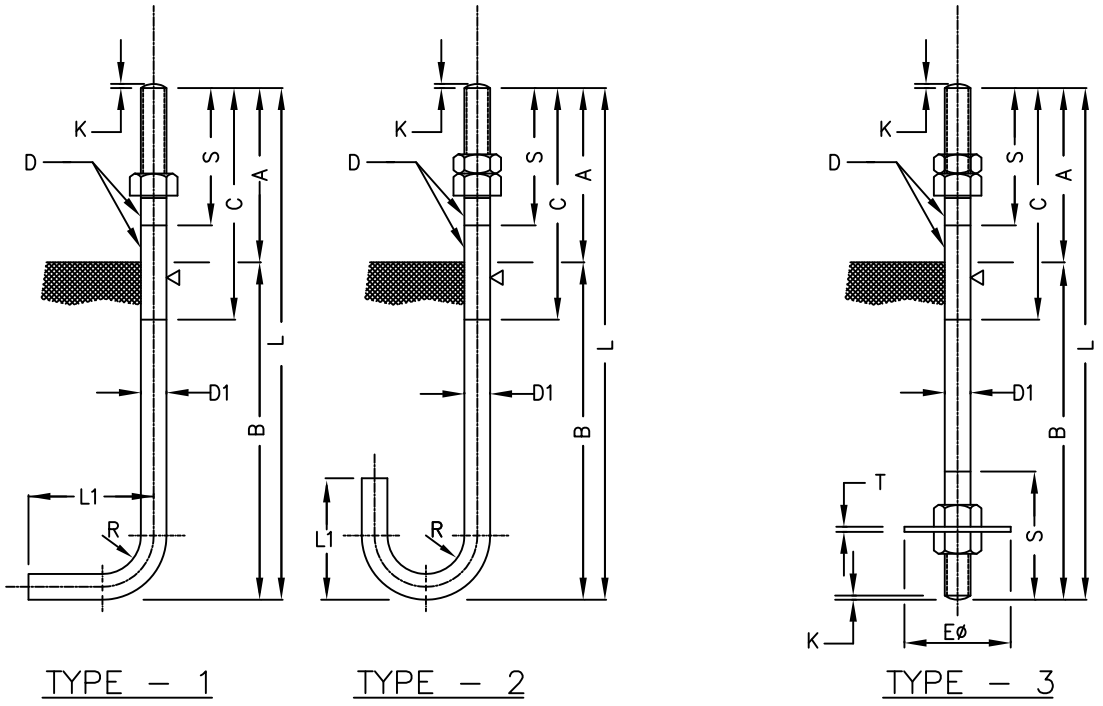
DATE	JULY.2010	JULY.2010	JULY.2010	JULY.2010	JULY.2010
BY	JC	CK	CK	CK	JK
	DRAWN	CHKD.	DSIGNED	CHKD.	APPD.

SCALE

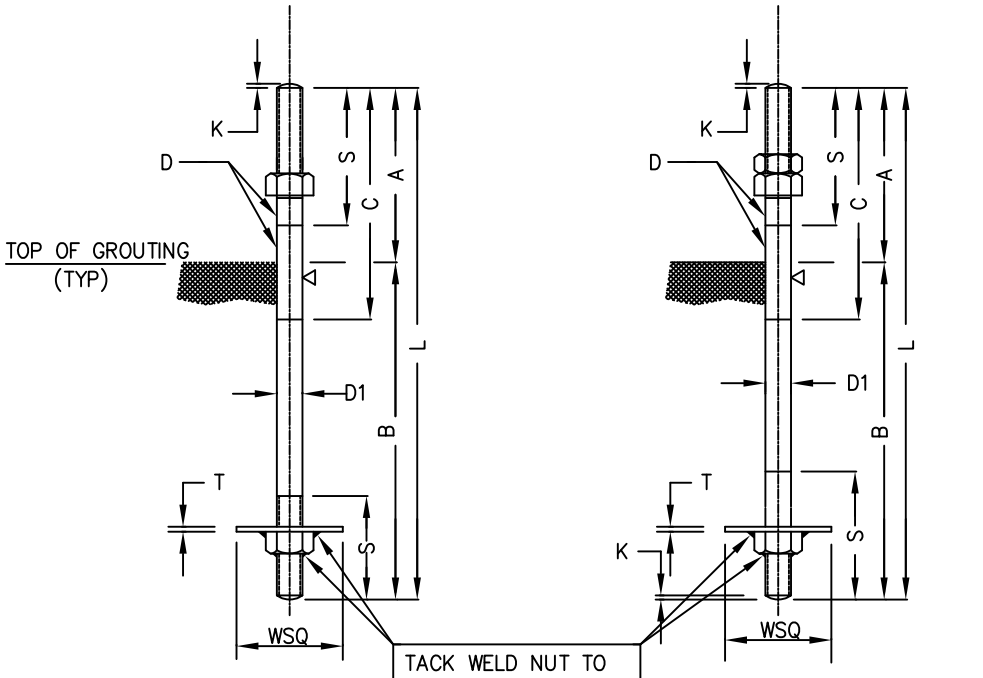
FACT ENGINEERING & DESIGN ORGANISATION
THE FERTILISERS AND CHEMICALS TRAVANCORE LTD.
UDYOGAMANDAL KERALA

FEDO

TITLE	PLATFORM		0
SHEET NO 1 OF 1	DRG.No.	02DS022/2010	REV



TYPE – 1 TYPE – 2 TYPE – 3



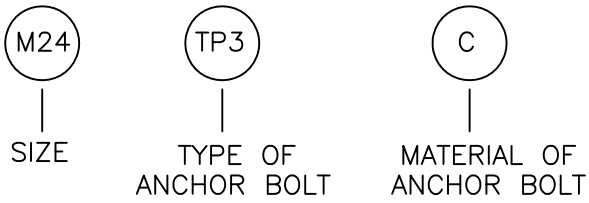
TYPE – 4 TYPE – 5,6 & 7

TYPE OF ANCHOR BOLT	D	D1	S	W	K	R	A	B	C	E	T	L	L1
TYPE – 1	M12	13	30	–	2	25	30	320	60	–	–	350	50
	M16	16	40	–	2	31.5	45	375	75	–	–	420	63
	M20	20	50	–	2.5	40	55	435	85	–	–	490	80
	M22	22	65	–	3	45	75	485	105	–	–	560	90
	M24	22	65	–	3	50	80	550	110	–	–	630	100
TYPE – 2	M16	16	60	–	2	31.5	70	500	80	–	–	570	71
	M20	20	70	–	2.5	40	80	640	100	–	–	720	90
	M22	22	85	–	3	45	95	825	115	–	–	920	100
TYPE – 3	M24	25	85	–	3	–	275	535	300	100	10	810	–
	M30	32	105	–	3.5	–	290	700	315	130	12	990	–
	M36	38	125	–	4	–	380	880	410	150	12	1260	–
	M42	44	140	–	4.5	–	400	1000	435	180	16	1400	–
	M48	50	160	–	5	–	500	1160	530	200	16	1660	–
	M64	65	210	–	6	–	540	1540	585	260	22	2080	–
	M80	80	260	–	7	–	610	1850	660	330	32	2460	–
TYPE – 4	M12	13	30	75	2	–	30	285	60	–	10	315	–
	M16	16	40	90	2	–	45	285	75	–	14	330	–
	M20	20	50	100	2.5	–	55	285	85	–	16	340	–
	M22	22	65	110	3	–	75	285	105	–	18	360	–
	M24	22	65	120	3	–	80	285	110	–	20	365	–
TYPE – 5	M24	25	85	120	3	–	275	285	300	–	20	560	–
TYPE – 6	M24	25	85	120	3	–	275	485	300	–	20	760	–
	M30	32	105	150	3.5	–	290	485	315	–	20	775	–
	M36	38	125	150	4	–	380	485	410	–	25	865	–
TYPE – 7	M16	16	60	90	2	–	70	285	80	–	14	355	–
	M20	20	70	100	2.5	–	80	285	100	–	16	365	–
	M22	22	85	110	3	–	95	285	115	–	18	380	–
TYPE – 8	M24	25	85	–	3	–	395	535	300	100	10	930	–
	M30	32	105	–	3.5	–	415	700	315	130	12	1115	–
	M36	38	125	–	4	–	440	880	410	150	12	1320	–
	M42	44	140	–	4.5	–	460	1000	435	180	16	1460	–
	M48	50	160	–	5	–	485	1160	530	200	16	1645	–
	M56	57	210	–	6	–	630	1540	585	260	22	2170	–
	M64	65	210	–	6	–	630	1540	585	260	22	2170	–
	M72	73	260	–	7	–	800	1800	660	330	32	2600	–
	M80	80	260	–	7	–	890	1850	660	330	32	2740	–

NOTES

1. ANCHOR BOLT DESIGNATION.

EXAMPLE



PART	MATERIAL		
	A	B	C
BOLT	SA 193 B7	IS 2062	SS 304
NUT	SA 194 2H	SA 194 2H	SS 304
PLATES	IS 2062	IS 2062	SS 304

2. APPLICATION

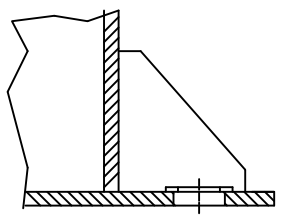
1. FOR EQUIPMENTS COMING ON GROUND LEVEL

TYPE–1: FOR EQUIPMENTS WITH SADDLE/BRACKET SUPPORTS.
TYPE–2: FOR VERTICAL EQUIPMENTS WITH BASE BLOCK TYPE–A AND EQUIPMENTS WITH LEG SUPPORTS.
TYPE–3: FOR VERTICAL EQUIPMENTS WITH BASE BLOCK TYPE–B.
TYPE–8: FOR VERTICAL EQUIPMENTS WITH BASE BLOCK TYPE–C.

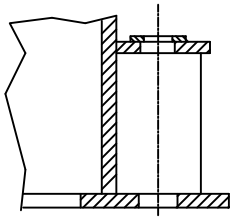
2. FOR EQUIPMENTS COMING ON CONCRETE BEAMS.

TYPE–4: FOR EQUIPMENTS WITH SADDLE/BRACKET SUPPORTS. CONCRETE BEAM DEPTH SHALL BE MORE THAN 350 mm.
TYPE–5: FOR VERTICAL EQUIPMENTS WITH BASE BLOCK TYPE–B AND LEG SUPPORTS. CONCRETE BEAM DEPTH SHALL BE 350 mm TO 450 mm.
TYPE–6: FOR VERTICAL EQUIPMENTS WITH BASE BLOCK TYPE–B AND LEG SUPPORTS. CONCRETE BEAM DEPTH SHALL BE MORE THAN 450 mm.
TYPE–7: FOR VERTICAL EQUIPMENTS WITH BASE BLOCK TYPE–A. CONCRETE BEAM DEPTH SHALL BE MORE THAN 350 mm.

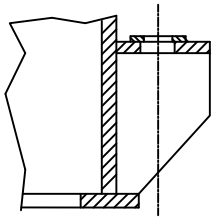
3. SCOPE OF SUPPLY OF ANCHOR BOLT SHALL BE COMPLETE WITH ALL ACCESSORIES LIKE NUTS, WASHERS ETC. AS INDICATED IN THIS DRAWING.
4. ALL DIMENSIONS ARE IN mm.



BASE BLOCK TYPE – A



BASE BLOCK TYPE – B



BASE BLOCK TYPE – C

Job No.	**:**	**32686**
Item	**:**	**FRP COOLING TOWER**
Item No.	**:**	**-**
Project	**:**	**NEW 10000 MT DOUBLE WALL DOUBLE INTEGRITY AMMONIA STORAGE TANK AND ASSOCIATED FACILITIES FOR FACT-CD, AMBALAMEDU ON LSTK BASIS**
Client	**:**	**FACT-CD**
Location	**:**	**AMBALAMEDU, COCHIN**

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 The cooling tower shall consist of single unit with two independent cells. Each cell shall be designed for independent handling of **100%** of the rated flow required for the complete unit. Cooling water basin shall have two partitions corresponding to each cell and these shall be interconnected with suitable piping systems. The scope of work includes complete design, fabrication, supply, erection, testing and commissioning of the FRP cooling tower.

1.2 To ensure safety of personnel at the time of working on cooling tower, necessary provisions shall be provided in such a manner and location as necessary to give safe and complete access to all the parts of the cooling tower requiring inspection or adjustments.

2.0 SCOPE OF WORK AND DELIVERABLES

Design, Supply, Installation, Commissioning and testing of FRP cooling tower and accessories, hereafter referred to as cooling tower system. Specifications of cooling tower system are given in the following sections.

2.1 MAJOR TASKS INVOLVED IN THE JOB ARE AS FOLLOWS:

2.1.1 Design, fabrication, installation and commissioning of a FRP cooling tower system along with all the specified accessories.

2.1.2 Supply, installation and commissioning of necessary motors, pumps, Fans, piping and pipe supports.

2.1.3 Supply and installation of necessary accessories like valves, pressure gauges, temperature gauges, flow meter, etc for efficient working of the cooling tower.

2.1.4 Complete design and construction of FRP tower including cold water basin, cooling tower and FRP super structure as allied systems for cooling tower system.

2.1.5 Supply, installation of the associated electrical equipments.

2.1.6 Inspection, commissioning and Performance testing of Cooling Tower as per CTI-ATC 105 standard.

2.1.7 Any other item/ work required for satisfactory and safe working of the cooling tower system.

3.0 COOLING TOWER (PACKAGED COOLING TOWER)

3.1 The cooling tower may be located at a well ventilated place at ground level. In addition there shall be ample open space all around cooling towers for free flow of air.

3.2 SPECIFICATIONS:-

Sl No	Description	Specification
1.	Type	Mechanical draft - Induced – Counter flow
2.	Construction of cooling tower	In Fibre glass Reinforced Plastic (FRP) construction in Stainless steel 304/Pultruded FRP supporting frame work with PVC fill
3.	Basin	RCC
4.	Rating and certification	To be rated for the heat rejection capacity.
5.	Range-Design	The Cooling tower shall be designed to cool the requisite quantity of water through a range of around 6 to 8 degree C against the prevailing wet

		bulb temperature.
6.	Design Ambient Air Wet bulb temp (Deg C)	29
7.	Wet Bulb approach-Design	The cooling tower shall be selected for a wet bulb approach of not more than 3.5 degree C.
8.	Outlet temperature:	The cold-water temperature from the cooling tower shall match the entering temperature for the requisite equipment.
9.	Heat to be rejected in the Cooling Tower (Rated)	To Suit the heat rejection capacity envisaged with sufficient margin
10	Flow rate:	The water flow rate through the cooling tower shall match the requisite equipments with sufficient margin
11	No of Cells	Two Nos.(1W+1S)
12	Capacity of Each cell	Each cell shall be designed for independent handling of 100% of the rated flow required for the complete unit.
13	Fan per cell	1 No
14	Fan Drive	Electric Motor with Variable Frequency Drive
15	Cold Water Pumps	2W+1S–CS/CI-Electric Motor Driven
16	HW inlet Temperature	Bidder to furnish
17	CW outlet temperature	Bidder to furnish
18	Cold Water Pump Type and Capacity	Horizontal-Centrifugal
19	Side Stream filter unit	1 No
20	Chemical Dosing	Supply of chemicals for the chemical treatment of Cooling water shall be in client scope.

NOTES:-

1) **Sand filter (Side stream filter) unit shall be complete with back wash arrangements like sand filter blower (air scouring blower) (1W+1S), necessary piping etc. Sand filter to be installed at cooling water pump discharge header side and outlet of Sand filter routed back to cooling tower basin. Sand filter to be suitably designed to obtain the suspended solid value of 5 PPM at the outlet for the specified raw water characteristics.**
2) **Cooling tower blow down and Sand filter backwash water shall be routed to ETP through collection pit and pump.**
3) **Copper and Copper based materials shall <u>not</u> be used.**

3.3 MATERIAL AND CONSTRUCTION

3.3.1 Fibre glass Reinforced Plastic (FRP) Cooling tower in SS supporting framework

3.3.2 The structural framework of the cooling tower including all members shall be designed for the load encountered during the normal operation of the cooling tower and its maintenance. The structure shall be rugged and rigid to prevent distortion and shall include tie arrangements as may be necessary.

3.3.3 The cooling tower shall be induced draft type, with FRP casing in rectangular shape, and with RCC basin to match the shape of the casing.

3.3.4 The supporting framework for the tower casing shall be in Stainless steel 304 / Pultruded FRP considering the overall corrosive nature of the surrounding area. Also fasteners, and all other wetted metallic parts shall be in Stainless Steel.

3.3.5 The fills shall be of PVC. Thickness of PVC fills shall not be less than 0.2 mm. These shall be

of such construction as to provide low air resistance, large wetted surface for a high heat transfer efficiency, and easy replace ability.

3.3.6 The water distribution shall be through fixed type spray nozzles in Poly Propylene ensuring uniform water loading and distribution of water over the fill.

3.3.7 Drift eliminators of PVC shall be provided for maximum removal of entrained water droplets. The spacers and tie rods used shall be of plastic material.

3.3.8 The fan shall be multi-blade axial flow type, made of FRP. The fan assembly shall be statically and dynamically balanced.

3.3.9 The fan drive shall be from a three phase induction motor, either direct or through a spiral gear work.

3.3.10 The entire drive arrangement shall be designed for a minimum noise and it shall be rigidly supported to the tower structure.

3.3.11 To ensure safety of personnel at the time of working on cooling tower a steel ladder shall be provided in such a manner and location as necessary to give safe and complete access to all the parts of the cooling tower requiring inspection or adjustments. The ladder shall be bolted to the tower at the top and grouted in masonry at the bottom end.

4.0 COOLING WATER PUMPS (2W+1S)

4.1.1 The cooling water pumps shall be of Horizontal centrifugal back pull out type construction and oil lubricated. The pumps shall be centrifugal type direct driven with a 3 phase, 415 + 10%volts, 50 Hz., A.C. motor. The pumps shall be suitable for continuous operation in the system.

4.1.2 Three Numbers of cold water pumps shall be supplied, (Two shall be operational and one standby) with suitable NRV at delivery lines. The pumps shall be driven by a Squirrel cage Induction motor of suitable HP to supply the rated water flow required for the cooling tower unit complete to the required head and with sufficient margin. Provision to be made to operate each pump independently or in any two pumps configuration. The motor shall be TEFC type and class ‘F’ insulation and of approved makes.

4.1.3 Cold Water pumps shall be housed in covered roofs of structural steel

4.2 MATERIALS AND CONSTRUCTION

4.2.1 The pump casing shall be of heavy section close grained cast iron. The casing shall be provided with air release cock, drain plug and shaft seal arrangement as well as flanges for suction and delivery pipe connections as required.

4.2.2 The impeller shall be of Cast Iron or as per manufacturer’s standard. This shall be shrouded type with machined collars. The impeller surface shall be smooth finished for minimum frictional loss. The impeller shall be secured to the shaft by a key.

4.2.3 The shaft shall be of CS and shall be accurately machined. The shaft shall be balanced to avoid vibrations at any speed within the operating range of the pump.

4.2.4 The shaft sleeve shall extend over the full length of the stuffing box or seal housing. The sleeve shall be machined all over and ground on the outside.

4.2.5 The bearings shall be ball or roller type suitable for the duty involved. These shall be grease lubricated (or oil lubricated as per standards) and shall be provided with grease nipples/cups. The bearings shall be effectively sealed against leakage of lubricant.

4.2.6 The shaft seal shall be stuffing box type, so as to allow minimum leakage compatible with the operation of the seal. The stuffing box shall be of adequate length and shall be packed with graphite asbestos or any other suitable material for the operating temperature. A drip well shall be provided beneath the seal.

4.2.7 The pump shall be directly coupled to the motor shaft through, a flexible coupling protected by a coupling guard.

4.2.8 The pump and motor shall be mounted on a common base plate either of cast iron or fabricated from rolled steel section. The base plate shall have rigid, flat and true surfaces to receive the pump and motor mounting feet.

5.0 COOLING TOWER BASIN

5.1 The cooling tower basin shall be of RCC construction, Actual capacity shall be designed taking into consideration water flow rate, drift and evaporation losses so as to run the cooling tower on full load without makeup water for at least 8 hrs per day. The construction should be such as to eliminate the danger of drawing air into the pump when operating with minimum water in the basin. The cooling tower basin with partition in between shall be such that the cold water pumps are always flooded with cooling water thereby avoiding the use of priming pumps, etc. Suitable isolation arrangements of individual basin enclosures from forebay space to be provided for maintenance purpose. Suitable piping and valve arrangements to be provided with the individual basins for filling the treated water, draining the basins during maintenance/ blowdown, and for overflow provisions.

6.0 COOLING FILL UNITS

6.1 The cooling fill unit shall be so designed that maximum duration of contact between water and air is achieved. The cooling fill shall be made of PVC and suitably arranged to give the maximum performance. The frames holding the fill in position shall be of stainless steel. The fill support shall be of Stainless steel construction. Thickness of PVC fills shall not be less than 0.2mm. These shall be of such construction as to provide low air resistance, large wetted surface for a high heat transfer efficiency, and easy replace ability.

7.0 DRIFT ELIMINATORS

7.1 The drift eliminators should be of PVC material laid down as per acceptable standard and designed to operate with minimum pressure drop and maximum efficiency. This arrangement should be suitably supported on Stainless steel structure Drift eliminators of PVC shall be provided for maximum removal of entrained water droplets.

8.0 FAN STACK/CASING

8.1 Separate fan casing is required for each cell, made of FRP with suitable diameter and shape to provide free flow of air.

9.0 HOT WATER DISTRIBUTION AND SPRAY NOZZLES

9.1 Hot water distribution system shall be designed for a water load of 115% of the circulation rate. The internal distribution of hot water in the cooling tower shall be of pressurized closed loop with self-adjusting, non-clogging and self-cleaning type of polypropylene spray

nozzles. The water distributions over the fill are to be uniform and free from dead zones, thereby attaining a better overall performance.

9.2 Material of Construction for Hot Water distribution:

- Hot Water Header pipe (inside tower): SS 304/PVC
- Hot Water Laterals / Branch Pipes: PVC
- Distribution/ Spray Nozzles: PP

10.0 FAN ASSEMBLY

10.1 Individual sets of fan assembly unit shall be provided for each cell so that the cells can be operated either individually or together. The fan assembly and drive system shall be designed for totally vibration free operation. Suitable lighting arrangements in the tower top shall also be provided.

11.0 FAN ELECTRIC MOTOR

11.1 The electric motors to drive the fan of each cell shall be of adequate capacity. Motors shall be Induction type, 3 phase, 50 cycles, 415± 10% Volts and they shall be totally enclosed and fan cooled. Start and stop controls to be provided both at the control panel and at the top of the cooling tower and shall be of manual reset type. The motors shall be provided with suitable push button operated direct On-line Starters and all required electrical accessories. The motor shall be TEFC type and class 'F' insulation and of approved makes. Variable frequency Drive shall be provided for the fan motor.

11.2 Motors for cooling tower fan drive shall have horse power ratings including service factor, if any, at least equal to the following percentage of rated brake horse power.

Nameplate rating, KW	% above rated BHP
18.5 and less	125
Above 18.5 & below 75	115
75 and above	110

11.3 Gear losses and transmission losses (as applicable) shall be added to fan power consumption before driver ratings are applied.

12.0 TESTS AND INSPECTION

12.1 The Cooling tower unit after complete erection and commissioning shall be field tested for performance. As far as possible the test shall be conducted at a time when the atmospheric conditions are close to the design conditions.

12.2 The test shall be conducted in accordance with "Acceptance test code for water-cooling tower of Cooling Tower Institute CTI-ATC 105 latest revisions". Measuring gauges/instruments required for these tests shall be provided by the vendor. Provision will be made to connect the gauges/instruments at appropriate location in the pipelines.

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APPENDIX-1

GENERAL CONDITIONS TO BE FOLLOWED BY THE LSTK BIDDER FOR SELECTION OF SUB-VENDORS FOR BROUGHT OUT ITEMS BY THE LSTK BIDDER FOR NEW 1650TPD NPK PLANT AND 10000MT AMMONIA TANK AT FACT-CD

1.0 LSTK BIDDER shall necessarily procure all the brought out material/equipment forming permanent part of the unit/plant from OWNER approved sub vendor only. This shall include sub ordered items/components also. The "Approved Sub-Vendors" shall be item specific.

2.0 (i) OWNER's recommended Sub-vendor list for the items is enclosed in this section **(Appendix-4)**

(ii) Special conditions to be followed for selection of sub-vendors for brought out items by the LSTK bidder: 1650 TPD NPK Plant is enclosed in **Appendix-2**

(iii) Special conditions to be followed for selection of sub-vendors for brought out items by the LSTK bidder: 10000 MT Ammonia storage and associated facilities is enclosed in **Appendix-3**

In case of a conflict between this general conditions and special conditions, the respective clauses under special conditions shall prevail to the extent of such conflict.

3.0 (i) LSTK BIDDER may procure material from any of OWNER recommended sub vendors. However current validity of sub-vendor approval & their approved product range and the conditions imposed while according sub-vendor approval shall be verified by the LSTK BIDDER before placement of order.

LSTK BIDDER shall also verify the work load, stability and solvency status of the vendor prior to placement of order.

(ii) **Sub Vendors on OWNER holiday list shall not be considered for ordering, which need to be verified by the LSTK BIDDER prior to placement of order. LSTK BIDDER shall comply with this requirement without any time or cost implication to Owner.**

(iii) In case any sub vendor is recommended subsequent to release of this sub-vendor list, the same may also be considered by the LSTK BIDDER with prior intimation to OWNER and obtain their concurrence prior to placement of order.

(iv) LSTK BIDDER may consider additional alternate sub-vendors not included in the above list, with prior intimation of OWNER approval status, documents/credentials

to be furnished by the vendor in such cases shall solely be the responsibility of the LSTK BIDDER. Also please note the special conditions in this regard.

4.0 Compliance to procurement of material from approved sub-vendors is mandatory and shall be fully complied with. No deviation to the recommended sub-vendor list shall generally be acceptable except in certain genuine/deserving cases. Also please note the special conditions in this regard.

5.0 For items not covered in the above list, the sub-vendor list shall be approved by OWNER prior to placement of order by LSTK BIDDER. LSTK BIDDER shall list down the proposed sub suppliers/vendors for such items and submit the same for OWNER's review/approval along with necessary documents/credentials. Non acceptance of a particular proposed sub-vendor due to any reasons whatsoever shall not be a cause of schedule and cost implication. Please refer special conditions also.

6.0 **LSTK BIDDER shall have an independent assessment of capability of all the sub-vendors for timely deliveries of material/equipment even if the sub-vendor is from the recommended list of the owner. Any delays in deliveries by vendor(s) shall not be a cause of schedule and cost implication.**

7.0 At any stage of the project, if it comes to the notice of OWNER that LSTK BIDDER has procured material/equipment, intentionally or unintentionally whatsoever, from an unapproved sub-vendor and/or items not falling in approved product range of vendor(s), then the same shall be rejected forthwith and LSTK BIDDER shall be liable to replace such material/plant/machinery within the contract price and without any time/schedule implication.

8.0 List of sub-vendors appearing anywhere else in the contract document in case of duplication of the items at two or more places (except for the sub-vendor list provided by Process Licensor, if applicable) shall not be considered by LSTK BIDDER and shall be superseded by the sub-vendor list enclosed herewith.

Sub-Vendor for any item not covered in this vendor list but appearing anywhere in the Licensor process package, Licensor vendor list shall be followed.

In case of any Mandatory/Proprietary items appearing in this vendor list as well as in the Licensor's process package, the sub-vendors as recommended by the Process Licensor shall be followed.

9.0 It is understood that should the name of sub-vendor be changed due to change in their Company or Corporate shareholding, OWNER will accept such sub-vendor under its new name with prior approval for which the requisite documentation shall be furnished by the LSTK BIDDER.

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Any such approval shall however, not release the LSTK BIDDER from any of his obligations under the CONTRACT; neither shall any such approval signify nominations or instruction to use such a sub-vendor. All approved sub-vendors are deemed to have been freely chosen by the LSTK BIDDER at his own risk

10.0 The recommended sub-vendor list for fabricated equipment (Vessels etc.) is for fabrication alone, where mechanical design of the equipment is included in LSTK BIDDER'S SCOPE, LSTK Bidder SHALL EITHER HIMSELF OR THROUGH HIS DETAILED Engineering sub LSTK Bidder be responsible for designing and obtaining approval/review of Mechanical design calculations as per codes/specifications specified elsewhere in the Bid/Contract documents from OWNER.

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Appendix-2

Sub : SPECIAL CONDITIONS TO BE FOLLOWED FOR SELECTION OF SUB VENDORS FOR BROUGHT OUT ITEMS BY LSTK BIDDER - **1650 TPD NPK Plant at FACT-CD**

The following conditions shall apply with regard to selection of sub vendors for 1650 TPD NPK plant.

1. **Supply of Equipments through Process Licensor(s) or through their Approved Vendor list**

The bidder shall obtain the list of such equipment(s) to be supplied through Process Licensor or through the approved OEM's / vendor list of Process Licensor as applicable along with reference of plant where such equipment supplied by these OEMs are in successful operation and submit to the owner (FACT/FEDO) for their approval.

In case of authorized dealers of the OEM, necessary authorization certificate from the OEM shall be submitted along with the bid.

2. **Supply of Equipments/ Machinery from the Owner's recommended Sub-Vendor list**

For equipment(s) not covered under Sl.No.1 above, the LSTK bidder should select sub-vendors primarily from the owners recommended list. However the following shall also apply:

a. Bidder is free to suggest certain new sub vendors in addition to the owner's recommended sub-vendor list as per their experience. In case certain new sub vendors are to be added by the bidder, the conditions specified in the tender document elsewhere and noted below shall be complied.

AND

b. For all critical items, the selected new sub vendor(s) should also be approved by Process Licensor even if the sub-vendor appears in the recommended sub vendor list of the owner.

3. **Supply of Equipments/Machinery not covered in the Owner's recommended sub vendor list/ new sub Vendors to be added**

A new sub vendor list shall be prepared by bidder for supply of Equipment(s) / Machinery not covered in OWNER's sub vendor list.

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As it is not possible by the Owner to ascertain credentials of all the added sub vendors in the new sub vendor list, the following prequalification criteria, with respect to Past Performance / Experience of the sub vendor for any Equipment / Machinery shall be applicable:

A. <u>For new Indian Sub Vendors proposed by the LSTK bidder</u>

1. The proposed sub vendor during the last 15 (fifteen) years from the date of publication of the tender, should have manufactured and supplied either by themselves or though their authorized dealers at least TWO similar Plant Equipments or Machinery for the specified duties and the same should be operating satisfactorily after commissioning for at least One Year. The LSTK Bidders should submit relevant documentary proof as follows:

   a. Copy of Purchase Orders with full technical details of the equipment or machinery supplied by the proposed sub vendor.

   b. Certificate(s) from user regarding satisfactory performance of the equipment(s) or machinery(s) after commissioning for at least One Year for the respective qualifying purchase order(s).

   <u>Notes:</u>

   i. Similar Plant Equipment or Machinery shall mean the respective Equipment / Machinery in any fertilizer / Refinery / Petrochemical / Chemical plant meant for performing the specified duty.
   ii. In case of authorized dealers of the manufacturer, necessary authorization certificate from the manufacturer shall be submitted.

AND

2. For all critical items: In addition to the above criteria, the sub Vendor should also be approved by Process Licensor.

B. <u>Applicable for new Foreign Sub Vendors proposed by the LSTK bidder:</u>

1. The proposed sub vendor during the last 15 (fifteen) years from the date of publication of the tender, should have manufactured and supplied either by themselves or though their authorized dealers at least **TWO** similar Plant Equipments or Machinery for the specified duties outside the country of origin of the sub vendor and the same should be operating satisfactorily after commissioning for at least One Year. The LSTK Bidders should submit relevant documentary proof as follows:

   a. Copy of Purchase Orders with full technical details of the equipment or machinery supplied by the proposed sub vendor.

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b. Certificate(s) from user regarding satisfactory performance of the equipment(s) or machinery(s) after commissioning for at least One Year for the respective qualifying purchase order(s).

Notes:

i. *Similar Plant Equipment or Machinery shall mean the respective Equipment / Machinery in any fertilizer / Refinery / Petrochemical / Chemical plant meant for performing the specified duty.*

ii. *In case of authorized dealers of the manufacturer, necessary authorization certificate from the manufacturer shall be submitted.*

AND

2. For all critical items: In addition to the above criteria, the sub Vendor should also be approved by Process Licensor.

However for all the above cases, it may not be mandatory by the owner to permit the LSTK bidder to add the sub-vendor(s) proposed by him even if the sub vendor(s) meets the specified criteria. The decision of the owner shall be final and binding on the LSTK bidder in all cases.

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Appendix-3

Sub : SPECIAL CONDITIONS TO BE FOLLOWED FOR SELECTION OF SUB VENDORS FOR BROUGHT OUT ITEMS BY LSTK BIDDER - **10000 MT Ammonia Storage and associated facilities at FACT-CD**

The following conditions shall apply with regard to selection of sub vendors for 10000 MT Ammonia Storage and associated facilities plant.

1. **Supply of equipments/machinery from the Owner's recommended sub vendor list**

The LSTK bidder should select sub vendors primarily from the owners recommended list. However the following shall also apply:

a. Bidder is free to suggest certain sub vendors in addition to the owner's recommended sub-vendor list as per their experience. In case certain new sub vendors are to be added by the bidder, the conditions specified in the tender document elsewhere and noted below shall be complied.

AND

b. For all critical items: The sub vendor should also be approved by the selected Specialist Sub-contractor of Engineering services for Ammonia Services (as applicable) even if the sub-vendor appears in the recommended sub vendor list of the owner.

2. **Supply of equipments/machinery not covered in the Owner's recommended sub vendor list/ new sub Vendors to be added**

A new sub vendor List shall be prepared by Bidder for supply of Equipment(s) / Machinery not covered in OWNER's sub Vendor List.

As it is not possible by the Owner to ascertain credentials of all the added sub vendors in the new sub vendor list, the following prequalification criteria, with respect to Past Performance / Experience of the sub vendor for any Equipment / Machinery shall be applicable:

A. **For new Indian Sub vendors proposed by the LSTK bidder**

1. The proposed sub Vendor during the last 15 (fifteen) years from the date of publication of the tender, should have manufactured and supplied either by themselves or though their authorized dealers at least TWO similar Plant Equipments or Machinery for the specified duties and the same should be operating satisfactorily after commissioning for at least One Year. The LSTK Bidders should submit relevant documentary proof as follows:

a. Copy of Purchase Orders with full technical details of the equipment or machinery supplied by the proposed sub vendor.

b. Certificate(s) from user regarding satisfactory performance after commissioning of the equipment(s) or machinery(s) for at least One Year for the respective qualifying purchase order(s).

Notes:

i. *Similar Plant Equipment or Machinery shall mean the respective equipment / machinery in any fertilizer / refinery / Petrochemical / Chemical plant meant for performing the specified duty.*
ii. *In case of authorized dealers of the manufacturer, necessary authorization certificate from the manufacturer shall be submitted.*

AND

2. For all critical items: The sub Vendor should also be approved by the selected Specialist Sub-contractor of Engineering services (as applicable) for Ammonia Services.

B. Applicable for Foreign Sub Vendors proposed by the LSTK bidder:

1. The proposed sub Vendor during the last 15 (fifteen) years from the date of publication of the tender, should have manufactured and supplied either by themselves or though their authorized dealers at least TWO similar Plant Equipment or Machinery for the specified duties outside the country of origin of the sub vendor and the same should be operating satisfactorily after commissioning for at least One Year. The LSTK Bidders should submit relevant documentary proof as follows:

   a. Copy of Purchase Orders with full technical details of the equipment or machinery supplied by the proposed sub vendor.

   b. Certificate(s) from user regarding satisfactory performance after commissioning of the equipment(s) or machinery(s) for at least One Year for the respective qualifying purchase order(s).

Notes:

i. *Similar Plant Equipment or Machinery shall mean the respective equipment / machinery in any fertilizer / refinery / Petrochemical / Chemical plant meant for performing the specified duty.*
ii. *In case of authorized dealers of the manufacturer, necessary authorization certificate from the manufacturer shall be submitted.*

AND

2. For all critical items: The sub Vendor should also be approved by the selected Specialist Sub-contractor of Engineering services (as applicable) for Ammonia Services.

However for all the above cases, it may not be mandatory by the owner to permit the LSTK bidder to add the sub-vendor(s) proposed by him even if the sub vendor(s) meets the specified criteria. The decision of the owner shall be final and binding on the LSTK bidder in all cases.

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