ANNEXURE-5

(ENGINEERING SPECIFICATION FOR PIPING)

TECHNICAL CONDITION & SCOPE OF WORK FOR

PIPING SUPPLY & ERECTION

FOR INSTALLATION OF

PURGE GAS RECOVERY UNIT

AMMONIA-II PLANT

NATIONAL FERTILIZERS LTD (NFL), VIJAIPUR

0	15.07.13		Comments incorporated &issued	RUPESH	AS	AMAR
P	27.06.13		DRAFT FOR COMMENTS	RUPESH	AS	AMAR
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	No. of sheets
PC65-00-0001_PGR_Amm2_R0	Existing plot plan of ammonia-2 with Proposed location for new PGR unit	01
ES-6001	Engineering standard piping design	19
ES-6004	Engg. Standard Fabrication, Assembly & Erection of Piping.	28
ES-6005	Inspection and examination of pipe welds	16
ES-6006	Pressure testing of piping	06
ES-6032	Engineering standard for flexibility analysis	08
ES-2001	Technical requirement for Shop & site application of Paint & Protective Coating	26
ES-6002(D24,D14,B24,B50,F24, B20,J24,F24S,F34,B24S)	Piping Specifications(Including valve data sheets & other detail)	44
PC65-TS-6700,PC65-TS-6701,PC65-6702	Technical specification for insulation	66
1054-35-0608 ,1054-35-0609,1054-35-0607 ,1054-32-0606 E95P002, 1054-39-0607	Existing piping GA with respective tie in points marked	06
PC-0065	Schematic isometric for TP - 13	01

1.0 GENERAL PIPING SCOPE OF WORK

1.1 The detail scope of work includes such as but not limited to complete management, Design, Detailed Engineering , to provide all the necessary data, drawings, documents required as per the project requirements, Procurement, Supply, Transportation of materials, shop & site Fabrication, Erection, Installation, Supporting, Non-Destructive Testing (NDT) & required Inspection , pre-heating, dye-penetrant test, Magnetic Particle Test, post weld heat treatment, radiography , Testing, Flushing, Air drying, blowing , cardboard-blasting , seal/leak-testing, Pre-Commissioning, Trial run, Commissioning and Guarantee of all the associated works pertaining to complete piping system and related facilities for **PURGE GAS HYDROGEN RECOVERY UNIT PACKAGE at NFL,VIJAYPUR.**

1.2 Design, material, fabrication and erection shall be in accordance with latest edition of ASME B 31.3 chemical plant and petroleum refinery piping code. The dimensions, manufacturing tolerances shall conform to applicable standards.

1.3 All works described in this package shall be performed in accordance with the design-basis, specifications, drawings, and other requirements of bid package and shall be subject to OWNER'S review and approval.

1.4 MATERIAL OF CONSTRUCTION

Materials as per internationally acceptable code shall be used for piping based on service requirement. All materials for piping Components shall confirm to ASTM or API Specifications as per enclosed piping specifications. All piping materials and valves shall be procured from the reputed approved suppliers/vendors.

1.5 Cost of piping job shall also include the cost of supervision, Labour, overheads / profits, materials, consumables, scaffolding and all other associated arrangements required to execute the related activities of this package.

1.6 VALVES:

Hydrostatic & Pneumatic testing shall be carried out for all valves i.e. 100% quantity as per relevant standard.

All valves shall be operated and checked for 100% trouble free operation.

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1.7 PIPING INTER - CONNECTION

All piping interconnection from B.L of the PGR package to tie in points for all lines as marked in P&ID's and piping GAD's shall be in the Scope of BIDDER. It is to be noted that BIDDER to physically verify all tie in points and pipe routing from B.L to tie in points and ascertain the pipe items, pipe support, insulation, structural requirement, supply, transportation to site ,fabrication & erection of all these items shall be in BIDDER scope.

Since all the piping from B.L. of PGR to the Tie-in Points shall be laid on existing pipe rack, the adequacy check of existing pipe rack for new pipe lines shall be in Bidder's scope.

BIDDER to note that tie-in with isolation valve and blind to be erected during next shut down of the plant tentatively planned in March/April 2014.

1.8 After completion of erection jobs, all piping system will be suitably hydraulically/pneumatically tested as per the test pressure indicated in the approved line list / relevant document & standard.

2.0 DESIGN AND DETAILED ENGINEERING

2.1 Collection of all data/ information furnished in the bid package and additionally collected/generated by BIDDER.

- Finalization of design data/ basis for carrying out design, detailed Engineering for complete **PURGE GAS HYDROGEN RECOVERY UNIT PACKAGE** as per project specifications, contained in this Enquiry documents.

2.1.1 Performing design and detailed engineering of the following:

a) Complete piping system for **PURGE GAS HYDROGEN RECOVERY UNIT PACKAGE** including all utilities such as drinking water distribution piping with eye washers cum safety showers shall be provided at all critical areas.

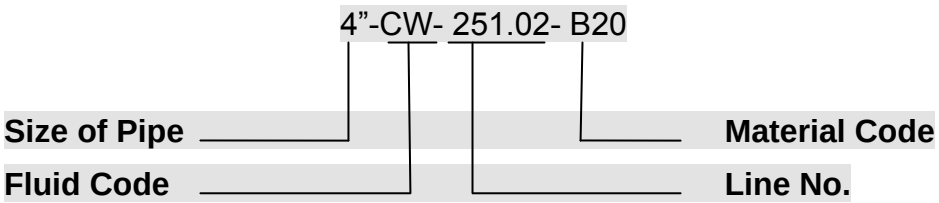
b) Carry Out all necessary calculations in accordance with approved design basis, drawings/documents and requirements of this bid package.

c) Finalization of layouts for the unit and preparation of construction drawing, preparation of piping drawings, equipment layouts, piping general layout drawings (GAD's) , pipe supports, piping isometrics, flexibility analysis. Typical indicative sketches/drawings included in this bid package document shall be taken as broad basis for developing the layouts. Since the availability of free space is limited, BIDDER shall plan his piping layouts in such a way so as to minimize the area requirement while giving due importance to ease of access, operation and maintenance of the facilities installed by the BIDDER. The fabrication/erection & all other piping jobs shall be carried out based on the "Approved for Construction (AFC)" Drawings.

d) Carrying out Material Take Off for the entire piping system.

e) The detail design shall take into consideration of all stipulations, practices followed by various Statutory Regulations/authorities for all types of piping.

f) Piping No. shall be as per HTAS Standard as given below:



2.1.2 Steam Piping - Indian Boiler Regulations (IBR)

Generally steam lines with conditions listed below fall in the scope of IBR.

- Lines having design pressure (maximum working pressure) Above 3.5 Kg/cm2 (g)

- Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm2 (g) & above Lines with pressure less than 1.0 Kg/cm2 (g) are excluded.
- Users of steam like steam tracing lines, jacket of the steam jacketed lines, steam heating coil Within the equipment are excluded from IBR scope.

- Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum as marked in P&I D shall be under purview of IBR.

IBR requirements (in brief)

a) All materials used on lines falling under IBR must be accompanied with IBR Inspection Certificate in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local IBR inspector is acceptable. Whereas for supply, only IBR is the inspection authority.

b) Drawings like General Arrangement Drawings (GAD) and system isometrics / line wise isometrics of lines falling under IBR must also be approved by IBR authority of State in which the system is being installed.

c) All welders used on fabrication of IBR system must possess IBR welding qualification certificate.

d) IBR system must be designed to comply IBR regulations as well as ASME B31.3. All design calculations towards the same must be approved by IBR authority.

e) IBR approval is obtained with requisite fees payable to Indian Boiler Board of the State concerned.

f) Steam generators (boilers/heat exchangers) shall require exclusive IBR approval along with its integral piping up to the final isolation valve.

g) The discretion of IBR authority of state is final and binding for the above cases.

h) For carbon steel pipes under IBR the chemical composition shall conform to the Following:
Carbon (Max) 0.25 %
Others (S, P, Mn) As prescribed in IBR regulation.
The chemical composition as indicated in this clause is not applicable for pipes Other than IBR services.

i) Pipes, Pipe Fittings, Valves & any other piping material under purview of IBR shall be accompanied with IBR certificates in relevant forms i.r. IIIA, IIIB, IIIC etc. duly Approved and countersigned by IBR authority/local authority empowered by Central boiler board of India.

2.2 PROCUREMENT AND SUPPLY

2.2.1 BIDDER shall procure and supply all materials whatsoever required for temporary/permanent installation of piping system in sequence and at appropriate time. All equipments, materials, components etc shall be suitable for the service and the design life of the system.

2.2.2 BIDDER shall procure all materials, components, equipments, consumables etc required for successful completion of the piping system. BIDDER shall also procure spares required for pre-commissioning and commissioning/start-up as recommended for all the items supplied by him as per specifications provided in this bid package. Where no specifications are available in the contract, the same shall be prepared by the BIDDER, and shall be subject to OWNER'S approval.

2.2.3 Material take-off with complete description of size, rating, material, thickness and specifications.

2.2.4 Preparation and finalization of data sheets for all piping materials e.g. all valves etc. All data-sheets shall be subject to review and approval by OWNER.

2.2.5 Preparation of Material requisitions, Request for Quotation & its evaluation and recommend BIDDERS for OWNER'S approval. Preparation of purchase requisitions, review of BIDDER'S drawings and calculations, approval of manufacturing procedures wherever necessary, and the party inspection at manufacturer's works of the materials by reputed agencies as required. Quality control and expediting of all procured items at BIDDER'S shop or at fabrication yard.

2.2.6 BIDDER shall procure materials as per specifications and list of approved Vendors/Suppliers (for major Items) included in the bid document.

2.2.7 Carry out proper documentation of inspection and quality assurance programs for all equipment and bulk materials duly approved by OWNER. BIDDER shall maintain an accurate and traceable listing of procurement records for the location, quality and character of all permanent materials in the Project.

2.2.8 BIDDER shall immediately report to the OWNER of all changes which will affect material quality, and take necessary corrective actions. Purchase requisitions including Purchase Orders of all major items shall be approved by OWNER. For balance items, records shall be furnished for information only.
Compliance with BIDDERS and supplier's instructions and recommendations for transportation, handling, installation and commissioning.

2.2.9 All welded pipes indicated as 'CRYO' & 'LT' in BOQ list or MR shall be impact tested, as

per requirement and acceptance criteria of ASME B31.3. The impact test temp shall be –196°C, -80°C & -45°C. For stainless steel, 3-1/2 Ni steel AND Carbon steel respectively Unless specifically mentioned otherwise in MR.

2.2.10 Test on pipe shall be conducted for all mandatory tests conforming the applicable Material specification .Test reports shall also be furnished for any supplementary test as Specified in the requisition.

2.2.11 All austenitic stainless steel pipes shall be supplied in solution annealed condition.

2.2.12 Gaskets in the piping shall be used as per relevant piping specifications and in no case Sheet / Flat Gaskets of CAF / Non-asbestos shall be used.

2.2.13 All materials shall be new materials with all surfaces clean and free from defects, Weld spatter, arc strike, rust, dirt, sand, scale, paint or any other foreign substance

2.2.14 Each Pipe fitting of thickness and sizes as mentioned below shall be ultrasonically tested as per ASTM A-388

Size range	**Sch./Thk**
Upto 4”	>Sch 120
> 5”	12mm

2.2.15 Electrodes and Filer Wires to be used at site shall be of Advani Oerlikon, D & H Secheron, ESAB, Bohler, Thyseen, Kobe, Sandvik, Avesta make only.

2.2.16 Inspection and tests at the Vendor's shop shall be carried out in conformance with the requirements of the material standards (ASME/ASTM/API) specified on the purchase order documents.

2.3 INSULATION AND PAINTING

All the insulation and painting material will be bought in accordance with Spec. PC65-PNMP-TS-6701-Rev-0 (Installation of high temperature insulation), PC65-PNMP-TS-6702-Rev-0 (Installation of low temperature insulation) & ES-2001 (Engg. Standard: Selection and Application of Protective Coating) or equivalent Standard applicable.

2.4 CONSTRUCTION

All construction works be carried out as per “Approved for Construction” drawings, procedures, specifications and applicable codes and standards. Any changes at site shall also need prior approval from the OWNER and revision of drawings.

BIDDER shall procure and supply all materials whatsoever required for temporary/permanent installations of piping system in required and at appropriate time. All equipment, materials, components etc. shall be suitable for the intended service and the design life of the system. Wherever no specification is available in the contract, the same shall be prepared by the BIDDER and shall be subject to OWNER approval.

3.0 BIDDER'S RESPONSIBILITY

All works shall be carried out by Bidder in accordance with the drawings / documents / specifications indicated in the subsequent paragraphs.

3.1 Specifications:
3.2 Standards:
3.3 Piping Support Standards:
3.4 Flexibility analysis
3.5 Drawings:
3.6 3D Modelling & Design Review:

Bidder shall submit all proposal designs, analysis, drawings, installation and testing procedure for review & approval by OWNER as mentioned in the scope work. Bidder shall as a minimum, provide above deliverables for OWNER'S information / records & review / approval.

3.7 Site location Plan drawing no-PC65-00-001_PGR_AMM2_RP of PURGE GAS HYDROGEN RECOVERY UNIT is included in the bid package. This drawing is INDICATIVE only and is furnished for Bidder's information. Issued for construction (IFC) drawings shall be prepared by BIDDER after detailed engineering being done by him and shall be subject to approval by the OWNER.

3.8 The BIDDER shall submit separately, the material take off for piping, valves, fittings and all other accessories as per requirements.

3.9 The BIDDER shall obtain statutory approval from various authorities having jurisdiction over the area as necessary for construction of the unit package.

3.10 It may be noted by bidders that sizes of various Piping indicated in the Tie-in List &P & I of PGR (PC65-1000-0021) is tentative and final sizes shall be as per designing & recommendation of Vendor. However, Sizes of existing lines where Tie-in is to be taken are actual.

3.11 It may be noted by bidder that piping specifications enclosed in ITB indicates all the details like Material & Class of Pipe, Pipe Fitting, Bolting, Valve Type / Tag No. etc.

4.0 DRAWINGS/ DOCUMENTATION SCHEDULE

Bidder shall furnish all the drawings/ documents to OWNER for comments/ approval. He shall incorporate all comments/ modification suggested by OWNER. The drawings/documents should be properly organised, supplied & submitted as per documentation schedule,

5.0 **PACKAGING**

Packaging of piping items shall be as per the guidelines of OWNER.

6.0 **DOCUMENTATION WITH BID**

Following drawings/documents must be submitted along with the bid.

i) Proposed equipment layout drawing.

ii) Proposed piping Layout drg.

iii) Quality control procedure & plan for piping system.

iv) Completion schedule of piping job in Bar-chart format.

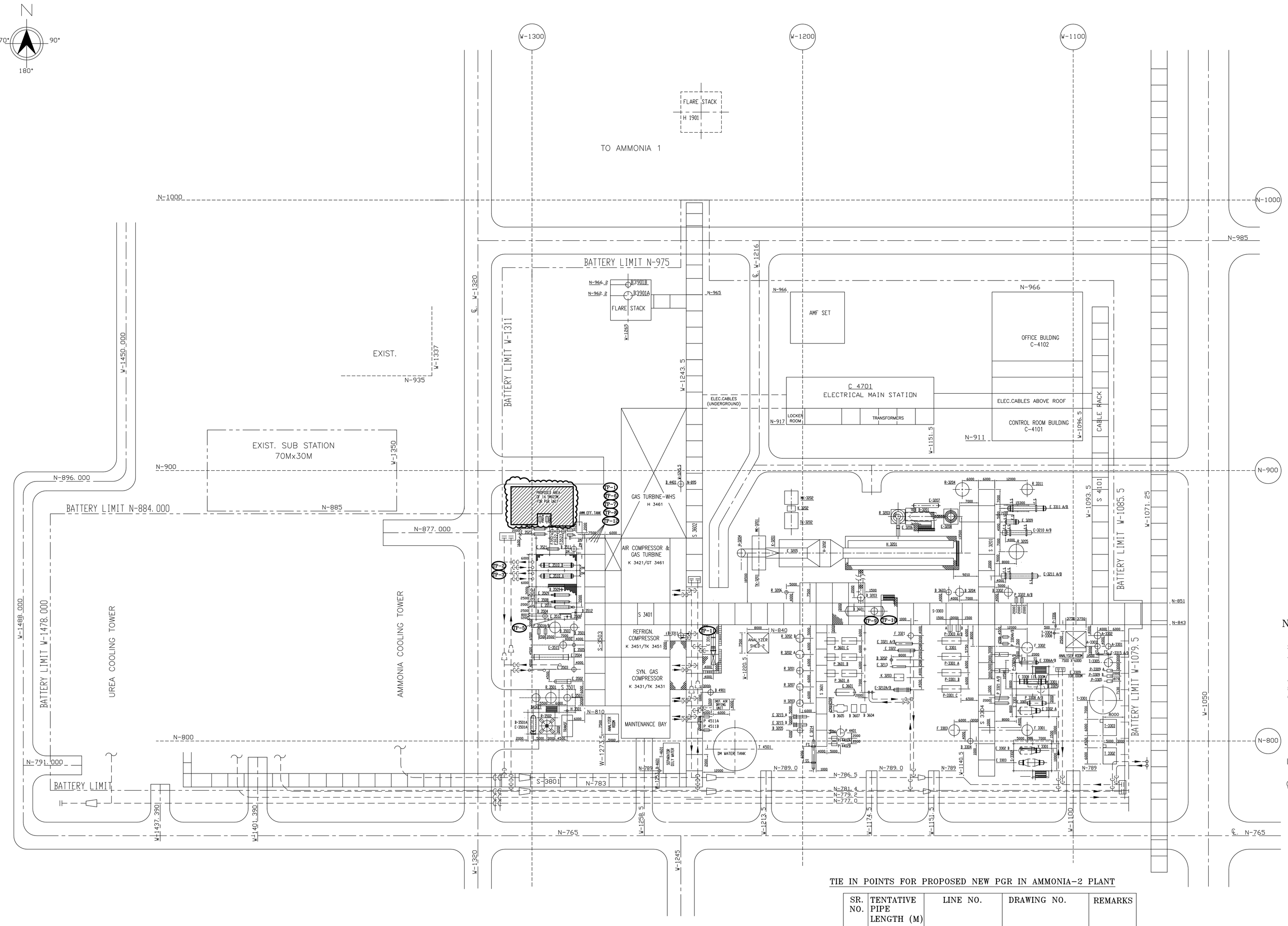
v) List of all construction equipments, tool-tackles & man power resources proposed to be used.

vi) Clause wise list of deviations / exclusions, if any, to bid requirements shall be furnished. BIDDER is cautioned that exclusions and deviations listed elsewhere in bidder's offer shall not be considered for evaluation

vii) List of existing drawings for existing plot plan, tentative location/size of PGR unit & tie in point location

Sr. No	Drawing no.	Detail
1	PC65-00-0001_PGR_Amm2_RP	Proposed location for new PGR unit
2	1054-35-0608(S-140)	Existing piping GA for tie in points TP-6,TP-1,TP-2,TP-3,TP-8
3	1054-35-0609(S-141)	Existing piping GA for tie in points TP-12,TP-7
4	1054-35-0607(S-132)	Existing piping GA for tie in points TP-5
5	1054-32-0606(R-160)	Existing piping GA for tie in points TP-9
6	1054-39-0607(Y-140)	Existing piping GA for tie in points TP-10
7	E95P002	Existing piping GA for tie in points TP-4

BIDDER to note that the location/size of PGR unit and Tie in points is tentative only & they have to physically verify all these points at site & quote accordingly.



NOTES :-

1. ALL CO-ORDINATES ARE IN METER & ALL DIMENSION ARE IN MM.
2. PLANT LEVEL 100.000 = 484.8M REDUCED LEVEL(R.L) ABOVE M.S.L.
3. NUMBER AND LOCATION OF TIE- IN POINTS AND PROPOSED LENGTH SHOWN IN THE TABLE IS INDICATIVE ONLY. BIDDER TO CHECK AND CONFIRM THE PIPE ROUTING FROM PACKAGE B.L. AND TIE-IN POINTS.
4. ALL INTERCONNECTION (FROM PGR B.L. TO TIE-IN POINT) TO BE CARRIED OUT BY LSTK BIDDER.
5. FOR EXACT LOCATION OF ALL TIE-IN POINTS REFER PIPING GA DRAWING NUMBER MENTIONED IN TABLE
6. ALL PIPE LENGTH ARE TENTATIVE BIDDER TO FINALIZE DURING SITE VISIT & QUOTE ACCORDINGLY.

LEGEND :-

TENTATIVE LOCATION FOR NEW PGR UNIT

TIE IN POINTS FOR PROPOSED NEW PGR IN AMMONIA-2 PLANT

SR. NO.	TENTATIVE PIPE LENGTH (M)	LINE NO.	DRAWING NO.	REMARKS
TP-1	35	2"-DW-251.01-B50	1054-35-0608 (S-140)	REFER NOTE'S
TP-2	35	4"-CW-251.01-B20	1054-35-0609 (S-141)	
TP-3	35	4"-CW-251.02-B20	1054-35-0609 (S-141)	
TP-4	120	4"-PG-251.01-F24	E95P002	
TP-5	70	3"-SG-252.01-J24	1054-35-0607 (S-132)	
TP-6	35	2"-NI-251.01-B24	1054-35-0608 (S-140)	
TP-7	35	2"-AL-251.01-D14	1054-35-0609 (S-141)	
TP-8	35	3"-SC-251.01-F24S	1054-35-0608 (S-140)	
TP-9	200	10"-FG-251.01-B24	1054-32-0606 (R-160)	
TP-10	100	10"-PGH-252.01-B24	1054-39-0607 (Y-140)	
TP-11	120	4"-SG-253.01-F24	1054-35-0609 (S-141)	
TP-12	35	3"-SM-251.01-F24S	1054-35-0609 (S-141)	

FOR TENDER PURPOSE ONLY

REV.	DATE	DESCRIPTION	PPS	CKD	APPD
0	15.07.2013	ISSUED	ANIL BHAVAN	AS	AMAR
P0	25.06.2013	ISSUED FOR COMMENTS	ANIL BHAVAN	AS	AMAR

CLIENT : NFL VIJAIPUR

TITLE : SITE LOCATION PLAN FOR NEW PGR UNIT (AMMONIA PLANT-2)

REV. P0 R0 | SCALE : 1 : 500 | DWG NO : PC65-00-0001_AMM2 | FILE : PC65-00-0001_PGR_AMM2_R0

PDIL — PROJECTS AND DEVELOPMENT INDIA LTD. NOIDA

ENGINEERING STANDARD

PIPING DESIGN

REV.	DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
0	JAN. '98	FOR IMPLEMENTATION	MKK, BKI, MKD		

LIST OF CONTENTS

3.8 **Safety Showers and Eye Baths**

3.9 **Steam Tracing**

3.10 **Special requirements for Toxic, Hydrocarbon and Flamable Fluide.**

1.0 SCOPE

1.1 This specification covers general design requirements with respect to layout and details for piping design.

1.2 Addendum Specification

This specification may be supplemented by special requirements for a particular job, in which event the later shall take precedence in case of a conflict.

2.0 SPECIFICATIONS

Criteria for design, fabrication and erection of non IBR piping systems shall be in accordance with ASME B 31.3 Process Piping Code latest edition and those for IBR piping shall be in accordance with Indian Boiler Regulations.

REFERENCE STANDARDS

ASME B 31.3 - Process Piping Code

IBR - Indian Boiler Regulations

PDIL Engineering Standards

ES 6002 -- General Piping Specification

ES 6012 -- Safety Valve Installation and Piping

ES 6029 -- Steam trap Installation

PDS : P (V 004)-- Dimension of Control Valve manifold

P 032 -- Pipe trench

P 123 -- Vent, drain, steam trap and Instrument tapping assemblies

PS 01 -- Pipe support - Standard type and applications

PS 02 -- Pipe spacing

ST 202 -- Details of sump for installation of Gate Valve

3.0 DESIGN

3.1 General Design

3.1.1 Clearances

(a) **Walkways and Platforms**

The minimum clear headroom over main walkways, passageways and working areas at grade or floor elevations shall be 2.20 m. The minimum clearance over secondary walkways and elevated platforms,

passageways and working areas shall be 2.0 m. The minimum width for main walkways shall be 1.2 m. The minimum width for secondary walks and minor access points shall be 0.75 m. The minimum width for catwalks shall be 0.6 m. (Ref./Fig.1)

(b) **Roads and Rail Roads**

The minimum clear head room over rail roads shall be 6.0 m measured from the top of track. The minimum clearance over primary roadways shall be 7.5 m. Secondary roads may have lower clearance, but not less than 5.0 m. Minimum clear head room over areas designated as main access ways or tracking areas (other than roads) shall be 3.7 m.

(c) **Equipment**

Clearance should be available for maintenance and removal of equipment without disturbing other equipment. Dismantling of sections of pipe is permissible, if required for removal of equipment, when not operating. Piping to equipment s hall be designed to permit ready removal of equipment without furt her pipe supports being required, Particular attention should be paid to layout of cable racks, instrument piping, etc. to ensure this.

In areas where entry of handling equi pment (e.g. Forklift truck or 5t Crane) is required for maintenanc e or handling of pumps and other machinery not otherwise accessible, the minimum clear head room for piping under which the handling equipment s are required to move shall be 4.5 m.

Manholes and other access openings shall have a minimum clearance of 0.75 metre in front of face of vesse l or equipment flange (not cover plate where larger clearance may be requi red), and a minimum of 0.30 m from edges of flanges to nearest pipe or construction.

(d) **Minimum Clearance for Piping Above Grade**

Usually bottom most part of any li ne is provided with a drain line. To facilitate proper draining (may be to a catch pot, in some cases) and proper supporting arrangement of t he pipe the bottom of pipe should normally be kept at a minimum elev ation of 400 mm from finished floor level. Where this is not possible elevation may be lowered to even 150 mm giving due care to proper drai ning and supporting of pipes. This does not apply to drain pipes. Insulation and valves, should be taken in consideration while determining this cl earance. In case of control valves, the minimum clearance shall be as per PDS: V 004.

3.1.2 **Clearance Between Piping**

In consideration of main tenance, the flange, or heat insulation, etc. the clearance between pipe surfaces should be sufficient but mi nimum for them. The clearances are shown in PDS: PS 02. The clearance indicated in PDS: PS 02 are minimum and shall have to be incr eased where large lateral thermal movements are involved, particularly w here high temperature pipes are taking a 90^{O} turn. Vertical pipe lines through fl oors shall be combined to reduce the opening size in floors.

3.1.3 **Sizes Allowed**

In general, no piping less than ½ // shall be used except for instrument piping. 1 ¼ //, 3 ½ // and 5// pipe sizes normally should not be used. Where such sizes are used, valves should be of 1//, 3// and 4// respectively.

3.1.4 **Material**

Piping material shall be selected in a ccordance with respective piping class. Reference may be made to General Piping Specification - Piping Element data sheet for selection of appropriate piping classification number for the specified service conditions. Where system of higher service rating tie into systems of lower rating, an isolation valve shall be provided and the higher service rating specification shall be continued including the isolation valve.

3.1.5 **Corrosion Allowance on Wall Thickness**

The minimum corrosion allowance for piping shall be as follows:

Cast iron and carbon steel piping -- 1mm

Corrosion resistant materials, including aluminimum, alloy steel, high nickel alloys and copper -- Nil

3.2 **Piping Arrangement**

3.2.1 **Under Ground Piping**

3.2.1.1 **Buried Pipes**

In general, pipes should not be buri ed unless a specific advantage like protection freezing, fire or accidental damage or easy draina ge by gravity flow etc. are gained. Traditionally the following lines may be buried:

(a) Cooling water distribution headers.

(b) Fire Water mains

(c) Sewage Lines

(d) Drain lines (where gravity flow requirement necessitates the lines to be burried).

3.2.1.2 **Piping in Trenches**

(a) All piping requiring inspection and servicing or being provided with protective heating and located below grade shall be in trenches.

(b) Pipe trenches shall be sufficiently lar ge to allow for repair of lines and shall be provided with removable co vers. Typical trenches details have been indicated in PDS: P 032. Sump for valves and trenches shall be as per PDS: ST 202 & ST 203.

Underground piping shall be done as per ES 6018. However, some of general precautions to be taken are as follows:

i) Provide casing pipe made of reinfo rced concrete or Carbon Steel to protect underground pipes pa ssing under roads or access ways.

ii) Wherever electrical cables are coming on the way of pipes, pipes will be taken below the cables.

iii) Wherever valves are to be prov ided, valve chamber of suitable size should be constructed of brick or concrete.

iv) Pipes shall clear the fouling wit h trench foundations and layout of trench will be such as not to interfere with construction access.

v) Trenches shall be provided with proper slope and suitable draining scheme.

3.2.2 **General Guide Lines for Routing of Pipe Lines**

(a) Pipe lines shall be installed neatly so as to be as short and direct as possible, with a minimum of direct ional changes. The flexibility shall be considered while deciding the routing of hot pipe lines.

(b) Dead legs and pockets shall be avoided. This is important in case of pipe line containing slurries or suspens ions, fluids of high crystallization point, corrosive fluids etc.

(c) Overflow lines, drain lines, barometri c lines from condensers etc. should be as steep as possible. Barometric lines should preferably be installed vertical, if this is not possible, one of the two alternatives indicated in Fig.2 can be adopted.

(d) All piping within battery limits shall be elevated to provide minimum clear head room as indicated in section 3.1 unless process consideration indicates otherwise, e.g. in pump suction lines.

(e) Main service pipes, such as HP and LP steam condensate, fuel oil, town's water, cooling water, town's gas, compressed air etc. will often most conveniently follow the road network and the pi ping layout thus is largely settled by general site conditions. However, use of 45 ^{O} bends and cross overs is permitted for economy reasons, where it does not impair the appearance of the plant.

(f) All piping shall be grouped in banks whenever practicable.

(g) All overhead piping shall be run at specific elevation established in advance for piping in any one direct ion say, North-South and at some other specific elevations for all pipi ng to other direction East-West (Fig.3). However, where unnecessary pockets & changes in elevation can be avoided, exceptions to the estab lished elevation are permitted. (This might occur in special cases such as overhead vapour lines, lines where pressure drop is critical, where vapour binding might occur or where sloping of lines is necessary).

(h) There shall preferably be no overhead piping over stirrers, submerged pumps, covers, etc. Where such pipings can not be avoided, due consideration will be given regarding s pace for removal of equipment on maintenance.

(i) On sites covering large areas with considerable distance between plants and where only infrequent access point s (as on tank farms) serve the purpose, it is economical to run t he interconnection piping on slippers instead of heavy raised pipe rack.

(j) In a rather compact layout of co mplex plants where access to various areas are important interconnecting pipes will be laid on raised pipe racks. Layout of racks most often c onveniently follow road network to cater the needs of main service pipes, such as, steam, condensate, fuel oil, cooling water, air, N_2 etc. by various plant areas.

In designing layout of pipes on rack some general rules may be followed:

i) Pipes should not obstruct access to crane or truck for maintenance requirements.

ii) Spacing of pipes should be minimum practical values, spacing may be reduced by staggering flanges and valves.

iii) While using two tiers of pipes to reduce width, it is advised to run utility lines on top rack so that any spillage from higher pipes to the lower is harmless (Ref. Fig.3). Steam pipes should be located on upper tier. In case a single tier is used process lines which inter connect equipments on the same side of yard will be located towards that edge of yard. (Ref. Fig.4)

iv) Regardless of service, heavy lines should be placed over or near the trestle column to reduce bendi ng moments on structure. (Ref. Fig.4 & 5)

v) Pipings along East-West will have an el evation different from those running North-South.

vi) Hot lines requiring expansion loops shall be grouped together and expansion loops, wherever required, will be tried to be put together with larger diameter/higher tem perature pipes forming outer loops. (Ref. Fig.6)

vii) Provision of space for electrical and instrument cables will be kept while deciding rack layout.

viii) To give adequate arm for expansi on loops of hot lines it is advantageous to put hotlines on one side of the rack rather than locating it in central location.

ix) Branch steam lines will preferrably be tapped from top of headers.

x) Screwed and flanged joints shall not be located over roads or walkways or burried under roads.

(k) Pipes carrying non-conducting flamm able volatiles must be bonded for electrical continuity and earthed to prevent the accumu lation of static electricity charges which can, if arcing to earth near the pipe discharge, cause fire or explosion. Screwed piping using PTFE threadseal tape on the screwed joints must also be bonded the PTFE tape can effectively insulate line sections from each other.

(l) No hot pipes shall run near power c ables. Any local heating of the cables will reduce its allowable power capac ity rating and may damage the cable. Do not run solvent or acid lines over plastic cables.

(m) **Slopes**

i) Slope shall be provided for saturat ed steam lines, other ordinary lines (if required for process reasons) and for slurry lines.

Line Sizes (inches)	Steam Lines and Ordinary Lines	Slurry Lines
1// -- 3//	1 : 200	1 : 100
4// -- 6//	1 : 400	1 : 200
8// -- 14//	1 : 600	1 : 300
16// -- 24//	1 : 800	1 : 400

ii) Overflow, drain and barometric li nes shall be provided with higher slopes as indicated below:

Overflow and Drain Lines -- 1 : 20 min.

Barometric Lines -- 1 : 2 min.

3.3 Guide Lines for different Piping Items

3.3.1 Pipe Flittings and Bends

(a) Detailed specifications for pipe fittings and bends depending on service and size are to be found in respective piping standards.

(b) Butt welding elbows shall normally be long radius type. Bends with a minimum radius of 3 times the nominal dia shall be used in slurry lines.

(c) Intersections at angles other than 90 ^{O} shall not be used except when specially required from process considerations.

(d) Welding caps, or in large pipe size s, semi-ellipsoidal heads shall be preferred for welded end enclosure s. Where required, bolted flange covers shall be used for cleaning or to provide for future connections.

(e) The use of flanges in piping shall be limited to connections at flanged equipment, for removable sections of pipe or for pipes requiring dismantling for maintenance. Field joints may be of flanged construction to avoid field welding on joints r equiring heat-treatment or examination and in pipe lines located in fire hazard areas where, after plant commissioning, no welding is permitted or welding would be difficult.

(f) Threaded or socket-welded piping shall be limited to 1 ½ // and smaller. Threading may be permitted in larger size galvanized piping. All pipe threads on piping components s hall be taper pipe threads in accordance with IS:554. Couplings 2 // and smaller with straight tapped pipe threads may be used on pi ping components with taper pipe threads if the design conditi ons do not exceed 10 kg/cm ^{2} or 200^{O}C and if the fluid handled is non-flammabl e and non-toxic. Threaded joints in piping handling flammable or toxic fl uids shall be seal welded and shall be of steel. Threaded and socket welded joints shall preferably not be used where severe crevice corrosion or erosion may occur.

3.3.2 **Valves**

(a) **Approach**

On the basis of frequency and necessi ty of operation valves shall be suitably located so that they ar e accessible and can conveniently be operated from the grade, floor or pl atform or from ladder. Where the hand wheel is higher than 2 metre from the operating floor, chain operating system may be provided. (Ref.Fig 7)

(b) All lubricated plug valves shall be accessible for lubrication either from stairs, platforms, grade or shall be within reach of portable ladders.

(c) Chain wheels shall preferably not be used on screwed valves. When absolutely necessary, welding or special support shall be used to prevent undesirable unscrewing.

(d) Chains shall extend within 1.0 m of operating floor and shall be located out of walkways so that the same does not obstruct passing personnel.

(e) Where practicable and unless otherwis e shown on the drawings, valve stems shall be installed in a vertical direction and shall not be installed with stems below the horizontal.

(f) Valves located underground, shall be provided with valves boxes (Pits).

(g) Swing type check valves may be used in horizontal lines and also in vertical lines having upward flow.

Piston/Ball lift type check valves may be used only in horizontal lines.

3.3.3 **Pipe Blinds (Spectacle Blind)**

(a) Pipe blinds (Spectacle Blind) shall be used in the following locations.

-- At inlet and outlet connections of equipment which periodically must be taken out of service for maintenance or inspection, without interfering with the oper ation of the unit, or when the omission of such blinds would present a hazard to personnel.

-- When required, at battery limits of units in process piping connected to other plant piping which may be in use during shut-down of the unit.

3.3.4 **Relief Valves**

(a) Relief or safety valves installati on and piping shall be in accordance with ES 6012.

3.3.5 **Automatic Control Valves**

(a) Control Valves which require periodic servicing shall be so located that they are easily accessible.

(b) Control Valves shall not be lo cated where they can be damaged by moving machinery, continuous vibration, steam or where the diaphragm is too near hot pipe lines, furnaces or other similar equipments.

(c) Sufficient clearance shall be allow ed both beneath and above the control valve for plug and diaphragm operator removal, as per PDS:V004.

(d) Control valves with manual hand wheels shall not require a by-pass.

(e) Block valves adjacent to control valves shall be of same size as the line, unless otherwise specified.

(f) By-pass valves shall be sized for the same pressure drop as the control valve.

(g) Concentric swaged nipples, or reducers, are to be used between the block valves and the control valves

(h) Downstream block valves also be of the higher pressure rating.

(i) Both upstream and down stream piping near pressure reducing stations in Oxygen lines should be provided with water jacket or suitable water sprinkling device in order to keep t he temperature in Oxygen line within safe limits.

(j) While using angle control valves layout will be made in such a way that outlet is in the same line as the axis of valve stem i.e. perpendicular to the plane of diaphragm. This helps to mainta in streamline flow at the ventury. However, in case of a conflict between supplier's recommendation and his requirement, the former will be honoured.

3.3.6 **Double Block Valves**

(a) Double valves shall be provided in following cases:-

i) Where contamination of stream is to be avoided.

ii) In blow-down lines from boilers

iii) Sample lines in case of high pressure

iv) Gauge glass connecting pipes in case of high pressure/ Vacuum

v) Isolation of Oxygen Compressors.

(g) In case of hazardous fluids it ma y be necessary to provide bleed valves between two block valves to ensure that no leakage occurs.

(c) Double block valves and bleed valve shall carry the higher rating specification of the connecting systems.

(d) A minimum straight length of 100 mm or five times the thickness of weld shall be provided between two Nos. welded type valves.

3.3.7 **Steam Traps**

(a) Reference may be made to ES6029 for typical steam trap installations. Steam traps shall be sized for normal condensate load and warming up load. The time for warming shall be taken as 20-30 minutes.

(b) Steam traps shall be located at ev ery low point of a header system and long supply mains such that each and every portion of the header can be drained through one trap or another. In ca se of straight or constanly slopping headers, interval between two adjacent traps may be as high as 100 to 160 meters provided traps are sized accordingly and provided that possibility of obstructions to steam flow due to carry over of condensate through a long length is not present.

(d) Each trap shall serve only one collecti on point, line or piece of equipment, except for steam tracing.

(d) Piping to trap shall never be smaller than ½ // or trap connection size.

(e) Strainers shall be installed ahead of tr aps and they shall be integral with the trap wherever possible.

(f) A shut-off valve shall be provided up stream of each trap and strainer. Unions or flanges shall be provided for the removal of traps.

3.3.8 **Strainers and Filters**

(a) Permanent type strainers shall be inst alled for the protection of the equipment as follows:

In pump suction lines for screw, re ciprocating, centrifugal and gear pumps.

In all steam turbines and steam jet ejector inlet lines.

In fuel oil supply piping to bumers.

In steam lines to essential traps.

(b) Air filters shall be provided in the air inlet line to all air compressors.

3.3.9 **Thermal Expansion of Piping**

(a) Wherever possible, provision for pipe expansion shall be made by changes in the direction of the pipe or by expansion loops.

(b) Expansion joints may be furnished eit her with plain ends for butt weld installation or with flanged ends.

(c) Where expansion joints are to be installed, about 100 mm additional length of pipe over the ac tual requirements on each side of the joint shall be provided to permit field adjustment when installing joint.

(d) Expansion joints may be installed with cold pull upon instruction of Engineer Incharge. The drawings shall show the amount of permitted cold pull (normally 50% of calculated expansion to be absorbed).

(e) Thrust load imposed on mechanical equipm ent such as pumps, turbines or compressors shall be limited to the equipment manufacturer's recommended values. Reference may be made to manufacturer's data/ relevant API Standards for allowable forces and moments for pumps, compressors and turbine nozzles.

3.4 **Guide Lines for Equipments**

3.4.1 **Pumps**

(a) Suction and discharge piping shall be in accordance with ES:6024.

(b) Vendor's drawings for glands, bearings , stuffing boxes, jackets, casing, vents, drain and base plate drains etc. shall be checked and necessary piping shall be provided for cooling water, steam, flushing and sealing liquids as required.

3.4.2 **Compressors**

(a) Strainers shall be installed in suction lines.

(b) Compressor piping should preferably be supported separately from other piping.

(c) Discharge line to surge drum should have unsupported elbow so that pipe can bend with thermal stress and relieve strain on compressor casing or cylinder.

(d) Short spool pieces should be provided in suction as well as discharge line for easy removal during maintenance of compressor. This is particularly important for centrifugal compressors having top halves that must be lifted for access to impellers.

(e) Loop and pockets should be avoided in suction piping to prevent collection of condensate that can cause great damage to compressors.

3.4.3 **Turbines & Steam Driven Equipment**

(a) Steam piping to turbines or other steam driven equipment shall be provided with an isolation valve at the header and except in the case of turbines, when a combination governing trip and manual throttle valve is provided, it shall be provided with a throttle valve located at the equipment. A valved bleed shall be placed upstream of the throttle valve to permit draining of the line before starting equipment.

(b) Steam exhaust piping from turbines and steam driven equipment other than that venting to the atmosphere or to a vacuum unit serving only that particular piece of equipment, shall be provided with a block valve located preferably at the header. A valved bleed shall be provided between the equipment and the valve.

(c) In instances where one vacuum unit serves two or more turbines, the exhaust piping from each turbine shall be provided with a block valve.

(d) Steam branches to turbines shall be taken from the top of the header.

3.4.4 **Heat Exhchanger**

(a) Exchangers using cooling water will be provided with block valves as follows:

-- Only one valve will be provided in cooling water line for those exchangers which are essential for operation of the unit.

-- Two valves, one each at inlet and outlet will be provided for those exchangers which may be taken out of line for maintenance while the unit is in operation.

(b) The levels of pipe lines to critical heat exchangers and equipment shall be such as to keep the equipment flooded. (Fig.8)

(c) When block valves are installed which will permit trapping the cold side of an exchanger unit full of liquid a relief valve shall be installed to prevent possible pressure build up.

(d) Cooling water piping to tubular exchanger units shall be arranged to ensure flooded tubes.

3.5 Auxiliary Connections

3.5.1 **Vents** : (for typical connection Ref. PDS P 123)

(a) Vents as per PDS P 123 (or blind flanged vents for equipments) shall be provided at high points of lines and equipment required to be hydrostatically tested. However if this vent isolation is used during normal operation from process consideration, valve will be provided.

(b) Minimum size of vent shall be in ½ ″.

3.5.2 **Drains** : (for typical connection Ref. PDS P 123)

(a) Valved or plugged drains shall be provided at trapped low points in piping or equipment to drain water, condensate or process liquids that must be drained during normal plant operations. Drain valves in slurry lines shall be of a type permitting rodding through e.g. Plug, Ball or Gate Valve.

(b) Minimum size of drain shall be ½″.

(c) Drains provided at low points of control valve stations shall be on the upstream side of Control Valve.

(d) Drains at low points of lines and equipment required to be used only for hydrostatic testing shall not be provided with valves. Instead threaded plugs (to be seal welded after testing) or blind flanges will be used.

3.5.3 **Flushing Connections**

Plugs or flushing connections shall be provided on all lines containing inflammable or toxic material, slurries or materials which solidify when the line is dead.

3.5.4 **Sample Connections**

(a) Sample connections shall be taken preferably from the side of the line.

(b) Sample connections in hot services shall be provided with sample coolers.

(c) Minimum pipe size for sample lines shall be ½ ″.

In case of dangerous & toxic media it is advisable to install more than one valve.

3.5.5 **Orifice Plates**

If restriction orifices are required, they shall preferably be installed in vertical line part, to enable complete drainage of the pipe lines. For the same reason orifices in horizontal part of the line shall preferably be equipped with an eccentric hole.

3.5.6 **Connection to Drinking Water**

No physical connection shall be made between a domestic water system and industrial piping system, vessels or other equipment. This will eleminate the possibility of contaminating drinking water.

3.6 Supports, Anchors & Guides

3.6.1 Accurate weight balance calculations shall be made to determine the required supporting force at each supporting point. Support shall be designed to withstand all static and dynamic conditions of loading to which the piping may be subjected. Load calculations shall give consideration to following:

(a) Weight of pipe, valves, flanges, fittings, insulating materials and normal fluid content.

(b) Weight of hydrostatic test fluid or cleaning fluid if normal operating fluid is lighter.

(c) Wind Load.

(d) Friction force on the trestle due to expansion of pipe.

(e) Thermal Load

(f) Force required to compress the bellow expansion joint (where applicable).

(g) Pressure thrust (only applicable where unbalanced below expansion joint is installed).

Weight balance calculations shall include a factor of reduced allowable stress or a load safety factor to allow for rigidity and/or continuity of piping system and the resultant transferring of over load to adjacent pipe support. It is suggested that this factor be 150 - 200% of theoretical load depending on line size, number and spacing of supports and operating condition.

3.6.2 Piping connected to equipment shall be designed, fabricated and installed with proper supports to facilitate servicing, inspection or removal of the equipment. Necessary clearances for installed hoists and cranes will be provided.

3.6.3 Reference may be made to PDS:PS01 for selection and application of pipe supports.

3.7 Service Connections and Utilities

¾ // hose connections for steam, air and water (not drinking water) shall be provided, grouped at convenient locations in the process area for general utility purposes.

3.8 Safety Showers and Eye Baths

Safety showers operating on quick opening chain operated valve and eye baths shall be provided at conveniant locations in hazardous areas of the plant.

3.9 Steam Tracing

Steam tracing shall be provided and installed for maintaining the product temperature when indicated in the flow sheet and shall be in accordance with ES 6016.

3.10 **Special Requirements for Toxic, Hydrocarbon and Flammable Fluids (Like Naphtha, Methanol, Fuel, Oil, CO)**

3.10.1 Cast Iron valves and fitting shall not be used for Toxic and Hydrocarbon services.

3.10.2 API 5LX pipe shall not be used for flammable or Toxic fluids within process unit limits.

3.10.3 Electrical continuity (jumper connection) shall be provided between flanges for pipe lines carry flammable fluids.

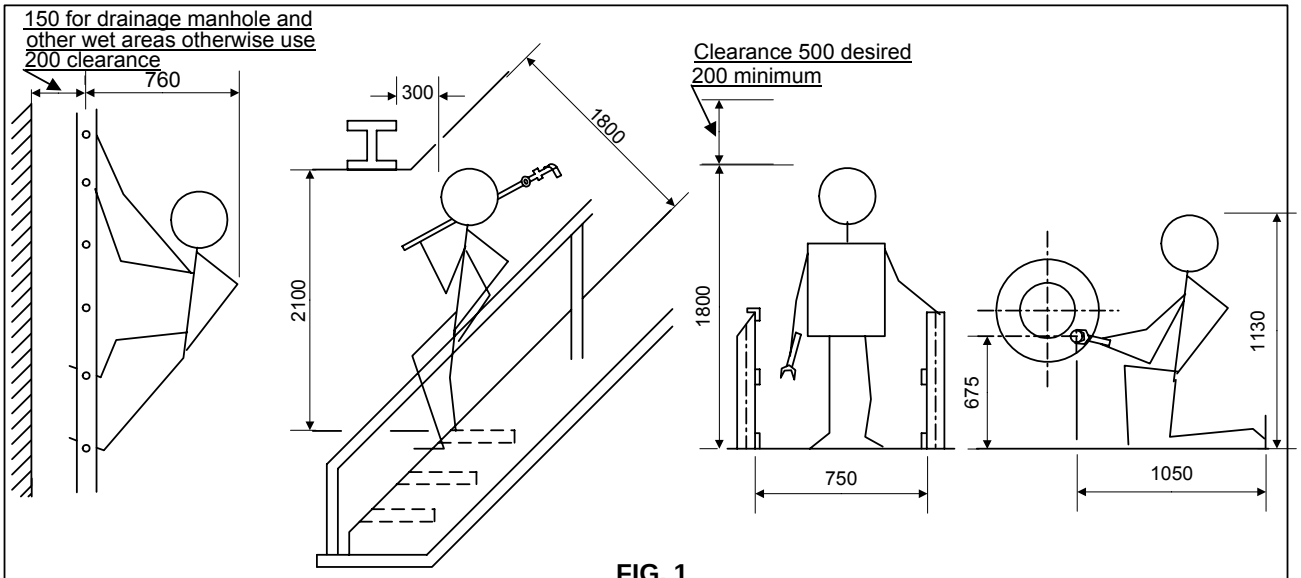


FIG. 1

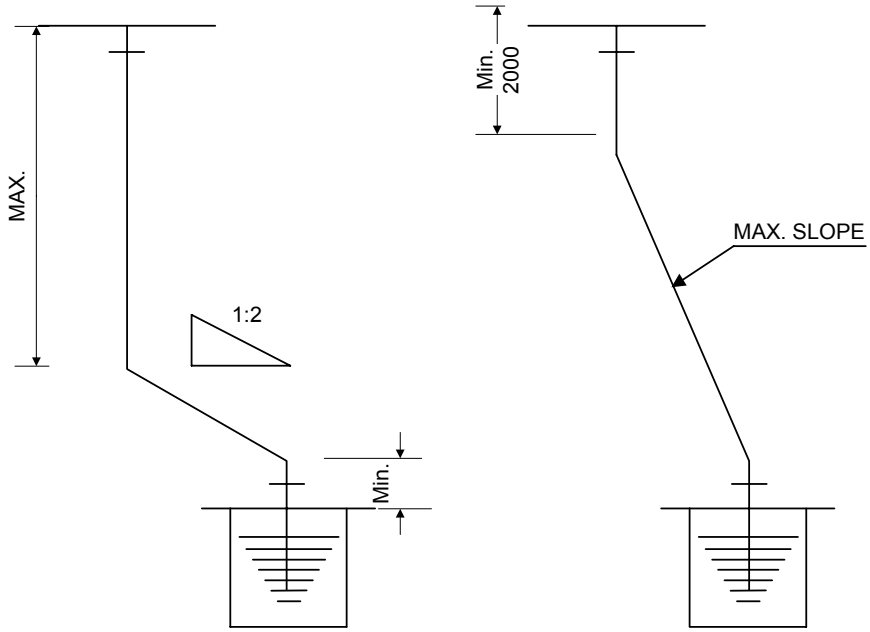


FIG. 2

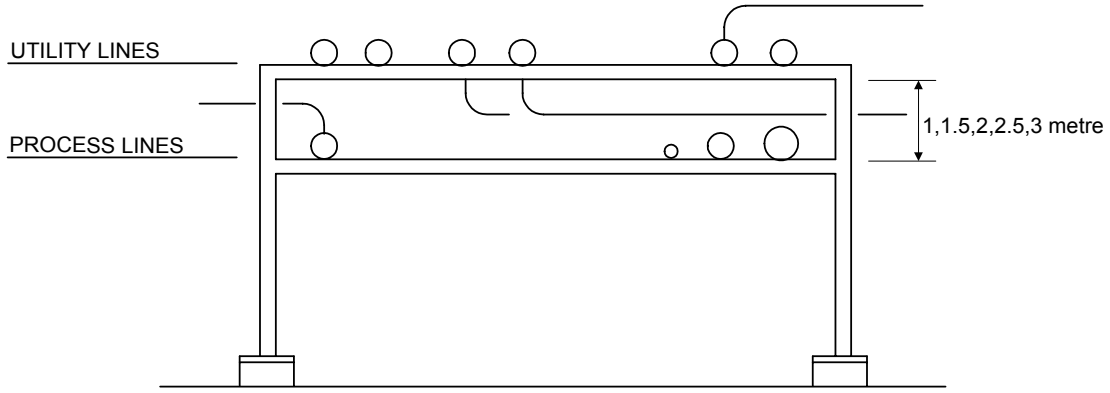


FIG. 3

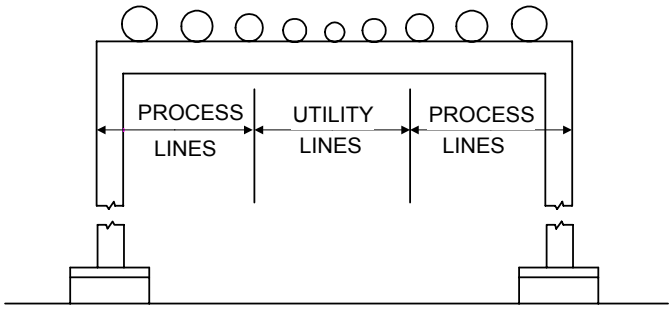


FIG-4

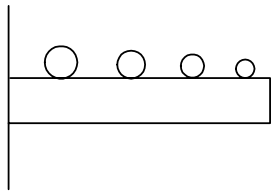


FIG-5

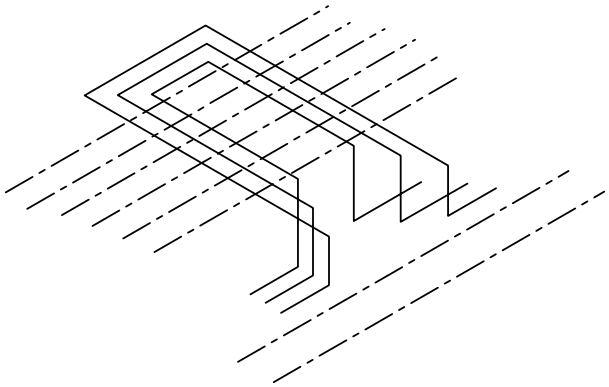


FIG-6

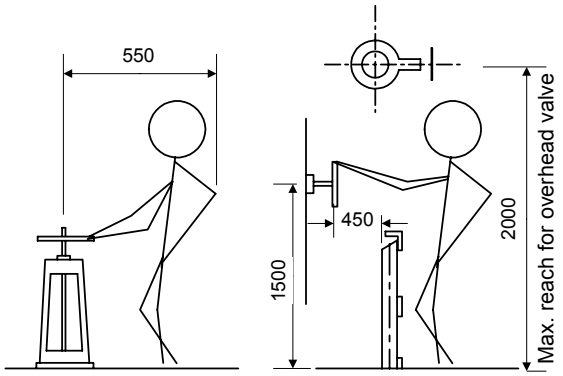


FIG-7

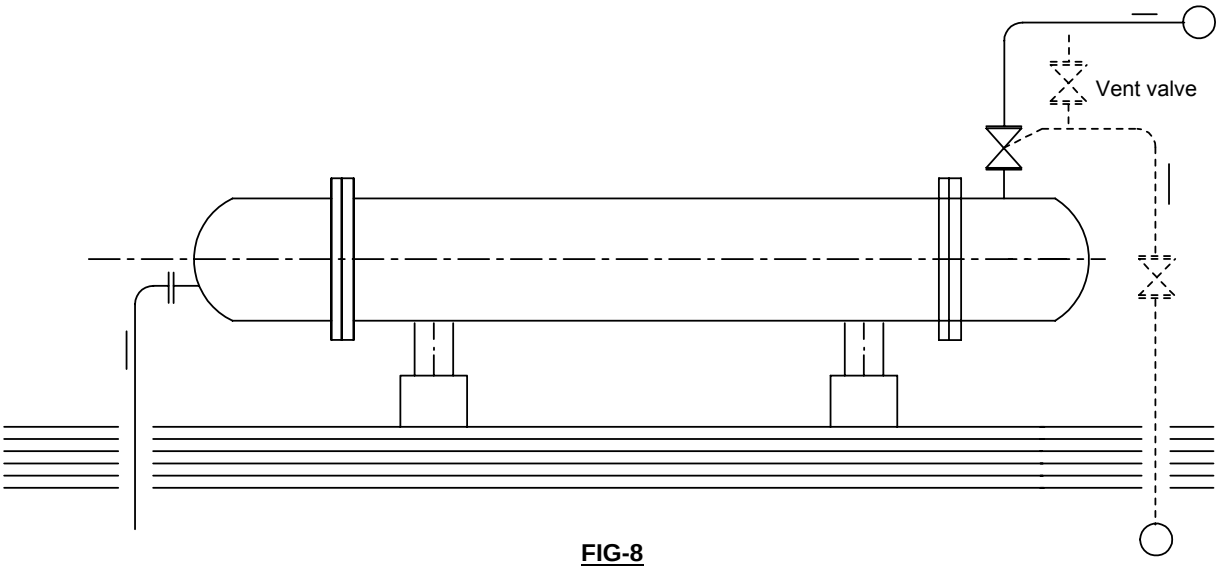


FIG-8

NOTE:

Piping shall be such as to keep the equipment flooded

ENGINEERING STANDARD

FABRICATION, ASSEMBLY AND ERECTION OF PIPING

REV.	DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
0	SEP. '99	ISSUED FOR IMPLEMENTATION			

INDEX

1.0 SCOPE

1.1 This specification covers the requirements of fabircation, assembly and erection of Carbon Steel, Alloy Steel and Stainless Steel pipes and fittings. These requirements conform to ASME Code of pressure piping Process piping ASME B 31.3 - 1999. This standard is meant for easy reference by the Inspector to all requirements of fabrication, assembly and erection of pipes at one place and should not be used as purchase requirements for an enquiry or an order.

1.2 For pipes to be used for steam services, the requirements of Indian Boiler Regulations shall apply in addition to all non-conflicting requirements of this specification.

1.3 Recommendations contained in this document do not in any way release a welding contractor from his responsibility with regard to correct choice of welding materials and procedures, neither do they constitute any commitment on the part of PDIL with regard to payment of any expenses incurred.

2.0 REFERENCE STANDARDS

ASME B 31.3 -- Code for pressure piping - Process Piping

ASME BPV Code Sec.II Part C -- Specification for Welding Rods, Electrodes and Filler Metals

AWS A 5.1 -- Carbon Steel Electrodes for Shielded Metal Arc Welding

AWS A 5.4 -- Stainless Steel Electrodes for Shielded Metal Arc Welding

AWS A 5.5 -- Low Alloy Steel Covered Arc Welding Electrodes

AWS A 5.11 -- Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arch Welding

ASME BPV Code Sec.IX -- Welding Qualification

3.0 WELDING

3.1 Welding Responsibility

Each employer is responsible for the welding done by the personnel of his organization and, except as provided in paras 3.2.2 and 3.2.3 shall conduct the tests required to qualify welding procedures and to qualify and as necessary requalify welders and welding operators.

3.2 Welding Qualifications

3.2.1 Qualification Requirements

(a) Qualification of the welding procedures to be used and of the performance of welders and welding operators shall conform to the requirements of the BPV Code, Section IX except as modified herein.

(b) Where the base metal will not withstand the 180 ^{O} guided bend required by Section IX, a qualifying welded specimen is required to undergo the same degree of bending as the base metal, within 5^{O}.

(c) The requirements for preheating in para 4.0 and for heat treatment in para 5.0 as well as such requirements in the engineering design, shall apply in qualifying welding procedures.

(d) When impact testing is required by this Standard or the engineering design, those requirements shall be met in qualifying welding procedures.

(e) To reduce the number of welding procedure qualifications required, P-Numbers or S-Numbers and Group Numbers are assigned in the BPV Code, Section IX, to groupings of metals generally based on composition, weldability and mechanical properties, insofar as practicable. The P-Numbers or S-Numbers for most metals are listed in Table A-1 of ASME B 31.3. See Section IX, QW/QB-422, for Group Numbers for respective P-Numbers and S-Numbers. Use of Section IX, QW-420.2 is required for this Standard.

3.2.2 **Procedure Qualification by Others**

Each employer is responsible for qualifying any welding procedure that personnel of the organization will use. Subject to the specific approval of the Inspector, welding procedures qualified by others may be used, provided that the following conditions are met.

(a) The Inspector shall be satisfied that :

1) the proposed welding procedure specification (WPS) has been prepared, qualified and executed by a responsible, recognized organization with expertise in the field of welding; and

2) the employer has not made any change in the welding procedure.

(b) The base material P-Number is either 1, 3, 4 Gr.No.1 (1¼ Cr max.), or 8; and impact testing is not required.

(c) The base metals to be joined are of the same P-Number, except that P-Nos. 1, 3 and 4 Gr.No.1 may be welded to each other as permitted by Section IX.

(d) The material to be welded is not more than 19 mm in thickness. Postweld heat treatment shall not be required.

(e) The design pressure does not exceed the ASME B 16.5, Class 300 rating for the material at design temperature; and the design temperature is in the range -29^{O}C to 399^{O}C, inclusive.

(f) The welding process is SMAW (Shielded Metal Arc Welding) or GTAW (Gas Tungstan Arc Welding) or a combination thereof.

(g) Welding electrodes for the SMAW process are selected from the following classifications.

AWS A 5.1	AWS A 5.4	AWS A 5.5
E6010	E308-15, -16	E7010 - A1
E6011	E308L-15, -16	E7018 - A1
E7015	E309-15, -16	E8016 - B1
E7016	E310-15, -16	E8018 - B1
E7018	E-16-8-2-15, -16	E8015 - B2L
	E316-15, -16	E8016 - B2
	E316L-15, -16	E8018 - B2
	E347-15, -16	E8018 - B2L

Recommended electrodes and bare wires for welding of certain selected pipe materials are shown in Table 1.

The figures in Table 4A & 4B are referring to the selection of welding material in Table 1 and the letters in Table 4A and 4B are referring to the selection of preheat and postweld heat temperature in Table 2 and 3 respectively. The suitability of these electrodes and wires (or materials which may be selected as alternatives) and the suitability of preheat and postweld heat temperatures shall be demonstrated in appropriate Welding Procedure Qualifications as described in ASME Section IX.

(h) By signature, the employer accepts responsibility for both the WPS and the procedure qualification record (PQR).

(i) The employer has at least one currently employed welder or welding operator who, while in his employ has satisfactorily passed a performance qualification test using the procedure and the P-Number material specified in the WPS. The perfor mance bend test required by Section IX. QW-302 shall be used for this purpose. Qualification by radiography is not acceptable.

The responsibility of the welding contractor shall include the provision of all materials, facilities and man powers for the procedure and performance qualification tests.

3.2.3 **Performance Qualification by Others**

To avoid duplication of effort, an employer may accept a performance qualification made for another employer, provided that the I nspector specifically approves. Acceptance is limited to qualification on piping using the same or e quivalent procedure wherein the essential variables are within the limits in Section IX. The employer shall obtain a copy from the previous employer of the performance

qualification test record, showing the name of the employer, name of the welder or welding operator, procedure identification, date of successful qualification and the date that the individual last used the procedure on pressure piping.

3.2.4 **Qualification Records**

The employer shall maintain a self-certified record, available to the owner (and the owner's agent) and the Inspector, of the procedures used and the welders and welding operators employed, showing the date and results of procedure and performance qualifications and the identification symbol assigned to each welder and welding operator.

3.3 **Welding Materials**

3.3.1 **Filler Metal**

Filler metal shall conform to the requirements of Section IX. A filler metal not yet incorporated in Section IX may be used with the owner's approval if a procedure qualification test is first successfully made.

3.3.2 **Weld Backing Material**

Permanent backing rings are not permitted except for use in refractor lined pipes.

When backing rings are used, they shall conform to the following :

(a) *Ferrous Metal Backing Rings*

These shall be of weldable quality. Sulfur content shall not exceed 0.05%.

(b) If two abutting surfaces are to be welded to a third member used as a backing ring nad one or two of the three members are ferritic and the other member or members are austenitic, the satisfactory use of such materials shall be demonstrated by welding procedure qualified as required by para 3.2.

Backing rings may be of the continuous machined or split-band type. Some commonly used types are shown in Fig.3.3.2.

(c) *Nonferrous and Nonmetallic Backing Rings*

Backing rings of nonferrous or nonmetallic material may be used, provided the designer approves their use and the welding procedure using them is qualified as required by para 3.2.

3.3.3 **Consumable Inserts**

Consumable inserts are not permitted.

3.4 **Preparation for Welding**

3.4.1 **Cleaning**

Internal and external surfaces to be thermally cut or welded shall be clean and free paint, oil, rust, scale and other material that would be detrimental to either the weld or the base metal when heat is applied.

Where root passes are made by GTAW (Gas Tungstan Arc Welding) or GMAW (Gas Metal Arc Welding) processes, the internal pipe surface shall be cleared before welding by means of grinding, brushing or equivalent for atleast 10 mm from the end of the pipe.

3.4.2 **End Preparation**

(a) *General*

1) End preparation is acceptable only if the surface is reasonably smooth and true and slag from oxygen or arc cutting is cleaned from thermally cut surfaces. Discoloration remaining on a thermally cut surface is not considered detrimental oxidation.

2) End preparation for groove welds specified in ASME B 16.25 or any other which meets the WPS, is acceptable. [For convenience, the basic bevel angles of ASME B 16.25 and some additional J-bevel angles are shown in Fig.3.4.2 sketches (a) and (b)].

3) The root opening is nom. 1.5 mm and shall not normally exceed 3 mm for root passes made by GTAW process and 4 mm for root passes made by GMAW or SMAW (Shielded Metal Arc Welding) process.

(b) *Circumferential Welds*

1) If component ends are trimmed as shown in Fig.3.3.2 sketch (a) or (b) to fit backing rings or consumable inserts or as shown in Fig.3.4.3 sketch (a) or (b) to correct internal misalignment, such trimming shall not reduce the finished wall thickness below the required minimum wall thickness t_m.

2) Component ends may be bored to allow for a completely recessed backing ring, provided the remaining net thickness of the finished ends is not less than t_m.

3) It is permissible to size pipe ends of the same nominal size to improve alignment if wall thickness requirements are maintained.

4) Where necessary, weld metal may be deposited inside or outside of the component to permit alignment to provide for maching to ensure satisfactory seating of rings or inserts.

5) When a girth or miter groove weld joins components of unequal wall thickness and one is more than 1½ times the thickness of the other end preparation and geometry shall be in accordance with acceptable designs for unequal wall thickness in ASME B 16.25.

3.4.3 **Alignment**

(a) *Circumferential Welds*

1) Inside surfaces of components at ends to be joined in girth or miter groove welds shall be aligned within the dimensional limits in the WPS and the engineering design.

Misalignment of pipe ends for butt welds shall not exceed 1.6 mm at any point on the bore of the pipe as shown in Fig. 3.4.3.

Alignment of girth butt joints may be achieved either by tack welding or by the use of welded yokes or pipe clamps.

2) If the external surfaces of the components are not aligned, the weld shall be tapered between them.

(b) *Longitudinal Welds*

Alignment of longitudinal groove welds (not made in accordance with ASME standard shall conform to the requirements of para 3.4.3(a).

(c) *Branch Connection Welds*

1) Branch connections which abut the outside surface of the run pipe shall be contoured for groove welds which meet the WPS requirements [see Fig.3.4.4 sketches (a) and (b)].

2) Branch connections which are inserted through a run opening shall be inserted at least as far as the inside surface of the run pipe at all points [see Fig.3.4.4 sketch (c)] and shall otherwise conform to para 3.4.3(c)(1).

3) Run openings for branch connections shall not deviate from the required contour more than the dimension m in Fig.3.4.4. In no case shall deviations of the shape of the opening cause the root spacing tolerance limits in the WPS to be exceeded. Weld metal may be added and refinished if necessary for compliance.

4) *Spacing*

The root opening of the joint shall be within the tolerance limits in the WPS.

3.5 **Welding Requirements**

3.5.1 **General**

(a) Welds, including addition of weld metal for alignment [paras 3.4.2 (b)(4) and 3.4.3 (c)(3)], shall be made in accordance with a qualified procedure and by qualified welders or welding operators.

(b) Each qualified welder and welding operator shall be assigned an identification symbol. Unless otherwise specified in the engineering design, each pressure containing weld or adjacent area sha ll be marked with the identification symbol of the welder or welding operator. In lieu of marking the weld, appropriate records shall be filed.

(c) Tack welds at the root of the joint shall be made with filler metal equivalent to that used in the root pass. Tack welds shall be made by a qualified welder or welding operator. Tack welds shall be fused with the root pass weld, except that those which have cracked shall be removed.

For pipe wall thickness above 8 mm bridge tacking (above the root) is preferred. Bridge tacks shall be removed completely before filler passes are added.

(d) Peening is prohibited on the root pass and final pass of a weld.

(e) No welding shall be done if there is impingement on the weld area of rain, snow, sleet or excessive wind, or if the weld area is frosted or wet.

(f) Root passes of all welds in inspection class 2 (see clause 5) and all welds in which either of the metals to be joined is austenitic steel shall be made using the GTAW process with inert backing gas. The inert gas shall preferably be Argon, although gas consisting of 85% N_2 + 15% H_2 may be used if argon is not available.

For pipes $\leq$ 2 inch nom. size, use GTAW for entire welding.

(g) *Welding End Valves*

The welding sequence and procedure and any heat treatment for a welding end valve shall be such as to preserve the seat tightness of the valve.

3.5.2 Fillet and Socket Welds

Fillet welds (including socket welds) may vary from convex to concave. The size of a fillet weld is determined as shown in Fig.3.5.2A.

(a) Typical weld details for slip-on and socket welding flanges are shown in Fig.3.5.2B; minimum welding dimensions for other socket welding components are shown in Fig.3.5.2C.

(b) If slip-on flanges are single welded, the weld shall be at the hub.

3.5.3 Seal Welds

Seal welding shall be done by a qualified welder. Seal welds shall cover all exposed threads except those for seal welded thermowell connections.

3.5.4 Welded Branch Connections

(a) Figures 3.5.4A through 3.5.4E show acceptable details of branch connections with and without added reinforcement, in which the branch pipe is connected directly to the run pipe. The illustrations are typical and are not intended to exclude acceptable types of construction not shown.

(b) Figure 3.5.4D shows basic types of weld attachments used in the fabrication of branch connections. The location and minimum size of attachment welds shall conform to the requirements herein. Welds shall be calculated in accordance with para 304.3.3 of ASME B 31.3 but shall be not less than the sizes shown in Fig. 3.5.4D.

(c) The nomenclature and symbols used herein and in Fig.3.5.4D are :

t_c = lesser of 0.7 T_b or 6 mm
T_b = nominal thickness of branch
T_h = nominal thickness of header
T_r = nominal thickness of reinforcing pad or saddle
$t_{min.}$ = lesser of T_b or T_r

(d) Branch connections, including branch connection fittings which abut the outside of the run or which are inserted in an opening in the run shall be attached by fully penetrated groove welds. The welds shall be finished with cover fillet welds having a throat dimension not less than t_c see Fig.3.5.4D sketches (1) and (2).

(e) A reinforcing pad or saddle shall be attached to the branch pipe by either:

1) a fully penetrated groove weld finished with a cover fillet weld having a throat dimension not less than t_c ; or

2) a fillet weld having a throat dimension not less than $0.7t_{min.}$ See Fig.3.5.4D sketch (5).

(f) The outer edge of a reinforcing pad or saddle shall be attached to the run pipe by a fillet weld having a throat dimension not less than $0.5T_r$. See Fig. 3.5.4D sketches (3), (4) and (5).

(g) Reinforcing pads and saddles shall have a good fit with the parts to which they are attached. A vent hole shall be provided at the side (not at the crotch)

of any pad or saddle to reveal leakage in the weld between branch and run and to allow venting during welding and heat treatment. A pad or saddle may be made in more than one piece if joints between pieces have strength equivalent to pad or saddle parent metal and if each piece has a vent hole.

(h) Examination and any necessary repairs of the completed weld between branch and run shall be made before adding a pad or saddle.

3.5.5 Fabricated Laps

Figure 3.5.5 shows typical fabricated laps. Fabrication shall be in accordance with the applicable requirements of para 3.5.4.

3.5.6 Welding for Severe Cyclic Conditions

A welding procedure shall be employed which provides a smooth, regular, fully penetrated inner surface.

3.6 Weld Repair

A weld defect to be repaired shall be removed to sound metal. Repair welds shall be made using a welding procedure qualified in accordance with para 3.2.1 recongnizing that the cavity to be repaired may differ in contour and dimensions from the original joint. Repair welds shall be made by welders or welding operators qualified in accordance with para 3.2.1. Preheating and heat treatment shall be as required for the original welding. See also para 3.3.3 of ES 6005.

4.0 PREHEATING

4.1 General

Preaheating is used, along with heat treatment, to minimize the detrimental effects of high temperature and severe ther mal gradients inherent in wel ding. The necessity for preheating and the temperature to be used shall be specified in the engineering design and demonstrated by proce dure qualification. The requirements and recommendations herein apply to all types of welding including tack welds, repair welds and seal welds of threaded joints.

4.1.1 Requirements and Recommendations

Required and recommended minimum preheat temperatures for materials of various P-Numbers are given in Table 2. If the ambient temperature is below $10^{O}C$ the recommendations in Table 2 become requirements. Preheating of all materials may be carried out by any controllable means. The thickness intended in Table 2 is that of the thicker component measured at the joint.

4.1.2 Unlisted Materials

Preheat requirements for an unlisted material shall be specified in the WPS.

4.1.3 **Temperature Verification**

(a) Preheat temperature shall be checked by use of temperature indicating crayons, thermocouple pyrometers or other suitable means to ensure that the temperature specified in the WPS is obtained prior to and maintained during welding.

(b) Thermocouples may be temporarily attached directly to pressure containing parts using the capacitor discharge method of welding without welding procedure and performance qualifications. After thermocouples are removed, the areas shall be visually examined for evidence of defects to be repaired.

4.1.4 **Preheat Zone**

The preheat zone shall extend at least 25 mm beyond each edge of the weld.

4.2 **Specific Requirements**

4.2.1 **Dissimilar Materials**

When materials having different preheat requirements are welded together, it is recommended that the higher temperature shown in Table 2 be used.

4.2.2 **Interrupted Welding**

If welding is interrupted the rate of cooling shall be controlled or other means shall be used to prevent detrimental effects in the piping. The preheat specified in the WPS shall be applied before welding is resumed.

TABLE-1

WELDING MATERIALS

WELDING MATERIALS					
NO.	MATERIAL	COATED ELECTRODES		BARE WIRES	
		ASME SFA	CLASSIFICATION	ASME SFA	CLASSIFICATION
1	C.S	5.1	E7018	5.18	ER70S-2
2	C.Mo.	5.5	E7018	5.18	ER70S-1B
3	1 ¼ Cr.Mo	5.5	E8018-B2	--	ER515
4	2 ¼ Cr.Mo	5.5	E8018-B3	--	ER521
5	5Cr.Mo	5.4	E502-16 or -15	5.9	ER502
6	9Cr.Mo	5.4	E505-16 or -15	--	ER505
7	12Cr	5.4	E410-16 or -15	5.9	ER410
8	3 ½ Ni	5.5	To match base metal	--	--
9	18Cr.8Ni (308,308L)	5.4	E308-16 or -15 E308L-16 or 15	5.9	ER308 ER308L
10	18Cr 10Ni Cb (347)	5.4	E347-16 or -15	5.9	ER347
11	18Cr 10Ni Mo (316 316L)	5.4	E316-16 or -15 E316L-16 or 15	5.9	ER316 ER316L
12	25Cr 12Ni (309) Inconel	5.4 5.11	E309-16 or -15 ENiCrFe-3	5.9 5.14	ER309 ERNiCr-3
13	Inconel	5.11	EniCrFe-3 (Inconel 182)	5.14	ERNiCr-3 (Inconel 82)

14	Monel	5.11	ENiCu-2 (Monel 190)	5.14	ERNiCu-7 (Monel 60)
15	Nickel	5.11	ENi-I (Nickel 141)	5.14	ERNi-3 (Nickel 61)
16	25Cr 20Ni (310)	5.4	E310-16 OR -15	5.9	ER310

Table 1 shall be used as indication only.

TABLE-2

PREHEAT TEMPERATURES

Heat Treatment Symbol (Note-1)	Base Metal P-No. or S-No.	Base Metal Group	Nominal Wall Thickness, mm	Specified Min. Tensile Strength, Base Metal Mpa (ksi)	Min. Temperature, ^{O}C
A	1	Carbon steel	< 25 ≥ 25 All	≤ 490 (71) All > 490 (71)	10 80 80
B	3	Alloy steels Cr ≤ ½ %	< 13 ≥ 13 All	≤ 490 (71) All > 490 (71)	10 80 80
C	4	Alloy steels ½ % < Cr ≤ 2%	All	All	150
D	5A,5B,5C	Alloy steels 2¼ % ≤ Cr ≤ 10%	All	All	177
E	6	High alloy steels martensitic	All	All	150 (Note 2)
F	7	High alloy steels ferritic	All	All	10
	8	High alloy steels austenitic	All	All	10
G	9A,9B	Nickel alloy steels	All	All	93
H	10	Cr-Cu steel	All	All	150-204
J	10I	27 Cr steel	All	All	150 (Note 3)
K	11A SG1	8 Ni, 9Ni steel	All	All	10

L	11A SG2	5 Ni steel	All	All	10
M	21 - 52		All	All	10

Notes:

(1) P - Number or S - Number from ASME BPV Code, Section IX, QW/QB - 422

(2) Maximum interpass temperature 316^{O}C.

(3) Maintain interpass temperature between 177^{O}C - 232^{O}C.

TABLE - 3

REQUIREMENT FOR HEAT TREATMENT

Heat Treatment Symbol (Note-1)	Base Metal P-No. or S-No.	Base Metal Group	Thickness mm	Specified Min. Tensile Strength, Base Metal Mpa (ksi)	Metal. Temperature Range ^{O}C	Holding Time (Note 2)	Brinell Hardness (Note-9) Max.
A	1	Carbon steel	≤ 19 > 19	All All	None 595 - 650	2.4 min./mm Minimum 1 hr.	--
B	3	Alloy steels Cr ≤ ½ %	≤ 19 > 19 All	≤ 490 (71) All > 490 (71)	None 595 - 720 595 - 720		-- 225 225
C	4 (Note-8)	Alloy steels ½ % < Cr ≤ 2%	≤ 13 > 13 All	≤ 490 (71) All > 490 (71)	None 705 - 745 705 - 745	2.4 min./mm Minimum 2 hr.	-- 225 225
D	5A,5B,5C (Note-8)	Alloy steels ≤ 3% Cr and ≤ 0.15% C	≤ 13 > 13 All	All All All	None 705 - 760 705 - 760		-- 241 241
E	6	High alloy steels martensitic A 240 Gr.429	All All	All All	732 - 788 621 - 663		241 241
F	7	High alloy steels ferritic	All	All	None	--	--
	8	High alloy steels austenitic	All	All	None	--	--
G	9A,9B	Nickel alloy steels	≤ 19 > 19	All All	None 595 - 635	2.4 min./mm Minimum 1 hr.	--

H	10	Cr-Cu steel	All	All	760 - 816 (Note-3)	1.2 min./mm Minimum ½ hr.	--
I	10H	Duplex stainless steel	All	All	(Note-5)		--
J	10I	27 Cr steel	All	All	663 - 704 (Note-4)	2.4 min./mm Minimum 1 hr.	--
K	11A SG1	8 Ni, 9Ni steel	≤ 51 > 51	All	None 552 - 585 (Note-6)		--
L	11A SG2	5 Ni steel	> 51	All	552 - 585 (Note-6)		--
N	62	Zr 60705	All	All	538 - 593 (Note-7)	Note-7 Minimum 1 hr.	--

Table 3 (Contd.)

Notes :

(1) P - Number or S - Number from ASME BPV Code, Section IX, QW/QB - 422

(2) Holding Time in min/mm (minutes per mm thickness).

(3) Cool as rapidly as possible after the hold period.

(4) Cooling rate to 649^{O}C shall be less than 56^{O}C/hr thereafter, the cooling rate shall be fast enough to prevent embrittlement.

(5) Postweld heat treatment is neither required nor probibited, but any heat treatment applied shall be as required in the material specification.

(6) Cooling rate shall be not greater than 167^{O}C/hr upto 316^{O}C.

(7) Heat treatment shall be carried out within 14 days after welding. Hold time shall be increased by ½ hr. for each 25 mm over 25 mm thickness. Cool to 427^{O}C at a rate < 278^{O}C/hr. per 25 mm nominal thickness, 278^{O}Chr. max. Cool in still air from 427^{O}C.

(8) Heat treatment temperatures listed in this table for some P.No.4 and P.No.5 materials may be higher than the minimum tempering temperatures specified in the ASTM specifications for the base material. For higher strength normalised and tempered materials there is consequently a possibility of reducing tensile properties of the base material, particularly if long holding times at higher temperatures are used.

(9) See para 331.1.7 of ASME B 31.3, reproduced below

Hardness tests of production welds and of hot bent and hot formed piping are intended to verify safisfactory heat treatment. The hardness limit applies to the weld and to the heat affected zone (HAZ) tested as close as preacticable to the edge of the weld.

(a) Where a hardness limit is specified in Table 3 at least 10% of welds, hot bends and hot formed components in each furnace heat treated batch and 100% of those locally heat treated shall be tested.

(b) When dissimilar metals are joined by welding the hardness limits specified for the base and welding materials in Table 3 shall be met for each material.

Welding Materials and Heat Treatment for Welding of Dissimilar Steels

TABLE 4A

Ferrous Material														
Materials	P No	310	316 316L	321 347	304 304L	3 ½ Ni	13Cr 405	13Cr 410	9Cr 1 Mo	5Cr ½Mo	2½Cr 1Mo	1½Cr ½Mo	C-Mo	C.S
C.S.	P-1	12A	12A	12A	12A	1G	1B	1E	1D	1D	1D	1C	1B	1A
C.Mo	P-3	12B	12B	12B	12B	2G	2B	2E	2D	2D	2D	2C	2B	
1 ½ Cr-½Mo	P-4	12C	12C	12C	12D	3C	3C	3E	3D	3D	3D	3C		
2 ½ Cr-1Mo	P-5	12D	12D	12D	12D	4D	4D	4E	4D	4D	4D			
5 Cr-½Mo	P-5	12D	12D	12D	12D	5D	5D	5E	5D	5D				
9 Cr-1Mo	P-5	12D	12D	12D	12D	6D	6D	6D	6D					
13 Cr, Type 410	P-6	12E	12E	12E	12E	7E	7E	7E						
13 Cr, Type 405	P-7	12F	12F	12F	12F	7G	12F							
3 ½ Nickel	P-9E	12G	12G	12G	12G	8G 13A,G								
18 Cr-8Ni Type 304, 304L	P-8	9F	9F	9F	9F									
18 Cr 10 Ni Type 347, 321	P-8	10F	10F	10F										
16 Cr 12Ni Type 316, 316L	P-8	11F	11F											
25 Cr 20Ni	P-8	16F												

Type 310		

TABLE 4B

Nickel Base Alloys					
Material	P.No.	Nickel	Monel	Inconel	Incoloy
C.S.	P-1	13F	14F	13F	13F
Stainless	P-8	13F	13F	13F	13F
Incoloy	P-45	13F	13F	13F	13F
Inconel	P-42	13F	13F	13F	
Monel	P-42	15F	14F		
Nickel	P-41	15F			

The figure in each block refers to the electrode or bare wire in Table1, while the letter refers to the preheat and post weld heat treatment shown in Table-2 and 3.

5.0 HEAT TREATMENT

Heat treatment is used to avert or relieve the detrimental effects of high temperature and severe temperature gradients inherent in welding and to relieve residual stresses created by bending and forming. These are basic practices which are suitable for most welding, bending and forming operations, but not necessarily appropriate for all service conditions.

5.1 General

5.1.1 Heat Treatment Requirements

(a) Heat treatment shall be in accordance with the material groupings and thickness ranges in Table 3 except as provided in paras 5.2.1 and 5.2.2.

(b) Heat treatment to be used after production welding shall be specified in the WPS and shall be used in qualifying the welding procedure.

(c) The engineering design shall specify the examination and/or other production quality control (not less than the requirements of this Standard) to ensure that the final welds are of adequate quality.

(d) Heat treatment for bending and forming shall be in accordance with para 6.4.

(e) Post -weld heat treatment of Cr.Mo. steels shall be carried out using either electric or gas fired furnaces. For local heat treatment heating by torches is not permitted. Electric heating shall be used.

5.1.2 Governing Thickness

When components are joined by welding, the thickness to be used in applying the heat treatment provisions of Table 5.1.1 shall be that of the thicker component measured at the joint except as follows :

(a) In the case of branch connections, metal (other than weld metal) added as reinforcement, whether an integral part of a branch fitting or attached as a reinforcing pad or saddle, shall not be considered in determining heat treatment requirements. Heat treatment is required, however, when the thickness through the weld in any plane through the branch is greater than twice the minimum material thickness requiring heat treatment, even though the thickness of the compo nents at the joint is less than the minimum thickness. Thickness through the weld for the details shown in Fig.3.5.4D shall be computed using the following formulas :

sketch (1) = $T_b + t_c$

sketch (2) = $T_h + t_c$

sketch (3) = greater of $T_b + t_c$ or $T_r + t_c$

sketch (4) = $T_h + T_r + t_c$

sketch (5) = $T_b + t_c$

(b) In the case of fillet welds at slip-on and socket welding flanges and piping connections NPS 2$^{//}$ and smaller for seal welding of threaded joints in piping NPS 2$^{//}$ and smaller and for attachment of external nonpressure parts such as lugs or other pipe supporting elements in all pipe sizes , heat treament is required when the thickness through the weld in any plane is more than twice the minimum material thickness requiring heat treatment (even though the thickness of the components at the joint is less than that minimum thickness except as follows :

1) not required for P-No.1 materials when weld throat thickness is 16 mm or less regardless of base metal thickness;

2) not requisred for P-No.3,4,5 or 10A materials when weld throat thickness is 13 mm or less, regardless of base metal thickness, provided that not less than the recommended preheat is applied and the specified minimum tensile strength of the base metal is less than 490 Mpa (71 ksi);

3) not required for ferritic materials when welds are made with filler metal which does not air harden. Austenitic welding materials may be used for welds to ferritic materials when the effects of service conditions, such as differential thermal expansion due to elevated temperature or corrosion, will not adversely affect the weldment.

5.1.3 Heating and Cooling

The heating method shall provide the required metal temperature, metal temperature uniformity and temperature control and may include an enclosed furnace, local flame heating, electric resistance, electric induction or exothermic chemical reaction. The cooling method shall provide the required or desired cooling rate and may include cooling in a furnace, in air, by application of local heat or insulation or by other suitable means.

5.1.4 **Temperature Verification**

Heat treatment temperature shall be checked by thermoc ouple pyrometers or other suitable methods to ensure that the WPS requirements are met. See para 4.1.3(b) for attachment of thermocouples by the capacitor discharge method of welding.

5.1.5 **Hardness Tests**

Hardness tests of production welds and of hot bent and hot formed piping are intended to verify satisfactory heat treatment. The hardness limit applies to the weld and to the heat affected zone (HAZ) tested as close as practicable to the edge of the weld.

Hardness testing shall be carried out using a portable Brinnell hardness tester using a standard 10 mm ball.

(a) Where a hardness limit is specified in Table 3 at least 10% of welds, hot bends and hot formed components in each furnace heat treated batch and 100% of those locally heat treated shall be tested.

(b) When dissimilar metals are joined by welding, the hardness limits specified for the base and welding materials in Table 3 shall be met for each material.

It should be noted that hardness test is not a substitute for notch testing.

5.2 **Specific Requirements**

Where warranted by experience or knowledge of service conditions, alternative methods of heat treatment or exceptions to the basic heat treatment provisions of para 5.1 may be adopted as provided in paras 5.2.1 and 5.2.2.

5.2.1 **Alternative Heat Treatment**

Normalizing or normalizing and tempering or annealing may be applied in lieu of the required heat treatment after w elding, bending or forming, provided that the mechanical properties of any affected weld and base metal meet specification requirements after such treatment and that the subst itution is approved by the designer.

5.2.2 **Exceptions to Basic Requirements**

As indicated in para 5.0 the basic practices therein may require modification to suit service conditions in some cases. In such cases, the designer may specify more stringent requirements in the engineering design, including heat treatment and hardness limitations for lesser thickness or may specify less stringent heat treatment and hardness requirements, including none.

When provisions less stringent than those in para 5.0 are specified, the designer must demonstrate to the owner's satisfaction the adequacy of those provisions by comparable service experience considering service temperature and its effects, frequency and intensity of thermal cycling, flexibility stress levels, probab ility of brittle failure and other pertinent factors. In additon, appropriate tests shall be conducted, including WPS qualification tests.

5.2.3 **Dissimilar Materials**

(a) Heat treatment of welded joints between dissimilar ferritic metals or between ferritic metals using dissimilar ferritic filler metal shall be at the higher of the temperature ranges in Table 3 for the materials in the joint.

(b) Heat treatment of welded joints including both ferritic and austenitic components and filler metals shall be as required for the ferritic material or materials unless otherwise specified in the engineering design.

(c) Recommended welding material and recommended heat treatment procedures to be employed when welding various combinations are shown in Table-4A and Table-4B.

(d) It should be noted that a high alloy electrode is recommended in all cases where low alloy steel is welded to austenitic steel.

5.2.4 **Delayed Heat Treatment**

If a weldment is allowed to cool prior to heat treatment, the rate of cooling shall be controlled or other means shall be used to prevent detrimental effects in the piping.

5.2.5 **Partial Heat Treatment**

When an entire piping assembly to be heat treated cannot be fitted into the furnace, it is permissible to heat treat in more than one heat, provided there is at least 300 mm overlap between successive heats and that parts of the assembly outside the furnace are protected from harmful temperature gradients.

5.2.6 **Local Heat Treatment**

When heat treatment is applied locally, a circumferential band of the run pipe and of the branch where applicable, shall be heated until the specified temperature range exists over the entire pipe section(s), gradually diminishing beyond a band which includes the weldment or the bent or formed section and at least 25 mm beyond the ends thereof.

6.0 BENDING AND FORMING

6.1 General

Pipe may be bent and components may be formed by any hot or cold method which is suitable for the material the fluid service and the severity of the bending or forming process. The finished surface shall be free of cracks and substantially free from buckling. Thickness after bending or forming shall be not less than that required by the design.

6.2 Bending

6.2.1 Bending Flattening

Flatening of a bend, the difference between maximum and minimum diameters at any cross section, shall not exceed 8% of nominal outside diameter for internal pressure and 3% for external pressure. Removal of metal shall not be used to achieve these requirements.

6.2.2 Bending Temperature

(a) Cold bending of ferritic materials shall be done at a temperature below the transformation range.

(b) Hot bending shall be done at a temperature above the transformation range and in any case within a temperature range consistent with the material and the intended service.

6.3 Forming

The temperature range for forming shall be consistent with material, intended service and specified heat treatment.

6.4 Required Heat Treatment

Heat treatment shall be performed in accordance with para 6.1.1 when required by the following :

6.4.1 Hot Bending and Forming

After hot bending and forming, heat treatment is required for P-Nos.3,4,5,6 and 10A materials in all thicknesses. Durations and temperatures shall be in accordance with para 5.0.

6.4.2 Cold Bending and Forming

After cold bending and forming, heat treatment is required (for all thicknesses and with temperature and duration as given in Table 5.1.1) when any of the following conditions exist :

(a) for P-Nos. 1 through 6 materials, where the maximum calculated fiber elongation after bending or forming exceeds 50% of specified basic minimum elongation (in the direction of severest forming) for the applicable specification, grade and thickness. This requirement may be waived if it can be demonstrated that the selection of pipe and the choice of bending or forming process provide assurance that in the finished condition the most severely strained material retains at least 10% elongation.

(b) for any material requiring impact testing, where the maximum calculated fiber elongation after bending or forming will exceed 5%.

(c) when specified in the engineering design.

7.0 ASSEMBLY AND ERECTION

7.1 General

7.1.1 Alignment

(a) **Piping Distortions**

Any distortion of piping to bring it into alignment for joint assembly which introduces a detrimental strain in equipment or piping components is prohibited.

(b) **Cold Spring**

Before assembling any joints to be cold sprung, guides, supports and anchors shall be examined for errors which might interfere with desired movement or lead to undesired movement. The gap or overlap of piping prior to assembly shall be checked against the drawisng and corrected if necessary. Heating shall not be used to help in closing the gap because it defeats the purpose of cold springing.

(c) **Flanged Joints**

Before bolting up, flange faces shall be aligned to the design plane within 1 mm in 200 mm measured across any diameter; flange bolt holes shall be aligned within 3 mm maximum offset.

7.2 Flanged Joints

7.2.1 Preparation for Assembly

Any damage to ghe gasket seating surface which would prevent gasket seating shall be repaired or the flange shall be replaced.

7.2.2 Boltling Torque

(a) In assembling flanged joints, the gasket shall be uniformly compressed to the proper design loading.

(b) Special care shall be used in assembling flanged joints in which the flanges have widely differing mechanical properties. Tightening to a pedetermined torque is recommended.

7.2.3 **Bolt Length**

Bolts should extend completely through their nuts. Any which fail to do so are considered acceptably engaged if the lack of complete engag ement is not more than one thread.

7.2.4 **Gaskets**

No more than one gasket shall be used between contact faces in assembling a flanged joint.

7.3 **Threaded Joints**

7.3.1 Thread Compound or Lubricant

Any compound or lubricant used on threads shall be suitable for the service conditions and shall not react unfavourably with either the service fluid or the piping material.

7.3.2 **Joints for Seal Welding**

A threaded joint to be seal welded shall be made up without thread compound. A joint containing thread compound which leaks during leak testing may be seal welded in accordance with para 3.5.3, provided all compound is removed from exposed threads.

7.3.3 **Straight Threaded Joints**

Typical joints using straight threads, with sealing at a surface other than the threads, are shown in Fig.7.3.3 sketches (a), (b) and (c). Care shall be taken to avoid distorting the seat when incorporating such joints into piping assemblies by welding.

7.4 **Tubing Joints**

7.4.1 **Flared Tubing Joints**

The sealing surface of the flare shall be examined for imperfections before assembly and any flare having imperfections shall be rejected.

7.4.2 **Flareless and Compression Tubing Joints**

Where the manufacturer's instructions call for a specified number of turns of the nut, these shall be counted from the point at which the nut becomes finger tight.

7.5 **Caulked Joints**

Caulked joints shall be installed and assembled in accordance with the manufacturer's instructions, as modified by the engineering design. Care shall be taken to ensure adequate engagement of joint members.

7.6 Expanded Joints and Special Joints

7.6.1 General

Expanded joints and special joints shall be installed and assembled in accordance with the manufacturer's instructions, as modified by the engineering design. Care shall be taken to ensure adequate engagement of joint members.

7.6.2 Packed Joints

Where a packed joint is used to absorb thermal expansion, proper clearance shall be provided at the bottom of the socket to permit this movement.

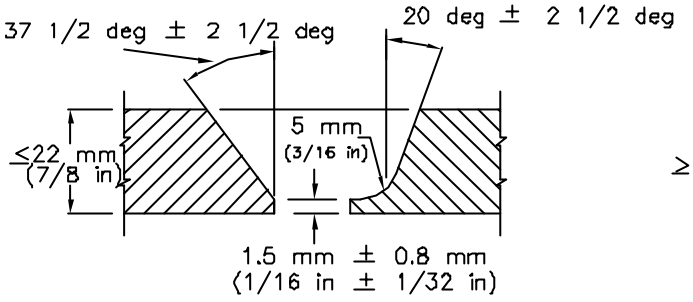
7.7 Cleaning of Piping

Following are some general considerations which may be evaluated in determining the need for cleaning of piping :

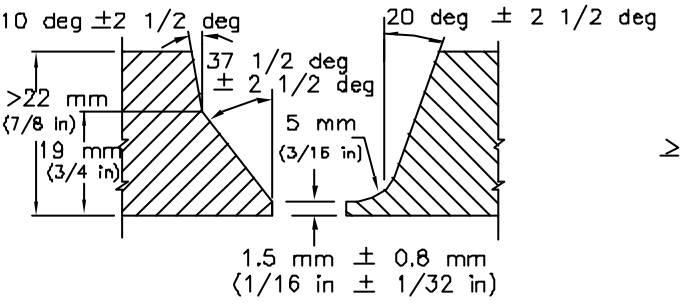
(a) Requirements of the service, including possible contaminants and corrosion products during fabrication, assembly, storage, erection and testing.

(b) For low temperature service, removal of moisture, oil, grease and other contaminants to prevent sticking of valves or blockage of piping and small cavities; and

(c) For strong oxidizer fluid service (e.g. oxygen or fluorine), special cleaning and inspection. Reference may be made to the Compressed Gas Association's Pamphlet G-4.1 Cleaning Equipment for Oxygen Service.

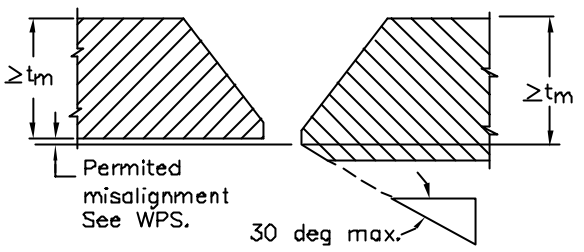


(a) Wall Thickness 6 mm to 22 mm , inclusive (3/16 in. to 7/8 in.)

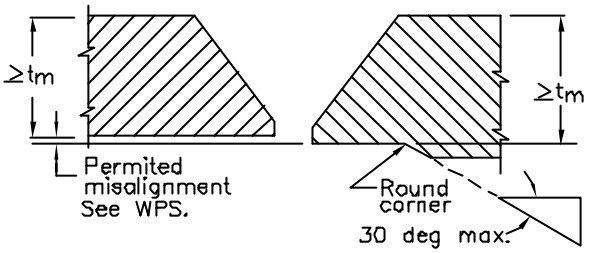


(b) Wall Thickness over 22 mm (7/8 in.)

FIG. 3.4.2 TYPICAL BUTT WELD END PREPARATION

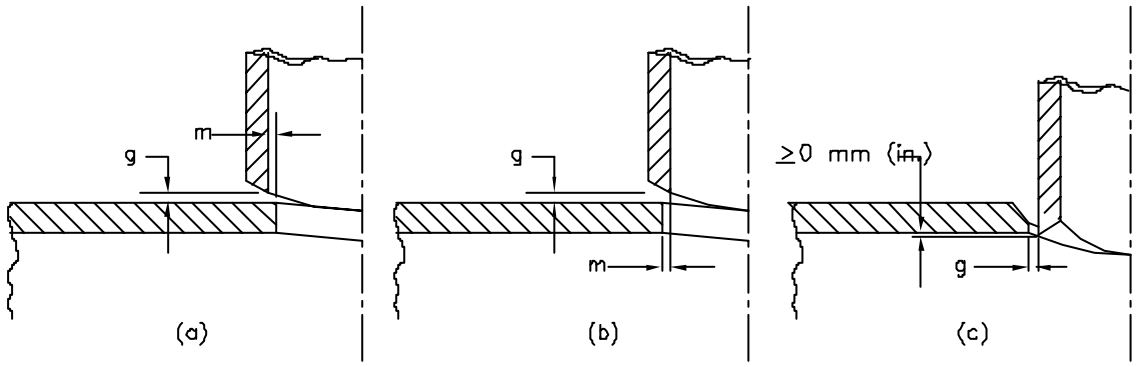


(a) Thicker Pipe Taper–Bored to Align



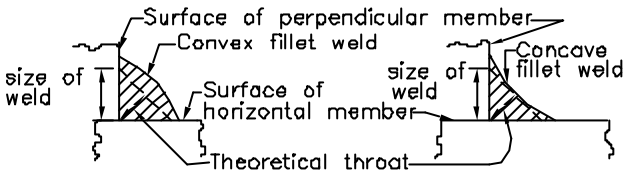
(b) Thicker Pipe Bored for Alignment

FIG. 3.4.3 TRIMMING AND PERMITTED MISALIGNMENT



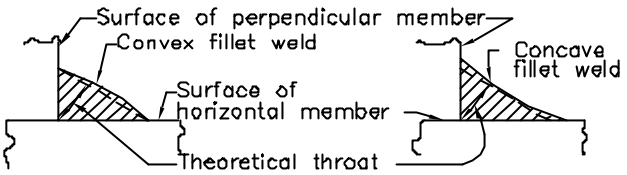
g = root gap per welding specification
m = the lesser of 3.2 mm (1/8 in.)or 0.5 T_b

FIG. 3.4.4 PREPARATION FOR BRANCH CONNECTIONS



Equal Leg Fillet Weld

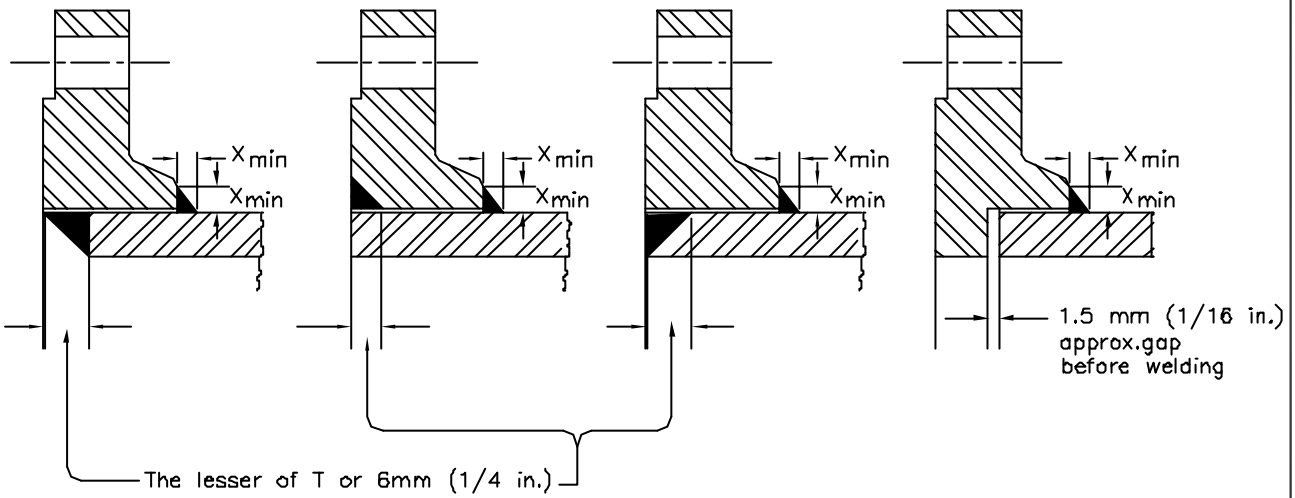
GENERAL NOTE:The size of an equal leg fillet weld is the leg length of the largest inscribed isosceles right triangle(theoretical throat=0.707 x size).



Unequal Leg Fillet Weld

GENERAL NOTE:The size of unequal leg fillet weld is the leg lengths of the largest right triangle which can be inscribed within the weld cross section,e.g.,13mm x 19mm(1/2in.x3/4in.)

FIG. 3.5.2A FILLET WELD SIZE



(1) Front and back welds (2) Face and back welds (3) Socket Welding Flanges

X_{min} = the lesser of $1.4\bar{T}$ or the thickness of the hub

FIG. 3.5.2B TYPICAL DETAILS FOR DOUBLE-WELDED SLIP-ON AND SOCKET WELDING FLANGE ATTACHMENT WELDS

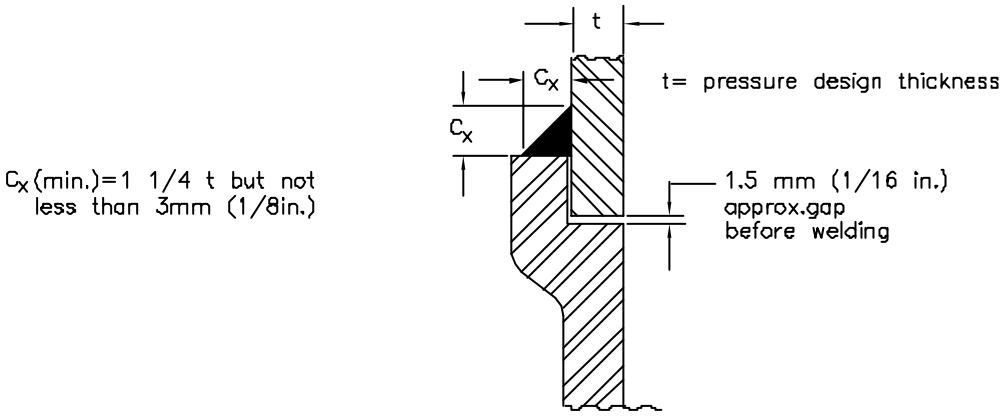
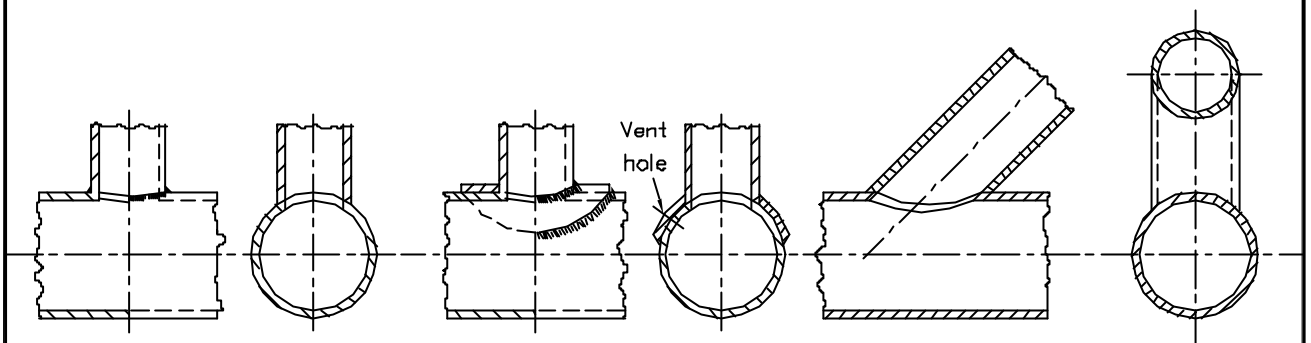


FIG. 3.5.2C MINIMUM WELDING DIMENSIONS FOR SOCKET WELDING COMPONENTS OTHER THAN FLANGES

	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED

FILE NAME :ES6004B

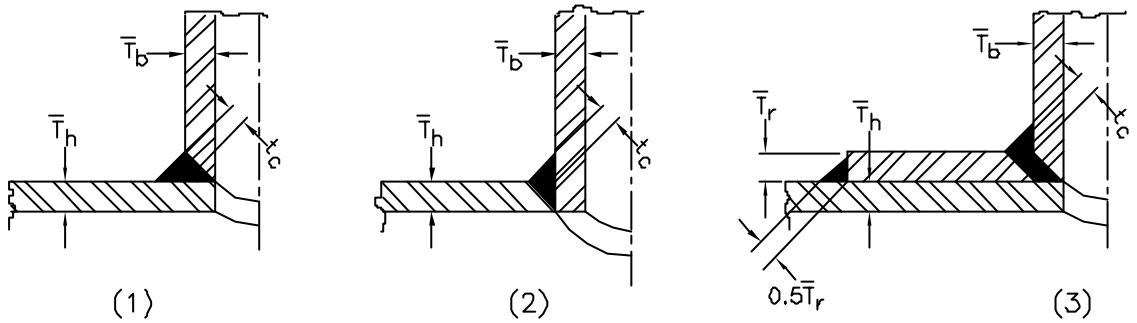


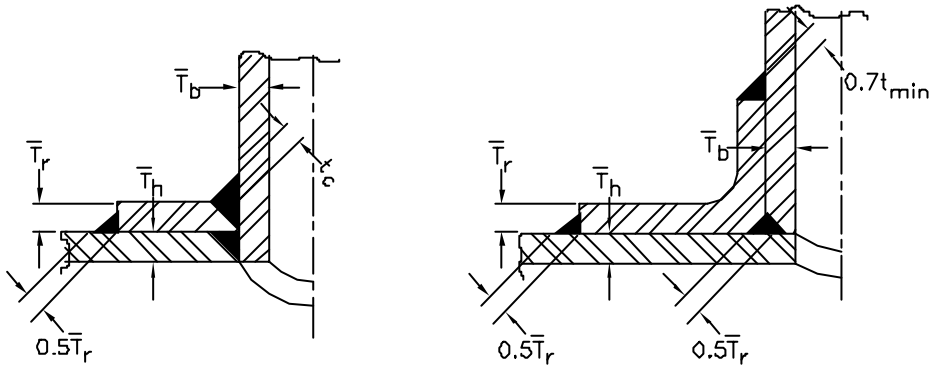
(a) Without Added Reinforcement

(b) With Added Reinforcement

(c) Angular Branch Without Added Reinforcement

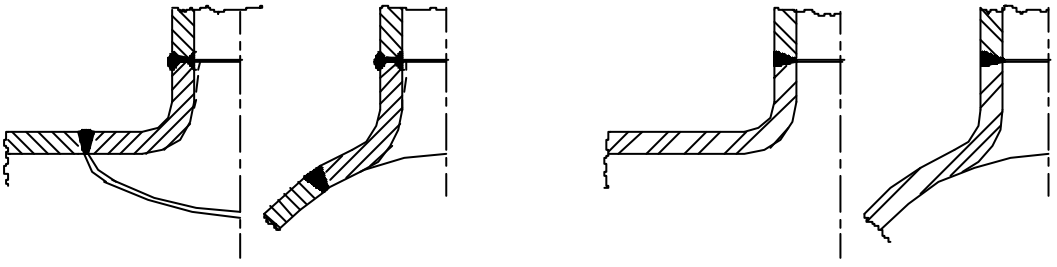
FIG. 3.5.4A,B,C. TYPICAL WELDED BRANCH CONNETIONS





GENERAL NOTE:These sketches show minimum acceptable welds. Welds may be larger than those shown here.

FIG. 3.5.4D ACCEPTABLE DETAILS FOR BRANCH ATTACHMENT WELDS

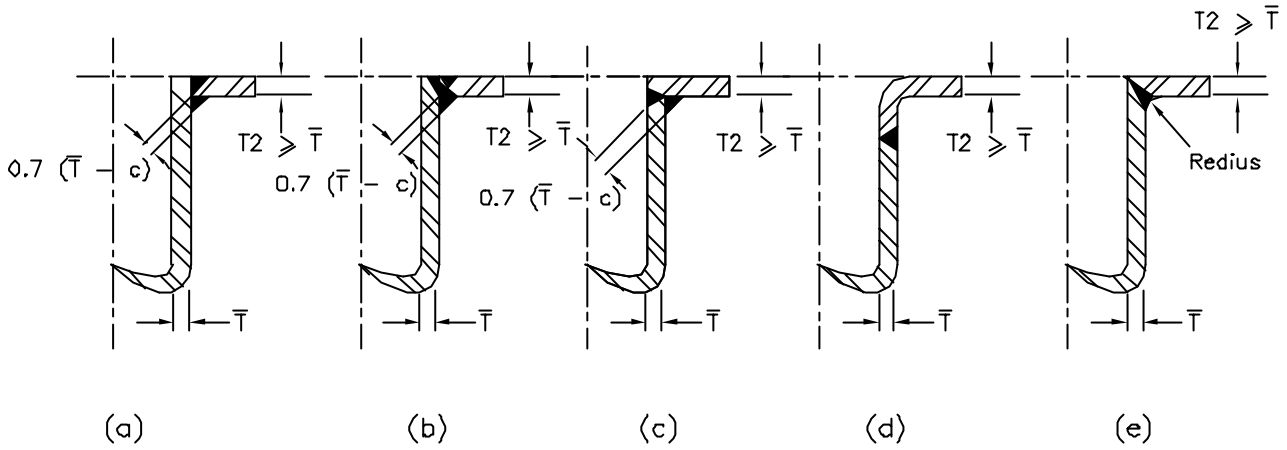


(1) Contour Outlet Fitting

(2) Extruded Header Outlet

FIG. 3.5.4E ACCEPTABLE DETAILS FOR BRANCH ATTACHMENT SUITABLE FOR 100% RADIOGRAPHY

	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED



GENERAL NOTE:Laps shall be machined (front and back)or trued after welding. Plate flanges per para. 304.5 or lap joint flanges per ASME B16.5 may be used.Welds may be machined to redius,as in sketch (e),if necessary to match ASME B16.5 lap joint flanges.

FIG. 3.5.5 TYPICAL FABRICATED LAPS

	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED

ENGINEERING STANDARD

INSPECTION, EXAMINATION OF WELDING OF PIPING

REV	DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
0	30/09/99	ISSUED FOR IMPLEMENTATION			

INDEX

1.0 SCOPE

This specification covers requirements of Inspection, Examination and Testing of welding of Carbon Steel, Alloy Steel and stainless steel pipes and fittings. These requirements conform to ASME Code of pressure piping - Process Piping ASME B 31.3 - 1999.This standard is meant for easy reference by the Inspector to all requirements of inspection, examination and testing of welding of pipes at one place and should not be used as purchase requirements for an enquiry or an order.

2.0 INSPECTION

2.1 General

This Standard distinguishes between examination (see para 3.0) and inspection. Inspection applies to functions performed for the owner by the owner's Inspector. References in this standard to the "Inspector" are to the owner's Inspector.

2.2 Responsibility for Inspection

It is the Owner's responsibility, exercised through the Owner's Inspector to verify that all required examinations and testing have been completed and to inspect the piping to the extent necessary to be satisfied that it conforms to all applicable examination requirements of the Code/Standard and of the engineering design.

2.3 Rights of the Owner's Inspector

The Owner's Inspector shall have access to any place where work concerned with the piping installation is being performed. This includes manufacture, fabrication, heat treatment, assembly, erection, examination and testing of the piping. They shall have the right to audit any examination, to inspect the piping using any examination method specified by the engineering design and to review all certifications and records necessary to satisfy the Owner's responsibility stated in para 2.2.

2.4 The qualifications of the Owner's Inspector shall be at the discretion of the Owner.

3.0 EXAMINATION

3.1 General

Examination applies to quality control functions performed by the manufacturer (for components only), fabricator or erector. Reference in this Standard to an examiner is to a person who performs quality control examinations.

3.2 Responsibility for Examination

Inspection does not relieve the manufacturer, the fabricator or the erector of the responsibility for :

(a) providing materials, components and workmanshi p in accordance with the requirements of the specification and of the engineering design.

(b) performing all required examinations; and

(c) preparing suitable records of examinations and tests for the Inspector's use.

3.3 Examination Requirements

3.3.1 General

Prior to initial operation each piping installation, including components and workmanship shall be examined in accordance with the applicable requirements of para 3.0. The type and extent of any additional examination required by the engineering design and the accepta nce criteria to be applied shall be specified. Joints not included in examinations required by para 3.4 or by the engineering design are accepted if they pass leak test/pressure test as per ES 6006.

(a) For P-Nos. 3, 4 and 5 materials, examination shall be performed after completion of any heat treatment.

(b) For a welded branch co nnection the examination of and any necessary repairs to the pressure containing weld shall be completed before any reinforcing pad or saddle is added.

3.3.2 Acceptance Criteria

Acceptance criteria shall be as stated in the engineering design and shall at least meet the applicable requirements stated below, in para 6.6.2 for ultrasonic examination of welds.

Table 3.3.2 states acceptance criteria (limits on imperfections) for welds. See Fig. 3.3.2 for typical weld imperfections.

3.3.3 Defective Components and workmanship

An examined item with one or more defects (imperfections of a type or magnitude exceeding the acceptance criteria of this Standard) shall be repaired or replaced; and the new work shall be reexamined by the same methods, to the same extent and by the same acceptance criteria as required for the original work.

3.3.4 Progressive Sampling for Examination

When required spot or random examination reveals a defect :

(a) two additional samples of the same kind (if welded or bonded joints, by the same welder, bonder, or operator) shall be given the same type of examination; and

(b) if the items examined as required by (a) above are acceptable, the defective item shall be repaired or replaced and reexamined as specified in para 3.3.3 and all items represented by these two additional samples shall be accepted; but

(c) if any of the items examined as required by (a) above reveals a defect, two further samples of the same kind shall be examined for each defective item found by that sampling; and

(d) if all the items examined as required by (c) above are acceptable, the defective item(s) shall be repaired or replaced and reexamined as specified in para 3.3.3 and all items represented by the additional sampling shall be accepted; but

(e) if any of the items examined as required by (c) above reveals a defect, all items represented by the progressive sampling shall be either;

1) repaired or replaced and reexamined as required; or

2) fully examined and repaired or replaced as necessary and reexamined as necessary to meet the requirements of this Standard.

3.4 Extent of Required Examination

3.4.1 Examination Normally Required

(Category of fluid services requiring the extent of examination as mentioned in para 3.4.1 to 3.4.4 have been defined in ASME B 31.3 and ES 6013)

Piping in **Normal Fluid Service** shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para 3.3.2 and in Table 3.3.2 for Normal Fluid Service unless otherwise specified.

(a) *Visual Examination*

At least the following shall be examined in accordance with para 6.2 ;

1) sufficient materals and components, selected at random, to satisfy the examiner that they conform to specifications and are free from defects;

2) at least 5% of fabrication. For welds, each welder's and welding operator's work shall be represented.

3) 100% of fabrication for longitudinal welds, except those in components made in accordance with a listed specification. See para 3.5.1(a) for examination of longitudinal welds required to have a joint factor E_j of 0.90.

4) random examination of the assembly of threaded, bolted and other joints to satisfy the examiner that they conform to the applicable requirements of assembly and erection as per para 7.0 of ES 6004. When pneumatic testing is to be performed, all threaded, bolted and other mechanical joints shall be examined.

5) random examination during erection of piping, including checking of alignment, supports and cold spring;

6) examination of erected piping for evidence of defects that would require repair or replacement and for other evident deviations from the intent of the design.

(b) *Other Examination*

1) Not less than 5% of circumferential butt and miter groove welds shall be examined fully by random radiography in accordance with para. 6.5 or by random ultrasonic examination in accordance with para 6.6. The welds to be examined shall be selected to ensure that the work product of each welder or welding operator doing the production welding is included. They shall also be selected to maximize coverage of intersections with longitudinal joints. When a circumferential weld with an intersecting longitudinal weld(s) is examined, at least the adjacent 38 mm (1½ in.) of each intersecting weld shall be examined. In-process examination in accordance with para 6.7 may be substituted for all or part of the radiographic or ultrasonic examination on a weld-for-weld basis if specified in the engineering design or specifically authorized by the Inspector.

2) Not less than 5% of all brazed joints shall be examined by in-process examination in accordance with para 6.7, the joints to be examined being selected to ensure that the work of each brazer making the production joints is included.

(c) *Certificates and Records*

The examiner shall be assured, by examination of certifications, records, and other evidence that the materials and components are of the specified grades and that they have received required heat tr eatment, examination and testing. The examiner shall provide the Inspector with a certification that all the quality control requirements of the Code and of the engineering design have been carried out.

3.4.2 **Examination -- Category D Fluid Service**

Piping and piping elements for Category D Fluid Service as designated in the engineering design shall be visually examined in accordance with para 6.2 to the extent necessary to satisfy the examiner that components, materials and workmanship conform to the requirements of ASME B 31.3 Code, this standard and the engineering design. Acceptance criteria are as stated in para. 3.3.2 and in Table 3.3.2 for Category D fluid service, unless otherwise specified.

3.4.3 **Examination -- Severe Cyclic Conditions**

Piping to be used under severe cyclic conditions shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para. 3.3.2 and in Table 3.3.2, for severe cyclic conditions, unless otherwise specified.

(a) *Visual Examination*

The requirements of para 3.4.1(a) apply with the following exceptions

1) All fabrication shall be examined.

2) All threaded, bolted and other joints shall be examined.

3) All piping erection shall be examined to verify dimensions and alignment. Supports, guides and points of cold spring shall be checked to ensure that movement of the piping under all conditions of startup, operation and shutdown will be accommo dated without undue binding or unanticipated constraint.

(b) *Other Examination*

All circumferential butt and miter groove welds and all fabricated branch connection welds comparable to those shown in Fig.3.5.4E of ES 6004 shall be examined by 100% radiography in accordance with para 6.5 or (if specified in the engineering design) by 100% ult rasonic examination in accordance with para 6.6. Socket welds and branch connection welds which are not radiographed shall be examined by magnetic particle or liquid penetrant methods in accordance with para 6.3 or 6.4.

(c) In-process examination in accordance with para 6.7, supp lemented by appropriate nondestructive examination, may be substi tuted for the examination required in (b) above on a weld-for-weld basis if specified in the engineering design or specifically authorized by the Inspector.

(d) *Certification and Records*

The requirements of para 3.4(c) apply.

3.4.4 **Examination - Category M Fluid Service**

Piping to be used under Category M Fluid Service shall be examined to the extent specified herein or to any greater extent specified in the engineering design.

(a) Visual Examination

1) All fabrication shall be examined.

2) All threaded, bolted and other mechanical joints shall be examined.

(b) Other Examination

1) The random radiography/ultrasonic examination requirement of para 3.4.1(b)(1) apply except that at least 20% of circumferential butt and mitre welds and of fabricated lap and branch connection welds comparable to those shown in Fig. 3.5.4(E) and 3.5.5 sketches (d) and (e) shall be examined.

2) The in-process examination alternative permitted in para 3.4.1 (b)(1) may be specified on a weld-for-weld basis in the engineering design or by the inspector. It shall be supplemented by appropriate non-destructive examination.

3.5 Supplementary Examination

Any of the methods of examination described in para 6.0 may be specified by the engineering design to supplement the examination required by para 3.4. The extent of supplementary examination to be performed and any acceptance criteria that differ from those in para 3.3.2 shall be specified in the engineering design.

3.5.1 Spot Radiography

(a) *Longitudinal Welds*

Spot radiography for longitudinal groove welds required to have a weld joint factor E_j of 0.90 requires examination by radiography in accordance with para 6.5 of at least 300 mm in each 30 m of weld for each welder or welding operator. Acceptance criteria are those stated in Table 3.3.2 for radiography under Normal Fluid Service.

(b) *Circumferential Butt Welds and Other* Welds

It is recommended that the extent of examination be not less than one shot on one in each 20 welds for each welder or welding operator. Unless otherwise specified, acceptance criteria are as stated in Table 3.3.2 for radiography under Normal Fluid Service for the type of joint examined.

(c) *Progressive Sampling for Examination*

The provisions of para 3.3.4 are applicable

(d) *Welds to Be Examined*

The locations of welds and the points at which they are to be examined by spot radiography shall be selected or approved by the Inspector.

3.5.2 **Hardness Tests**

The extent of hardness testing required shall be in accordance with following para except as otherwise specified in the engineering design.

Hardness tests of production welds and of hot b ent and hot formed piping are intended to verify safisfactory heat treatment. The hardness limit applies to the weld and to the heat affected zone (HAZ) tested as close as practicable (with in 2-3 mm) to the edge of the weld.

(a) Where a hardness limit is specified in Table 3 at least 10% of welds, hot bends and hot formed components in each furnace heat treated batch and 100% of those locally heat treated shall be tested.

(b) When dissimilar metals are joined by welding the hardness limits specified for the base and welding materials in Table 3 shall be met for each material.

3.5.3 **Examinations to Resolve Uncertainty**

Any method may be used to resolve doubtful indications. Acceptance criteria shall be those for the required examination.

4.0 EXAMINATION PERSONNEL

4.1 Personnel Qualification and Certification

Examiners shall have training and experience commensurate with the needs of the specified examinations. The employer shall certify records of the examiners employed, showing dates and results of personnel qualifications and shall maintain them and make them available to the Inspector.

4.2 Specific Requirement

For in-process examination, the examinations shall be performed by personnel other than those performing the production work.

5.0 EXAMINATION PROCEDURES

Any examination shall be performed in accordance with a written procedure that conforms to one of the methods specified in para 6.0, including special methods (see para 6.1.2). Procedures shall be written as required in the ASME BPV Code, Section V, Article 1, T-150. The employer shall certify records of the examination procedures employed, showing dates and results of procedure qualifications and shall maintain them and make them available to the Inspector.

6.0 TYPES OF EXAMINATION

6.1 General

6.1.1 Methods

Except as provided in para 6.1.2, any examination required by this Standard, by the engineering design or by the Inspector shall be performed in accordance with one of the methods specified herein.

6.1.2 Special Methods

If a method not specified herein is to be used, it and its acceptance criteria shall be specified in the engineering design in enough detail to permit qualification of the necessary procedures and examiners.

6.1.3 Definitions

The following terms apply to any type of examination

100% Examination : complete examination of all of a specified kind of item in a designated lot of piping.

Random Examination : complete examination of a percentage of a specified kind of item in a designated lot of piping

Spot Examination : a specified partial examination of each of a specified kind of item in a designated lot of piping. e.g. of part of the length of all shop- fabricated welds in a lot of jacketed piping.

Random Spot Examination : a specified partial examination of a percentage of a specified kind of item in a designated lot of piping.

6.2 Visual Examination

6.2.1 Definition

Visual examination is observation of the portion of components, joints and other piping elements that are or can be exposed to view before, during or after manufacture, fabrication, assembly, erection, examination or testing. This examination includes verification of Code and engineering design requirements for materials, components, dimensions, joint preparation, alignment, welding, bonding, brazing, bolting, threading or other joining method, supports, assembly and erection.

6.2.2 Method

Visual examination shall be performed in accordance with the BPV Code, Section V, Article 9. Records of individual visual examinations are not required, except for those of in-process examination as specified in para 6.7.

6.3 **Magnetic Particle Examination**

Magnetic particle examination of welds shall be performed in accordance with ASME BPV Code, Section V, Article 7. Magnetic particle examination is not normally required for site welded joints. Liquid penetrant examinations normally preferred.

6.4 **Liquid Penetrant Examination**

Liquid penetrant examination of welds shall be performed in accordance with ASME BPV Code, Section V, Article 6.

6.5 **Radiographic Examination**

6.5.1 **Method**

Radiography of welds shall be performed in accordance with ASME BPV Code, Section V, Article 2.

6.5.2 **Extent of Radiography**

(a) *100% Radiography*

This applies only to girth and miter groove welds and to fabricated branch connection welds comparable to Fig.3.5.4E, unless otherwise specified in the engineering design.

(b) *Random Radiography*

This applies only to girth and miter groove welds.

(c) *Spot Radiography*

This requires a single exposure radiograph in accordance with para 6.5.1 at a point within a specified extent of welding. For girth, miter and branch groove welds the minimum requirement is :

1) for sizes $\leq$ NPS 2½″, a single el liptical exposure encompassing the entire weld circumference;

2) for sizes > NPS 2½″, the lesser of 25% of the inside circumference or 152 mm.

For longitudinal welds the minimum requirement is 152 mm of weld length.

6.6 **Ultrasonic Examination**

6.6.1 **Method**

Ultrasonic examination of welds shall be performed in accordance with ASME BPV Code, Section V, Article 5, except that the alternative specified in (a) and (b) below is permitted for basic calibration blocks specified in T-542.2.1 and T-542.8.1.1.

(a) When the basic calibration blocks have not received heat treatment in accordance with T-542.1.1(c) and T-542.8.1.1, transfer methods shall be used to correlate the responses from the basic calibration block and the component. Transfer is accomplished by noting the difference between responses received from the same reference reflector in the basic calibration block and in the component and correcting for the difference.

(b) The reference reflector may be a V-notch (which must subsequently be removed), an angle beam search unit acting as a reflector or any other reflector which will aid in accomplishing the transfer.

(c) When the transfer method is chosen as an alternative, it shall be used, at the minimum :

1) for sizes $\leq$ NPS 2″, once in each 10 welded joints examined.

2) for sizes > NPS 2″ and $\leq$ NPS 18″, once in each 1.5 m of welding examined.

3) for sizes > NPS 18″ once for each welded joint examined.

(d) Each type of material and each size and wall thickness shall be considered separately in applying the transfer method. In addition, the transfer method shall be used at least twice on each type of weld joint.

(e) The reference level for monitoring discontinuities shall be modified to reflect the transfer correction when the transfer method is used.

6.6.2 **Acceptance Criteria**

A linear-type discontinuity is unacceptable if the amplit ude of the indication exceeds the reference level and its length exceeds :

(a) 6 mm for $T_w \leq 19$ mm
(b) $T_w/3$ for 19 mm < $T_w \leq 57$ mm
(c) 19 mm for $T_w > 57$ mm

6.7 **In-Process Examination**

6.7.1 **Definition**

In-process examination comprises examination of the following, as applicable:

(a) joint preparation and cleanliness;

(b) preheating;

(c) fit-up, joint clearance and internal alignment prior to joining;

(d) variables specified by the joining procedure, including filler material; and

1) (for welding) position and electrode;
2) (for brazing) position, flux, brazing temperature, proper wetting and capillary action;

(e) (for welding) condition of the root pass after cleaning - external and where accessible, internal - aided by liquid penetrant or magnetic particle examination when specified in the engineering design;

(f) (for welding) slag removal and weld condition between passes; and

(g) appearance of the finished joint.

6.7.2 **Method**

The examination is visual, in accordance with para 6.2, unless additional methods are specified in the engineering design.

TABLE 3.3.2

ACCEPTANCE CRITERIA FOR WELDS

Kind of Implementation	Normal Fluid Service						Severe Cyclic Conditions								Category D Fluid Service				
	Methods		Types of Weld				Methods				Types of Weld				Method	Types of Weld			
	Visual	Radiography	Girth and Miter Groove	Longitudinal Groove [Note	Fillet [Note (3)]	Branch Connection [Note (4)]	Visual	Radiography	Magnetic Particle	Liquid Penetrant	Girth and Miter Groove	Longitudinal Groove [Note	Fillet [Note (3)]	Branch Connection [Note (4)]	Visual	Girth and Miter Groove	Longitudinal Groove [Note (2)]	Fillet [Note (3)]	Branch Connection [Note (4)]
Crack	X	X	A	A	A	A	X	X	X	X	A	A	A	A	X	A	A	A	A
Lack of fusion	X	X	A	A	A	A	X	X	--	--	A	A	A	A	X }	C	{ A	NA	A
Incomplete penetration	X	X	B	A	NA	B	X	X	--	--	A	A	NA	A	X }		{ A	NA	B
Internal porosity	--	X	E	E	NA	E	--	X	--	--	D	D	NA	D	--	--	--	--	--
Slag inclusion, tungsten inclusion or elongated indication	--	X	G	G	NA	G	--	X	--	--	F	F	NA	F	--	--	--	--	--
Undercutting	X	--	H	A	H	H	X	X	--	--	A	A	A	A	X	I	A	H	H
Surface porosity or exposed slag inclusion [Note (5)]	X	--	A	A	A	A	X	--	--	--	A	A	A	A	X	A	A	A	A
Surface finish	--	--	--	--	--	--	X	--	--	--	J	J	J	J	--	--	--	--	--
Concave root surface (suck-up)	X	X	K	K	NA	K	X	X	--	--	K	K	NA	K	X	K	K	NA	K
Reinforcement or internal protrusion	X	--	L	L	L	L	X	--	--	--	L	L	L	L	X	M	M	M	M

CRITERION VALUE NOTES FOR TABLE 3.3.2

Criterion		Acceptable Value Limits [Note (6)]
Symbol	Measure	
A	Extent of imperfection	Zero (no evident imperfection)
B	Depth of incomplete penetration	$\leq$ 1 mm and $\leq 0.2\ T_w$
	Cumulative length of incomplete penetration	$\leq$ 38 mm in any 150 mm weld length
C	Depth of lack of fusion and incomplete penetration	$\leq 0.2\ T_w$
	Cumulative length of lack of fustion and incomplete penetration [Note (7)]	$\leq$ 38 mm in any 150 mm weld length
D	Size and distribution of internal porosity	See ASME BPV Code, Section VIII, Division 1, Appendix 4
E	Size and distribution of internal porosity	For $T_w \leq 6$ mm limit is same as D For $T_w > 6$ mm limit is 1.5 x D
F	Slag inclusion, tungsten inclusion or elongated indication	
	Individual length -- -- Individual width -- -- Cumulative length -- --	 $\leq T_w / 3$ $\leq$ 2.5 mm and $< T_w / 3$ $\leq T_w$ in any 12 T_w weld length
G	Slag inclusion, tungsten inclusion or elongated indication	
	Individual length Individual width Cumulative length	 $\leq 2\ T_w$ $\leq$ 3 mm and $< T_w / 2$ $\leq 4\ T_w$ in any 150 mm weld length
H	Depth of undercut	$\leq$ 1 mm and $\leq T_w / 4$
I	Depth of undercut	$\leq$ 1.5 mm and $\leq (T_w / 4$ or 1 mm)
J	Surface roughness	$\leq$ 500 mm Ra per ASME B 46.1
K	Depth of root surface concavity	Total joint thickness, incl. weld reinf., $\geq T_w$
L	Height of reinforcement or internal protrusion [Note (8)] in any plane through the weld shall be within limits of the applicable height value in the tabulation at right, except as provided in Note (9). Weld metal shall merge smoothly into the component surfaces	For T_w mm / Height, mm $\leq$ 6 / $\leq$ 1.5 > 6 , $\leq$ 13 / $\leq$ 3 > 13, $\leq$ 25 / $\leq$ 4 > 25 / $\leq$ 5
M	Height of reinforcement or internal protrusion [Note (8)] as described in L. Note (9) does not apply	Limit is twice the value applicable for L above.

X = required examination NA = not applicable -- = not required

TABLE 3.3.21 (CONTD.)

NOTES :

(1) Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also paras 3.5 and 3.5.3.

(2) Longitudinal groove weld includes straight and spiral seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1 or Table 326.1 of Code ASME B 31.3.

(3) Fillet weld includes socket and seal welds and attachment welds for slip-on flanges, branch reinforcement and supports.

(4) Branch connection weld includes pressure containing welds in branches and fabricated laps.

(5) These imperfections are evaluated only for welds $\leq$ 5 mm in nominal thickness.

(6) Where two limiting values are separated by "and" the lesser of the values determines acceptance. Where two sets of values are separated by "or" the larger value is acceptable. T_w is the nominal wall thickness of the thinner of two components joined by a butt weld.

(7) Tightly butted unfused root faces are unacceptable.

(8) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat Fig. 3.5.2A of ES 6004; internal protrusion does not apply.

(9) For welds in aluminium alloy only, internal protrusion shall not exceed the following values:
(a) For thickness $\leq$ 2 mm : 1.5 mm
(b) For thickness > 2 mm and < 6 mm : 2.5 mm
For external reinforcement and for greater thicknesses, see the tabulation for Symbol L.

ENGINEERING STANDARD

PRESSURE TESTING OF PIPING

REV.	DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
2	26/04/2000	PARA 7.0 ADDED & OTHER REVISIONS			
1	28/09/1999	FOR IMPLEMENTATION	ENGG.COMM.		
0	FEB.'98	FOR IMPLEMENTATION	MKD. APP.		

1.0 SCOPE

All installed piping after completion of the applicable examinations, but prior to initial operation shall be pressure tested to ensure tightness in accordance with the requirements of this specification. However, piping built, in conformance with the ASME Boiler & PV code or Indian Boiler Regulation shall be pressure tested in compliance of such code or regulations.

Piping systems open to atmosphere, such as drains, vents, outlet piping for relief valves discharging to atmosphere and underground sewers shall not require any pressure testing. These lines shall be examined visually to determine that all joints are properly made up.

2.0 GENERAL REQUIREMENTS FOR LEAK/ PRESSURE TESTS

Following requirements apply to both hydraulic as well as pneumatic leak/ pressure tests.

2.1 Limitations on Pressure

(a) *Stress Exceeding Yield Strength*

If the test pressure would produce a nominal pressure stress or longitudinal stress in excess of yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

(b) *Test Fluid Expansion*

If a pressure test is to be maintained for a period of time and the test fluid in the system is subject to thermal expansion, precautions shall be taken to avoid excessive pressure.

(c) *Preliminary Pneumatic Test*

A preliminary test using air at no more than 170 kPa (25 psi) gauge pressure may be made prior to hydrostatic testing to locate major leaks.

2.2 Other Test Requirements

(a) *Examination for Leaks*

Test pressure during leak/pressure test shall be maintained for at least 10 min. and all joints and connections shall be examined for leaks.

(b) *Heat Treatment*

Leak tests shall be conducted after any heat treatment has been completed.

(c) *Low Test Temperature*

The possibility of brittle fracture shall be considered when conducting leak tests at metal temperatures near the ductile-brittle transition temperature.

2.3 **Special Provisions for Testing**

(d) *Piping Subassemblies*

Piping subassemblies may be tested either separately or as assembled piping.

(e) *Flanged Joints*

A flanged joint at which a blank is inserted to isolate other equipment during a test need not be tested.

(f) *Closure Welds*

The final weld connecting piping systems or components which have been successfully tested in accordance with this engineering standard need not be leak tested provided the weld is examined in process in accordance with para 344.7 of ASME B 31.3 (para 6.7 of ES:6005) and passes with 100% radiographic examination in accordance with para 344.5 of ASME B 31.3 (Para 6.5 of ES 6005) or 100% ultrasonic examination in accordance with para 344.6 of ASME B 31.3 (Para 6.6 of ES 6005).

2.4 **Externally Pressured Piping**

Piping subject to external pressure shall be tested at an internal gauge pressure 1.5 times the external differential pressure, but not less than 105 kPa (15 psi).

2.5 **Jacketed Piping**

(a) The internal line shall be leak tested on the basis of the internal or external design pressure, whichever is critical. This test must be performed before the jacket is completed if it is necessary to provide visual access to joints of the internal line.

(b) The jacket shall be leak tested on the basis of the jacket design pressure unless otherwise specified in the engineering design.

3.0 **PREPARATION FOR LEAK/PRESSURE TEST**

3.1 All joints, including welds and bends, shall be left uninsulated & exposed for examination during leak testing, except that joints previously tested may be insulated or covered. All joints may be primed and painted only after leak testing.

3.2 Major equipment, such as compressors, pumps, vessels and exchangers shall be isolated from pipe line during hydrostatic test. When necessary for practicability, exchangers and vessels may be included with the connected piping provided the piping test pressure is within the allowable cold pressure limits of the equipment.

3.3 All air present in the system to be tested shall be vented while admitting the test fluid.

All vent valves during filling up as well as during draining must be fully open.

3.4 Piping designed for vapour and gas shall be provided with additional temporary supports if necessary, to support the weight of test fluid.

3.5 Instruments, expansion joints, filters etc., for which the maximum permissible cold test pressures are lower than the specified hydrostatic test pressure for piping, shall be isolated and excluded from the test.

3.6 Lines containing check valves shall have source of test pressure on the up-stream side.

3.7 Valves shall not be subjected to a test pressure in excess of manufactures allowable test rating. When permitted, the installed valves shall be kept open.

3.8 Relief valves shall be excluded from the test and shall be suitably blanked off.

Orifice plates in horizontal lines shall not be installed till completion of test.

Control valves shall not be field tested. All flanged control valves shall be removed before hydraulic testing of the pipe lines. Welded end control valves shall be welded after hydraulic test, cleaning and blowing.

Indicating pressure gauges mounted locally may be tested with the lines provided the test pressure is not in excess of their scale ratings.

3.9 Instrument take-off piping up to the first block valve shall be tested with piping to which it is connected. Testing of remainder of lead line upto instrument can also be done at the same time provided instruments are blocked off from source of pressure and vented to atmosphere.

3.10 The test shall be carried out at ambient temperature and the water temperature shall not be less than $7^{O}C$.

4.0 HYDROSTATIC LEAK/ PRESSURE TEST

4.1 Test Fluid

The fluid shall be water unless there is the possibility of damage due to freezing or to adverse effects of water on the piping or the process. In that case another suitable nontoxic liquid may be used. If the liequid is flammable, its flash point shall be at least $49^{O}C$ and consideration shall be given to the test environment.

4.2 Test Pressue

Except as provided in para 4.3, the hydrostatic test pressure at any point in a metallic piping system shall be as follows:

(a) Not less than 1½ times the design pressure ;

(b) For design temperature above the test temperature, the minimum test pressure shall be calculated by following equation except that the value of S_T / S shall not exceed 6.5 ;

$$P_T = \frac{1.5PS_T}{S}$$

Where

P_T = minimum test gauge pressure
P = internal design gauge pressure
S_T = stress value at test temperature
S = stress value at design temperature

(c) If the test pressure as defined above would produce a stress in excess of the yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature.

4.3 Hydrostatic Test of Piping With Vessels as a System

(a) Where the test pressure of piping attached to a vessel is the same as or less that the test pressure for the vessel, the piping may be tested with the vessel at the piping test pressure.

(b) Where the test pressure of the piping exceeds the vessel test pressure, and it is not considered practicable to isolate the piping from the vessel, the piping and the vessel may be tested together at the vessel test pressure, provided the owner approves and the vessel test pressure is not less than 77% of the piping test pressure calculated in accordance with para 4.2(b).

4.4 Lines at Atmospheric Pressure

All liquid lines at atmospheric pressure ($\leq$ 1 Kg ./cm^2g) shall be tested hydrostatically at 2 Kg/cm^2g.

5.0 PNEUMATIC LEAK/ PRESSURE TEST

Piping may be tested pneumatically if these cannot be safely filled with water or where traces of water cannot be tolerated or if these have been previously tested hydrostatically.

5.1 Precautions

Pneumatic testing involves the hazard of released energy stored in compressed gas. Particular care must therefore be taken to minimize the chance of brittle failure during a pneumatic leak test. Test temperature is important in this regard and must be considered when the designer chooses the material of construction.

5.2 Pressure Relief Device

A pressure relief device shall be provided, having a set pressure not higher than the test pressure plus the lesser of 345 kPa (50 psi) or 10% of the test pressure.

5.3 Test Fluid

The gas used as test fluid, if not air, shall be nonflammable and nontoxic.

5.4 Test Pressure

The test pressure shall be 110% of design pressure.

5.5 **Procedure**

5.6 The pressure shall be gradually increased until a gage pressure which is the lesser of one-half the test pressure or 170 kPa (25 psi) is attained, at which time a preliminary check shall be made, including visual examination of joints. Thereafter, the pressure shall be gradually increased in steps until the test pressure is reached, holding the pressure at each step long enough to equalize piping strains. The pressure shall then be reduced to the design pressure before examining for leakage in accordance with para 2.2.

5.7 **Lines at Atmospheric Pressure**

All gas lines at atmospheric pressure ($\leq$ 1 Kg/cm^{2}g) shall be tested pneumatically at 0.5 Kg.cm^{2}g.

6.0 **VACUUM SERVICES**

Lines in vacuum services shall be hydrostatically tested at a minimum internal pressure of 1.5 Kg/cm^{2}g unless limited to a lower value by design. Where it is not possible to test hydrostatically, the pipe lines shall be tested pneumatically at 1 Kg/cm^{2}g.

7.0 **SENSITIVE LEAK TEST**

The test shall be in accordance with the Gas and Bubble Test method specified in the BPV Code, Section V, Article 10, or by another method demonstrated to have equal sensitivity. Sensitivity of the test shall be not less than 10^{-3} atm.ml/sec under test conditions.

a) The test pressure shall be at least the lesser of 105 kPa (15 psi) gage, or 25% or the design pressure.

b) The pressure shall be gradually increased until a gage pressure the lesser of one-half the test pressure or 170 kPa (25 pai) is attained, at which time a preliminary check shall be made. Then the pressure shall be gradually increased in steps until the test pressure is reached, the pressure being held long enough at each step to equalize piping strains.

8.0 **REPAIRS OR ADDITIONS AFTER LEAK TESTING**

If repairs or additions are made following the leak test, the affected piping shall be retested, except that for minor repairs or additions the owner may waive retest requirements when precautionary measures are taken to assure sound construction.

9.0 **TEST RECORDS**

Records shall be made of each piping system during the testing, including :

a) Date of Test
b) Identification of the piping tested.
c) Test Method
d) Test Pressure and duration
e) Certification of results by examiner *
f) Approval by the Inspector

ENGINEERING STANDARD

FLEXIBILITY ANALYSIS BY COMPUTER PROGRAMME

REV	DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
O	14-05-98	ISSUED FOR IMPLEMENTATION	RPM		

CONTENTS

LIST OF ATTACHMENTS

1.0 INTRODUCTION

In the computer program CAESAR-II, stress analysis is carried out taking into account the effects of thermal strain, internal pressure and self weight of the pipe simultaneously. Externally applied restraints, concentrated loads and spring effects are also taken care of in the analysis. Stress intensification factors in conformity with ANSI-B31.3 have been used for various pipe members like bends and tee joints.

2.0 PURPOSE

To ensure that the piping system have sufficient flexibility and serve the following purpose:

a) To control within acceptable limits, the piping reactions on connected equipment located between or at the terminals of the line.

b) To maintain the stresses in the pipe itself within a range to limit direct or fatigue failure of pipe line and the failure of intermediate supports and end anchors.

c) To avoid the leakage of joints due to over stressing and bending of pipe lines.

3.0 REQUIREMENT OF FLEXIBILITY ANALYSIS

No formal analysis for adequate flexibility is required in system which :

a) are duplicates of successfully operating installations or replacements without significant change of system with a satisfactory service record:

b) can readily be judged adequate by comparison with previously analysed system:

c) are of uniform size, have no more than two points of fixation, no intermadiate restraints, and fall within the limitations of empirical equation as given below:

$$\frac{D\ Y}{(L-U)^2} < 208.0 \quad \text{..... (1)}$$

Where :

D = Outside diameter of pipe, (mm)

Y = Resultant of total displacement strains, (mm) to be absorbed by the piping system.

L = Developed length of piping between anchors, (m).

U = Anchor distances, straight line between anchors, (m).

Pipe lines which do not fall within the above categories equire flexibility analysis. Such pipe lines can again be categorized into non-critical and critical. For non-critical piping, analysi s without consideration of the self weight / internal pressure of the pipe may be sufficient as far as the safety of the pipe line is concerned. However, analysis with self weight of the pipe would be useful in finalisi ng the supports. All process pipe lines below 400^{O}C and not being directly connec ted to sensitive equipment nozzles like turbines, pumps et c. can be designated as being non-critical.

Critical pipe lines can be desi gnated as those which are of high temperature service (> 400 ^{O}C) or those which ar e directly connected to sensitive equipment nozzles. Flexibilit y analysis of such pipes should be done as follows:

All the supports should be decided. Approximate loads being taken up by various springs should be estimated.

Flexibility analysis should be done with th ermal expansion, self weight as well as internal pressure. Maxi mum calculated stress should be compared with allowable stress range.

4.0 SOFTWARE FOR ANALYSIS

CAESAR-II-VERSION 3.21a

5.0 DEFINITIONS

5.1 CO-ORDINATE AXES

These are three mutually perpendicu lar directions along the plant main axes and vertical. These are represented by X, Y & Z.

5.2 ORIGIN

It is the reference point w.r.t. wh ich distances along the Co-ordinate axes are measured for defining the location of other points.

5.3 END ANCHOR

The equipment nozzles where the pi pe lines are connected or the fixed points are refered as end anchors for the pipe line. Every end anchor is either starting or terminating point of one branch. Anchors which have movement due to thermal expansion, are called moving anchor. When end anchor has no movement in any direction, it is termed 'fixed anchor'.

5.4 NODE OR BRANCH POINTS

All such points where a pipe bifurc ates are called node or branch points. All support points are also node points.

5.5 RESTRAINT :

Any restriction on free movement or rotation of pipe is termed as restraint.

6.0 PROCEDURE:

6.1 Design Requirement

6.1.1 All lines falling under the followi ng categories shall require flexibility analysis:

pipe size 3"-8" & temp > $100^{O}C$
>10" & temp > $80^{O}C$

6.1.2 Wherever possible provisi on for pipe expansion shall be made by changes in the direction of the pipe or by expansion loops.

6.2 MINIMUM INPUT:

a) Dimensioned isometric drawing of the system showing distance between various nodes.

b) Pipe size (NB/OD, thk/sch.), Material, Insulation thickness and density, Operating Pressure, Design temp, Allowable stress of piping material at the design temp, valve weight, fluid density, etc.

c) Axial/ transverse stiffness and we ight of bellow expansion joints, if used.

6.3 REQUIRED INPUT :

Besides the data mentioned under 6.2 following are required.

a) Nozzle movement due to thermal expansion/contraction.

b) Concentrated mass if any.

c) Externally applied force, moment and movement at any point.

6.4 DESIRABLE INPUT

Besides the data mentioned under 6.2 and 6.3, following are required.

a) Actual valve weight received from vendor.

b) Displacement of nozzles (Pumps/Turbines) received from vendor.

c) Allowable forces and moments on nozzles for Pumps/ Turbines.

d) Axial/transverse stiffness of bellow expansion joints received from vendor.

e) Process operating philosophy of the plant. This is necessary to analyze the system under di fferent working condition where it is subjected to varying operating condition.

7.0 FEEDING OF INPUT DATA IN THE COMPUTER:

a) First of all, Node numbers are marked on the Isometric drawing.

b) Pipe routing as shown in the dimensioned Isometric drawing, is fed in the computer starting from the first node to the last node.

c) Restraints are fed as marked on the Isometric.

d) Nozzle movements are fed wherever required.

e) Anchor points are properly fed.

f) Operating Pressure, Temp., Ma terial, Allowable stress,pipe size, thickness, Insulation thk. and dens ity, corrosion allowance, fluid density etc, are fed.

g) Spring supports, wherever required, are fed.

8.0 OUTPUT

After feeding the input data, the programme is run for static analysis processor.

8.1 Following cases are analysed.

a) Sustained load case

b) Expansion load case

c) Operating load case

8.2 Following report options are available.

a) Displacements

b) Restraints

c) Restraint summary

d) Global element forces

e) Local element forces

f) Stresses

h) Sorted stresses

i) Hanger tables

9.0 INTERPRETATION OF RESULTS:

a) First of all, the calculated stress is compared with the allowable stress.

b) Forces and moments on restrain ts are reviewed whether these are within permissible limits. Fo rces and moments on equipment nozzles are given special attent ion particularly for pumps and Turbines and any other critical equi pment. In case of heavy restraint force and any node, support at that point is to be reviewed.

c) Displacements are reviewed for

- Supports should not leave the structure.

- Pipe should not hit the neighbouring pipe.

- Any other abnormal movement.

d) Stresses on flanged joints are re viewed to see that joints are not over stressed to avoid leakage. Checking is done as per the procedure laid down in "Flange Leakage/ Stress calculation".

e) Finally the pipe is passed for flexibility if following conditions are satisfied.

I) Calculated stress at any point is less than the allowable stress obtained from the code ANSI B31.3.

ii) Forces and moments on restraints are within reasonable permissible limit.

iii) Joints are not over stressed.

iv) Displacements are within reasonable limits.

v) Forces & moments on mechanical equipment such as pumps, turbines or compressors are limited to the equipment manufacturer's recommended values. These forc es and moments may also be checked from "Equipment check" (Rotating equipment).

TECHNICAL SPECIFICATION

FOR

PAINT & PROTECTIVE COATINGS

ON STEEL SURFACES

0	**01.01.2011**	**01.01.2011**	**FOR IMPLEMENTATION**	**RV**	**MKS**	**MKS**
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

ATTACHMENTS

ANNEXURE- I Brand Names of approved Paints

ANNEXURE- II Technical data Sheet of approved Paint Manufacturer

1.0 GENERAL

1.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of mechanical equipment, structural steelwork, plate work, tankage, guards, pipe work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants**.**

1.2 Definitions

C.S	-	Carbon steel and low chrome (1-$^1/_4$ Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304,316, 321, 347,
Non-ferrous	-	Copper, aluminium, and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DFT coating	-	Dry Film thickness, the thickness of the dried or curved paint or film.

1.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

1.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and Material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

1.5 Materials

All paints and paint materials shall be obtained fr om the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

Specification number
Colour reference number
Method of application
Batch number
Date of Manufacture
Shelf life expiry date
Manufacturer's name or recognised trade mark.

2.0 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

2.1 Indian Standards:

IS-5: 1994	Colors for ready mixed paints and enamels.
IS-2379: 1990	Color codes for identification of pipe lines.
IS-2629: 1985	Recommended practice for hot-dip galvanizing on iron and steel.
IS-2633: 1986	Methods for testing uniformity of coating of zinc-coated articles.
IS-8629: 1977	Code of practice for protection of iron and steel structures from atmospheric corrosion.
IS:110	Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers
IS:101	Methods of test for ready mixed paints & enamels.

2.2 Other Standards:

2.2.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988
(Surface preparations standards for Painting Steel Surface).
This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

2.2.1 DIN: 53151 Standards for Adhesion test.

2.3 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a) Instructions for storage to avoid exposure as well as extremes of temperature.

b) Surface preparation prior to painting.

c) Mixing and thinning.

d) Application of paints and the recommended limit on time intervals between coats.

3.0 SURFACE PREPARATION

3.1 Metal Surface Preparation

3.1.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

3.1.2 Pre-cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cl eaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating

3.1.3 Surface Decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired.

Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces.

Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m2 of surface area to be painted.
Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm2;

Soluble iron salts, less than 7 microgram / cm2; and

pH between 6 – 8

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

3.1.4 Abrasive Blasting

All C.S. materials shall be abrasive blast cleaned in accordance with Codes (Ref. Clause 2.0). To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination).When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 ^{o} C above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/Cm^2 using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

3.1.5 Alternate Methods of Surface Preparation

When open air blasting is not permitted on site, or when space limitations or surface configurations preclude blasting, the alternate cleaning methods listed below may be used with prior approval. Alternate cleaning methods shall consider the degree of surface cleanliness and roughness profile required by the specified coating system.

- Vacuum or suction head abrasive blast-cleaning,
- Wet jet abrasive blast-cleaning,
- Compressed-air wet abrasive blast cleaning,
- Pressurized liquid blast-cleaning,
- Power tool cleaning,
- Hand or power tool cleaning,

Hand and/or power tool cleaning shall only be used for spot repair where abrasive blasting is not permitted or is impractical, and on items whic h could be damaged by abrasive blasting. Power tool cleaning shall not be carried out with tools which polish the surface, e.g. power wire brushes.

The surfaces of equipments and prefabricated piping etc. which are received at site Primerised or with finish paints, depending upon their conditions, shall be touched up and painted at site. For these surfaces sand blasting is not envisaged and these surfaces shall be prepared using power brushes, buffing or scraping, so as to achieve a surface finish to St-3 as per SIS-05-5900 . After wash-up the area to be touched up shall be jointly marked, measured and recorded for payment purposes. The type of system & nos. of coat (primer and/or finish paint) to be applied after touch up, which shall be decided by OWNER/CONSULTANT in writing before taking up the job.

When paint is to be applied on damaged painted surfaces of equipments all loose and flaking paint work should be removed to a firm feathered edge. Rusted spots should be cleaned by one of the methods specified in the clauses 4.4.1 & 4.4.2 above. In case the previous paint work is not compatible to the specified one the entire coating must be removed.

It shall be ensured that sand blasted surface/machine cleaned surface is not contaminated with oil and grease. Water shall also not be allowed to come in contact with sand blasted surface.

4.0 APPLICATION

4.1 General

The final specification of paint systems to be us ed to suit the exposure conditions of equipment and steelwork, shall be as specified on the scope of work, equipment data sheets or the drawings.

All coatings shall be in accordance with Indian / International Standards, the coating manufacturer's product data sheets and application instructions and the requirements contained in this specification.

4.1.1 General Requirements for Shop Application

All structural steelwork shall be surface prepared for painting and have the paint system applied before installation.

In all cases, where surfaces will be inaccessible after shop assembly, they shall be prepared and have the paint system applied before assembly is carried out. Drying times between successive coats shall be at least those recommended by the manufacturer.

All known field weld areas shall be given the specified abrasive blast surface preparation but left uncoated for a distance of 50mm from the weld line. Such areas shall be given the appropriate touch-up treatment after installation.

The manufacturer's directions for preparation and application of coatings shall be followed to ensure that the durability of the coating system is not impaired.

The Contractor shall submit the full details of the proposed surface preparation and paint systems prior to the commencement of any surface preparation.

4.1.2 General Requirements for Site Application

Paint shall be stored only in accordance with the manufacturer's instructions.

All materials used for the specific system being applied shall be products supplied by one manufacturer and details of such product shall be submitted for approval before commencement of work.

The contents of cans shall be thoroughly stirred before being poured into paint pots and shall be thinned only in the specified proportions in accordance with the manufacturer's instructions.

Finish coats may be applied by spraying except where any over spray is likely to affect finished surfaces or where spraying constitutes a health hazard to workmen in the other areas. Brush and roller application will require multiple coats to achieve the specified dry film thickness.

Brush application may be used only with the approval of the company.

Roller application shall only be used on relatively large surface areas (i.e. > 50m2) and only if spraying is not an option.

The Contractor shall complete the application of any one type of paint or each coat thereof, before beginning the next coat on that section.

In cases nominated as critical, the application of each coat shall be approved before application of the next coat can proceed, in accordance with 'hold' points nominated in the Inspection and Test Plans (ITPs)

All fittings within any given area are to be painted with the same system as the area unless otherwise specified.

Where 2 coat of finish paint are indicated they shall be applied in two different shades to ensure that two coat are applied.

Paint shall not be applied in rain, snow, fog or mist or when the relative humidity is such as to cause condensation on metal surface.

The CONTRACTOR must ensure the availability of a specialist from the paint manufacturer, at SITE during pendency of CONTRACT within his quoted rates to ensure the quality of painting & procedure. Addition of drying agents, pigments or other substances is not allowed unless specifically prescribed or approved by paint manufacturer's specialist.

Name plates/tags attached to the equipments/machineries shall not be painted or removed during painting job. Failing to comply with above, the CONTRACTOR may be required to replace name plates/tags at his cost.

4.1.3 Qualifications and Materials

All surface preparation, coatings application and inspection, shall be carried out by personnel experienced in that particular field. Contractors shall submit the names of subcontractors to be employed for the specific work together with the brand names of coating materials for approval prior to commencement of application.

4.1.4 Handling and Transport

All pipe work, steelwork and equipment that have been finish coated shall be handled with care to preserve the coating in the best practical condition.

Painted materials shall not be handled until the coating has completely cured and dried hard Supports in contact with coated steel during transport and storage shall be covered with a soft material to prevent damage to the coating. Appropriate materials shall be used during transportation between coated steelwork and holding down chains to prevent damage to the coating.

4.2 Application of Coatings

4.2.1 General

The application method and type of equipment to be used shall be suitable for the paint specified and the surface being painted.

Paints and thinners shall be brought to the point of usage in unopened original containers bearing the manufacturer's brand name and co lour designation and ready-mixed unless otherwise specified. Two-pack systems shall be mixed at the site of application to the paint manufacturer's recommendations. The mixed amount prepared shall be no more than the amount that can be applied during the stated pot life.

Paint shall be applied so that an even film of uniform thickness, tint and consistency covers the entire surface and is free of pin holes, runs, sags or excessive brush marks. Film finish shall be equal to that of first class brushwork.
Unless it is practical to do so colour shades for primer, intermediate coat and finish coat must be different to identify each coat without any ambiguity

Paint ingredients shall be kept properly mixed during paint application.

Equipment shall be kept clean to ensure dirt, dried paint and other foreign materials are not deposited in the paint film. Any cleaning solvents left in the equipment shall be completely removed before painting.

To ensure the required film thickness is achieved on angles, welds, sharp external edges, nuts and bolts, a coat shall be applied to such items/locations immediately prior to the application of each coating to the whole area.

Care shall be taken to ensure paint application into all joints and crevices.

The contact surfaces between steelwork to be fastened by means of friction grip bolting shall be abrasive blast cleaned and prime coated only, prior to erection.

4.2.2 Atmospheric conditions

Surface preparation and coating shall not be carried out in inclement weather and shall be carried out such that the surface being coated is free of moisture, wind-borne or blast cleaning dust.

Coatings shall not be applied if:

- The relative humidity exceeds 85%.
- The ambient temperature is less than 5^0C (depending on local condition)

- The metal temperature is less than 3^0C above the dew point.
- There is likely hood of an unfavourable change in weather conditions within two hours after painting.

As a general rule, sufficient ventilation, dehumidification and heating capacity to cope with local climatic conditions must be secured before any coating – related work is started.

In any case, humidity, ambient and surface temperature conditions at the time of paint application, and curing and drying time before application of the next coat, shall be in accordance with the paint manufacturer's recommendations. These conditions shall be recorded in the Inspection Test Record (ITR) by the Contractor and be available for review.

4.2.3 Conventional or Airless Spray

Spray equipment shall be equipped with accurate pressure regulators and gauges. Spray gun nozzles and needles shall be those recommended by the paint manufacturer.

Air from the spray gun shall be clean and dry with no traces of oil or moisture.

Coatings shall be wet on contacting the painted surface. Areas of dry spray shall be removed and the correct system re-applied.

4.2.4 Brush Application

The method of "laying-off" shall be suited to the paint specified and shall ensure minimum brush marking.

4.2.5 Roller Application

A uniform method of application shall be adopted when painting large areas. The rolling direction shall minimise paint joint build up. Edges and areas subject to possible roller damage shall be brush-painted prior to rolling.

4.2.6 Thickness of Coatings

The maximum thickness DFT in any one application shall not exceed that specified in Technical specifications/ recommended by the paint manufacturer.

Wet film thickness gauges shall be used to make frequent checks on the applied wet film. The Contractor shall maintain at the site of painting operations, a dry film thickness tester of an approved type with a valid current calibration.

Coating thickness checks in accordance with reference code shall be performed, and the Contractor shall undertake remedial action if the measured thickness is less than specified.

Build up of each material to required thickness shall be made prior to the application of the subsequent coat; final film build shall be the minimum specified.

4.2.7 Multiple Coat Applications (Except Wet-On-Wet)

Before successive paint coats are applied, intermediate coats shall be inspected for surface contamination. The presence of any grease or oil, shall be removed by a suitable solvent, and any salt and dirt adhering to the surface shall be removed by scrubbing with a solution of non-

toxic detergent (except those prescribed by the manufacturer as “wet-on-wet"). Removal of contaminants shall only be performed after an intermediate coat has had sufficient time to cure.

The surface shall then be pressure hosed or dusted down by brush to disturb and remove deposits not apparent on visual inspection.

Coatings shall be applied only under the following conditions:

- The surface has been cleaned and is dry;
- The manufacturer's stated minimum time for re-coat has elapsed;
- The manufacturer's stated maximum time for re-coat has not elapsed. If the maximum time has elapsed then pre-treatment shall be in accordance with the paint manufacturer's recommendations; and

  Damaged areas in preceding coat have been made good in accordance with this Specification.

When multiple coat of finish paint are indicated, they shall be applied in different shades to ensure that multiple coats have been applied.

4.2.8 Protective Coatings for Fasteners

Black and galvanised erection bolts and galvanised holding down bolts shall be prepared and painted in accordance with Section 4.4 of this Specification.

Black high tensile bolts shall be painted after erection to the same paint system specification as the surrounding structural steel.

4.3 Hot Dip Galvanising

All galvanising shall be carried out by the hot dipping process and conform to the requirements of IS-2629:1985 and uniformity of coating shall confirm to IS 2633:1986.

All welding slag shall be removed by chipping, wire brushing, flame cleaning or abrasive blast cleaning where necessary.

For temporary identification, either water-soluble marking paints or detachable metal labels shall be used. For permanent identification, figur es shall be heavily punched or embossed by the fabricator.

For galvanised items after pickling, the work shall be inspected and any defects that render the work unsuitable for galvanising shall be repaired. After such repairs, the work shall again be cleaned by pickling.

The coating mass of zinc shall be as specified on equipment data sheets and the Drawings. Galvanised coatings shall be tested by the methods described in referred code.

After galvanising all material shall be cooled to air temperature in such a manner that no embrittlement occurs.

Galvanised coatings shall be smooth, uniform, adherent and free from stains, surface imperfections and inclusions.

All gratings and fixtures including nuts, bolts and washers that are required to be galvanised, shall be hot dipped galvanised and all nut threads shall be re-tapped after galvanising and a lubricant applied on Cold working of galvanised steelwork shall be avoided.

4.4 Damaged or Inaccessible Surfaces

4.4.1 Damaged Paint Surface

Repair of damaged painted surfaces, as well as painting of galvanised and black bolts, and galvanised holding down bolts after erection shall comply with this Clause. The treatment shall be:

- Pre-clean the damaged or unpainted areas in accordance with Section 4.2.1 of this Specification;
- Disc or hand sand to clean bright metal;
- Inorganic zinc primers subject to mechanical damage or weld etc shall be power tool cleaned
- Feather backs by sandpapering or whip blasting the original coatings surrounding the damaged area over a 50mm distance. A rough surface shall be obtained on epoxy coatings;
- Clean surface to remove all dust;
- Conduct surface contaminant test in accordance with Section 4.2.2 of this document; and

  Build up a new paint system over the affect ed area with paints equal to those originally used and having the same dry film thickness for each coat. As an exception, damaged inorganic zinc primers shall be repaired with epoxy organic zinc rich paint and shall be applied within four hours of blast cleaning.

The new coatings shall overlap the original coating over the 50mm prepared distance and shall be colour matched to the specified colour of the original coating.

4.4.2 Damaged Galvanised Surfaces

Damaged areas caused by oxy-cutting, welding or physical impact shall be treated as follows:

- Prepare the surface by removing any weld slag followed by vigorous power wire brushing of the coating surrounding the damaged area over a 50mm distance;
- Clean surface to remove all dust; and
- Apply two coats of organic zinc-rich primer to a minimum DFT of 100 microns.

The area to be reinstated shall be colour matched to the surrounding finish colour with 40 microns of aluminium paint to the manufacturer's **written instructions.**

4.4.3 Inaccessible Surfaces

Surfaces that will be inaccessible after erection of other elements of the structure, shall be fully painted prior to the installation of the obstructing item.

4.5 Surfaces Not To Be Coated

The following surfaces shall not be blasted or coated unless specifically directed:

Machined surfaces, bearings, seals, grease fittings, adjusting screws and name plates, and identification tags.

- Valve stems;
- Raised faces on pipe and equipment flanges;
- Electrical cabling;
- Instrumentation, gauges and sight glasses;
- Titanium, stainless steel and non-metallic surfaces; and

  Field weld margins, 50mm either side of weld, on tankage and piping, prior welding.

The rear face of piping flanges shall be shop prime coated only. Flange holes for fasteners shall be fully coated.

4.6 Wash-Up

All surface of equipments/prefabricated piping etc. Primerised / painted at Vendor shop and received at site if required shall be washed up as follow:

a) Washing with clean water (Pressure 7 Kg/cm2) using suitable nozzles. During washing, broomcorn brushes shall be used to remove foreign matter.

b) Solvent washing, if required , to remove traces of wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates of oil, grease etc. Wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates.

4.7 Touch-Up Painting

Prior to the application of any coat, all damage to the previous coat(s) shall be touched-up. Damage to finished work shall be thoroughly cleaned and re-coated.

Surface preparation shall be done as per clause no. 3.0.....

Items supplied with the manufacturer’s standard coating system shall be touched-up with the same generic coating system or recoated.

4.8 Paint Storage

The following must be ensured:

a) All paints and painting material shall be stored only in such rooms assigned for the purpose. All necessary precaution shall be taken to prevent fire. The Storage building shall preferably be separate from adjacent buildings. A sign-board bearing the Words "PAINT STORAGE- NO NAKED LIGHT" sha ll be clearly displayed outside. The building shall be properly ventilated and shall be adequately protected with fire fighting equipment.

b) Storage shall be far away from heated su rface open flames, sparks & well protected from sun rays.

c) Ambient temperature at which paints are stored shall be intimated to paint manufacturer & their advice sought regarding precautions to be taken if any,

regarding flammability, explosiveness & toxicity.

d) Maximum allowed storage time for various paint materials shall be clearly indicated on individual containers. Materials which have passed expiry date shall not be used.

e) Paints in non-original containers and/or in containers without seals, shall not be used.

5.0 COATING SYSTEM SELECTION

Coating Systems for Structures Piping and Equipment

The following Table 1 shall be used as a general guide for the selection of a paint system suitable for a particular plant area application. Paint systems specified on equipment data sheets and the Drawings shall take precedence over the general paint system area applications listed in Table 1

TABLE - 1

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
01	Structural Steel work with operating temp. Up to 90^{O} C (Steel structures, Piping support, uninsulated CS piping, flanges, valves, stairways, walkways etc. except grating).	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no.4.70	Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat: Three coats of two packs. Polyamide Cured Epoxy.	Primer :35 microns For each coat (Total-70microns). Finish: 40 microns for each coat (Total– 120 microns.	Total dry film thickness of paint system: 190 microns.
02	Uninsulated CS piping, flanges, valves with operating temp. From 90^{O} C to 200^{O} C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.	Primer: 75 microns Finish: 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
	NOTE : Only for valves where it will be impossible to blas t cleaning, four to five c oats of Heat Resisting, ready mixed Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).				
03	Uninsulated CS piping, flanges, valves with operating temp. Over 200^{O} C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no.4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicon Aluminium Paint.	Primer: 75 microns Finish: 20 microns for each coat Total - 40 microns.	Total dry film thickness of paint system: 115 microns.

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	NOTE: Only for valves where it will be impossible to bl ast cleaning, four to five coats of Heat Resisting Silicon Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).				
04	Insulated CS piping flanges, valves with operating temp up to 90^{O} C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no.4.70	Primer: One coat of high temperature phenolic epoxy Finish Coat : One coat of high temperature phenolic epoxy	Primer :100 microns Finish : 100 micron	Total dry film thickness of paint system: 200 microns.
05	Insulated CS piping, flanges, valves with operating temp. From 90^{O} C to 200^{O} C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	Primer: One coat of high temperature phenolic epoxy Finish coat : One coat of high temperature phenolic epoxy	Primer: 100 microns Finish: 100 micron	Total dry film thickness of paint system:200 microns
	NOTE : Only for valves where it will be impossible to blas t cleaning, four to five c oats of Heat Resisting, ready mixed Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).				
06	Insulated CS piping, flanges, valves with operating temp. Over 200^{O} C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no.4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Heat resisting Silicon Aluminium paint.	Primer: 75 microns Finish: 25 micron	Total dry film thickness of paint system: 100 microns.
	NOTE: Only for valves where it will be impossible to bl ast cleaning, four to five coats of Heat Resisting Silicon Aluminium Paint will be applied on surface without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).				
07	Uninsulated CS equipment with operating temp. Up to 90^{O} C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no.4.70.	Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat : Three coats of two pack Polyamide Cured Epoxy	Primer: 35 micron for each coat. Total – 70 microns. Finish: N.A Finish: 40 microns for each coat Total - 120 microns.	Total dry film thickness of paint system: 190 microns.
08	Uninsulated CS equipment with operating temp. From 91^{O} C to 200^{o}C, to be treated at	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-	Primer: One coat of Ethyl Silicate zinc rich with solvent.	Primer: 75 microns Finish:	Total dry film thickness of paint system: 125 microns.

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	Manufacturer's shop.	5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.	Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.	25 microns for each coat Total - 50 microns.	
09	Uninsulated CS equipment with operating temp. Over 200°C , to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicon Aluminium Paint.	Primer: 75 microns Finish: 20 microns for each coat Total - 40 microns.	Total dry film thickness of paint system: 115 microns.
10	Insulated CS equipment with operating temp. Up to 90° C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no.4.70.	Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	Primer: 100 micron Finish: 100 microns	Total dry film thickness of paint system: 200 microns.
11	Insulated CS equipment with operating temp. From 91° C to 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	Primer: 100 microns Finish: 100 micron	Total dry film thickness of paint system: 200 microns.
12	Insulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Heat resisting Silicon Aluminium paint.	Primer: 75 microns Finish: 25 microns	Total dry film thickness of paint system: 100 microns.
13	Stainless steel pipe flanges, valves, equipments with operating temp. Up to 200°C	Lightly Blast cleaned as per grade Sa-1.0, of Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	Primer: 100 microns Finish: 100 microns	Total dry film thickness of paint system: 200 microns.
14	Surface of structural steel for furnaces, external	Blast cleaning to near white metal grade 2	Primer: One coat of Ethyl Silicate	Primer: 75 microns	Total dry film thickness of

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	surface of furnaces, external surface of flue duct, metal stacks and similar with operating temp. Up to 200°C. (With exclusion of stair ways, walk ways etc.).	½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no.4.70.	zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.	Finish: 25 microns for each coat Total - 50 microns.	paint system: 125 microns.
15	For external surfaces of flue ducts, metal stacks, and similar with operating temp. Above 200°C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicon Aluminium Paint.	Primer: 75 microns Finish: 20 microns for each coat Total - 40 microns.	Total dry film thickness of paint system: 115 microns.
	NOTE: Only for zones where it will be impossible to blast cleaning, four to five coats of Heat Resisting Silicone Aluminium Paint will be applied on surfac e without inorganic zinc primer and surface preparation to grade Sa-2 ½ of Swedish Standard SIS-05-5900 (Latest).				
16	For surfaces of air cooler heads not galvanized with operating temperature up to 90° C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat: Three coats of two pack. Polyamide Cured Epoxy.	Primer: 35 micron for each coat. Finish: 40 microns for each coat Total - 120 microns.	Total dry film thickness of paint system: 190 microns.
	NOTE: All surfaces shall be galvanized at manufacturer's shop with excepti on of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
17	For surfaces of air cooler heads not galvanized with operating temperature up to 91° C TO 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.	Primer: 75 microns Finish: 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
	NOTE: All surfaces shall be galvanized at manufacturer's shop with excepti on of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
18	**STORAGE TANKS**				
a)	Acid / Alkali CS Storage Tank (External Surface	Blast cleaning to near white metal grade 2	Primer: Two coats of two pack zinc	Primer: 35 micron for each	Total dry film thickness of

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	including all stair ways)	½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	rich epoxy polyamide cured Primer. Finish coat: Three coats of two packs. Polyamide Cured Epoxy.	coat. Total – 70 microns. Finish: 40 microns for each coat Total - 120 microns.	paint system: 190 microns.
b)	CS Storage Tanks, Excluding indicated in Sl. No. (a)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of epoxy amine cured tank liner.	Primer: 75 microns Finish: 30 microns for each coat Total - 60 microns.	Total dry film thickness of paint system: 135 microns.
19	Cold Insulated Carbon Steel and low alloy Steel (1-$^1/_4$ Cr through 9 Cr) Piping and Equipment.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Epoxy Coal Tar paint with solvent.	Primer: 75 microns Finish: 40 microns	Total dry film thickness of paint system: 115 microns.
20	Cold Insulated high alloy Steel piping and Equipment	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	Primer: 100 microns Finish: 100 microns	Total dry film thickness of paint system: 200 microns
21	Cold insulated Stainless Steel piping and equipments	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	Primer: 100 microns Finish: 100 microns for each coat	Total dry film thickness of paint system: 200 microns
22	Surface (CS) with Equipment with temp. Indicating paint from 220°C to 240°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat : Two	Primer: 75 microns Finish: 25 microns for	Total dry film thickness of paint system: 125 microns.

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
		Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	coats of Silicon Acrylic Paint	each coat Total - 50 microns.	
23	PACKAGE:				
a)	Surface(CS) with operating temperature upto 90^{o}C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no.4.70.	Primer: Two coats of two pack zinc rich epoxy polyamide cured Primer. Finish coat: Three coats of two packs. Polyamide Cured Epoxy.	Primer: 35 micron for each coat. Total – 70 microns. Finish: 40 microns for each coat Total - 120 microns.	Total dry film thickness of paint system: 190 microns.
b)	Surfaces (CS) with operating temperature upto 91^{0} C TO 200^{O}C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.	Primer: 75 microns Finish: 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
c)	Surface (CS) with operating temp. Over 200^{o}C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of Heat Resisting Silicone Aluminium Paint.	Primer: 75 microns Finish: 20 microns for each coat Total - 40 microns.	Total dry film thickness of paint system: 115 microns.
d)	Package in Carbon Steel and low Alloy Steel (1-$^{1}/_{4}$ Cr through 9 Cr) with cold insulated surface treated at manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: One coat of Epoxy Coal Tar paint with solvent.	Primer: 75 microns Finish: 40 microns	Total dry film thickness of paint system: 115 microns.
e)	Package in Cold Insulated high alloy Steel.	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	Primer: 100 microns Finish: 100 microns	Total dry film thickness of paint system: 200 microns
f)	Package in Cold insulated	Lightly Blast cleaned	Primer: One coat	Primer: 100	Total dry film

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
	Stainless Steel.	as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest) wash-up – As per clause no. 4.60. Touch-up – As per clause no. 4.70	of high temperature phenolic epoxy Finish coat: One coat of high temperature phenolic epoxy	microns Finish: 100 microns	thickness of paint system: 200 microns
24	For external surface of shell, roof of CS tanks, with operating temp. Upto 110°C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Ethyl Silicate zinc rich with solvent. Finish coat: Two coats of single pack special Synthetic Rubber based heat resistant ready mixed Aluminium Paint.	Primer: 75 microns Finish: 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
25	For down external surfaces(CS) below only of the fixed tanks, bottom & shell shall be treated as follows:	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	Primer : None Finish Coat: Two coats of Epoxy Coal Tar Solvent base.	200 microns for each coat Total: 400 microns	Total dry film thickness of paint system : 400 microns
26	CS Equipment and associated piping subject to cyclic, intermittent or regeneration operating condition (e.g. Molecular Sieve Driers) subjected to very severe corrosion with wide operating temperature range.	Blast cleaning to near white metal grade 3, of Swedish Standards SIS-05-5900 (Latest). Wash-up – As per clause no.4.60. Touch-up – As per clause no. 4.70.	Primer: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal Finish Coat: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal.	Primer: 125 microns Finish: 125 microns	Total dry film thickness of paint system 250 microns.

6.0 MACHINERY, ELECTRICAL AND INSTRUMENT EQUIPMENT:

6.1 Machinery

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std. However, suitable for operating condition and the environmental condition where the machinery will operate. Where necessary machinery shall be restored at site by Contractor with suitable finish.

6.2 Electrical and Instrument Equipment

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std., however suitable for operating condition and the environmental condition where the electrical and instrument equipment will operate. Where necessary Electrical and Instrument Equipment shall be restored at site by Contractor with suitable finish.

7.0 COLOURS:

These shall be as required by specification and in particular for :

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Piping with temperature less than 90°C	GREY	7035	
- Piping, hot surface, flue gas ducts and stacks with temperature above 90°C	SMOOTH	ALUMINIUM	"
- Cooling Water Piping	SEA GREEN		"
- Fire fighting Piping	Red	3002	"
- Structures upto 2 MT	BLACK	9005	"
- Structures above 2 MT	GREY	7010	"
- Stair cases – ladders	BLACK	9005	"
- Walkwais	GREY	7010	"
- Handrails assemblies	YELLOW	1004	"
- Equipment	GREY	7035	"
- Hot equipment	SMOOTH	ALUMINIUM	"
- Fire fighting equipment	RED	3002	"
- Valves in general	GREY	7035	"
- Hot valves	SMOOTH	ALUMINIUM	"
- Safety and Fire fighting valves	RED	3002	"
- Valves handwheels	BLACK	9005	
- Electric Rotary Machines	SKY BLUE	5012	
- Electric Static Machines	GREY	7035	
- Machinery (compressors & pumps) with operating temperature less than 90°C	GREY	7035	"
- Machinery (compressors & pumps) with operating temperature above 90°C	SMOOTH	ALUMINIUM	"
FURNACES			
- Cassing and connected steel	SMOOTH	ALUMINIUM	"

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
works			
- Steel work not connected to casing	SMOOTH	ALUMINIUM	"
AIR COOLER			
- High Temperature Surfaces (Temp. > 90°C)	SMOOTH	ALUMINIUM	
- Low Temperature surface (Temp. ≤ 90°C)	GREY	7035	"
- Flare ≤ 90°C	GREY	7035	"
- Flare ≥ 90°C)	SMOOTH	ALUMINIUM	"
TANKS			
- Shell of fixed roof	WHITE	9010	"
- Roof of fixed roof tank	WHITE	9010	
- T-301	SMOOTH	ALUMINIUM	"
- T-303	WHITE	9010	"

NOTE-1: The colours shall be according to IS2379:1990/International STD. RAL or BS, proposed by Contractor or Manufacturer

8.0 PARTICULAR DESCRIPTION

The abrasive to be used shall be chloride-free siliceous sand (marine sand excluded) or metal grit.

Primerized surface shall be faultless and shall not have mud-cracking, dripping over thickness and dry sprays.

Blast cleaning and painting shall not be carried out on wet surfaces.
Blast cleaning shall not be done when surfaces temperatures are less than 3°C above dew point of below 5°C.

No acid washes or other cleaning solutions or solvents shall be used on metal surfaces after they have been blasted.

The surface preparation of all steel surfaces to be coated shall be free of all mill scale, rust corrosion product, oxides, paint, oil or other foreign matter

Only dry sand blasting procedures will be allo wed. The compressed air supply used for blasting shall be free of detrimental amounts of water and oil. Adequate separator and traps shall be provided and these shall be kept emptied of water and oil.
All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations and underlying mill scale exposed during sand blasting shall be removed or repaired.

The blast-cleaned or power brushing surfaces shall be coated with primer within four hours of surface preparation.

No primer or intermediate or finishing coating shall be applied without prior notification to the Company.

The application of the products shall be carried out in strict compliance with the paint manufacturer's recommendation.

The Contractor shall provide suitable protection for all adjacent plants or equipment from airbone during spraying and sand blasting.

9.0 INSPECTION AND TESTING

The inspection and testing requirements outlined in this section shall be performed for shop and site applied coating systems.

Preference shall be given to manufacturers and applicators that are quality certified to ISO 9001: 2000.

Documentation of coating material manufacturers and applicators shall include daily inspection reports, equipment reports, and shall clearly identify and trace materials supply and testing performed on coated items and areas.

Inspection and Test Plans (ITPs), and quality control procedures used for application of coating systems shall form part of the Method Statem ent and shall be submitted for approval by the Principal prior to commencement of work.

The applicator shall appoint a certified inspector of coatings for inspection and testing of coating systems.

Tests of coated areas and items shall form part of the ITPs.

- Surface Preparation in accordance to Swedish Standard SIS-05-5900 (Latest).
- Blast Cleaning profile shall be checked using a suitable profile meter – Acceptable profile shall be 25-30 microns.
- Check of time of top coating and drying in accordance with the direction of the paint manufacturer.
- Check of dry film thickness by suitable non-destructive Instrument such as "MIKROTEST", "DIAMETER" or equivalent.
- Before any coating work is preformed on the site, the contractor shall ensure that any works applied by others is acceptable.

  Any defect that are discovered, are to be notified in writing to the owner before proceeding with the contract work. To ensure the good execution of painting work following test shall be performed:

  - Surface Preparation
  - Surface contaminant tests
  - Surface profile tests
  - Coating thickness tests
  - Tests for cure of coatings
  - Adhesion tests

- Continuity testing
- Iron contamination
- Chloride contamination
- Dust Contamination

All Inspection and Test Records (ITRs) shall be submitted with the Manufacturer's Data Report (MDR) at the conclusion of the job.

Defective coated areas shall be suitably marked for rectification work to be performed in compliance with this specification.

Access shall be granted for inspection of all paint work, and witnessing of test work. This shall not however relieve the Contractor of their own QA/QC responsibilities.

10.0 ADHESION TEST RESULTS

For all type of primer the Contractor shall guarantee the Classification of Adhesion Test Results as per DIN 53151. The acceptable Rate Adhesion Test Results shall be for sandblasted and primerized surfaces upto GT2.

For primer plus finishing coat(s) the Contractor shall guarantee the Classification of Adhesion Test Results as per DIN 53151. The acceptable Rate Adhesion Test Results shall be for sandblasted and painted surfaces upto GT2.

After test, the surface must be repaired according to the system applied.

11.0 SUBMISSION OF DATA

Contractor shall submit in phase of bid the original technical data sheet and system for all material supplied by him to apply for the permanent works and test report for the paint in compliance to IS101.This material shall be subject to Owner's approval.

12.0 LETTER AND NUMBER INSCRIPTION

Inscriptions letters, as herebelow indicated, shall be made on equipments, piping, storage tanks, machinery etc.

12.1 Geometric forms and dimensions

Letters and numbers dimensions shall be orientatively fixed according to following:

(A – Dimension of side of unitary elements of grid)

a) Storage Tanks A – 60 mm

b) Equipments and piping with O.D. above 600 mm A– 40 mm and

c) Equipments and pipings with O.D. from 300 to 600 mm and for machinery of great dimensions A – 20 mm

d) Equipments and pipings with O.D. less than 300 mm and for machinery with small dimensions A – 10 mm

12.2 Inscription's Colours

Inscriptions shall be Black ENI 901 (RAL 9005) on light base

Inscriptions shall be White ENI 101 (RAL 9010) on dark base

12.3 Spaces and Interspaces

Spaces between words and assemblage of numbers shall have dimensions equal to 2A

Interspaces between letters or numbers shall have dimensions equal to A.

13.0 Colour Band for piping ;-

As a rule minimum width of colour band shall confirm to the following Table:-

Nominal pipe Size	Width L (mm)
3” & below	25
4” NB-6” NB	50
8” NB-12”NB	75
14” OD & above	100

14.0 LIST OF MANUFACTURERS :

1. M/s Berger Paints
2. M/s Asian Paints
3. M/s GRAUER & WEIL (I) LTD, (Unit-Bombay Paints)