ENGINEERING AND MATERIAL STANDARD

FOR

TOWERS, REACTORS, PRESSURE VESSELS AND INTERNALS

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0. INTRODUCTION

The term of pressure vessels has a large variety of applications in oil industries. It includes process pressure vessels and receivers, drums, towers, columns, heavy wall pressure vessels, reactors, etc. Since all of these vessels have different technical specifications from the point of view of materials and engineering design, which can not be verified under one subject of heading, therefore, this Standard Specification is prepared in three parts as follow:

Part I: Covers the minimum Engineering and Material requirements for process pressure vessels, receivers, towers and columns.

Part II: Contains the Engineering and Material requirements for trays and tower internals.

Part III: Gives the minimum Engineering design and Material specifications for heavy wall pressure vessels and reactors and additional requirements for the internals of these type of vessels.

PART I
TOWERS, COLUMNS AND PROCESS PRESSURE VESSELS

1. SCOPE

1.1 This Part of Engineering and Material Standard specification covers the minimum requirements for materials, design, fabrication, inspection and testing, and preparation for shipment of unfired pressure vessels, including towers, columns receivers, etc.

1.2 The requirements cover steel pressure vessels of carbon steels, alloy steels, and carbon steel clad or lined with stainless steels.

1.3 In all cases where more than one code or Standard applies to the same conditions, the company shall be consulted for selection of the applicable standard.

2. REFERENCES

Throughout this Standard the following Standards and Codes are referred to. The editions of these Standards and Codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in Standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor:

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE)

A 58.1 "Building Code Requirements for Minimum Design Loads in Buildings and other Structures"
B 1.1 "Unified Inch Screw Threads (UN and UNR Thread Form)"
B 16.5 "Pipe Flanges and Flanged Fittings"

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

MR-01-75 "Sulfide Stress Cracking Resistance Material for Oil Field Equipment"

API (AMERICAN PETROLEUM INSTITUTE)

601 "Metallic Gaskets for Raised Face Pipe Flanges and Flanged Connections (Double Jacketed Corrugated and Spiral-Wound)"

605 "Large Diameter Carbon Steel Flanges (Nom. Pipe Size 26 Through 60 in.)"

Publ. 941 "Steel for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS) (BOILER AND PRESSURE VESSEL CODE)

Section II "Material Specification"
Section VIII, Division 1 "Pressure Vessels"
Section VIII, Division 2 "Pressure Vessels Alternative Rules"

Section V	"Non-Destructive Examination"
Section IX	"Welding and Brazing Qualifications"
SA-266	"Forgings, Carbon Steel for Pressure Vessel Components"
SA-336	"Forgings, Alloy Steel for Pressure and High Temperature Parts"
SA-370	"Mechanical Testing of Steel Products"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

AWS (AMERICAN WELDING SOCIETY)

EJMA (EXPANSION JOINT MANUFACTURERS ASSOCIATION, INC.)

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-TP-100	"Engineering Standard for Paint"

3. UNITS

This Standard is based on International System of Units (SI) except where otherwise is specified.

4. DOCUMENTATION REQUIREMENTS

4.1 General

4.1.1 Welding and weld repair procedures shall be submitted to the Company for review prior to start of fabrication.

4.1.2 The vendor shall submit a proposed schedule for the submission of drawings and data to the Company for approval. The vendor shall furnish drawings in the quantity specified by the Company.

4.1.3 The fabricator shall provide a detailed drawing based on the submitted outline drawing of the pressure vessel, including the internals of the vessel. The following information shall be included on the detailed drawings and on other drawings and data sheet, as applicable:

1) Order number,

2) vessel component and tag number,

3) material specification,

4) complete dimensions, thicknesses, and details of construction including pictorial and dimensional location of circumferential and longitudinal seams, all nozzles on plan (or orientation) and elevation views, and all internals,

5) size and pressure rating of all nozzles on the vessel,

6) head and shell thicknesses, head type, flange type, and other details of construction materials,

7) total weight of vessel (empty),

8) total weight of vessel (full of water),

9) heat treatment requirements,

10) non-destructive testing requirements,

11) design pressure and temperature and major structural loadings,

12) joint efficiency,

13) test pressure,

14) corrosion allowance,

15) reference drawings.

4.1.4 Manufacturing shall not proceed without written approval of drawings by the Company.

4.1.5 Approval of drawings does not constitute permission to deviate from any requirements in the order unless specifically agreed to in writing. After the drawings have been approved, the vendor shall also furnish certified Micro film copies in the quantity specified. The Micro film copies shall have a minimum thickness of 4 mils and shall be developed by the photographic process (film negative).

4.2 Final Reports, Data Sheets, and Manuals

Installation, operations, and maintenance data for each pressure vessel shall be provided no later than the date of shipment. The data shall include the following:

a) Manuals for instruments, valves, and gage cocks furnished by the vendor including special operating and maintenance information.

b) Manufacturer's data report, form U-1 of the ASME code.

c) Manufacturer's data report, form U-2 of the ASME code.

d) Certified material records report containing the complete chemical analysis, physical properties, and location of each plate, forging, and all other material subject to pressure. Information covering alloy material shall be included in the report even though the material may not be subject to pressure. The location of the plates, forgings, and other material shall be indicated on the as-built drawings.

e) Photostatic copies of recording charts indicating temperature conditions during thermal stress relief. The complete temperature cycle of heating, soaking, and cooling shall be indicated.

f) Hydrostatic test chart for each vessel.

g) Copy (rubbing) of nameplate.

h) Records of N.D.T inspection.

i) A parts list shall be supplied for each item of equipment furnished and shall be complete with pattern, stock, or production drawings numbers that completely identify each part so that the Company can determine part interchangeability with other equipment furnished by the same manufacturer.

j) The Vendor shall submit a supplementary proposal for spare parts other than the parts included in the Vendor's original quotation.

The supplementary proposal shall include recommended spare parts for startup and 1 year of operation including assembly type drawings, parts numbers, materials, prices, and delivery. Parts numbers shall identify each part for interchangeability purposes. The supplementary proposal shall be forwarded to the Company after receipt of approved drawings and in time to permit ordering and delivery of parts with the vessel.

k) W.P.R. (Welding Procedure Report) and W.Q.R. (Welder Qualification Report) shall be submitted to the Company.

l) Final drawings.

m) Final calculation.

5. MATERIALS

5.1 General

5.1.1 In general, all materials shall be in conformity with the ASME Standard specification for equivalent material approval of the company is required.

5.1.2 Proposals to use materials having a specified maximum tensile strength greater than 620 MPa (90,000 PSI) at room temperature shall be submitted to the Company for approval.

5.1.3 Materials of construction for vessel components shall be selected so as to produce an economical design for the specified design service conditions.

5.1.4 Cast iron shall not be acceptable.

5.1.5 The use of carbon -½ moly materials is not generally permitted. Exceptions shall be subject to Company's approval and then only if the working temperature does not exceed 400°C (750°F).

5.2 Pressure Parts

5.2.1 Some materials for typical conditions in oil refinery services are listed in Appendix A of this Standard.

5.2.2 Carbon steel materials for pressure retaining parts for normal service are given in Appendix B.

5.2.3 Pressure retaining materials to be welded shall have the following chemical composition:

Carbon content (C) : C $\leq$ 0.25%

Carbon equivalent (C eq.) : C eq. $\leq$ 0.45%

where: **C eq. = C+Mn/4**

5.2.4 Pressure retaining parts for hydrogen service, where defined at a hydrogen partial pressure at 7 kg/cm^2, shall be selected in accordance with Fig. 1 of API Publ. 941 "Operating Limitation for Steel in Hydrogen Service".

5.2.5 Pressure retaining parts for H_2S service, where defined in Paragraph 1.3 of NACE (National Association of Corrosion Engineers) standard MR-OI-75, shall be selected in accordance with the said standard.

5.3 Non-Pressure Parts

5.3.1 Materials of non-pressure retaining parts to be directly welded to pressure retaining parts, having a design temperature of 343°C (650°F) or more, shall be of the same materials as the pressure retaining parts.

5.3.2 Steel plate for base rings, reinforcement for skirt openings, saddles, external lugs for platforms ladders, insulation supports and pipe supports shall be SA 283 Gr.C or better. Angles and rods shall be SA 36.

5.3.3 Name plates shall be type 316 stainless steel.

5.3.4 Internal support rings and lugs welded to the shell or head made of killed steel shall be made of the same material. For other than killed steel vessels, the following materials may be used except in case of Paragraph 5.3.1.

a) Plates : ASTM A 283 Gr.C or equivalent.
b) Pipe : ASTM A 106 or A 53 or equivalent.

5.4 Expansion Joints

The design and fabrication for expansion joints installed on vessel shell or other portions, shall be in accordance with EJMA (Expansion Joint Manufacturers Association) standard and specific requirements.

5.5 Bolting

5.5.1 Bolting shall be selected per the following Table:

TABLE 1

DESIGN METAL TEMPERATURE	BOLTS		NUTS	
°C	GRADE	ASME STD.	GRADE	ASME STD.
-29 to 427	B7	SA 193	2 [1)]	SA 194
>427 to 593	B16	SA 193	2H [1)]	SA 194
538 to 815	B8M [4)]	SA 193	8M	SA 194
-255 to -102	B8 [4)]	SA 320 [3)]	8	SA 194
-101 to -29	L7 [5)]	SA 320	4 [1) 2) 5)]	SA 194

Notes:

1) Nuts larger than in (12 mm) shall not be machined from barstock.
2) Nuts ½ in. and smaller shall not be machined from cold finished barstock.
3) ASTM A 193 Grade B8 bolts with ASME SA 194 Grade 8 nuts may be used as an alternative.
4) B8M and B8 bolts shall be strain hardened.
5) The test temperature for impact testing of all L7 bolts and grade 4 nuts per ASME SA 320, shall be -101°C (-150°F)

5.5.2 Stud bolts shall be threaded full length with continuous threads.

5.5.3 Bolt length specified is the effective thread length. Rounded or chamfered end points shall not be included when measuring length of bolts.

6. DESIGN

6.1 General

6.1.1 Pressure vessels shall be designed in accordance with the ASME Code for unfired pressure vessels, Section VIII, Division 1.

6.1.2 Pressure vessels shall be designed to ensure safe operation in the specified internal and external environments.

6.1.3 Vertical and horizontal vessels including their supports shall be capable of supporting a full load of water in the installed position.

6.1.4 Any part for which detail design and drawing(s) is not prepared shall be designed by the Vendor. The design shall be approved by the Company.

6.2 Design Data

6.2.1 Design pressure

6.2.1.1 The design pressure of vessel shall be at least equal to the maximum operating pressure plus 10 percent or plus 350 kPa, whichever is greater.

6.2.1.2 Vessels subject to external pressure shall be designed for full vacuum.

6.2.1.3 The design pressure and maximum allowable working pressure of a vessel shall not be limited by minor components such as flanges, nozzles, manholes, or reinforcing pads.

6.2.2 Design temperature

6.2.2.1 The design temperature shall be at least 15°C above the maximum working temperature. For cold service, the design temperature shall be 6°C below the minimum operating temperature unless otherwise specified.

6.2.2.2 Vessels which will operate at temperature above 400°C shall be designed for a temperature equal to the maximum anticipated operating temperature.

6.2.2.3 Dual temperatures shall be listed on the nameplate. The two temperatures shall be the cold design-temperature and the maximum hot design temperature allowed by the ASME Code for the as-built vessel.

6.2.2.4 If variant temperatures can be definitely predicted for zones of a vessel in operation, the variant temperatures may be taken into account in the design of the applicable zones.

6.2.3 Design loadings

6.2.3.1 Loading shall be in accordance with ASME Section VIII, Div. 1. Wind and earthquake loads shall be in accordance with ANSI A 58.1, "Building Code Requirements for Minimum Design Loads in Building and other Structures".

6.2.3.2 The wind or earthquake load, whichever is the greater, shall be considered in design.

6.2.3.3 All vessels shall be designed to be self-supporting without benefit of guys or braces.

6.2.3.4 During erection, start-up, or operation, all applicable loads shall be considered as acting simultaneously, including either wind or earthquake, whichever governs.

6.2.3.5 During hydrostatic testing, wind load (wind pressure) equivalent to a 16 m/s wind speed shall be considered acting simultaneously with the hydrostatic test load.

6.2.3.6 Lateral deflection due to wind, of vessels under normal operating conditions, shall not exceed 150 mm per 30 meters of height.

6.2.3.7 Vibration and critical wind velocity shall be considered in the design of tall, slender columns with a length-to-diameter ratio exceeding 8 to 1.

6.2.3.8 Vessel supports shall be capable of withstanding the wind load when vessel is empty and the test conditions when the vessel is full of water. (e.g. wind velocity 16 m/s).

6.2.4 Allowable stresses

6.2.4.1 For non-pressure parts the permissible design stresses shall be the least of the following values at design metal temperature:

a) One third of minimum ultimate tensile strength.
b) Two thirds of minimum yield strength.
c) That stress producing a creep rate of 1% in 10,000 hours.

6.2.4.2 The stresses determined from the ASME code shall also apply to the supporting skirt of the vessel.

6.2.4.3 For anchor bolting, the following limits shall be used for design at the thread root diameter:

Tension	**96 MPa**
Shear	**96.5 MPa**

6.2.5 Corrosion allowance

6.2.5.1 The specified corrosion allowance shall be added to the calculated thickness of all pressure-containing parts including the shell, heads, nozzles, manways, and manway covers.

6.2.5.2 The minimum corrosion allowance for carbon steel shall be 1.6 mm for sweet service and 3.2 mm for sour service unless otherwise specified.

6.2.5.3 The specified corrosion allowance for compartmented vessels shall be added to the calculated thickness of each side of the internal head or partition.

6.2.5.4 Corrosion-resistant linings shall be provided for vessels in highly corrosive service. The thickness of liners, cladding, or weld overlays shall not be included in calculating the minimum thickness of pressure-containing parts.

6.2.5.5 Unless otherwise specified, vessel corrosion allowance shall be provided to all exposed surfaces of non-removable internal parts and half this amount to surface of removable parts (except demister-wire, column packing, etc.)

6.2.6 Alloy protective lining

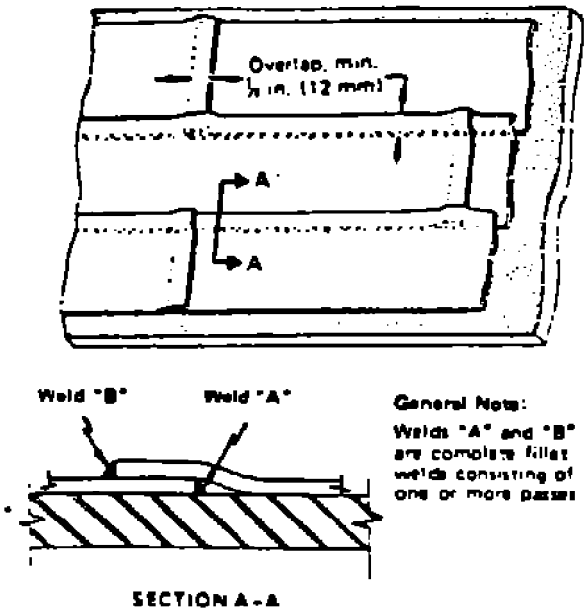
6.2.6.1 Integral clad plate bonded by rolling or explosion method shall be homogeneously made to have a material quality and a thickness as specified. The clad plate to be used for pressure vessel shall meet one of the following standard specifications or equivalent.

a) ASME SA 263 "Corrosion-Resisting Chromium Steel Clad Plate, Sheet, and Strip"
b) ASME SA 264 "Stainless Chromium-Nickel Steel Clad Plate, Sheet, and Strip"
c) ASME SA 265 "Nickel-Base Alloy Clad Steel Plate"
d) ASTM B 432 "Copper and Copper Alloy Clad Steel Plate"

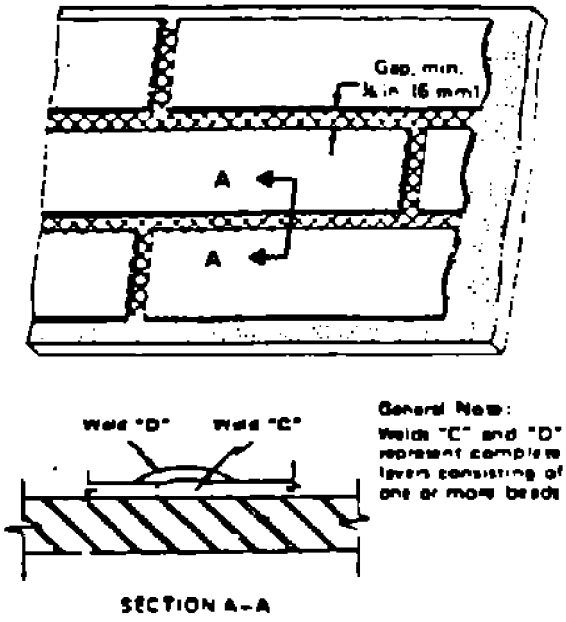
6.2.6.2 Weld metal overlay cladding shall be mainly used for "Hydrogen Service": Vessels operating at elevated temperature and high pressure at a hydrogen partial pressure of 7 kg/cm^2 and over.

6.2.6.3 When the "Hydrogen Service" vessel is to be operated at a special condition such as in "Hydrocracking Process" and " Hydro-Desulferization Process", the weld metal overlay cladding shall be strictly adopted for all inside surface of the vessel.

6.2.6.4 Strip lining shall be lap welded per Fig. 1, or butt welded per Fig. 2 fabrication drawings and the welding procedure specification shall describe the system to be used; and the welding procedure shall be qualified for the specific method.



LAP WELDED STRIP LINING (DETAIL)
Fig. 1



BUTTWELDED STRIP LINING (DETAIL)
Fig. 2

6.2.6.5 Strip or sleeve lining shall not be used for the following:

a) Shells and heads of vessels in hydrogen service.
b) Vessels subject to PWHT.
c) Vessels with design temperature greater than 440°C.

6.2.6.6 Dimensions of individual strips, excluding single piece sleeves, shall be limited by the following:

a) Thickness shall not be less than 3 mm
b) Widths shall be limited by design temperature and materials as per Table 2.

TABLE 2

DESIGN TEMPERATURE °C	MATERIALS	MAXIMUM WIDTH mm
< 315	ALL	150
≥ 315	STAINLESS STEEL INCOLOY	100
≥ 315	405, 410 S, INCONEL, HASTELLOY	150

6.2.6.7 Material used for weld overlay, integral cladding, sleeve liners or strip lining of connections shall be the same material and thickness as required for the lining or cladding to the vessel or head to which they are attached.

6.2.6.8 The minimum thickness of cladding shall be 2 mm and the minimum thickness of weld metal overlays shall be 2.5 mm.

6.2.6.9 The thickness of cladding or weld overlays shall not be included in calculating the required shell thickness.

6.2.6.10 Connections of DN 50 mm (2 in.) and smaller shall be either of the following:

a) Weld overlayed, integrally clad by the explosive bonding method, or sleeve lined on the I.D.
b) Solid alloy provided the following conditions are met:
  1) Vessel design temperature is below 440°C.
  2) Tests are performed to demonstrate the alloy's weld-ability.

6.2.6.11 Connections over DN 50 (2 in.) up to and including DN 300 (12 in.) shall be lined by any of the following methods:

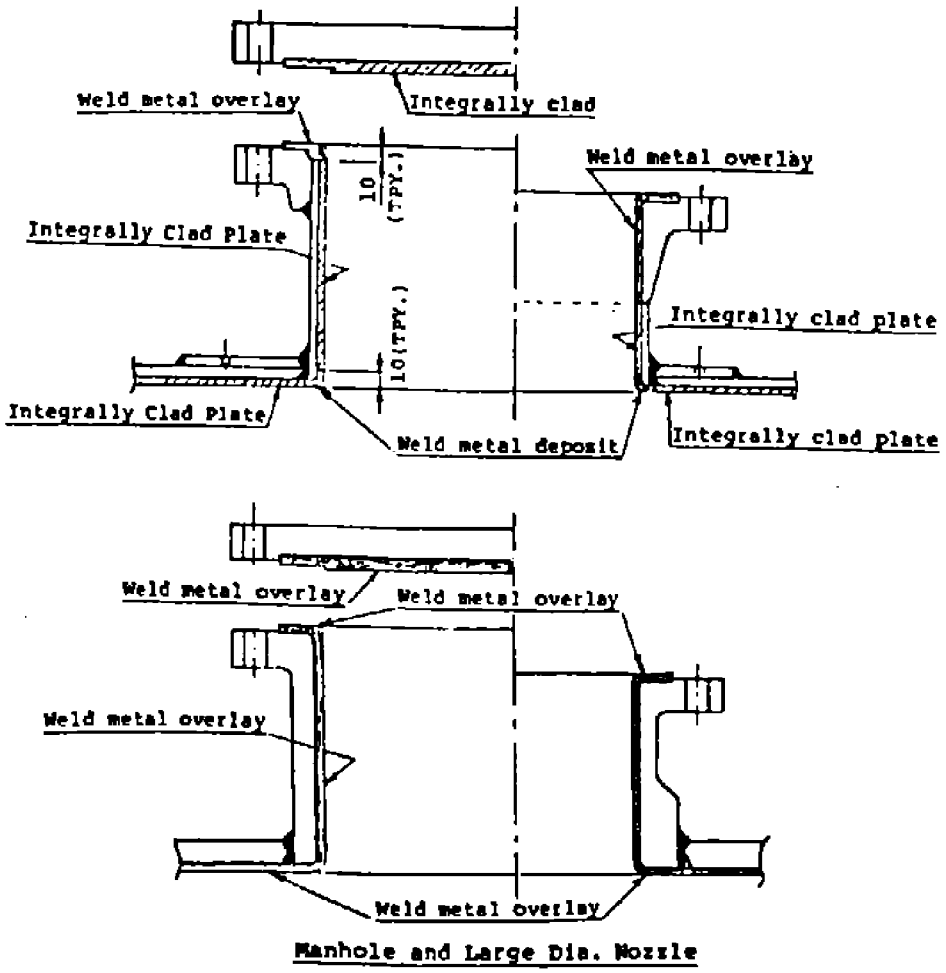
Weld overlay, integral cladding, sleeve liner, or strip lining.

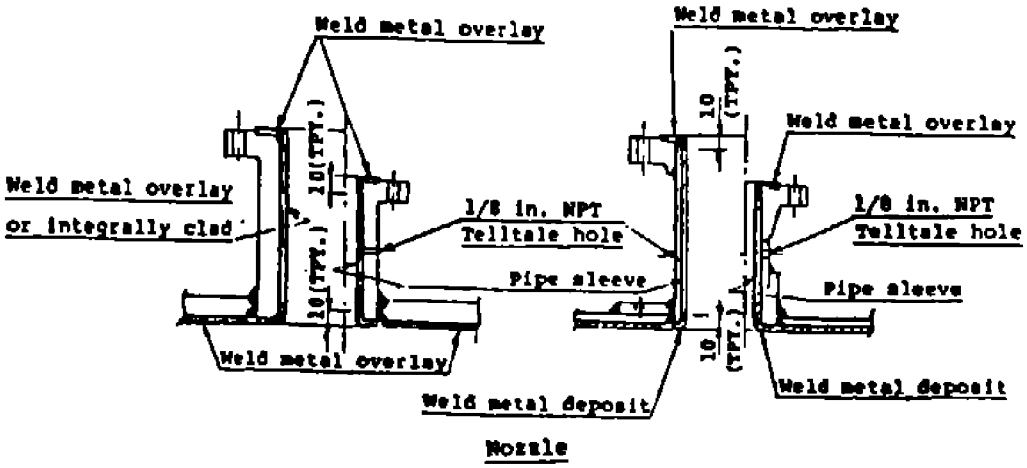
6.2.6.12 Lining for connections larger than DN 300 (12 in.) shall be selected on the basis of vessel design as follow:

a) For strip lined vessels: Strip lined, weld overlayed, or claded connections
b) For overlayed or claded vessels: overlayed, or clad connections

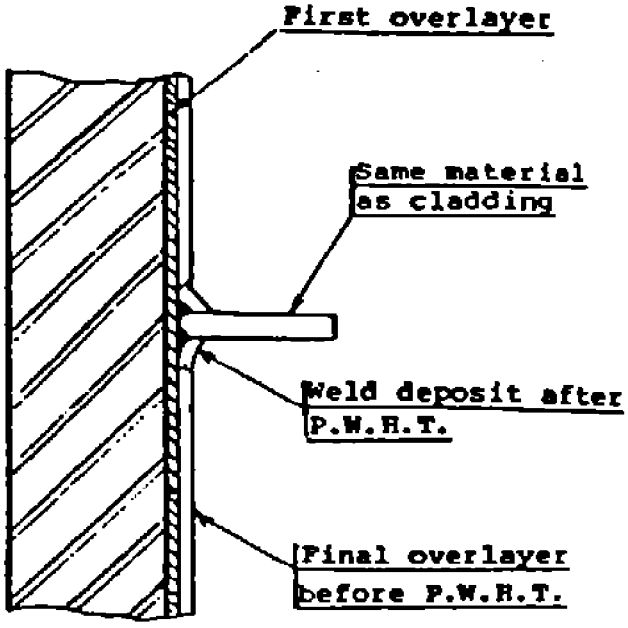
6.2.6.13 The flange facings and neck connection weld of shell to nozzles and manholes shall be lined with weld metal overlay cladding as shown in Fig. 3. (Flange face serration shall be devised).

6.2.6.14 Welding of internal support lugs and rings to be directly attached to the shell or head of special hydrogen service vessel shall be performed with full penetration prior to postweld heat treatment, and the final weld overlayer around the support lugs and rings shall be applied after postweld heat treatment, as shown in Fig. 4.





TYPICAL DETAIL OF LINED NOZZLES AND MANHOLES
Fig. 3



LINED DETAILS OF INTERNAL SUPPORT
Fig. 4

6.2.7 Shell and heads

6.2.7.1 The minimum shell thickness for vessels including corrosion allowance shall be as follows:

Shell Diameter	Shell Thickness
Up to 1525 mm	6 mm
1525 to 2125 mm	8 mm
2125 to 3625 mm	10 mm
3625 and larger	11 mm

The above minimum thicknesses are for the general stability of pressure and temperature requirements.

6.2.7.2 ASME 2 to 1 ellipsoidal or hemispherical heads shall be provided for design pressures exceeding 700 kPa(ga) ASME flanged and torispherical heads are not acceptable.

6.2.7.3 Conical transitions shall have a 6% knuckle radius when the design pressure exceeds 1700 kPa (ga) or design temperature exceeds 230°C.

6.2.7.4 Shell stiffening rings on vessels in vacuum service shall be installed externally and designed according to ASME Section VIII, Division 1, Paragraphs UG-28, UG-29 and UG-30.

6.2.8 Nozzles, flanges, manholes and connections

6.2.8.1 The minimum size of nozzles shall be DN 25 (1 in.) except that for alloy lined nozzles the minimum size shall be DN 40 (1½ in.). For vessels in hydrogen service all connections shall be flanged.

6.2.8.2 Nozzles in portions of vessels with gunite linings shall have internal projections such that the nozzle end is flush with the lining.

6.2.8.3 Nozzles shall be attached to the vessel by complete penetration welds. Partial penetration welding is acceptable for attachment of reinforcing pad plates.

6.2.8.4 Necks of nozzles and manholes shall be made of seamless pipe except for necks of DN 350 or more which can be made of plate materials. Where plate materials are used for nozzle and manhole necks, the method specified in ASTM A 672 shall be used.

6.2.8.5 Rolled plate nozzle necks and reinforcing pads shall be the same material as specified for the vessel shell and head to which they are attached.

6.2.8.6 All bolt holes in flanges on manways, hand holes and nozzles shall straddle the normal vessel center lines.

6.2.8.7 The thickness of nozzle neck shall not limit the maximum allowable working pressure.

6.2.8.8 Nozzle necks DN 25 shall be constructed of schedule 160 pipe, as a minimum. Nozzle necks DN 40 to DN 200 pipe size shall be a minimum of schedule 80 seamless pipe. Larger nozzle necks, shall be a minimum 12.7 mm.

6.2.8.9 For claded vessels, nozzles shall be claded or lined in accordance with paragraph 6.2.6.

6.2.8.10 Nozzles in vessels shall project a minimum of 150 mm from outside of shell or head on uninsulated vessels. On insulated vessels the nozzles should project a minimum of 150 mm from outside of shell or head plus thickness of insulation.

6.2.8.11 Flanges shall conform to ANSI B 16.5, "Pipe Flanges and Flanged Fittings".

6.2.8.12 Flanges larger than DN 600 shall be per API 605.

6.2.8.13 Non-Standard flanges shall be calculated per ASME Code section VIII, Division 1, Appendix 2 according to the design conditions of the vessels, and external loads imposed by piping reaction.

6.2.8.14 Welding neck flanges shall be used where the pressure-temperature design conditions require an ANSI class 300 or greater flange.

6.2.8.15 Slip-on flanges may be used for ANSI class 150 where the design temperature is under 260°C.

6.2.8.16 ANSI class 600 flanges and below shall be of the raised-face type with a serrated spiral finish. Flanges ANSI class 900 and above shall be ring-type joint. Ring-type joint facing shall be of the flat bottom groove type.

6.2.8.17 All vessels of 900 mm inside diameter or greater shall be provided with at least one 450 mm inside diameter manhole opening. Manholes providing access for removal of equipment shall not be less than 600 mm in diameter. Davits or hinges shall be provided for handling manhole covers.

6.2.8.18 Manways and nozzles shall not be located in longitudinal weld seam and insofar as it is practical, they shall avoid girth seams.

6.2.8.19 Handholes shall be a minimum of DN 150 nominal size and shall be preferably of the studded pad type and shall be provided with a bolted cover.

6.2.8.20 A vent of DN 150 minimum diameter must be provided at or near the top of the vessel on all vessels with manways. The vent may be another manway or flanged process nozzle which can be disconnected at the vessel. On horizontal vessels, the vent and manway shall be on opposite ends of the vessel.

6.2.8.21 Drain connections shall be flush with the bottom of the vessel. These and internal siphon drains shall, as a minimum, be schedule 160 pipe.

6.2.8.22 Threaded connections, if specified, shall be 6000 class ASTM A 105 forged steel couplings.

6.2.8.23 All nozzles over DN 40 mm shall be flanged connections of DN 40. Smaller nozzles on vessels may be provided with forged steel couplings. Couplings shall be ASTM A 105, 42000 kPa. (6000 psi). Such connections shall be limited to vessels with a design pressure of less than 4200 kPa (600 psig) and/or a design temperature not exceeding 343°C.

Couplings shall not be provided in lined portions of alloy-lined vessels and in bottom heads of vertical vessels.

6.2.9 Internals

6.2.9.1 The vessel fabricator shall furnish and install all internal attachments such as clips, lugs, and brackets.

6.2.9.2 Internal shell attachments such as deck support angles, lugs, clips, and seats shall be designed to be welded to the vessel shell or head by continuous fillet welds.

6.2.9.3 Removable piping and fitting internals shall be flanged for ease of removal.

6.2.9.4 All detachable internal parts shall have free access through manholes, or be divided into parts to enable them to pass through manholes.

6.2.9.5 All internal flange bolting shall be securely tightened, and the bolt heads and nuts shall be tack welded to prevent loosening.

6.2.9.6 Vortex breakers shall be provided on liquid bottom outlet nozzles from vessels as follows:

a) Pump suction connection.
b) Vessels where two phases may be present.

6.2.9.7 Impingement plates attached to shell or baffles shall be provided where severe erosion may occur, such as opposite inlet connections. These and all internal supports shall be attached with full fillet welds.

6.2.9.8 For designing wire mesh blanket supports, flow direction, pressure drop, weights of wire mesh proper and load of maintenance period shall be considered. The minimum numbers of support beam for wire mesh blanket shall be as follows:

a) Vessel inside diameter 1,200 - 2,500 mm : One support beam.
b) Vessel inside diameter over 2,500 mm : Two or more support beams.

6.2.10 Supports & external attachments

6.2.10.1 Horizontal pressure vessels supported on concrete or steel saddles shall be provided with corrosion plates between the saddle and the pressure vessel.

Corrosion plates shall be 6 mm thick and shall be continuously welded to shell of vessel. Corrosion plates shall have minimum of one 6 mm tell tale hole.

6.2.10.2 Vertical vessels shall be provided with skirts of the same outside diameter as the vessel shell. Skirts shall be 6 mm minimum thick, and shall be designed to withstand the combined stresses of dead load, live load, wind or earthquake load, whichever is the greater, and reactions of piping more than DN 300.

6.2.10.3 Vessel skirts shall have a manhole of DN 500 if piping is located inside the skirt.

Openings for piping connections to the bottom of the vessel shall be provided in the skirt as required. In addition, two DN 100 vent holes 180° apart shall be provided in the upper part of the skirt. Reference is made to standard drawing No. IPS-D-ME-010.

6.2.10.4 Skirt shall be provided with 12 mm thickness minimum base ring which shall include anchor bolt chairs.

Anchor bolts for skirts and saddles shall be a minimum of M20 and bolt holes shall be 22 mm. diameter minimum. Reference is made to standard drawing No. IPS-D-ME-017.

6.2.10.5 Skirts shall be of sufficient length so that the bottom of vessel head shall be minimum 450 mm from top of base ring.

6.2.10.6 Insulation support shall be furnished welded to vessel in shop and shall be spaced on 3.5 m. maximum centers for both blanket and block insulation.

6.2.10.7 Insulation support shall be skip welded to vessel shell and skirt, and shall be same width as insulation.

6.2.10.8 Vessels shall be provided with adequate lifting lugs or ears to facilitate handling. Where thin wall vessels are involved, load distribution and reinforcing pads shall be used with the lugs.

6.2.10.9 Lifting lugs shall be designed with a safety factor of 4 based on the static weight of vessel, including internals. Lugs on insulated vessels shall be long enough to allow sling hook-up after the insulation is installed. Lug holes if possible shall be drilled. Reference is made to standard drawings No. IPS-D-ME-001, 2, 3, 4.

6.2.10.10 If the vessel operating points are located higher than 2 meters above the deck, vessels shall be provided with ladders and platforms to facilitate access to the following equipment. The maximum lateral reach to the equipment shall not exceed 45 cm.

a) Safety and control valves
b) Controllers
c) Shutoff valves
d) Access openings and manways
e) Thermowells
f) Sample points

6.2.10.11 Support clips for ladders, platforms, and stairs shall be shop-welded to the vessel. If the vessel is to be stress relieved, the supports clips shall be welded prior to stress relieving.

6.2.10.12 Support clips on insulated vessels shall be long enough to allow for bolting beyond the insulation limits.

6.2.11 Gaskets & bolting *

6.2.11.1 Graphite with perforated or with flat stainless steel insertion are frequently used as an alternative for asbestos fibers.

6.2.11.2 Solid metal gasket shall be fully annealed and of one piece construction.

6.2.11.3 Spiral wound gaskets for raised-face flanges shall be per API Standard 601.

*** Note:**
Due to the health hazards concerned with the asbestos materials, therefore, wherever asbestos is specified, materials with equivalent characteristics may be used upon approval of the Company.

6.2.11.4 Bolting for vessel internals constructed of carbon steel shall be ASTM A193, Grade B6 bolts and ASTM A194, Grade 6 nuts, as a minimum. Bolting for vessel internals constructed of higher alloy material shall match the material that is being joined.

6.2.11.5 External bolting shall be continuous-thread alloy steel bolt studs in accordance with ASTM A193, Grade B7 for design temperatures less than 454°C (850°F) or ASTM A193, Grade B16, for design temperatures between 454°C (850°F) and 593°C (1100°F) and semi-finished hex nuts in accordance with ASTM A194, Gr. 2H.

6.2.11.6 Threads of bolts and nuts shall be of the course thread series in accordance with ANSI B1.1, Class 1A and 1B, respectively.

7. FABRICATION

7.1 General

7.1.1 Fabrication shall not begin until the fabricator has received written approval from the Company for the detailed drawings.

7.1.2 Intermediate heads shall be attached to the shell per ASME Code Section VIII, Division 1, Figure UW 13-1-(f) with fillet weld.

7.1.3 Anchor bolt holes of baseplate for vertical vessels shall be provided straddling the principal centerlines of the vessel.

7.1.4 The inner edge of manholes and nozzles shall conform to the vessel inside radius except for those exceeding DN 600 and be smooth without sharp edges.

7.1.5 All reinforcement plates shall be provided with a 6 mm NPT tell-taile hole which shall be left open.

Where a reinforcement plate consists of two or more plates welded together after being fit to the vessel, a test hole shall be provided for each sealed section of the plate.

7.1.6 Backing strips shall not be permitted without prior approval, by the Company.

7.1.7 All flange facing and threaded connections shall be protected against oxidation during heat treatment.

7.1.8 Before fabrication the manufacturer shall submit for approval by the Company a fully dimensioned drawing showing the pressure portions of the vessel and carrying the following information:

a) A statement that the vessel is to be constructed in accordance with this Standard.

b) Specification(s) with which materials shall comply.

c) Welding procedures with approved P.Q.R to be adopted for all parts of the vessel.

d) Large-scale dimensional details of the weld preparation for the longitudinal and circumferential seams, and details of the joints for branch pipes, seatings, etc., and the position of these seams and other openings.

e) Heat treatment procedure.

f) Non-destructive testing method.

g) Test plate requirements.

h) Design pressure(s) and temperature(s) and major structural loadings.

i) Test pressure(s).

j) Amount and location of corrosion allowance.

By agreement between the Company and the manufacturer, it is permissible to commence the manufacture of individual parts of the vessel before approval of the drawings of the complete vessel.

No modifications shall be made to the approved design drawing unless approved by the Company.

7.1.11 Material identification

The manufacturer shall maintain, to the satisfaction of the Inspecting Authority, a system of identification for the material used in fabrication in order that all material for pressure parts in the completed work can be traced to its origin. The system shall incorporate appropriate procedures for verifying the identity of material as received from the supplier via the material manufacturer's test certificates and/or appropriate acceptance tests. In laying out and cutting the material, the material identification mark shall be so located as to be clearly visible when the pressure part is completed.

Where the material identification mark is unavoidably cut out during manufacture of a pressure part, it shall be transferred by the pressure part manufacturer to another part of this component.

Batch No. of welding consumables shall be retained.

7.1.12 Order of completion of weld seams

Where any part of vessel is made in two or more courses, the longitudinal seams shall be completed before commencing the adjoining circumferential seam(s) and, where practicable, the longitudinal seams of adjacent courses shall be staggered.

7.1.13 Junction of more than two weld seams

Where meeting of more than two weld seams is unavoidable, then intermediate stress relief shall be applied.

7.2 Cutting, Forming and Tolerances

7.2.1 Cutting of material

7.2.1.1 Method

All material shall be cut to size and shape preferably by thermal cutting or machining. However, for plates less than 25 mm thick, it is permissible to use cold shearing provided that the cut edges are dressed back mechanically by not less than 1.5 mm to provide a suitable surface to permit a satisfactory examination of the edges prior to welding.

It is permissible for plates less than 10 mm thick, which are cold sheared, not to be dressed where the cut edges are to be subsequently welded.

Note:

Where preheat is specified for welding the type of material being cut by a thermal process, it may also be necessary to preheat during cutting.

Surfaces which have been thermally cut shall be dressed back by machining or grinding to remove severe notches, slag and scale. Slight oxidation of the cut edges of carbon steel and carbon manganese steel type steels produced by machine thermal cutting shall not be regarded as detrimental.

The cut edges of ferritic alloy steel, which are cut by a thermal process, shall be dressed back by grinding or machining for a distance of 1.5 mm unless the manufacturer can demonstrate to the satisfaction of the Inspecting Authority that the material has not been adversely affected by the cutting process.

7.2.1.2 Examination of cut edges

Before carrying out further work, cut surfaces and heat affected zones shall be examined for defects, including laminations, cracks and slag inclusions. Major defects shall be notified to the Company or his representative.

Any material damaged in the process of cutting to size and preparation of edges shall be removed by machining, grinding or chipping back to undamaged metal.

7.2.2 Forming of shell sections and plates

7.2.2.1 General

Prior to forming, a visual examination of all plates shall be carried out, followed by measurement of the thickness. As far as practicable, all hot and cold forming shall be done by machine; local heating or hammering shall not be used.

Heavy scale remaining after any hot forming operation shall be removed by a suitable descaling process which will not impair the quality of the material or have an adverse effect on the corrosion resistance of the exposed surfaces.

7.2.2.2 Plates welded prior to hot or cold forming

It is permissible to butt weld plates together prior to forming provided that the joint is non-destructively tested after forming by a method agreed between the Company and manufacturer.

Since welds in items subjected to hot forming temperatures, or normalized, will generally suffer significant strength reduction, the manufacturer shall ensure that the filler metal used will satisfy the weld joint design requirements after such heat treatment.

7.2.2.3 Cold forming

7.2.2.3.1 Ferritic steel

If the inside radius of curvature of a cold formed cylindrical pressure part is less than 10 times the thickness in the case of carbon and carbon manganese steels, or 18 times the thickness in the case of all other ferritic materials, an appropriate post forming heat treatment shall be applied to restore properties to levels which will ensure that the material properties are not significantly altered from those assumed in design.

All ends which have been cold formed shall be heat treated for the same purpose unless the manufacturer demonstrates that the cold formed properties are adequate and the material properties are not significantly altered from those assumed in design.

7.2.2.3.2 Austenitic steel

Austenitic steel which has been cold formed shall subsequently be softended (as described in 7.2.2.4.2) and descaled unless:

a) The thickness is less than 10 mm; or
b) The Company has agreed with the manufacturer that the extent of cold forming does not necessitate heat treatment.

7.2.2.4 Hot forming

7.2.2.4.1 Ferritic steel

Forming procedures involving plate heating shall be agreed between the Company and the manufacturer.

The forming procedure shall specify the plate heating rate, the holding temperature, the temperature range and time in which the forming takes place and shall give details of any heat treatment to be given to the formed part. When required by the Company or Inspecting Authority the manufacturer shall provide data to support his procedure.

7.2.2.4.2 Austenitic steel

Austenitic steel plates to be heated for hot working shall be heated uniformly in a neutral or oxidizing atmosphere without flame impingement, to a temperature not exceeding the recommended hot working temperature of the material. Deformation shall not be carried out after the temperature of the materials has fallen below 900°C. Local heating shall not be applied.

After hot working is completed the material shall be heated to the agreed softening temperature for a period not less than 30 min. The softening temperatures and period for warm worked, high proof material shall be agreed between the Company and the manufacturer. After softening, the surface shall be descaled.

7.2.2.5 Manufacture of shell plates and ends

Shell plates shall be formed to the correct contour to ensure compliance with tolerances specified in the applicable code.

Where practicable, head plates and ends shall be made from one plate. Dishing and peripheral flanging of end plates shall be done by machine, flanging preferably being done in one operation. Sectional flanging is permitted provided that it is agreed between the Company and the manufacturer. The flanges shall be cylindrical, of good surface and free from irregularities.

7.2.2.6 Examination of formed plates

All plates, after being formed and before carrying out further work upon them, shall be examined visually and checked for thickness and any injurious defect.

7.3 Welding

7.3.1 Qualification for welding procedures and welders shall be in accordance with the requirements of ASME Code Section IX.

7.3.2 All welding shall be done by Shielded Metal-Arc welding (SMAW) or submerged Arc welding (SAW) processes. Gas metal Arc welding (GMAW) shall be limited to the root pass only and limited to the flat position. Oxy-acetylene or forge welding is not acceptable.

7.3.3 Welding by the SAW processes shall be performed only by fully-automatic or semi-automatic equipment.

7.3.4 Welding electrodes shall be of AWS approved quality or equivalent. Welding materials for use with carbon steels shall be "low-hydrogen" types.

7.3.5 Alloy elements containing flux powder for submerged arc automatic and semi-automatic welding techniques may be employed, provided that the flux shall be new (Reused Flux is not permitted).

7.3.6 All welding shall be completed prior to final heat treatment.

7.3.7 A carbon equivalent shall be determined for all materials to be welded by using the following equation.

$$\textbf{Carbon equivalent} = \textbf{percent carbon} + \frac{\textbf{percent manganese}}{4}$$

Carbon content (C): $C \leq 0.25\%$

Carbon equivalent (C eq.): $C\ eq. \leq 0.45\%$

7.3.8 Welding electrodes, wires and fluxes shall be shipped, stored and used in accordance with the manufacturer's recommended practices. Damaged or non-traceable consumables shall not be used.

7.3.9 All welding of pressure parts shall conform to the requirements, of Section VIII, Division 1 and Section IX. of ASME Code.

7.3.10 All longitudinal and circumferential seams in shells and all seams in heads shall be full penetration double butt welds of the "V" or "U" type. Lap welds are not permitted. Joints that are not accessible for double welding may be single butt-welded with full penetration.

7.3.11 Adjacent longitudinal seams shall be staggered so as to give a minimum of 60° orientation between seams. Shell seams shall be located away from long internal attachment welds.

7.3.12 Skirt and other attachment welds shall have complete fusion for the full length of the weld and shall be within permissible limits undercut, overlap, abrupt ridges or valleys.

7.4 Welding Electrodes

Welding electrodes for cladded materials shall be used as shown in Table 3.

TABLE 3 - WELDING ELECTRODES FOR CLADDED MATERIALS

ASME/ASTM Spec. SA263	Cladding Material	AWS-Welding Electrode Specifications *	
		Weld to Base Metal	Weld to Cladding Metal
SA 264	Type 405 or 410S	E 310 - xx or E 309 - xx	E 310 - xx or E 309 - xx
	Type 304		E 308 - xx
	Type 304 L		E 308 L - xx
	Type 316 Type 316 L	E 310 - Mo - xx or E 309 - Mo - xx	E 316 - xx
			E 316 L - xx
	Type 321 or 347	E 310 - xx or E 309 - xx	E 347 - xx
SA 265	UNS 04400 (Ni-Cu Alloy)	E Ni Cu - 7	E Ni Cu - 7
B 432	UNS C 70600 UNS C 72200 UNS C 71500 (Cu-Ni Alloy)	E Ni Cu - 7 or E Ni - 1	E Ni Cu - 7 or E Cu Ni

*** Note:**

AWS electrode designation xx are 15 or 16. The equivalent grade of AWS specifications may be used.

7.5 Clad Disbonding Prevention

Preventives of weld metal overlay clad disbonding, which may occur during operation of the "Special Hydrogen Service" vessel, shall be provided in the vessel fabrication.

7.6 Preheating

7.6.1 The manufacturer shall state the proposed preheat temperature to avoid hard zone cracking in the heat affected zone, for each type of weld including those for all attachments and tack welds. No welding shall be carried out when the temperature of the parent metal within 200 mm of the joint is less than 5°C. Austenitic steels do not require preheat for welding.

7.6.2 Where preheat is specified welding shall continue without interruption. If, however, continuity is affected, preheat shall be maintained or the joint shall be slowly cooled under an insulation blanket. Before recommencing welding preheat shall be applied.

7.6.3 The preheat area shall be at least 200 mm wide, where possible, centered about the weld and shall extend around the entire circumference.

7.7 Post-Weld Heat Treatment (PWHT)

7.7.1 Welded vessels shall be stress relieved if required by the ASME Code and with regards to the following:

a) Vessels subject to stress corrosion
b) Vessels with unusual configurations
c) Vessels in which high stresses may develop in the welds because of restraint

7.7.2 Flange facings shall be protected against oxidation during heat treatment.

7.7.3 Where post-weld heat treatment is required because of process or service condition, the temperature range and the holding time shall be as specified by the Company.

7.8 Tolerances

7.8.1 General

As a general rule, the limits of dimensional acceptability will be defined by the tolerances specified in this Standard.

For vessels fabricated from pipe, the diameter and out-of roundness tolerances shall be in accordance with relevant ASME Code specification.

7.8.2 Shell tolerances

7.8.2.1 Tolerances for vessels under external pressure shall be as specified in ASME Code Section VIII, Division I.

7.8.2.2 Tolerances for vessels subject to internal pressure shall be as follow:

a) Tolerances for inside nominal shell diameter as measured by external strapping shall be as shown in the following table:

NOMINAL I.D. mm	< 1200	> 1200 TO 2100	> 2100 TO 4800	> 4800
TOLERANCE mm	3	5	6	8

b) Circularity (out-of-roundness)

The difference between the maximum and minimum internal diameters shall be in accordance with the following table:

NOMINAL INTERNAL DIAMETER OF VESSEL mm	DIFFERENCE BETWEEN MAXIMUM AND MINIMUM INTERNAL DIAMETERS
To 800 incl.	0.8% of nominal internal diameter
Over 800 to 3000	0.5% of nominal internal diameter
Over 3000 to 5000	20 mm or 0.5% of nominal internal diameter, whichever is the smaller
Over 5000	25 mm or 0.4% of nominal internal diameter, whichever is the smaller

7.8.3 Straightness

The maximum deviation measured at the outside surface of the cylindrical parent plate from a straight line parallel to the vessel axis shall not exceed 1 mm per 1000 mm shell length, with a maximum of 25 mm.

7.8.4 Length

Tolerance on overall length measured between the tangent lines shall be in accordance with the following table:

LENGTH mm	TOLERANCE mm
Up to 1000 incl.	±2.0
Over 1000 to 4000	±4.0
Over 4000 to 10000	±8.0
Over 10000 and all vessels having a wall thickness over 70 mm	±13.0

Note:

Tangent lines to be punch-marked on the dished heads, both externally and internally at the intersection of knuckle with the cylindrical section.

7.8.5 Tolerance for formed heads

Tolerances for formed heads shall be as specified in the ASME, Section VIII, Division I.

7.8.6 Attachments

Tolerances for attachments are given below. The alphabetical coding is explained in Fig. 1.

Nozzles in Shells and Domed Ends (except for nozzles for level instruments):

a) Position

Measured from tangent line, ±6 mm.

b) Projection

For nozzles on shell measured from shell curvature, and for nozzles on domes measured from tangent line, ±6 mm.

c) Alignment

Of nozzle flange face with the indicated plane, maximum ½ degree in any direction.

d) Radial orientation

Measured from reference center line to center line of nozzle, ±1 degree with a maximum circumferential tolerance of 15 mm.

e) Bolt hole orientation

Maximum rotation 1.5 mm measured at bolt circle.

Note:

Bolt holes to straddle center lines, if not indicated otherwise.

f) Deviation of nozzle center line in head

Not to exceed 3 mm.

Note:

Stacked heat exchangers.

Nozzles and supports for stacked heat exchangers shall be checked for correct alignment during fabrication-due allowance being made for the gaskets specified.

Nozzles for Level Instruments:

g) Distance

measured from center to center ±1.5 mm.

h) Projection difference

for each pair of flanges, measured from shell curvature 1.0 mm.

i) Alignment

of nozzle flange face with the indicated plane maximum ¼ degree in any direction. Further tolerances for level instrument nozzle shall be in accordance with 7.8.6 a, b and e.

Manholes:

j) Position

Measured from bottom tangent line ±12 mm. Further tolerances for manholes shall be in accordance with 7.8.6 d and e.

k) Height

Measured from shell curvature ±12 mm.

l) Alignment

Of flange face maximum l degree in any direction.

Vessel Supports:

m) Support height

DISTANCE FROM LOWER TANGENT LINE TO BASE OR SUPPORT mm	TOLERANCE mm
To 1000 incl. Over 1000 to 4000 Over 4000 to 10000	±2.0 ±4.0 ±8.0

n) Base ring or support out of levelness

0.2% of nominal diameter with a maximum of 12 mm.

p) Foundation bolt pitch circle

±3 mm, for ID of vessel < 2100 mm.
±6 mm, for ID of vessel ≥ 2100 mm.

q) Distance between legs (horizontal vessel)

Max. ±3 mm.

r) Height of leg (horizontal vessel)

Max. ±5 mm.

Tray Supports:

s) Tray support ring levelness

Measured as greatest difference all around, tolerance 0.15% of the outside tray diameter, with a maximum of 4 mm.

t) Tray support ring position

Distance of tray support ring to lower tangent line ±6 mm.

u) Distance between two adjacent tray support rings

And from tray support ring to center of adjacent nozzle or instrument connection ±3 mm, except for the distance of a draw-off tray support ring to the center of the corresponding nozzle, for which the maximum tolerance is ±2 mm.

v) Distance of vertical downcomer plate to vessel axis

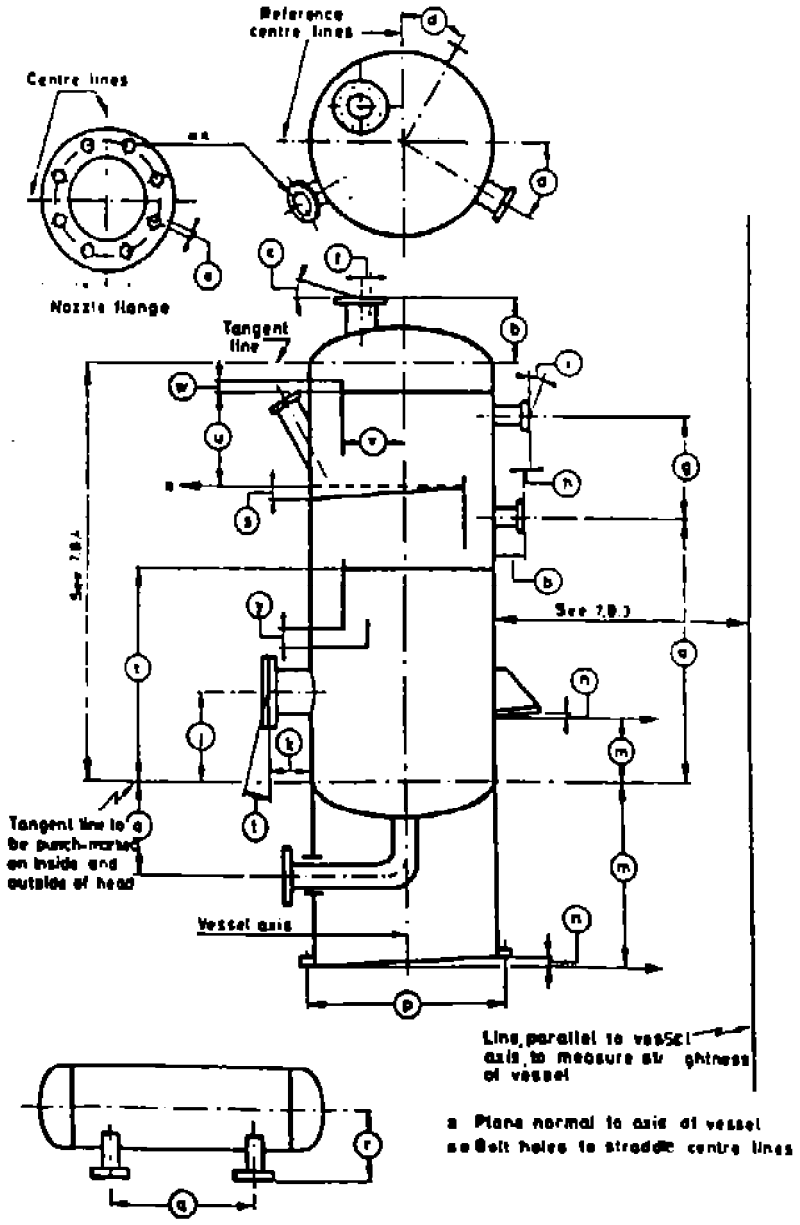
Maximum ±3 mm.

w) Height of fixed weir above tray support ring

Maximum ±3 mm.

y) Distance from downcomer bottom to tray support

Maximum ±3 mm.



NUMBERING CODE
Fig. 1

8. INSPECTION AND TESTING

8.1 General

8.1.1 The term inspector, as used in this Standard, refers to the inspector assigned by the Company.

8.1.2 Manufacturer's data reports shall be made available to the inspector at the time of inspection.

8.1.3 When the code symbol stamping is not required to the vessels, the items of inspection and testing which are designated to be performed by the manufacturer in the code are considered as the same as the case of the code symbol stamping.

8.1.4 An inspection and testing plan shall be prepared in accordance with the test descriptions described in this specification. The fabricator shall notify the Company representative at least 10 working days prior to the start of fabrication and to the scheduled time of each test to be conducted.

8.1.5 The responsibility for inspection of the vessel in accordance with the ASME code rests with the fabricator. The Company representative will inspect the vessels at any time during fabrication to ensure that the vessel materials and workmanship are in accordance with this specification and the ASME code.

8.1.6 All reinforcing pads or each segment thereof shall be air tested to 345 kPa (50 psig) prior to postweld heat treating and/or hydrostatic testing. All welds shall be inspected inside and outside during the test. Test holes shall be open during the hydrostatic test and plugged with a nonhardening sealant or heavy grease after the hydrostatic test.

8.1.7 All covers, gaskets, bolting, apparatus and tools for inspection and testing shall be prepared by the manufacturer.

8.2 Material Inspection

8.2.1 The material inspection shall be conducted to confirm the material certificates or mill test reports of pressure retaining parts.

8.2.2 Where hydrogen or wet H_2S service is specified, all plate materials to be used for pressure retaining portion shall be subjected to an ultrasonic examination. The method and acceptance criteria of ultrasonic examination for the plates material to be used for the vessels shall be in accordance with ASTM Standard Specification A 578, acceptance "level 1".

8.2.3 Heat treated materials

Specimens for testing shall be prepared from actual vessel material which has been subjected to an equivalent total thermal treatment as the vessel material in the final fabricated condition.

8.3 Welding Inspection

8.3.1 Radiographic examination

8.3.1.1 100% radiography according to ASME code Section VIII, Division 1, Paragraph UW-51, or Division 2, Article L-5 is required for vessels with shell thickness greater than 50 mm. Spot radiography shall be applied for thicknesses of 50 mm. and lower upon approval of the Company.

8.3.1.2 The radiographic examination shall be carried out before postweld heat treatment, except when the code specifies that examination is to be performed after heat treatment.

8.3.1.3 Skirt butt welds shall be inspected as follows:

a) Finished weld shall be inspected by spot radiography.

b) At least one radiograph shall be made for every two girth seams, and one for every two vertical seams, at locations selected by the inspector. At least two radiographs shall be taken of each welder’s work.

c) In lieu of spot radiography, magnetic particle examination shall be used on any back gouged area prior to rewelding and on the OD and ID cover pass.

8.3.1.4 Radiographs shall have a density between 2.0 and 3.0 high definition, high contrast film shall be used. Fluorescent intensifying screen shall not be used.

8.3.1.5 If a weld is to be subjected to forming operations, as might occur in a welded head, radiographic examination shall be performed after forming.

8.3.1.6 According to ASME Code if the radiographs show unacceptable defects, the defective welding shall be cut out and rewelded.

8.3.2 Ultrasonic examination

Where ulterasonic examination is specified, it shall be carried out before postweld heat treatment where this is to be conducted, except when the code specifies that the examination is performed after heat treatment. The portion of the examination may be specified by the inspector at the shop.

8.3.3 Magnetic particle examination (MT) and liquid penetrant examination (PT)

8.3.3.1 Magnetic particle examination and acceptance criteria shall be per ASME code Section VIII, Division 1, Appendix 6. The D-C prod method shall be used prior to final postweld heat treatment, and the a.c. yoke or coil method after final postweld heat treatment.

8.3.3.2 Magnetic particle examination of welds shall include a bond of base metal at least 25 mm wide on each side of the welds.

8.3.3.3 Liquid penetrant examination of welds shall include a bond of base metal at least 25 mm wide on each side of the weld.

8.3.3.4 Fillet welds on intermediate heads shall be given a magnetic particle or liquid penetrant examination after hydrostatic testing.

8.3.3.5 Except for austenitic stainless steel and nickel steels, material having either:

a) A minimum specified tensile strength of 550 MPa (80,000 psi) or greater, or
b) A total nominal alloy content greater than 4%:

Shall have all attachment welds and all areas fitup bars etc. Were temporarily attached examined by magnetic particle techniques before final PWHT and after hydrostatic testing.

8.3.4 Hardness test

8.3.4.1 For wet H_2S, caustic or amine service, the hardness of weld seams including heat affected zones of the joint categories A, B, C and D [only for butt joints where the connection is DN 50 mm (NPS 2) or larger] per ASME Code shall be tested.

8.3.4.2 The hardness test shall be made against the weldments of each welding procedure per vessel.

8.3.4.3 The hardness test locations shall be designated by the inspector.

8.3.4.4 The location to be hardness tested shall be flushed smoothly.

8.3.4.5 Hardness of hot formed sections, base metal, weld metal and the related heat affected zone (HAZ) of all welds shall not exceed the limits given below:

MATERIAL P-NUMBER	BRINELL HARDNESS
P-1	225
P-3, P-4	225
P-5, P-6, P-7	235
P-10	225

8.4 Inspection and Testing Records

The manufacturer's inspection and testing records shall be prepared in accordance with Table 5 and the following data shall be submitted in the forms as given in the Appendices of this Standard.

a) Dimensional inspection records (Consisting of two (2) sheets)-Appendix "D".
b) Radiographic examination record-Appendix "E".
c) Ultrasonic examination record-Appendix "F".
d) Magnetic particle examination record-Appendix"G".
e) Liquid penetrant examination record-Appendix "H".

8.5 Scope of Inspection and Testing

In general, the items of inspection and testing and/or verification of the records at the manufacturer's shop shall be as shown in Table 4.

TABLE 4 - SCOPE OF INSPECTION AND TESTING

INSPECTION AND TESTING ITEMS	DIVISION OF WORK		REMARKS
	C	MFR	
1. Welding Qualification			
1.1 Confirmation of procedure qualification record	R	S	
1.2 Welding procedure qualification test	R	Tr & S	Before fabrication
1.3 Welding performance qualification test	R	Tr & S	
1.4 Confirmation of qualified welder's list	R	S	
2. Material Inspection			
2.1 Verification of material certificate mill test report	R	Tr & S	
2.2 Non-Destructive examination	R	Tr & S	
3. Component Inspection			
3.1 Inspection of jig plate and anchor bolts	W	Tr	
3.2 Inspection of expansion joint	R	Tr	
3.3 Inspection of formed head and cone	R	Tr & S	
4. Inspection Of Welding Edge Preparation			
4.1 Magnetic particle or liquid penetrant examination	R	Tr & S	Back gouged portion of double groove joint
4.2 Fit-Up inspection	R	Tr	
5. Welding Inspection			
5.1 Visual inspection for weldment	W	T	Verifying the films
5.2 Radiographic examination	W/R	Tr & S	
5.3 Magnetic particle examination	W/R	Tr & S	
5.4 Liquid penetrant examination	W/R	Tr & S	
5.5 Ultrasonic examination	W/R	Tr & S	
5.6 Hardness test	W/R	Tr & S	
5.7 Confirmation of heat treatment	R	Tr & S	
6. Inspection For Completed Vessel			
6.1 Overall dimensional inspection	W/R	Tr & S	
6.2 Inspection of completed surface	W	T	
6.3 Inspection of internal parts and tray assembly	W	Tr	As built
6.4 Confirmation of material identification marks on vessel	R	Tr & S	Sketch or material locations and heat number of material
6.5 Pressure test	W/R	Tr & S	
6.6 Leak test for opening reinforcing pad	R	Tr & S	
7. Confirmation Of Accessories	R	Tr & S	List of accessories or a copy of accessories packing list

Abbreviations:

MFR : The manufacturer
R : Verify by reviewing the manufacturer's inspection/test record
W : Witness inspection/testing
Tr : Manufacturer's own inspection/testing with the record to be prepared
T : Manufacturer's own inspection/testing
S : Submission of manufacturer's inspection/testing record
C : Company

8.6 Hydrostatic Testing

8.6.1 After fabrication of the vessel is completed and the vessel stress relieved, a hydrostatic test shall be conducted as per ASME Code.

8.6.2 All hydrostatic tests shall be made in the presence of an authorized ASME Code inspector or at the discretion of purchaser, the Company representation. Vessels shall not have been previously tested by the fabricator.

8.6.3 Horizontal vessels shall be supported on the saddle supports during hydrostatic testing.

8.6.4 The minimum test water temperature and metal temperature shall be 10°C. If the design temperature is below 10°C, the minimum water temperature may be equal to the design temperature.

8.6.5 After the final hydrostatic test, vessel shall be drained and dried completely.

8.6.6 Vessel with solid or lined austenitic stainless components shall have test water with a chloride content not exceeding 150 ppm.

8.6.7 The test pressure shall be held not less than 30 minutes.

8.6.8 Pneumatic test for vessels partially or completely filled with air may be performed with prior approval.

8.6.9 No abnormal deformation or leak of test medium shall be acceptable.

9. PREPARATION FOR SHIPMENT

9.1 Cleaning and Blanking

Vessel shall be free of loose scale, dirt and foreign material. Liquid used for testing or cleaning shall be completely drained. Vessel openings shall be blanked.

High alloy vessels shall be blown dry with air, and all nozzle, manhole, vent and connection openings shall be blanked, plugged or capped to prevent the entry of moisture.

9.2 Machined or threaded exterior surfaces of carbon steel, and ferrous alloys with a nominal chemistry of 12 Cr and below, shall be protected from corrosion during shipment and subsequent storage by coating with a rust preventive of a type :

1) To provide protection during outdoor storage for a period of twelve months exposed to a normal industrial environment, and

2) to be removable with mineral spirits or any stoddard solvent.

9.3 Protection From Salt Water

Austenitic stainless steels used in vessels shall not be exposed to wetting by salt water or salt spray. Protective coating or coverings used to prevent such exposure shall be approved by the Company.

9.4 Temporary supports in contact with high alloy vessels, for shipping and storage, shall not be of a moisture retaining material such as raw wood.

9.5 Paint and Protection

9.5.1 Painting requirements shall be as specified in the purchase order or in accordance with IPS-E-TP-100.

The entire vessel (including inside of the skirt, outside of the bottom head, entire base ring, and all skirt attachments) shall be primed and/or painted. Nozzles shall be painted on the flange edges, inside bolt holes, and up to the gasket surface. Prior to shipping, vessel shall be internally purged with pressurized inert gas.

9.5.2 Exposed edges of shells shipped in 2 or more pieces shall be protected by welding ring angles extending beyond the edges.

9.5.3 Each loose piece or assembly shall be properly protected to prevent damage during normal shipping and handling.

9.6 Marking

9.6.1 All parts shall be marked for identification and preparation for shipment.

9.6.2 Each removable piece of equipment that will be shipped separately from the vessel shall be identified with a metal tag. The tag shall be securely wired to each item with stainless steel wire.

The identification tag shall be metal die stamped with the item number, platform number, piece number, and total number of pieces. The identification tag shall include the vessel tag number to which each piece corresponds.

10. GUARANTEE

10.1 The Vendor shall guarantee the vessel against defective workmanship and improper mechanical and process design for one year after placement in the specified service.

10.2 The Vendor, without charge, shall repair or replace any parts having defects or improper workmanship within the guarantee period.

PART II
TRAYS AND TOWER INTERNALS

1. SCOPE

1.1 This Standard covers the minimum requirements for design, materials, fabrication, inspection, testing, and preparation for shipment of trays and other internals of vessel, together with tower internals specification sheet and some Standard drawings.

1.2 Internals for fixed or fluid bed reactors are not covered in this Part of the Standard.

1.3 This Standard specification supplements the basic requirements given in Part I of this Standard "Material and Engineering Standard for Towers and Pressure Vessels".

2. MATERIALS

2.1 Materials of construction shall be as specified on data sheet, or purchase order.

Vendors proposals to use materials, or thicknesses alternative to those specified shall be submitted to purchaser for approval.

2.2 Where tray material is specified to be stainless steel, tray plate and valve parts shall be of the same material.

2.3 Free machining grades of steel are not permitted, except that Type 416 nuts furnished to ASTM A 194 Gr 6F with Selenium are acceptable for use with ASTM A 193 B6 bolts.

2.4 Acceptable grades and specifications for a number of standard internal materials are as follows:

2.4.1 Ferritic stainless steel assemblies

2.4.1.1 The sheet and plate materials shall be in accordance with ASTM A 240 Type 410S or 405 stainless steel with No. 1 finish quality or equivalent.

2.4.1.2 Support rings, downcomer bars and other parts welded to the vessel wall shall be carbon steel in accordance with ASTM A 283-C or equivalent, unless where alloy steel material is specified and/or shall have the design temperature of 343°C (650°F) and higher in which case, they shall be of the same material as the vessel wall.

2.4.1.3 The bolting material shall be type 410 stainless steel which comforms to ASTM A 193 Gr. B6 and the nuts shall be ASTM A 194 Gr. 6 or equivalent.

2.4.2 Monel assemblies

2.4.2.1 All sheet and plates material shall be hot rolled annealed and pickled weldable Monel in accordance with ASTM B-127.

2.4.2.2 Support rings and downcomer bars and other parts welded to the vessel shall be in accordance with 2.4.2.1.

2.4.2.3 All bolting material shall be Monel.

2.4.3 Austenitic stainless steel assemblies

2.4.3.1 The sheet and plate materials shall be in accordance with ASTM A 240 Type 304 stainless steel with No. 1 finish or equivalent.

2.4.3.2 Support rings, downcomer bars and other parts welded to the vessel wall shall be carbon steel, in accordance with ASTM A 283-C or equivalent, unless where alloy steel material is specified and/or design temperature is 343°C (650°F) or higher. In case of the above, they shall be of the same material as the vessel wall.

2.4.3.3 The bolting material shall be type 304 stainless steel which conforms to ASTM A 193 Gr. B8 and nuts shall be A 194 Gr. 8.

2.4.4 Carbon steel assemblies

2.4.4.1 The plate and bar materials shall be in accordance with ASTM A 283-C or equivalent. The sheet and strip material shall be commercial grade carbon steel, except for vessel design temperatures 343°C (650°F) or higher.

2.4.4.2 For vessel design temperatures 343°C (650°F) or higher, the plate and bar materials shall be of the same material as the vessel wall.

2.4.4.3 The bolting material shall be same as in Paragraph 2.4.1.3.

2.5 Gaskets

2.5.1 Minimum size of asbestos gasket shall be 1.6 mm in thickness and 25 mm in width.

2.5.2 Asbestos washers shall be white millboard.

2.5.3 The Vendor may propose the use of alternate materials. Such alternates shall be clearly indicated in the Vendor's proposal giving the official material designation or its chemical and physical properties.

However, the Vendor shall obtain written approval of the Company for using equivalent and/or alternate materials.

2.6 Washers

All bolting shall be provided with washer having the same quality as that of the bolts and nuts.

3. DESIGN

3.1 General

3.1.1 All internal assemblies shall be designed to take into consideration the corrosion problems (including galvanic and S.C.C.) and the differential strain.

3.1.2 Trays for vessels less than 800 mm in diameter shall be of the cartridge type.

3.1.3 Design of trays must ensure that the setting can not be loosened by vibration.

3.2 Loads and Stresses

3.2.1 Design loads

Trays, pans, draw-off boxes, or similar internals, shall be designed using a corroded thickness of 1.5 mm to support their own weight plus the following live loads at design temperatures:

a) Fractionating trays

Design live load shall be the greater of 98 kg/m² or the weight of water 50 mm over the highest weir setting. At normal operating tray loadings, the deviation from the horizontal shall not exceed 1/900 of the tower diameter.

b) Areas under downcomers

Design live load shall be the greater of 314 kg/m² or a head of water one half of the height of the downcomer.

3.2.2 For maintenance purposes, all assemblies shall be designed for a concentrated load of 135 kg at any point and at ambient temperature.

3.2.3 Allowable stress

The allowable stresses of all structural materials shall be as given in ASME Code Section VIII "Pressure Vessel", Division 1.

In the case of stress corrosion cracking, the allowable stress shall be reduced to ½ of the allowable stress in the ASME code.

3.3 Tray Support

3.3.1 General

Where support beams or other materials are bolted to the column wall, slotted holes shall be provided. The location of these holes shall be determined by the tray manufacturer. Trays shall be fastened to support rings and beams in such a way that they can be easily mounted and dismounted.

3.3.2 Rings

Stacked trays shall be installed in columns with a nominal diameter of up to 800 mm.

For columns with a nominal diameter of 800 mm and larger, tray support rings shall be welded to the column wall. For tray support rings, reference is made to Appendix N of this Standard.

3.4 Corrosion Allowance

3.4.1 The corrosion allowance for all surface of floors, beams trusses or other support members of carbon steel assemblies shall be one-fourth (¼) of the specified corrosion allowance of the vessel wall.

3.4.2 For support rings, etc., directly welded to the vessel wall, one-half (½) of the corrosion allowance of the vessel wall shall be provided on both sides.

3.5 Thickness of Tray

3.5.1 Minimum thickness of stainless steel trays shall be as follows:

Tray floors	: 1.5 mm
Caps	: 1.5 mm
Support rings	: 6 mm for alloy steel
Downcomer bars	: 6 mm for alloy steel
Parts welded to vessel	: 6 mm for carbon steel
All other tray parts	: 2.0 mm

3.5.2 Minimum thickness of carbon steel trays shall be as follows:

Tray floor	: 1.5 mm
Long caps	: 2.0 mm
Round caps	: 3.6 mm
Support rings	: 9.0 mm
Downcomer bars	: 9.0 mm
Parts welded to vessel	: 9.0 mm
Floor plates for sieve and dual flow trays	: 2.0 mm
Beams	: 2.0 mm
All other tray parts	: 3.6 mm

3.6 Bolts and Nuts

3.6.1 The minimum size of bolting shall be 9 mm (3/8 in.) in diameter.

3.6.2 Thread of bolts and nuts shall conform to ANSI B 1.1 and thread series employed shall be UNC for all sizes.

3.6.3 Nuts shall conform to ANSI B 18.2.2 "Heavy Hex Nut"; however, "Heavy Hex Jam Nut" shall be employed as specified.

3.6.4 Thread tolerance class of bolts and nuts shall conform to ANSI Standard Class 1 A and 1 B.

3.7 Tray Manways and Access

3.7.1 Access through trays shall be provided as follows:

a) All trays of 1050 mm in diameter and larger shall be equipped with manways.
b) All trays smaller than 1050 mm in diameter shall be either split or equipped with manways.
c) Trays having 2 or more liquid passes shall contain manways on each pass.

3.7.2 Tray manways shall be as follow:

a) Tray manways shall provide a minimum rectangular opening of 380 × 460 mm .If necessary, a 330 × 560 mm rectangular opening can be used.

b) If opening under or through major support beams is less than those in sub paragraph a, tray manways shall be installed on both sides of the beam.

c) Tray manways shall not form a part of the downcomer seal area.

d) Tray manways shall be vertically aligned, unless otherwise specified.

e) Tray manways (or tray sections used in lieu of manways in towers of 1050 mm in diameter or smaller) shall be removable from both above and below the tray.

4. FABRICATION

4.1 General

4.1.1 All parts of tray shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be interchangeable.

4.1.2 Support rings, downcomer bars and beam support brackets in the vessel shall be seal-welded on the top or one side and intermittent welded with 25 mm welds at 150 mm centers on the other side when made of carbon steel, or seal welded both sides when made of alloy. Brackets shall be continuously welded all around.

4.2 Tolerances

4.2.1 Tolerances of vessel tray for fabrication and assembly shall be as shown in Appendix L.

4.2.2 The tray supports welded to inside of vessel shell, shall maintain the tolerances specified by tray fabricator.

4.3 Gaskets and Packing

4.3.1 Downcomers

Gaskets and packing may be used to install downcomers on all tray types, but shall not be used in areas under downcomers, except for towers of 900 mm in diameter or smaller. Overlapping joints for downcomers and all openinings for support beams passing through downcomers shall be sealed so that no vapor bypassing will occur.

4.3.2 Jet, sieve, or valve trays

Gaskets and packing shall not be used between tray decks and support rings or beams when installing jet, sieve, or valve trays.

4.4 Surface Finishing

The surfaces and edges shall be finished as follows:

a) Surfaces of fabricated parts shall be smooth and free of dents, hammer marks, kinks, or other defects, particularly in locations which might prevent close metal-to-metal fit.

b) Edges of all surfaces shall be free of burrs.

c) Edges of tray accessways shall be bevelled or rounded for safety.

4.5 Welding

4.5.1 All welding shall be done by metal-arc process. Gas or carbon-arc welding shall not be permitted.

4.5.2 Welds shall be smooth and free from slag and spatter.

4.5.3 Welding electrodes of a composition similar to tray material shall be used, except that austenitic electrodes of higher chromium and nickel (E-309 or E-310) may be used for 13 Cr. and 18/8 stainless steel.

4.5.4 Where wet H_2S service is specified. Weld hardness verification is required for internals joined, or attached, by welding. Hardness of the base metal, the weld metal and the related Heat Affected Zone (HAZ) of all welds shall not exceed the limits given below:

These tests shall be made with a vicker Testing Machine. A portable hardness tester may be used.

MATERIAL P-NUMBER	VICKERS HARDNESS
P-1 [1)]	237
P-3, P-4	237
P-5, P-6, P-7	247
P-10	237

Note:

1) Base metal hardness tests are not required on P-1 material.

The vessel fabricator shall check the weld hardness of the initial production weld for each welding process, filler metal, and technique used. If the clearances are such that it is not possible to check the production weld, a make-up with identical conditions shall be used.

4.6 Marking

4.6.1 All internals shall be clearly marked with corresponding markings provided on assembly drawings to permit rapid assembly.

4.6.2 All parts shall be marked with the part number shown on the drawings. Painting is an acceptable method of marking.

4.6.3 The purchase order number and vessel number shall be prominently marked on the side of the shipping containers as shipped.

4.6.4 All similar pieces shall have the same marking.

4.6.5 Non-leaded paint shall be used for marking.

5. INSPECTION AND TESTING

5.1 Tray Fit-Up

One tray of each size and type with its accessories shall be assembled in shop to the extent necessary to check fit-up.

5.2 Leakage Tests

All draw-off pans shall be tested for leakage after installation in the erected vessel. Tests shall be made with drain holes plugged. Water levels shall be at overflow weir height or chimney height, as applicable, leakage, as permitted, shall be uniformly distributed across the area's under test. Leakage rates shall not exceed the following:

LEAKAGE CLASS	SERVICE	LEAKAGE RATE m^3/h PER SQ. METER OF AREA UNDER TEST
1	All towers except those covered below in classes 2 or 3	0.13
2	Vacuum towers, except as in class 3	0.06
3	Pans immediately above a packed fractionation zone	0.02

5.2.1 Leakage tests shall not be performed on jet, sieve, valve, cartridge or pedestal trays.

5.2.2 Leakage tests and washing of austenitic stainless steel components shall be conducted with water having less than 150 ppm (150 mg/L) chloride ion content. Potable water will meet this requirement. Components shall be dried immediately after testing, by blowing with air.

6. PREPARATION FOR SHIPMENT

6.1 General

6.1.1 All parts are to be properly packed in wooden boxes or crates. Carbon steel trays are normally packed in crates lined with waterproof paper.

6.1.2 Of the following component parts an excess percentage of each size and type shall be furnished to cover loss, waste and shrinkage.

For valves, bolts,nuts,clamps, wedges, washers, etc.	minimum 10% but not less than 4 pieces
For jointing materials(gaskets, packings)	minimum 25%

6.2 Handling and Storage

Tower packing shall be packaged to affect protection against corrosion or degradation during shipping and storage at site, as follows:

a) Metal packings (excluding Glitsch Grid and Flexigrid) shall be packaged in sealed plastic bags.
b) Plastic packings shall be packaged in opaque bags.

6.3 Release for Shipment

No material shall be released for shipment until it has been approved by the Company's inspector.

PART III
ADDITIONAL REQUIREMENTS FOR PRESSURE VESSELS AND REACTORS HAVING WALL THICKNESS OVER 50 mm

1. SCOPE

1.1 This Part of Standard Specification covers additional requirements for material, design, fabrication and inspection of pressure vessels and reactors having a wall thickness over 50 mm.

1.2 This Standard Specification supplements the basic requirements given in Part I of this standard "Material and Engineering Standard for Towers and Pressure Vessels".

1.3 In case of conflict between this specification and the pertinent drawings, the latter requirements shall take precedence.

2. MATERIALS

2.1 The steel used for fabrication of heavy wall pressure vessels shall be made by the basic electric and oxygen furnace and shall be vacuum degassed.

2.2 When specified and for hydrocracking and hydrotreating reactors, reactors shell shall be made from forged cylindrical rings without having any longitudinal seam.

2.3 The forging material shall be in accordance with the ASME Section II Part A, SA-266 "Forgings Carbon Steel for Pressure Vessel Components" and SA-336 "Forgings Alloy Steel for Pressure and High Temperature parts as applicable.

2.4 Temper embrittlement of 1 cr-½ Mo, 1¼ cr-½ Mo, 2¼ cr-1 Mo and 3 cr-1 Mo class low alloy steels to be operated at temperatures of 350°C and over shall be minimized by controlling the temper embrittlement factor (called J-factor) below 100. J-factor is defined as:

$$\textbf{J-factor} = (Si+Mn) \times (P+Sn) \times 10^{4} \leq 100$$

Where Si, Mn, P and Sn are weight percentage of silicon, manganese, phosphorous and tin respectively.

2.5 For weld metal of low alloy steels (1cr- ½Mo, 1¼cr-½Mo, 2¼cr-1Mo and 3cr-1Mo) in the SAW (Submerged Arc Welding) and SMAW (Shielded Metal Arc Welding) processes, the temper embrittlement factor called X-factor shall be 15 ppm maximum. X-factor is defined as:

$$\textbf{X-factor} = (10P+5Sb+4Sn+As) \times 10^{-2} \leq 15 \text{ ppm}$$

Where P, Sb, Sn, and As are weight percentage of phosphorous, Antimony, tin and Arsenic respectively.

2.6 Pressure vessels may have heads made from plates conforming to its relative ASME standard.

Silicon content of head plates and shell forgings for vessels made of Cr-Mo alloy steels shall be 0.07% maximum.

2.7 All wrought materials used in, or welded to pressure parts of the heavy wall pressure vessels shall have an alloy composition in the same range as specified for the shell and heads and shall be in the same heat treated condition. This includes non-pressure parts such as skirt, clips, lugs and all internals of non-cladded vessels. The tensile strength of such parts shall be in the same range as specified for the shell and heads.

2.8 When the vessel drawings and data sheet specify stainless steel cladding, the metallic internals and all materials welded to cladding or not welded (including bolting material) shall be stainless steel of the compositions specified on the data sheet.

2.9 Mechanical properties of plate and forgings shall meet the requirements of the specified material standard. Maximum tensile strength at room temperature shall be 690 MPa (100,000 psi). If design temperature of the vessel is greater than 343°C (650°F), tensile test at design temperature shall be conducted with results reported to the company.

2.10 One set of 3 charpy V-notch impact tests according to ASME standard SA-370 shall be conducted on completely heat treated specimens from plates and forgings of each heat treated lot. Toughness requirements for low alloy steel materials after temper embrittlement test shall meet the following criterion:

VTr 54 + 2.5 (VTr'54-VTr 54) ≤ 38°C (100°F)

Where:

54 is 54 Jouls (40 ft-lbs) transition temperature in the min. PWHT condition.
VTr'54 is 54 Jouls (40 ft-lbs) transition temperature in the min. PWHT plus step cooled condition.

Step cooling procedures shall be approved by the company.

Impact values for carbon steel material shall be as specified on the ASME code section VIII Division 2.

Lateral expansion in mils and percent shear fracture shall be reported with the impact test results.

2.11 Ferrite content of type 347 stainless steel weld overlay by schaefller's diagram shall be controlled between 3 to 10 percent.

3. DESIGN

3.1 The design of shell, heads, nozzles, skirt and other parts within code jurisdiction shall be in accordance with ASME code section VIII Division 2 except as specified otherwise. For Cr-Mo alloy steel plates and forgings, the allowable stress intensity values used shall be that of normalized (with accelerated cooling) and tempered material.

3.2 When thermal gradients exceed 83°C in a distance equal to $\sqrt{RT}$ where R and T are the radius and thickness of the vessel component in question, a thermal stress analysis shall be performed. The procedures of the ASME Code Section VIII Division 2 shall be used for this analysis. The thermal stress shall not exceed the minimum guaranteed yield strength of the material.

3.3 When approved by the company and when the vessel fabricator will guarantee strength properties, the maximum allowable stress in tension shall be the lowest of:

a) 42.5% of the guaranteed tensile strength at room or design temperature, whichever strength is lower.
b) 66.7% of the guaranteed yield strength at room or design temperature, whichever strength is lower.
c) The average stress to cause 1% creep in 100,000 hours.
d) Two-thirds of the average, or 80% of the minimum, stress required to cause rupture in 100,000 hours, whichever is lower.

3.4 A fatigue analysis shall be performed when the allowable stress in tension exceeds 33.3% of the guaranteed tensile strength. The procedure of ASME Code Section VIII Division 2 shall be used for this analysis.

3.5 The acceptable types of nozzles for pressure vessels shall be the integral reinforced forging type and shall be welded to the shell and head as per Fig. UW 16-1 (a), (b), (c), (d), (f-1) to (f-4) and (g) and Fig. UHT-18.1 (e) and (f) and Fig. UHT- 18.2 (f) of the ASME Code Section VIII Division 1 as applicable.

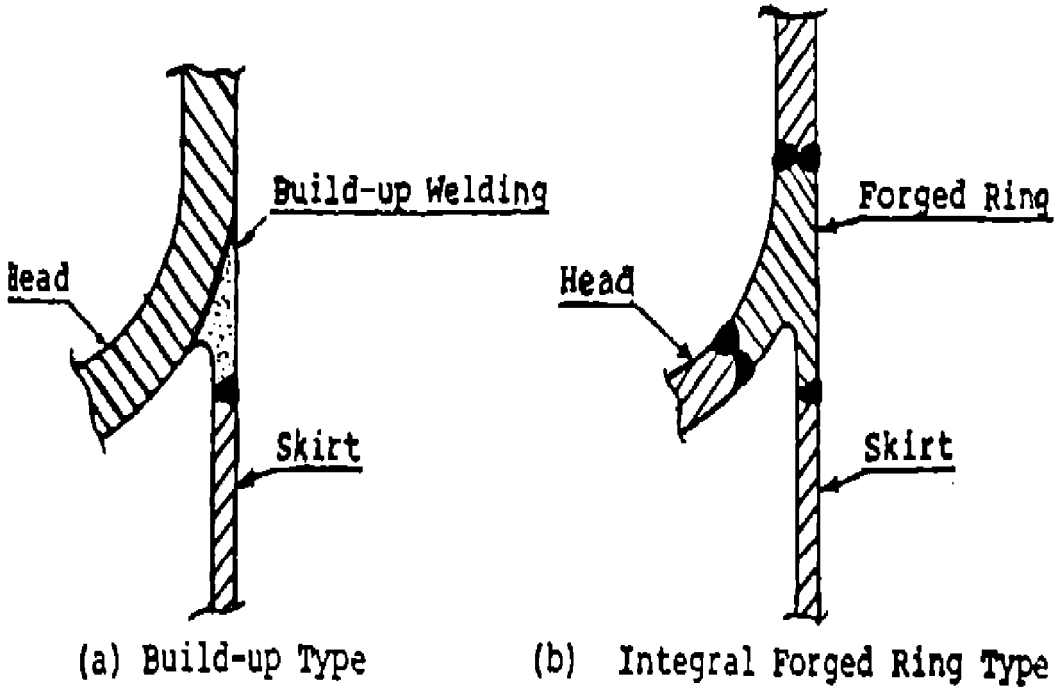
For pressure vessels to be operated at temperatures 350°C (660°F) and over, the acceptable type of nozzles shall be the integral reinforced forging type as per (f-1) to (f-4) in Fig. UW 16.1 of the ASME Code Section VIII Division 1. The nozzle types of (a), (b), (c), (d) and (g) in Fig. UW 16.1 and (f) in Fig. UHT-18.1 may be used with approval provided that a smooth finish on the fillet weld and sharp corners are avoided.

3.6 The minimum inside corner radius for all openings shall be the lesser of the following:

a) ¼ of the thickness of the vessel component penetrated.
b) ¼ of the finished inside diameter of the opening.
c) 19 mm (¾ in).

3.7 No exterior radius for attachments shall be less than 6 mm (¼ in.).

3.8 Pressure vessels made of carbon steel, carbon - molybdenum, chromium-molybdenum low alloy steels (1 cr- ½Mo, 1¼ cr-½ Mo, 2¼ cr-1 Mo and 3 cr- 1 Mo) to be operated at temperatures of 350°C (660°F) and over, shall have a skirt joint construction as shown in Fig. 1. Skirt shall be jointed with full penetration weld from outside of the skirt by build-up welding or forged ring as shown in Fig. 1.



SKIRT JOINT CONSTRUCTION
Fig. 1

3.9 The region of the bottom head-to skirt intersection shall be analyzed for membrane and bending stress intensities. The temperature distribution in this region, including the gradient down the skirt, shall be determined using design temperature inside the vessel, plus the insulating information furnished by the user or contractor. The stress analysis shall include effects of internal pressure, skirt loads and temperature distribution.

3.10 Attachment welds of all accessories such as plate lugs for platforms, ladders and others including internal support lugs and rings shall be continuous welds for heavy wall pressure vessels. Full penetration welds shall be employed as attachment welds for the vessels in hydrogen services.

3.11 When weld overlay clad is specified, the thickness of cladding shall not be included in design pressure calculations, but the minimum cladding thickness shall be included in calculating the hydrotest pressure, new and old.

4. INTERNALS

4.1 When materials are not specified, vendor's proposals shall be submitted to the company for approval. Vendor's proposals to use materials alternative to those specified shall also be submitted to the company for review and approval.

4.2 Where Aluminized stainless steel screens are specified, aluminizing shall be applied by a high temperature diffusion process, "Alonizing" or equivalent process. Other aluminizing processes proposed shall be submitted for company's approval.

4.3 Free machining grades of steel are not permitted, except that type 416 nuts furnished to ASTM A-194 Gr 6F with selenium are acceptable for use with ASTM A-193 Gr B6 Bolts.

4.4 All bolting for internals shall be a minimum of 10 mm diameter.

4.5 All bolting hardware shall be of the same type of material as the internal which they are connecting or which are being connected to support members. However, 12% Cr shall be used for carbon steel internals.

4.6 All stainless steel type 300 series bolts and nuts shall have micro-coating to prevent ceasing and for ease of opening.

4.7 All removable internals shall be designed to permit installation and removal from the top side.

4.8 Vessel internals which contribute to the total reactor height shall be designed for minimum height. Similar parts shall be interchangeable where possible.

4.9 Screens shall be attached on top of grids and catalyst support members to prevent inerts and catalyst from falling through holes or slot openings and blocking clearances in support members that are required for thermal expansion.

4.10 A minimum of 25 mm overlap under the most adverse operating conditions shall be provided between the support ring and the O.D of trays, decks and grids.

4.11 Clearance between thermowell and thermowell nozzle shall be minimum.

4.12 Bed support grids shall be covered with wire screen. All layers of screen shall extend a minimum distance of 75 mm up the web section of the support beams and the vessel shell.

4.13 All internals welded to the vessel shall be attached with full penetration welds.

4.14 Surfaces of fabricated parts shall be smooth and free of dents/hammer marks, kinks and other defects, particularly in locations which might prevent close metal-to-metal fit.

4.15 Tolerances for fabrication and assembly of internals for heavy wall pressure vessels and reactors shall be in accordance with Table 1 below:

TABLE 1 - FABRICATION AND ASSEMBLY TOLERANCES FOR INTERNALS OF HEAVY WALL PRESSURE VESSELS AND REACTORS

DESCRIPTION	TOLERANCES mm
Location of parts bolted to clips or brackets welded to reactor	±3
Height of tubes chimneys, or weir notches above top of tray	±1.5
Distributor tray level:	
Reactor ID- ≤(1200 mm) 4 ft.	±3
Reactor ID- >(1200 TO 2100 mm) 4 TO 7 ft.	±5
Reactor ID- > (2100 mm)7 ft.	±6
• Flatness for tray floor	6 Max.
• Leveling for support ring	±2
• Clearance between tray and support ring and between tray and support beam	2 Max.
Deformation of support beam:	
1) Vertical	3.2 Max.
2) Lateral	3.2 Max.
Diameter of hole (except bolt hole)	±0.1
Triangular pitch of hole	±2.0
Clearance between section tray deck:	
1) For perforated tray	0, +3.0
2) For chimney tray	±1.0
Distance between tray support ring and grid support ring, and between tray support ring and chimney tray	±2.0
Clearance between sectional grids, and between grid and support beam	0, +1.6
Location of hole for catalyst drain pipe:	
1) Orientation	±0.5°
2) Distance from vessel center line	±3.2
Location of hole for quench pipe:	
1) Orientation	±0.25°
2) Distance from vessel center line	±1.6

4.16 One tray, grid and deck of each diameter and type shall be assembled in the vessel at fabricator's shop to the extent necessary to check fit-up.

4.17 All welds on internal parts shall be examined using N.D.T. Scope of examinations and tests shall be approved by the company.

4.18 Trays shall be leakage tested after installation in the erected reactor. Permissible leakage shall be uniformly distributed across the area tested.

4.19 Quench nozzle spray pattern shall be tested with steam.

5. FABRICATION

5.1 Defects requiring removal in plates and forgings shall be repaired by welding by the vessel fabricator in accordance with ASME pressure vessel code section VIII Division 2 requirements. The repair weld shall be examined by radiography and ultrasonic means. A record of all such repairs shall be maintained.

5.2 Where weld overlay cladding is specified, heads and nozzles shall also be overlay cladded except that heads less than 100 mm thick may be integral clad with material similar to the specified overlay. Such integral cladding shall be 100% ultrasonic examined for lack of disbond after forming. Unbonded areas shall be removed and repaired by weld overlay.

5.3 The weld overlay shall be applied circumferentially to the vessel and shall be relatively smooth with no notches and undercuts that would act as stress raisers.

5.4 Stainless steel Type 347 weld overlay shall be applied after the vessel final post weld heat treatment if practical. Otherwise, weld overlay cladding (Type 347) of ring joint gasket grooves and other areas of high stress concentration shall be applied after final post-weld heat treatment.

5.5 Nozzles shall be flush and ground smooth with the inside of the vessel wall to form a smooth rounded contour. External attachment welds of nozzles shall be ground to provide a smooth transition between head or shell and nozzle neck.

6. WELDING

6.1 Welding procedure qualification test in strict accordance with the ASME Code Section IX and company's requirements shall be performed. Records of such tests shall be submitted to the company for review.

6.2 Production weld test plates are required when the vessel thickness exceeds 100 mm. At least one plate shall be prepared for each type of shell welding in each vessel. The plates shall be subjected to the total thermal treatment as the finished vessel. The test plates shall be prepared from material actually used in construction of the vessel having a thickness equal to the finished vessel thickness. Production weld test plate shall be made in accordance with ASME Code Section VIII, Division 2 and the company specification.

6.3 Each test plate shall be subjected to charpy V-notch impact test in accordance with the ASME Code Section VIII Division 2 (At-203). Impact values shall conform to Paragraph 2.10 of this part of this Standard.

6.4 The weld overlay procedure shall be qualified on base metal of the same chemical composition as the vessel and thickness of not less than one half of the vessel thickness. Flaws on the surfaces of the base metal that would interfere with bonding of the overlay shall be removed by grinding.

7. INSPECTION AND TESTING

7.1 Visual and Dimensional Inspection

The following areas shall be visually and dimensionally inspected. Acceptance of results shall be according to the relative drawings and specifications.

7.1.1 Fit-up of category A (shell to head), B(shell to shell) and D(nozzles to shell and heads) joints and skirt to bottom head joint.

7.1.2 As built dimensions of pressure bearing parts.

7.1.3 As built dimensions of attachments.

7.1.4 Visual inspection of internal surface of vessel.

7.1.5 Visual inspection of full area of first layer weld overlay cladding.

7.2 Radiographic Examination

The following welds shall be radiographic examined to the extent specified. Radiographic examination shall be in accordance with article I-5 of the ASME Code Section VIII Division 2.

7.2.1 100% of category A,B and D joints in shell and heads.

7.2.2 Repair weld in base metal having a depth over 10 mm.

7.2.3 100% of Cr-Mo to Cr-Mo butt joint within the skirt (longitudinal and girth seams).

7.2.4 One spot per each seam of Cr-Mo to carbon steel and carbon steel to carbon steel within the skirt.

7.3 Ultrasonic Examination

The following areas shall be ultrasonically inspected. Ultrasonic inspection shall be in accordance with the ASME Code Section V and Section VIII Division 2, Paragraphs AM-203.1 and, AM-203.2.

7.3.1 Steel plates or plate like forgings such as shell rings after final machining.

7.3.2 All forged materials except plate-like forgings such as forged nozzles after machininig.

7.3.3 Head plates before hot forming (100% scanning).

7.3.4 100% scanning of head plates after hot forming and heat treatment.

7.3.5 Cr-Mo skirt plate after heat treatment (100% scanning)

7.3.6 Carbon steel skirt plate, base plate and compression ring after heat treatment (230 mm grid scanning).

7.3.7 100% of category A,B and D joint in shell and heads after final postweld heat treatment (PWHT) and after hydro-static testing.

7.3.8 100% of attachment weld of skirt to bottom head and longitudinal seams of Cr-Mo steel skirt after PWHT.

7.3.9 Repair welds in base metal after PWHT. For repair welds in base metal having a depth 10 mm and less, the repair weld shall also be ultrasonically inspected before PWHT.

7.3.10 Overlay cladding of shells and heads including weld joint overlay after cladding and after PWHT.

7.3.11 Weld overlay cladding of nozzles with inside diameter 200 mm and larger after cladding and after PWHT.

7.3.12 Weld build-up deposit of low alloy steel material after final machining.

7.4 Magnetic Particle Inspection

The following areas shall be magnetic particle inspected. Magnetic particle inspection shall be in accordance with ASME Code Section V and Section VIII Division 2 article 9-2.

7.4.1 Welding edges (Bevels) for category A,B and D joints.

7.4.2 Back gouged surfaces of category A,B and D joints and skirt to bottom head joint.

7.4.3 All inside surfaces of category A,B and D joints prior to weld overlay cladding.

7.4.4 All outside surfaces of category A,B and D joints and attachment weld of skirt to bottom head after PWHT and hydrostatic testing.

7.4.5 All weld joints (circumferential and longitudinal seams) in the skirt both inside and outside after PWHT.

7.4.6 The areas where temporary attachment welds have been removed. The areas shall also be examined after final PWHT.

7.4.7 Repaired areas (if any) shall be examined after final PWHT.

7.4.8 External attachment welds shall be examined after final PWHT.

7.5 Liquid Penetrant Examination

The undermentioned parts and areas shall be liquid penetrant examined according to the ASME Code Section V and Section VIII Division 2 article 9-2.

7.5.1 Full area of final weld overlay cladding of shell and heads after cladding and after PWHT.

7.5.2 Gasket seating surfaces of nozzles after final machining and also after PWHT.

7.5.3 Inside surface of attachment welds of skirt to bottom head after PWHT.

7.5.4 All internal attachment welds shall be examined after PWHT.

7.5.5 Repaired areas (if any) shall be examined after PWHT.

7.6 Hardness Test

7.6.1 Hardness test on weld metal, base metal and heat affected zones shall be performed after PWHT as per the followings:

7.6.2 One per each weld seam between shell and shell and shell and head.

7.6.3 One per each size and each WPS for nozzle attachment weld of heads and shell.

7.7 Chemical Analysis

Chemical analysis of base metal welds and chemical analysis and ferrite check of weld overlay cladding shall be made before PWHT as per the following. Acceptance shall be per ASME Code Section II Part C and this Standard Specification.

7.7.1 For base metal

a) One per each circumferential weld seam between shell and shell and shell and head.
b) One per each nozzle attachment weld of shell and head.

7.7.2 For weld overlay cladding:

a) two per each shell course;
b) two per each head;
c) one per each girth seam;
d) one per each nozzle size from inside the nozzle;
e) one per gasket seating surface of each nozzle size.

7.8 Hydrostatic Testing

7.8.1 Heavy wall pressure vessels shall be hydrostatic tested in accordance with the ASME Code Section VIII Division 2 Paragraph AT-301.

7.8.2 The vessel metal temperature during hydrostatic test shall be 21°C minimum.

7.8.3 Water used for testing heavy wall cladded pressure vessels shall contain not more than 30 ppm chloride

APPENDICES

APPENDIX A
GENERALLY USED MATERIALS IN OIL REFINERY SERVICES

SERVICE	MATERIAL	TEMPERATURE, °C
Non or mildly corrosive	C or C-Mn Steel	0-400
Oil containing sulfur Compounds if hydrogen Partial pressure ≥ 7 bar abs. and temperature ≥ 260°C	See Nelson curves**	See Nelson curves**
Pressure vessels in crude Distillers, where temperature of feed at inlet of column does not exceed 350°C (outlet temperature of furnace maximum 355°C)	C or C-Mn Steel	≤ 350
Pressure vessels in units Other than crude distillers, and pressure vessels in crude distillers where temperature of feed at inlet of column exceeds 350°C (outlet temperature of furnace over 355°C)	C or C-Mn Steel C or C-Mn Steel Base material with Type 405 or 410 S Cladding Steel base material with 410 S Cladding	≤ 330 ≥ 330 ≤ 400 ≥ 400 ≤ 500
Oil containing naphthenic acids	C or C-Mn Steel	≤ 230
Oil with acids value ≥ 0.5 mg KOH/g oil in addition to sulfur compounds	C or C-Mn Steel Base material with AISI 316L Cladding	≥ 230 ≤ 400
For oil containing naphthenic acids with Neutralization No. 0.3-0.5 mg KOH/g	Steel Base material with type 410 S Cladding	≥ 400 ≤ 500
Hydrogen service Platformer reactors Cold wall Hot wall Hydrodesulphurizer/Hydrotreater Reactors Hydrodesulphurizer/Hydrotreater Reactors For feedstock containing naphthenic acid	 Steel 1.0 CR-0.5 Mo Steel *** Cr-Mo Steel Base material** with Type 321/347 Cladding Cr-Mo Steel Base material** with Type 316 L Cladding	Max. allowable temperature is dependent on hydrogen partial pressure, see Nelson curves **

Note:

**** API Pub. 1941**

***** Min. 1.0% Cr**

APPENDIX B
MATERIALS FOR PRESSURE PARTS FOR NORMAL SERVICE

PARTS	UP TO 427°C (800°F)
Shells, heads conicals, etc.	ASTM A 285 Gr. C ASTM A 515 Gr. 60 ASTM A 516 Gr. 60 ASTM A 516 Gr. 70
Flanges	ASTM A 105, A 181
Nozzle necks	ASTM A 106 Gr. B, A 53
Large size nozzle neck and M.H. neck	Same material as shell
Bolts and nuts	ASTM A 193 Gr. B7 AND A 194 Gr. 2H

APPENDIX C
GASKETS

1. External Gaskets

Manholes, handholes and blanked-off nozzles shall have gaskets conforming to the piping specification for lines connecting to nozzles in the same zone of the vessel, unless otherwise specified.

2. Internal Gaskets

a) Use of internal gaskets shall be as per Table 1:

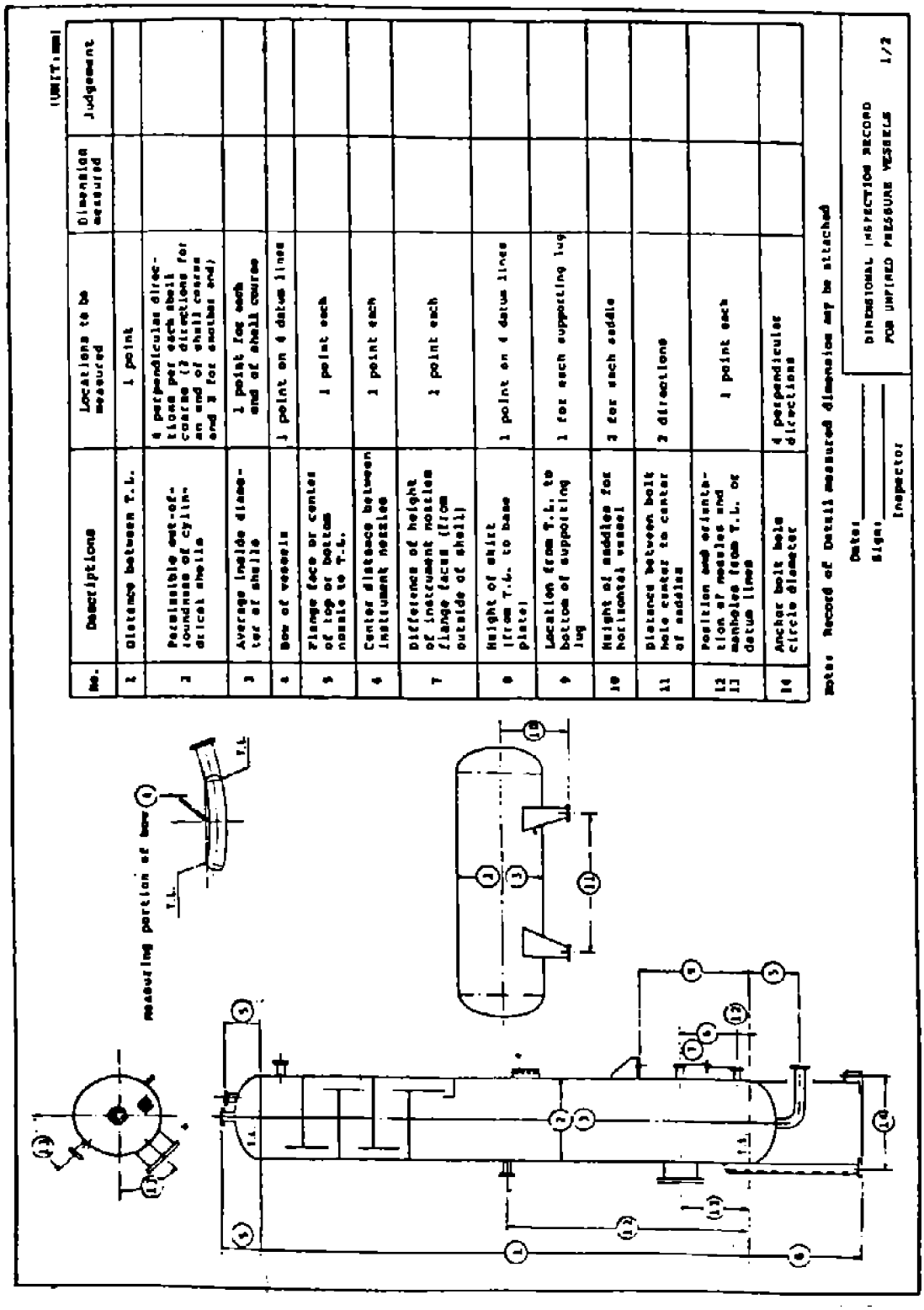
TABLE 1 - USE OF INTERNAL GASKETS

VESSEL DESIGN TEMP.	GASKET MATERIALS
Up to 232°C (450°F)	85% asbestos
Over 232°C (450°F) to 399°C (750°F)	AAA grade asbestos
Over 399°C (750°F) to 482°C (900°F)	AAAA grade asbestos
Over 482°C (900°F)	Pure asbestos with stainless steel wire

b) Blue asbestos material shall not be used.

3. Solid metal gasket shall be fully annealed and one piece construction.

APPENDIX D
MANUFACTURER'S INSPECTION RECORD



No.	Descriptions	Locations to be measured	Dimension measured	Judgement
1	Distance between T.L.	1 point		
2	Permissible out-of-roundness of cylindrical shells	4 perpendicular directions per each shell course (2 directions for an end of shell course and 3 for another end)		
3	Average inside diameter of shells	1 point for each end of shell course		
4	Bow of vessels	1 point on 4 datum lines		
5	Flange face or center of lug or bottom nozzle to T.L.	1 point each		
6	Center distance between instrument nozzles	1 point each		
7	Difference of height of instrument nozzles flange faces (from outside of shell)	1 point each		
8	Height of skirt (from T.L. to base plate)	1 point on 4 datum lines		
9	Location from T.L. to bottom of supporting lug	1 for each supporting lug		
10	Height of saddles for horizontal vessel	2 for each saddle		
11	Distance between bolt hole center to center of saddles	2 directions		
12 13	Position and orientation of nozzles and manholes from T.L. or datum lines	1 point each		
14	Anchor bolt hole circle diameter	4 perpendicular directions		

Note: Record of Detail measured dimension may be attached

Date: _____
Sign: _____
Inspector

DIMENSIONAL INSPECTION RECORD
FOR UNFIRED PRESSURE VESSELS 1/2

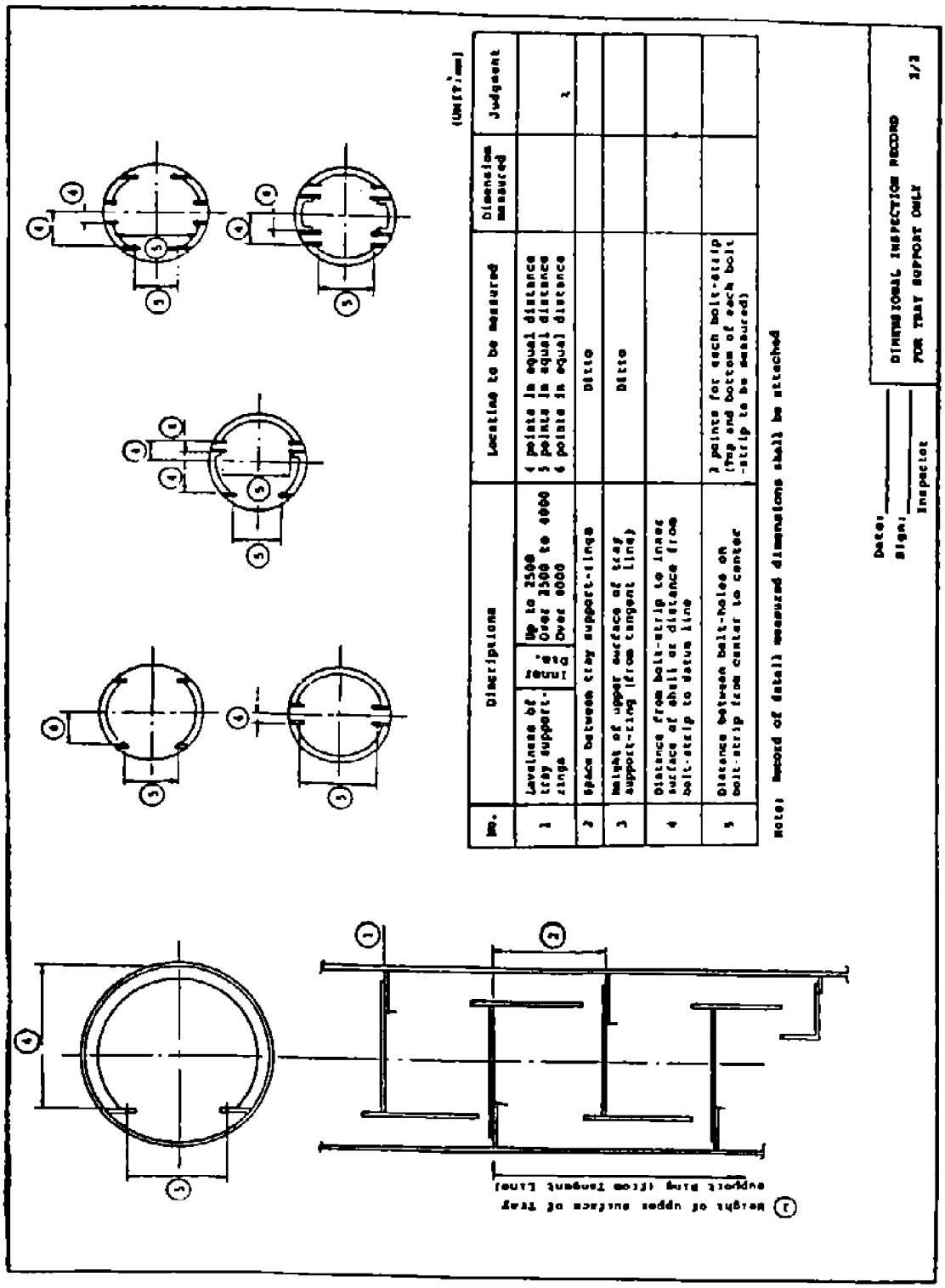
(UNIT: mm)

measuring portion of bow

T.L.

(to be continued)

APPENDIX D (continued)



DIMENSIONAL INSPECTION RECORD 1/2
FOR TRAY SUPPORT ONLY

Date:
Sign:
Inspector

(Unit: mm)

No.	Descriptions		Locations to be measured	Dimension measured	Judgment
1	Levelness of tray support-rings	Dia. of vessel	Up to 2500: 4 points in equal distance Over 2500 to 4000: 5 points in equal distance Over 4000: 6 points in equal distance		
2	Space between tray support-rings		Ditto		
3	Height of upper surface of tray support-ring (from tangent line)		Ditto		
4	Distance from bolt-strip to inner surface of shell or distance from bolt-strip to datum line				
5	Distance between bolt-holes on bolt-strip from center to center		3 points for each bolt-strip (Top and bottom of each bolt-strip to be measured)		

Note: Record of details measured dimensions shall be attached

① Height of upper surface of tray support ring (from tangent line)

APPENDIX E
MANUFACTURER'S INSPECTION RECORD FOR RADIOGRAPHIC EXAMINATION

PURCHASER _____ **(JOB CODE No.) (** **)**	**ITEM No.** _____
USER _____	**EQUIPMENT** _____
PROJECT _____	**APPLICABLE CODE OR SPEC.** _____
P.O. No. _____	**MANUFACTURER** _____

Radiation source	X-RAY : b X-RAY (upto 400 kVP) b Linear accelerator b other X-RAY : b Iridium b Coblt b Other
Source size	
Voltage and amperage	
Distance (source to film)	
Film type	
Screen type	
IQI (Penetramater designation)	
Radiographic technique	b Single wall b Double wall
Location examined, weld no., thickness, film no. or film mark	b See attached detail record
Judgement	b See attached detail record

Date _____

Sign. _____
Inspector

APPENDIX F
MANUFACTURER'S INSPECTION RECORD FOR ULTRASONIC EXAMINATION

PURCHASER _____ **ITEM No.** _____
(JOB CODE No.) ( )

USER _____ **EQUIPMENT** _____

APPLICABLE CODE OR
PROJECT _____ **SPEC.** _____

P.O. No. _____

MANUFACTURER _____

Type of equipment	Brand name :		Type :			
Method	Transducer type	Transducer frequency (MHz)	Transducer size	Transducer material	Reflection angle	Remarks
Angle beam						
Straight beam						
Reference sensitivity	Basic calibration block (size)		Calibration block for pipe (size)		Reference hole and sensitivity	
Angle beam method						
Straight beam method						
Scanning Sensitivity	Angle beam method					
	Straight beam method					
Coupling medium	b Oil	b Glycerin	b Water	b Other		
Surface condition	b As ground	b Other				
Scanning direction	Angle beam method	b From outside b From inside b Perpendicular to weld b Parallel to weld				
	Straight beam method	b From outside b From inside				
Location examined	b See attached detail record					
Judgment	b See attached detail record					

Date _____

Sign. _____
Inspector

APPENDIX G
MANUFACTURER'S INSPECTION RECORD FOR MAGNETIC PARTICLE EXAMINATION

PURCHASER		**ITEM No.**	
(JOB CODE No.) ( )			
CLIENT		**EQUIPMENT**	
PROJECT		**APPLICABLE CODE OR SPEC.**	
P.O. No.		**MANUFACTURER**	

Stage of exmination	b Prepared edge b As welded	b After P.W.H.T b After hydro test	b Other		
Surface preparation	b Grinding	b Machining	b As welded	b Other	
Instrument			Type		
Mag. method	b Yoke	b Prod	b Other		
Calibration					
Prod. space		mm			
Current	b AC	b DC	A	AT	
Test temperature					
Particle	b Dry	b Wet	b Black	b Brown	b Fluorescent
Location examined	b See attached detail record				
Result	b See attached detail record				

Date _____

Sign. _____
Inspector

APPENDIX H
MANUFACTURER'S INSPECTION RECORD FOR LIQUID PENETRANT EXAMINATION

PURCHASER _____ **(JOB CODE No.) ( )**	**ITEM No.** _____
USER _____	**EQUIPMENT** _____
PROJECT _____	**APPLICABLE CODE OR SPEC.** _____
P.O. No. _____	**MANUFACTURER** _____

Stage of exmination	b Prepared edge b As Welded	b After P.W.H.T b After hydro test	b Other	
Surface preparation	b Grinding	b Machining	b As welded	b Other
Penetrant	Type	b Color Contrast	b Fluorescent	
	Application	b Brushing	b Spraying	
	Temperature	°C	Penetrant Time	min.
Removal	b Water washable penetrants b Post emulsifying penetrants b Solvent removal penetrants		Developing	b Dry developer b Wet developer
Location examined	b See attached detail record			
Result	b See attached detail record			

Date _____

Sign. _____
Inspector

APPENDIX K
PRESSURE VESSEL SPECIFICATION

PROJECT .....

VESSEL NAME ..... TAG No. .....

SERVICE .....

I DESIGN DATA

DIAMETER ..... mm LENGTH ..... T/T mm
DESIGN PRESSURE ..... kPa(g) DESIGN TEMPERATURE ..... °C
MAX. OPER. PRESSURE ..... kPa(g) MAX. OPER. TEMPERATURE ..... °C
ORIENTATION - VERTICAL ..... - HORIZONTAL .....
SERVICE - SOUR ..... - SWEET .....
WIND VELOCITY ..... km/hr
CORROSION ALLOWANCE - SHELL ..... mm - INTERNALS ..... mm
INSULATION - TYPE ..... - THICKNESS ..... mm
CODE ..... STAMP .....
STRESS RELIEVED ..... X-RAY .....
CERTIFICATE ..... DRAWINGS .....

II MATERIALS SPECIFICATION

SHELL .....
HEADS ..... HEAD TYPE .....
INTERNALS ..... TRAYS .....
SUPPORTS ..... REINFORCING PADS .....
NOZZLES ..... FLANGES .....
FITTINGS .....
GASKETS .....
NUTS ..... BOLTS .....
PAINT .....

III ACCESSORIES

	REQ.	REMARKS
TRAYS		
LADDER (w/cage) (without cage)		
PLATFORMS		
LIFTING LUGS		
SADDLES		
BASE PLATE		
VESSEL SKIRT		
INSULATION RINGS		
OVERHEAD PIPE SUPPORTS		
INLET TANGENT BAFFLE		
NOZZLE PROJECTION		
VORTEX BREAKER		
PLATFORM DAVIT		
MANHOLE DAVIT		
MIST ELIMINATOR		
- SUPPORT		

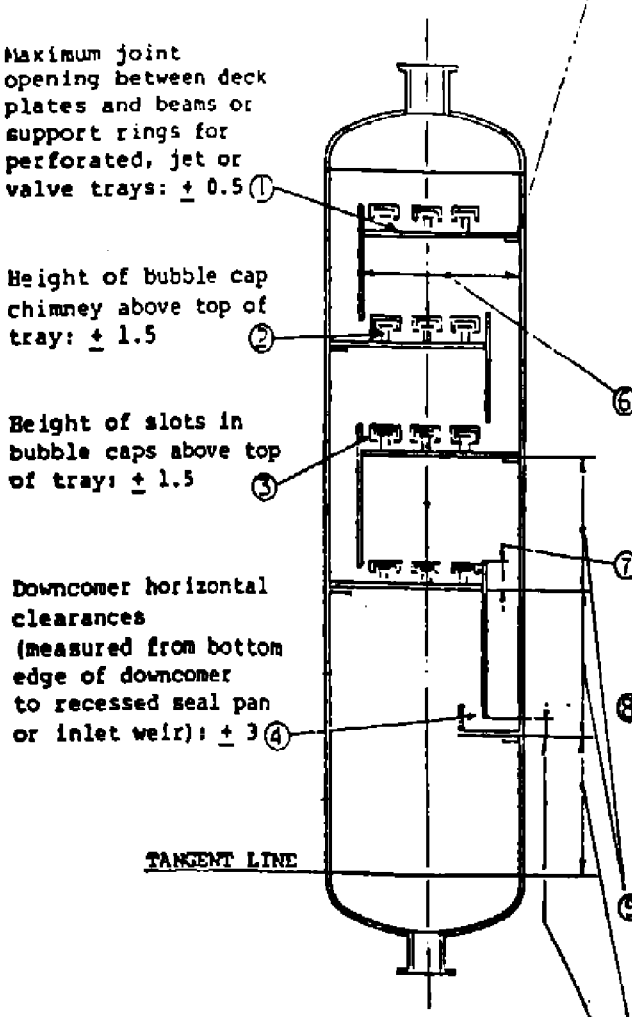
IV NOZZLE SCHEDULE

MK	NO.	SERVICE	SIZE	RATING	FACING

REMARKS :

PREPARED BY :
DATE :
DRAWING No. :
REVISION :

APPENDIX L
VESSEL TRAYS TOLERANCES FOR FABRICATION AND ASSEMBLY



⑤ Tray supports must present a flat surface for metal to metal contact between tray and support. Support shall be flat within 1.0 on any 300 chord. For tray supports and tray decks, out of level tolerance over any diameter shall be:

Tower Diameter	Tolerance
1500 and under	3
Over 1500 to 2500	4.5
Over 2500 to 4000	6
Over 4000 to 6000	9
Over 6000 to 8000	12
Over 8000 to 10000	15
Over 10000	(*1)

(*1) shall be specified individually.

⑥ For side of tower to weir:

Tower Diameter	Tolerance
1500 and under	± 3
Over 1500 to 4000	± 6
Over 4000	± (0.0025I.D)

⑦ Height of weir above tray support ring:
± 1.5 for I.D up to 3,000,
± 3.0 for I.D 3,000 over

⑧ Top of weir plate out of level across length of weir:

Tower Diameter	Tolerance
1500 and under	± 3
Over 1500 to 2500	± 4.5
Over 2500	± 6

⑨ Tolerance top of support to top of support ring of tray or related parts:
± 1.5 per 300, Max. ± 3

⑩ Location of tray support ring from reference plane: ± 10

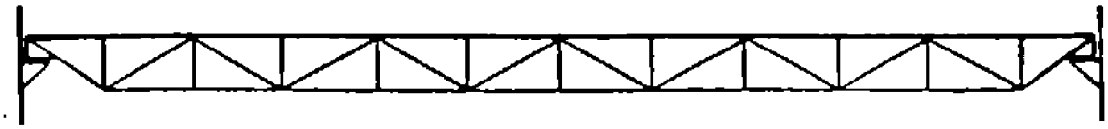
⑪ Bottom of downcomer above tray of seal pan support ring: ± 3

Dimensions in mm.

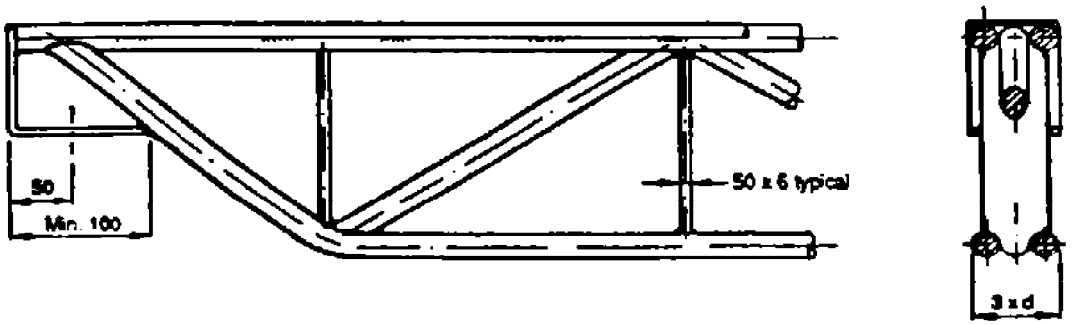
Description	Tolerance
Tolerances not shown on drawing:	
1. Location of parts bolted to clips or brackets welded to tower by others	± 3

APPENDIX M
OPEN STRUCTURE SUPPORT BEAM

a) Schematic Illustration



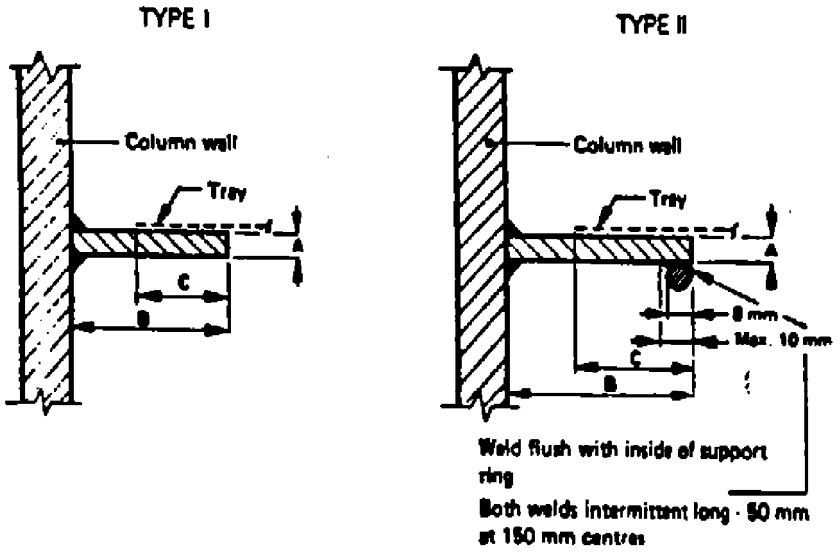
b) Detail



APPENDIX N
TRAY SUPPORT RINGS

TYPE I For columns in which an instantaneous pressure surge is not expected.

TYPE II For columns in which an instantaneous pressure surge may occur, e.g. vacuum columns, main crude oil columns and strippers.



ID of column mm	Tray support ring size B × A mm	Size C, mm	
		Nom.	Min.
All trays, except draw-off trays			
Up to 800 *	40 × 8	25	18
800 to 2500	50 × 8	30	25
2500 to 3500	60 × 8	35	25
3500 to 5000	75 × 8	35	25
5000 to 7000	85 × 8	40	30
7000 and over	individual design		
Draw-off trays			
800 to 6000	85 × 8	40	30
6000 and over	100 × 12	58	48

A total of 3 mm corrosion allowance has been included in dimension A.

*** Normally stacked trays to be used.**

APPENDIX O
SPECIFICATION SHEET

REV.	DATE

REF. _____
JOB NO. _____
ITEM NO. _____
SHEET _____ OF _____
DATE _____ BY _____
ENQUIRY NO. _____
P.O. NO. _____

PROJECT				
SERVICE				
TOWER INSIDE DIAMETER (mm)				
TOTAL TRAYS IN SECTION				
TRAY SPACE (mm)				
NUMBER OF LIQUID PASSES				
MAX Δ P ( ) / TRAY (bar)				
TYPE OF TRAYS				
INTERNAL CONDITIONS AT TRAY NUMBER (NOTE 1)				
VAPOR TO TRAY:				
RATE (kg/hr)				
DENSITY (kg/m³)				
PRESSURE (bar) (gage Note)				
TEMPERATURE (°C)				
LIQUID FROM TRAY:				
RATE (kg/hr)				
DENSITY (kg/m³)				
TEMPERATURE (°C)				
VISCOSITY (Pa s)				
FOAMING TENDENCY				
MECHANICAL DATA				
TOWER MANHOLE No. (NOTE 2) (mm)				
MATERIAL				
DECK				
CAP				
LOUVR				
NUTS & BOLTS				
SUPPORT RING				
DECK THICKNESS (mm)				
SUPPORT RING WIDTH & THK. (mm)				
DOWNCOMER BOLT BAR THK. (mm)				
CORROSION ALLOWANCE:				
TRAYS (mm)				
TOWER ATTACHMENTS (mm)				
TRAYS INSTALLED FROM TOP OR BOTTOM				
TRAYS HANDLED FROM TOP OR BOTTOM				

NOTE 1: INTERNAL VAPOR AND LIQUID LOADINGS AT THE LIMITING SECTIONS ARE REQUIRED TO INSURE PROPER TRAY DESIGN. DENSITIES ARE REQUIRED AT ACTUAL INSIDE TOWER CONDITIONS OF TEMPERATURE & PRESSURE. VISCOSITY IS NOT REQUIRED UNLESS GREATER THAN 0.1 CP.

NOTE 2: SMALLEST I.D. THROUGH WHICH TRAY PARTS MUST PASS

INSPECTION REQUIREMENTS:

REMARKS: