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NATIONAL IRANIAN OIL REFINING & DISTRIBUTION COMPANY
NATIONAL IRANIAN OIL ENGINEERING
& CONSTRUCTION COMPANY

NIOEC SP

NIOEC SPECIFICATION FOR PRESSURE VESSELS

FIRST EDITION

JULY, 2005

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IN THE NAME OF GOD**FOREWORD**

By their very nature, technical Specifications are continuously subject to modifications and revisions. To strengthen their merit and usefulness, continuous improvements, addendum, deletion of disparate information and consequently provision of updated revisions are to be made in order to ascertain that such Specifications meet the current requirements, inclusive of Iranian Petroleum Standards (IPS) and the recognized and acceptable national and international Standards, as well as the optimal codes and practices based on the accumulated in-house know-how and plant knowledge and experiences.

However, in reality, due to several reasons, not to mention the complexity of the matter, the ultimate goal of continuous direct embedment of the required changes on the relevant Specifications may be far reaching. Therefore, in the interim periods between the officially issued revisions, the required changes will appear in other documents related to the engineering and design work of the ongoing projects.

In response to the initiative of the Design and Engineering Directorate, and considering that the task of the execution of several important and mega projects for the realization of the new oil refineries, pipelines and oil terminals as well as improvements of the existing facilities, has been assigned to NIOEC, it was decided to update the NIOEC Specifications and to issue new official revisions.

The Design and Engineering Directorate was itself entrusted to carry out this important task, and as such by forming several special technical committees, working in close co-operation and cohesion and sharing their expertise and knowledge, the updated and revised NIOEC Specifications were successfully prepared and complied.

These Specifications are intended to be used for Oil Refineries, Distribution Depots, Oil Terminals, Pipelines and Pump Stations within NIOEC's projects, and have been proven to be of high value for such purposes. It must however be appreciated that these Specifications represent the minimum requirements and should in no way be interpreted as a restriction on the use of better procedures, engineering and design practices or materials.

We encourage and highly appreciate the users and other clear sighted and experts to send their comments on the Specifications to the Design and Engineering Director of NIOEC for evaluation and approval.

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NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 3) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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1. SCOPE

This Specification defines NIOEC's minimum requirements for design, fabrication, test and inspection of fusion welded unfired pressure vessels.

Deviations from this specification will only be permitted on obtaining written approval from NIOEC.

Resolution on cases not explicitly stipulated in this specification, or on cases where conflicts may arise among the requirements of the referenced international standards, shall be made through written consent and approval of NIOEC.

- 1.1. The design, fabrication, test and inspection of unfired pressure vessels shall conform to ASME Code Sect. VIII, Div. I, "ASME Boiler and Pressure Vessel Code" ASME Code Sect. VIII, Div. II may only be used with NIOEC's approval for the vessels and reactors exceeding 50mm wall thickness as per the code requirements specified in NIOEC-SP-41-04.
- 1.2. This Specification, when accompanied by the particular vessel description, vessel drawings, and typical details, constitute a complete set of standards outlining acceptable construction for unfired pressure vessels. All requirements of the ASME Code Section VIII, Division I, for pressure vessels shall be followed whether or not the vessel is to be Code stamped.
- 1.3. This Specification does not cover vessels made of nonferrous materials (such as Al or Cu alloys), low-temperature vessels (below -10°C) and spheres.
- 1.4. Vessels with operating pressures between 0 and 1 barg (15 psig) shall have a design pressure of at least 3.5 barg (52psig), hence falling within the scope of this Specification, except storage tanks covered by NIOEC-SP-41-06.
- 1.5. This Specification covers steel pressure vessels having a design temperature not lower than -10°C . Carbon steels, high strength steels, low alloy steels, alloy steels, Cr-Ni stainless steels, clad or not, are included.
- 1.6. Any vessel in H₂S service shall be subjected to the NACE MR 01-03 requirements.

2. REFERENCES

The following standards, codes and specifications, to the extent specified hereinafter, shall constitute a part of this NIOEC specification. Latest edition of the undated referenced documents and the cited edition of the dated references shall apply. The applicability of changes made to the dated references after the cited date shall be agreed upon between NIOEC and the Vendor/Contractor.

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME Code Sect. II	"Materials"
ASME Code Sect. V	"Nondestructive Examination"
ASME Code Sect. IX	"Welding and Brazing Qualifications"
ASME Code Sect. VIII, Div.I	"Rules for Construction of Pressure Vessels"

ASME Code Sect. VIII, Div.II	“Alternative Rules”
ASME B.1.1	“Unified Screw Thread”
ASME B.1.20.1	“Pipe Thread”
ASME B.16.5	“Steel Pipe Flanges and Flanged Fittings”
ASME B16.9	“Factory-Made Wrought Steel Butt Welding Fittings”
ASME B.16.20	“Metallic Gasket for Pipe Flanges”
ASME B16.21	“Nonmetallic Flat Gaskets for Pipe Flanges”
ASME B16.25	“Butt-welding Ends”
ASME B16.30	“Unfired Pressure Vessel Flange Dimensions”
ASME B.16.47	“Large Diameter Steel Flanges”
ASME B.18.2.1	“Square and Hex Bolts and Screw”
ASME B.18.2.2	“Square and Hex Nuts”
ASME B.36.10	“Welded and Seamless Wrought Steel Pipe”
ASME B.36.19	“Stainless Steel Pipe”
ASME B46.1	“Surface Texture”

NIOEC-SP (NIOEC SPECIFICATIONS)

NIOEC-SP-20-01	“NIOEC Specification for Structural Steel Specification”
NIOEC-SP-80-02	“NIOEC Specification for Painting”
NIOEC-SP-80-01	“NIOEC Specification for Insulation”
NIOEC-SP-00-50	“NIOEC Specification for Design Criteria”
NIOEC-SP-00-01	“NIOEC Specification for Civil Design Criteria”
NIOEC-SP-50-04	“NIOEC Specification for Piping Material Specification”
NIOEC-SP-00-11	“NIOEC Specification for Site Conditions”
NIOEC-SP-41-04	“NIOEC Specification for Code Requirements for Heavy Wall Pressure Vessels”
NIOEC-SP-00-10	“NIOEC Specification for Units”

NIOEC-SIP (NIOEC SHOP INSPECTION PROCEDURE)

NIOEC-SIP-41-03	“Shop Inspection Procedure for Pressure Vessels”
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NIOEC-SD (NIOEC STANDARD DRAWINGS)

Applicable standard drawings shall be those shown in Appendix I of this Specification.

EN (EUROPEAN NORM)

EN 10204	“Metallic Products-Type of Inspection Documents”
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AWS (AMERICAN WELDING STANDARDS)

AWS A2.4	“Standard Symbols for Welding, Brazing and Nondestructive Examination”
AWS D10.8	“Recommended Practices for Welding of Chromium-Molybdenum Steel Piping and Tubing”

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

ASTM E-165	“Standard Practice for Liquid Penetrant Examination for General Industry”
ASTM E-109	“Method for Dry Powder Magnetic Particle Inspection”

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

NACE MR01-03	“Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments.”
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3. UNITS

International system of units (SI) shall be used in accordance with NIOEC-SP-00-10, unless otherwise specified.

4. DEFINITIONS & TERMINOLOGY

- 4.1. Employer:** The National Iranian Oil Engineering & Construction Company (NIOEC).
- 4.2. Purchaser:** National Iranian Oil Engineering & Construction Company in the case where this Specification is part of a direct purchase order by NIOEC and Contractor, where this Specification is part of Contract Documents.
- 4.3. Vendor:** The manufacturer and/or fabricator from which the equipment is to be purchased.
- 4.4. Erector:** The Company which is responsible for the erection of the vessels at site.
- 4.5. Contractor:** The person, firm, company or consortium whose tender has been accepted by the Employer or legal successors in title to such person.

5. GENERAL

- 5.1.** Vessel shall be built in fabricators shop for delivery to site proposed by National Iranian Oil Engineering & Construction Company, or shall be field assembled at site.
- 5.2.** The vessel fabricator shall be approved for this type of work.
- 5.3.** The compliance of design, material and fabrication with the regulations in force in the country where the vessel is to be installed is the full and exclusive responsibility of the vessel Vendor.
- 5.4.** The compliance with this Specification and accompanying data does not relieve the vessel Vendor/Contractor from his own responsibilities and guarantees nor from any further contract obligations.
- 5.5.** In case of vessel's data sheet/drawing is specified for design metal temperature lower than -10oC, the material selection, fabrication, test and inspection shall be in accordance with the requirements of ASME Code Sec. VIII, Div.I.

5.6. Code Stamp

ASME U-Stamp is generally not required, unless otherwise specified. However the manufacturer of pressure vessels shall be internationally reputable and authorized by international inspection organizations confirmed by client.

6. DESIGN

6.1. Design Pressure and Temperature

Design pressure and temperature occurs at most severe coincident conditions of fluid pressure and temperature calculated for steady balanced operation considering expected variations in process conditions and also considering multiple services: if any. Special short time operating conditions, such as occurring during catalyst regeneration or unit upsets should also be considered where relevant.

Other factors to be considered shall include margins to cover tolerances and uncertainties in basic data calculations or operations, arbitrary minimum design conditions and other fluid outlet operating conditions under continuous operation.

Mechanical properties of materials for minimum ambient temperature of site and necessary heat treatment shall also be taken into account.

Minimum design metal temperature (MDMT) with regard to the lowest ambient temperature of site shall be established as per ASME Sec. VIII, Div. I Code. This temperature as well as maximum design temperature shall be specified on design drawings.

Design pressure and temperature shall be as per clause 5.1 of NIOEC-SP-00-50 "Design Criteria".

6.2. Minimum Diameter

6.2.1. The normal minimum diameter shall be 914mm (36") ID for vessels requiring removal of internals, except where internals can be removed as one unit or vessel is flanged in short sections.

6.2.2. Special approval by NIOEC is required for vessels with internals with an absolute minimum diameter of 760 mm (30") where provision for removal of trays through manway below trays shall be provided.

6.3. Loading Conditions

6.3.1. All combinations of loads shall be considered to determine the maximum design stress conditions for design as follows:

- a) Hydrostatic test loads shall be considered simultaneous with the minimum 20% of wind load, and not coincident with snow and earthquake loads.
- b) Earthquake loads shall not be considered, simultaneous with wind loads.

6.3.2. Specified loads due to earthquake, and climatic conditions shall be specified. Should other loads such as listed below be of significance for the purposes of vessel design those shall also be specified.

- a) Erection loads: The loading to cover loads during construction.
- b) Overhaul loads: The maximum maintenance loading conditions including hydrostatic testing of pipes and equipment and partial loading for equipment loading.

- c) Normal loads: Operating loads coincident with climatic or earthquake loads.
- d) Conversion unit upsets: Conditions of normal operation plus the load imposed by the weight of catalyst content that can build up inside towers, vessels or piping covered by a sudden stoppage of flow at any point in the system.
- e) Internal equipment loads: If the actual tray weights are not known at vessel design stage, loading estimates shall be made on the following basis:
 - Bubble trays: 1436.4 Pa (30 psf) (pressed carbon steel).
 - 1197.0 Pa (25 psf) (pressed alloy steel).
 - Plus equivalent of 10 cm liquid on each tray to be added to operating condition.
- f) Earthquake and wind load shall be in accordance with civil design criteria NIOEC-SP-00-01. (clause 2.10)
- g) Basic wind speed and exposure coefficient at site as per NIOEC-SP-00-11. (Site Condition)
- h) Snow load shall be considered as per Spec. No. NIOEC-SP-00-11 (Site Conditions)

6.3.3. Eccentric loads

If the exact eccentric loading is not known, an eccentric moment equal to a minimum of 10% of the vessel shell weight multiplied by the maximum outside shell radius plus 0.61m (2 ft) shall be used.

6.3.4. Hydrostatic test in fully corroded condition

Hydrostatic test shall be in accordance with the requirements of ASME Code. Sec. VIII Div.I.

6.3.5. Allowable Stress

The maximum combined stresses in vessels shall not exceed all the stresses specified as per ASME Sec.VIII. Div.I.

6.4. Materials

6.4.1. Materials used shall be exclusively those listed in the relevant tables of the applicable Code (i.e., ASME Sec II or ASME Sec VIII division 1).

The selection of materials as a function of the design data must be made in conformity with Table 6.1. The Client specifies the materials for each vessel which may be different from the materials of Table 6.1 in certain special cases arising from the nature of the fluids or from corrosion.

The Manufacturer must request a waiver for any different selection.

6.4.2. Material for vessels supports (skirts, saddles, legs, etc., including their weir plates if applicable) shall be of the same material grade as for the shell/head components to which they are welded, particularly with regards to impact test requirements.

6.4.3. In case of vessels subject to PWHT, materials shall be ordered with guaranteed properties on the basis of simulated post weld heat treatment according to the intended heat treatment of the vessel and provisions for repairs.

6.4.4. For vessels subject to autorefrigeration, all materials shall be impact tested (impact test exemptions of the Code are not permitted in that situation). In this case, and wherever the

Code requirements are less restrictive, the difference of the final autorefrigeration temperature with the impact test temperature of the materials shall not exceed 30°C.

6.4.5. Whenever the Manufacturer cannot use the materials specified in table 6.1, equivalent materials shall be proposed to the NIOEC for approval; his choice should be substantiated by equivalencies recognised by standards.

Table 6.1 Selection of materials in relation to design temperatures

Design temperature	+ 380°C to - 196°C (1)	+ 380°C to - 101°C	+ 380°C to - 46°C	+ 380°C to - 29°C	+380°C to + 21°C	Max. 468°C
Type of steel	18/8 stainless steel	3.5 % Ni	Normalized carbon steel	Carbon steel	Carbon steel	1.25 Cr-0.5 Mo
Rolled sheet	SA 240 304 (2) SA 240 304L SA 240 316 (2) SA 240 316L SA 240 321 (3) SA 240 347	SA 203 Grade D or Grade E	SA 516 Grade 60 Grade 70	SA 516 Grade 60 Grade 70	SA 515 Grade 60 Grade 70	SA 387 Grade 11 Class 1 1.25 Cr-0.5 Mo
	9 % Ni SA 353					
Forgings	SA 182 F 304 (2) SA 182 F 304L SA 182 F 316 (2) SA 182 F 316L SA 182 F 321 (3)	SA 350 LF 3	SA 350 LF 2	SA 105	SA 105	SA 182-F11 1.25 Cr-0.5 Mo
	9 % Ni SA 522 Grade 1					
Pipes	SA 312 TP 304 (2) SA 312 TP 304L SA 312 TP 316 (2) SA 312 TP 316L SA 312 TP 321 (3)	SA 333 Grade 3	SA 333 Grade 6	SA 106 Grade B	SA 106 Grade B	SA 335-P11 1.25 Cr-0.5 Mo
	9 % Ni: SA 333 Grade 8					
Threaded rods	SA 320 - B8	SA320-L7	SA320-L7	SA193-B7	SA193-B7	SA193-B16
Nuts	SA194GrB	SA194Gr4	SA194Gr4	SA194Gr2H	SA194Gr2H	SA194Gr4

Notes to table 6.1:

The above materials are to ASME II standards.

1. Materials to equivalent ASTM standards are authorized for non-stamped vessels.
2. TP304 and 316 alloys are not authorized in welded applications.
3. TP321 alloy is limited in temperature to a minimum of -145°C in welded applications.

Note:

Other parts shall be as follows:

- A. Structure steel, all thickness, ASME SA573 or ASME SA36 with silicon – killed fine –grain practice.
- B. Casting, ASME SA216 Grade WCB Normalized and tempered.
- C. Fittings, ASME SA234WPB or WPBW. All materials shall be normalized.

D. Name Plate, Plate material shall be type ASME SA316 SS.

- 6.4.6.** Material substitution during vessel fabrication must have the written approval of Purchaser/NIOEC before being used in actual construction.
- 6.4.7.** A request by the vessel fabricator for material substitution must be accompanied by complete information including corrected thickness, and must state the complete ASME designation including any applicable grade, type, quality or finish, such as ASME SA-516-GR60
- 6.4.8.** Mo and Cr-Mo low alloy steel shall be produced by the open-hearth or electric furnace process.
- Austenitic steel shall be produced by electric furnace process.
- 6.4.9.** For vessels with non-austenitic steel plates, if vessel design temperature is lower than 0°C, impact test shall be made.. Generally the tests shall be made on three Charpy V-notch specimens (with the notch perpendicular to milling surface).
- 6.4.10.** Non carbon steel parts to be welded, shall have a carbon content higher than 0.25%.
- 6.4.11.** All carbon steel internal piping shall be schedule 80 up to 8" (in.) inclusive, and 1/2" wall thickness for sizes 10" (in.) and over. All alloy steel internal piping shall be schedule 40 up to 10" (in.) inclusive, and 3/8" thickness for 12" (in.) and over.

6.5. Corrosion Allowance

Refer to clause 5.2 of NIOEC-SP-00-50 "Design Criteria".

6.6. Alloy Protective Lining

Alloy cladding shall be carried out in accordance with the requirements of ASME SA 263, SA 264 and SA265.

For vessels where the partial pressure of H₂ exceeds 100 psig partial pressure in H₂/HC mixtures or high hydrogen content services the manufacturing process for integrally clad plate shall be such that the bonding material used and/or the final bond obtained between cladding and base plate material shall have hydrogen attack resistant properties equal to that of the base plate metal.

- 6.6.1.** The extent of the alloy protective lining or cladding shall be indicated on the vessel drawing.
- 6.6.2.** The lining or cladding material for manhole and nozzle necks, manhole cover plates and other internals shall be the same as that used for the shell.
- 6.6.3.** The calculation of the required pressure vessel thickness may take credit for the cladding only to the extent permitted by the ASME Code. Nozzle and manway link attachment shall be made with weld deposit which is at least as thick as the lining when properly machined.
- 6.6.4.** Unless otherwise specified on the vessel drawings, the thickness of applied liners and cladding shall be 3mm minimum.
- 6.6.5.** All vessels made from austenitic steel clad plates shall be subjected to the necessary tests for measurement of the relative susceptibility of stainless steel to intergranular attack as per procedure outlined in ASTM Specification A 393 except that thickness of test specimens shall be 60% of stainless steel clad thickness measured from the clad face. Also, vessel fabricator shall submit qualified welding procedure for approval showing adherence of stainless steel weld deposits and heat effected zone of clad requirements set

forth in A 393.

- 6.6.6.** In clad or metal-lined vessels, the thickness of cladding or applied lining shall not be considered for the purpose of calculation in design conditions, except as specified under 6.6.3 whereas cladding can be taken into consideration for the calculation at hydrostatic test conditions.
- 6.6.7.** Where metal lining consists of metal strips they shall be welded to the vessel. On the shell, the strips shall be fitted circumferentially, whereas on the heads they shall be arranged symmetrically along two orthogonal axes. Each individual strip shall be welded separately, and the spacing between two adjacent strips shall be such that the relevant welds do not come into contact. A third welding pass shall cover both adjacent welds until leveling the lining thickness.

Strip width shall not exceed the values shown in the following table:

Vessel Design Temperature		Max. Strip Width	
°C	°F	mm	inches
up to 340	up to 645	114	4 ½
341 to 400	646 to 752	102	4
401 to 450	754 to 842	90	3 ½
451 to 540	844 to 1004	76	3

- 6.6.8.** The method of lining large nozzles and manways shall preferably be the same as that used on the shell. Alternately, strip lining may be applied using the three-bead method of welding. The overlap method may be used for Monel, Plug welding is not acceptable. Strips shall be 64mm (2½") maximum width.
- 6.6.9.** For small nozzles, tubular liner may be used. They shall be made in proper diameter to allow for radial expansion and shall be welded to the alloy facing at the flange end and to the inside, flush with the vessel lining.
- 6.6.10.** Tubular liners in nozzles where the design temperature exceeds 400°C (750°F) or in nozzles which exceed 15 inches in length shall be attached to the vessel lining by means of an expansion collar.
- 6.6.11.** Solid alloy nozzles are not recommended.
- 6.6.12.** Lightly loaded supports and continuous supports for trays, baffles etc, may be welded directly to alloy cladding. Attachment welds may coincide with strip welds attaching liner to shell.
- 6.6.13.** Supports for heavy loads of clad vessels shall be welded to the base metal and the joint overlaid with alloy weld to the same composition as the lining and built up to include corrosion allowance.
- 6.6.14.** Alloy clad overlay welding details for nozzles shell and head joints shall be according to NIOEC-SD-4114-1/1-A3.
- 6.6.15.** The alloy lining in vessel shells shall be cut back at all seams to permit back welding of the base metal. Weld metal shall be ground flush and fully covered with the applicable weld deposit. The weld deposit shall be at least as thick as the lining but no greater than twice its thickness.

6.7. Shell and Heads

- 6.7.1.** The minimum thickness of shell and heads shall not be less than:

$$t = (D/800) + 3 + C$$

Where:

t : Minimum thickness in mm (rounded up to next higher mm)

D: Outside diameter in mm

C: Corrosion allowance in mm

This requirement applies to:

- Walls consisting of a single material (i.e. carbon, low alloy, or stainless steel, etc.)
- Clad vessels made of carbon steel (or low alloy steel) with stainless steel clad. In this case, the thickness of stainless steel shall not be included in the minimum thickness.

- 6.7.2.** Vessel drawings shall specify the minimum head thickness including corrosion allowance and cladding (if any) and additional material must be added to allow for thinning due to forming. Conical heads and reducer sections with knuckle radii may have the knuckle section formed separately, but the metal thickness for the knuckle section shall be the same as for the head or reducer section at point of attachment. Any conical head or reducer section made in more than one thickness shall have the thickness change in the cone section and not in the knuckle section.
- 6.7.3.** A tolerance up to minus 0.25 mm (0.01”) is allowed on thickness. A larger tolerance may be allowed only if it is within rounding-up of the thickness after calculation. On vertical vessels, the shell and bottom head thicknesses shall be based upon pressure plus structural strength requirements, and shall not be reduced without written approval.
- 6.7.4.** Large diameter vessels which have their thickness based on “Practical” minimums may sometimes be made of lighter material, if the fabricator can show from experience that it is safe with respect to all structural conditions encountered, as well as local buckling stresses and erection stresses. A revision of this nature may be proposed as an alternate to the quotation, but may not be made after a purchase order is issued.
- 6.7.5.** No longitudinal joints shall be allowed within the downcomer area or behind any other plate or obstruction which prevents proper inspection of the weld. Circumferential welded joints shall clear tray support ring welds by 1” minimum and be located so as to allow inspection with all internal equipment in place. Vessel skirt shall not hide circumferential welds.
- 6.7.6.** Vertical vessels specified with varying wall thickness shall be so designed to resist forces caused by wind, earthquake, pressure, or dynamic conditions. These vessels may have thicker shell plates for the lower courses, and the plate thickness is decreased for courses at the higher elevations. The plate thicknesses indicated must be maintained, except that heavier plate may be extended higher than specified in order to use standard widths of plate. As an example, if 22mm (7/8”) plate is shown extending 8534mm (28’-0”) above the tangent line, it may be extended to 9626 or 9958mm at the fabricator’s option. A similar increase in the width of a thick section may also be made for vessels which have thicker plates in zones of high temperature operation.
- 6.7.7.** Vessel fabricator shall show, on his own drawings, longitudinal and circumferential welds of shell and heads, with levels. Wherever possible, these welds shall not interfere with welds of nozzles and anything also welded to vessel. In no case shall welds be tangential. Internal welds shall have corrosion allowance according to wall included. Longitudinal joints of adjacent courses shall be staggered as much as possible.
- 6.7.8.** Plates of different thickness shall be aligned along the inside of the vessel, unless otherwise indicated.

6.7.9. The number of shell and heads welded joints shall be minimized.

Shell rings 2800 mm or less in outside diameter shall have not more than one longitudinal welded joint.

The maximum number of circumferential joints, exclusive of head-to-shell joints, shall be determined as a function of the total length “L” of the cylindrical shell between tangent lines as follows:

Table 6.2- Shell circumferential welded joints number

L (mm)	Number of circumferential joints
≤ 2400	0
≤ 4800	1
≤ 7200	2
≤ 9500	3
> 9500	(See note below)

Note: Beyond these length values, one additional joint every 2500-mm of L.

6.7.10. Vessel heads shall be the type specified on the vessel drawing. Normally, top and bottom heads shall be semi-elliptical or torispherical, and shall have an integral straight flange t not less than $0.015 D+s$ (where D =vessel outside diameter, and s =minimum wall thickness of head), and anyway not less than 50mm. Skirts of spherical and conical heads and of conical reducers, should comply with ASME Code.. Hemispherical heads shall be used preferably for High Pressure Vessels even if not already specified in the vessel data sheet.

Conical heads and reducing sections shall normally be of the toriconical design with transition knuckle. All semi-elliptical heads shall be 2:1 ratio.

6.7.11. Heads shall preferably consist of one piece only, but, if not practicable they should consist of the minimum possible number of pieces.

Welds, if any, shall intersect, or at least touch, a circle of diameter $0.75D$ concentric to the head.

6.7.12. Welded joint layout

Welded joints shall be so arranged that:

- Visual inspection can be made with all internals in place
- No openings intersect with a weld seam
- No saddle bearing plates, nozzle-reinforcing pads, or wear plate cover longitudinal or girth joints
- No nozzle or other attachment weld edge shall be closer to the nearest weld edge than 1.5 times the related shell or head wall thickness, with a minimum distance of 50 mm
- Centres of the longitudinal joints of two adjacent courses shall be staggered 30° minimum apart and preferably be off-centre relative to the vessel main centrelines. For horizontal vessels, they shall be located above the horizontal plane through the centreline of the vessel.

6.7.13. Type of welded joints

All longitudinal and circumferential joints, and in as much as possible, all pressure retaining joints, shall be double-sided butt-welds and shall conform to type no. (1) of the Code table UW-12.

Welds inaccessible for double-sided welding (e.g. circumferential closing joint of small diameter vessels, piping and fitting butt welds) shall be single butt welds equivalent to a double butt welded type no. (1) of the Code table UW-12 (which means in particular full access for visual

inspection at the back side of the weld).

Attachment of intermediate heads shall be as shown in the Code Fig UW-13.1 sketch (f).

6.7.14. Reinforcement

Added reinforcement plate, when provided, shall have a minimum width of 50 mm and shall be in one piece.

Welded reinforcement should also be avoided when the temperature of the vessel exceeds 400°C, regardless of pressure. In this case, integral reinforcement, tapered for butt-welding to the shell, should be used.

Self-reinforcing forged nozzles shall also be used for High Pressure Vessels or vessels in Hydrogen or H₂S service.

With reference to UG-40 of ASME VIII div. 1, self-reinforcing nozzle dimensions shall be such that the length "L" is always equal or greater than 2.5 t

6.8. Connections - Nozzles and Manholes

Threaded fittings or couplings shall not be utilised.

Self reinforced type nozzles shall mandatorily be used on high pressure vessels and H₂S service.

6.8.1. Reference Standards

Connection components shall conform to the following standards:

6.8.1.1. Flanges

Flanges shall be of welding neck type and shall comply with the following standards:

- Up to NPS 24: ASME B 16.5
- Over NPS 24: ASME B 16.47 Series A only.

Outside the limits of the above standards, flanges shall be calculated according to the Code.

6.8.1.2. Nozzles

Nozzles shall comply with the standard ASME B 36.10M. Carbon and low alloy steel pipes 16 inches and smaller in diameter shall be seamless.

6.8.1.3. Welding fittings

Welding fittings shall comply with the standard ASME B 16.9.

6.8.2. Sizes

Minimum nozzle size shall be 2" NPS. However, when a connection must be smaller, a reducing flange matching a 2" nozzle neck may be used. Alternatively, a concentric reducer may be inserted between a 2" pipe neck and the required smaller flange. Sizes 2¹/₂", 3¹/₂" and 5" NPS shall not be used.

When specified in the particular specifications, the inside diameter of nozzles shall be maintained, particularly for connections that must receive equipment or manholes through which internals shall be installed.

6.8.3. The thickness of nozzles shall be as calculated according to ASME code Sec. VIII Div. I, however the minimum thickness of nozzles and standard dimension of reinforcing pad shall be in accordance with Appendix II, unless otherwise specified or approved by the Purchaser. The reinforcement of nozzles and manholes shall not limit the maximum allowable working pressure at the design condition or for the new/cold and uncorroded condition.