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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 standard 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 standard 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 standard 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 on going projects.

In response to the initiative of the Design Division of the Engineering and Construction 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 Division of the Engineering and Construction 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 Deputy of the Engineering and Construction Director of NIOEC for evaluation and consideration.

S. R. KASAEIZADEH



EXECUTIVE DIRECTOR

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NOTES:

- 1) THIS SHEET IS A RECORD OF ALL REVISIONS TO THIS SPECIFICATION.
- 2) REMARKS RELATED TO EACH REVISION SHOW A BRIEF DESCRIPTION. THESE REMARKS SHALL BE INTERPRETED IN CONJUNCTION WITH THE REVISED TEXT MARKED BY REVISION NUMBERS.
- 3) WHEN APPROVED EACH REVISION SHALL BE CONSIDERED AS A PART OF THE ORIGINAL DOCUMENT.
- 4) NUMBER OF PAGES EXCLUDES THIS SHEET AND THE COVER SHEET.

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1. SCOPE

This NIOEC Specification covers minimum requirements for design, fabrication, installation and testing of pressure vessels.

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 1 barg (15 psig), hence falling within the scope of this Specification, except storage tanks covered by API 620.

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 Order of Precedence

In the event of a conflict among the various documents, the order of precedence shall be as follows:

- The purchase order (including attachments) and variations thereon.
- The data sheets and drawings.
- This Specification.
- ASME Code Section VIII, Div.I “Rules for Construction of Pressure Vessels”.

If conflict is discovered between the items listed, it shall be the responsibility of the Vendor to call attention to the conflict.

2. REFERENCES

Throughout this Specification the following dated and undated standards/ codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this Specification.

For undated references, the latest edition of the referenced document (including any supplements and amendments) applies. For dated references, the edition cited applies.

The applicability of changes in dated references that occur after the cited date, shall mutually be agreed upon by 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”

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)**UBC (UNIFORM BUILDING CODE)**

Edition 1997

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

B.1.1	“Unified Screw Thread”	Edition 1989
B.1.20.1	“Pipe Thread”	Edition 1983
B.16.5	“Steel Pipe Flanges and Flanged Fittings”	Edition 1996
B.18.2.1	“Square and Hex Bolts and Screw”	Edition 1996
B.18.2.2	“Square and Hex Nuts”	Edition 1987
B.36.10	“Welded and Seamless Wrought Steel Pipe”	Edition 2000
B.36.19	“Stainless Steel Pipe”	Edition 1985
B.16.20	“Metallic Gasket for Pipe Flanges”	Edition 1998
B.16.47	“Large Diameter Steel Flanges”	

NIOEC-SP (NIOEC SPECIFICATIONS)

NIOEC-SP-20-01	“NIOEC Specification for Structural Steel Specification”
NIOEC-SP-80-02	“NIOEC Specification for Painting”
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-SD (NIOEC STANDARD DRAWINGS)

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

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 The Employer means: The National Iranian Oil Engineering & Construction Company (NIOEC).

4.2 “Purchaser” means: 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” means: The manufacturer and/or fabricator from which the equipment is to be purchased.

4.4 “Erector” means: The Company which is responsible for the erection of the vessels at site.

4.5 “Contractor” means: 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 -10°C , 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 heavy wall (W.T.> 2in.) pressure vessels shall be internationally reputable and authorized by international inspection organizations for manufacturing of such pressure vessels.

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 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 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 load shall be in accordance with civil design criteria [NIOEC-SP-00-01](#). (clause 2.10)
- g) Wind load shall be in accordance with Chapter 16 of U. B. C. as following:
 - 1) Basic wind speed and exposure coefficient at site as per [NIOEC-SP-00-11](#). (Site Condition)
 - 2) Design wind pressure shall be in accordance with the chapter 16 of UBC Vol. 2, division III.
- 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 Vessel fabricators are permitted to quote prices on alternative materials and construction in cases where a more economical unit can be produced, or in order to conform to their fabricating facilities. In general, quotations should always be based upon the construction specified, with the alternate listed separately. Minor deviations in construction shall be listed as deviations or exceptions for consideration. Alternative proposals must be clearly described and accompanied by sketches or drawings when a written description is inadequate to convey the detail construction.

Purchaser reserves the right to accept or reject alternates, and in no case shall alternative construction be used without written approval by NIOEC.

It is understood that alternative construction, if accepted, is the responsibility of the Contractor vessel fabricator with respect to manufacture, performance, codes and legal requirements, and in no instance shall NIOEC/Purchaser be held responsible for failure or rejection by code inspectors or legal authorities.

- 6.4.2** Equivalent substitutes to materials specified in Section II of ASME Code and those specified on vessel in drawings may be used subject to NIOEC approval, such as to JIS, BS and DIN standards. However materials stresses shall in any case be based on ASME code requirements.
- 6.4.3** Materials of construction for vessel components shall be selected so as to produce an economical design for the specified design service conditions and have adequate mechanical properties at low ambient temperature of site.
- 6.4.4** Pressure holding components constructed of rolled plated for carbon steel vessels shall generally be of the same or comparable material as that used for the shell and heads.
- 6.4.5** Material substitution during vessel fabrication must have the written approval of Purchaser/NIOEC before being used in actual construction. Price adjustments shall be clearly stated in requests for substitution, and Purchaser shall not be held responsible for increased cost unless it is included in the written request and approved by the Purchaser/NIOEC.
- 6.4.6** A request by the vessel fabricator for material substitution must be accompanied by complete information including corrected thickness, and must state the complete ASME (or ASTM) or equivalent designation including any applicable grade, type, quality or finish, such as ASME SA-516-GR55. In cases where the material has no standard designation, complete description of chemical and mechanical properties shall be submitted and it shall be the responsibility of the vessel fabricator to obtain ASME Code approval. The vessel fabricator shall be in his request whether or not ASME Code approval has been obtained. Trade names and proprietary designation do not constitute sufficient information, except when accompanied by descriptions of chemical and mechanical properties.
- 6.4.7** Pressure vessel plate and supporting material shall be killed carbon steel ASTM 516 GR55 or 60 preferred, normalized. 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.
- 6.4.8** If vessel design temperature is lower than 0°C, impact test at temperature not higher than above mentioned temperatures shall be made for non austenitic steel plates. Generally the tests shall be made on three Charpy V-notch specimens (with the notch perpendicular to milling surface). Minimum required impact values are as follows:

<u>Material</u>	<u>Mean value Thickness (inches)</u>	<u>Minimum of 3 Specimens kgm/cm²</u>	<u>of 1 Specimen kgm/cm²</u>
Fully Killed and Medium Strength carbon and low alloy:			
a. Material with a specified minimum yield strength ≤ 43000 psi	$t \leq 1/2$ $1/2 < t \leq 1-1/2$	2.7 3.45	2.2 2.76
i.e.: SA 516 GR55,60,65	$t > 1-1/2$	4.84	3.87
b. Material with a specified minimum yield strength ≤ 70000 psi	$t \leq 1/2$	4.15	3.46
i.e.:			
Low alloy steel SA 387 GR 11 CL 2			
Low alloy steel SA 204 B.	$1/2 < t \leq 1-1/2$	4.84	3.87
Carbon steel SA 516 GR 70	$t > 1-1/2$	6.22	4.97

6.4.9 If the design temperature is between 0°C and +20°C (32°F and 68°F) impact tests similar to those specified in paragraph 5.4.8 are required for killed carbon steel or Cr-Mo low alloy steel, or high-strength steel used for non-insulated storage tanks.

6.4.10 No carbon steel parts to be welded shall have a carbon content higher than 0.25%.

6.4.11 Nozzle and manway materials:

<u>Item</u>	<u>Material</u>
Necks.	
Pipe less than 16" I. D.	A106 Gr B Normalized
Pipe 16" I. D. or over	A106 Gr B Normalized or same grade material as for vessel
Rolled plate	Same as vessel
Flanges	
Long welding neck	A105 Normalized
Welding neck or slip on	A105 Normalized

6.4.12 Material for vessel support skirts welded directly to the vessel shall be based on the design temperature of the vessel at the point of attachment.

Design temperatureSkirt Material

343°C (650°F) or higher

At least the upper 1 m shall be the same material as the vessel; the lower portions may be as listed below.

343°C (650°F) or lower

Killed carbon steel SA516 Gr 55 or 60 Normalized.

6.4.13 Steel Plate for reinforcement of skirt opening and saddles shall be SA516 Gr 55 or 60 normalized. Other parts shall be as follows:

A. Structure steel, all thickness, ASTM A573 or ASTM A36 with silicon – killed fine – grain practice.

B. Forgings ASTM A105 Normalized.

C. Piping ASTM A106 Gr B Normalized.

D. Casting ASTM A216 Grade WCB Normalized and tempered.

E. Fittings ASTM A234 WPA, WPAW, WPB or WPBW.
All materials shall be normalized.

F. Bolting Flange bolting for process equipment shall be ASTM A193 Gr B7 with A194 Gr 2H nuts, Anchor bolting per ASTM A307 shall be in accordance with A36 with silicon – killed fine – grain practice or A193 Gr B7 with A194 Gr 2H nuts.

6.4.14 Lugs welded to the shell for support of distributors and internal non pressure parts shall be SA516 Gr 55 or 60 normalized, except in lined portion of vessels where they shall be alloy corresponding to the lining.

6.4.15 All carbon steel internal piping shall be A 106 or A 53 schedule 80 upto 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 & 3/8” thickness for 12”(in.) and over.

6.4.16 Bolting for distributors, baffles or other miscellaneous items not furnished by the tray supplier shall be SA193 Gr B7 with A194 Gr 2H nuts, unless otherwise specified, except for tray manholes which should be 11-13% Cr.

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 A 263, A 264 and A265.

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 indicated otherwise on the vessel drawings, the thickness of applied liners shall be 2mm (5/64") and the thickness of alloy cladding on clad steels shall approximate 2mm (5/64") as closely as standard mill practices will permit.

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 levelling 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 man ways 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 Monet, 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 of 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 may be welded to integrally clad or continuously bonded linings, but for strip lining 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 shown in proceeding table. 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 shell plate thickness for vessels including corrosion allowance shall be as follows:

I.D. 914 mm (36") and under	5mm (3/16")
Over 914 mm (36") to 1524 mm (60") (1/4")	6mm
Over 1524 mm (60") to 2134 mm (84") (5/16")	8mm

Over (3/8")	2160 mm (84") to 3658 mm (144")	10mm
Over (7/16")	3658 mm (144")	over 11mm

Above minimum thickness are for the general stability immaterial of Pressure and Temperature requirements.

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 down comer 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 Plate courses of a diameter equal to or less than 2m (7') shall be only one longitudinal weld.

6.7.10 Vessel heads shall be the type specified on the vessel drawing. Normally, top and bottom heads shall be Ellipsoidal or semispherical, and shall have a skirt not less than $0.015 D+s$ (where D =vessel outside diameter, and s =minimum wall thickness of head), and anyway not less than 30mm. Skirts of spherical and conical heads and of conical reducers, should comply with ASME Code. Hemispherical heads may be used when so indicated by the design conditions. 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.

6.8 Nozzles Couplings and Flanges

6.8.1 All nozzles over 1-1/2" shall be flanged. Connections 1-1/2" and smaller may be made with forged steel couplings. Such connections shall be limited to vessels for which the design pressure and temperature is less than 600 psig (43 kg/cm²) and 232°C (450°F) respectively. Couplings shall be 6000 psi rating for 1-1/2" and smaller connections. Couplings shall not be used in lined portions of alloy lined vessels, on bottom heads of vertical vessels. Threaded fittings or tapped holes are not permitted. The minimum size of nozzles shall be 1", except that for alloy lined nozzle the minimum size is 1-1/2". For vessels in hydrogen service minimum size connection shall be 1" and all connections shall be flanged.

6.8.2 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.

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

6.8.4 Flanges shall be of forged steel, of a type conforming to NIOEC piping Specification and vessel drawings. This applies also to blind flanges.

6.8.5 For sizes up to 2", long-welding-neck flanges are required; in the case where 1" and 1-1/2" size flanges are indicated on drawings, rating shall be not be less than 300 lb.