**TABLE OF CONTENT**

[1.0 INTRODUCTION 2](#_Toc480451642)

[2.0 REFERENCE CODES & STANDARDS (LATEST EDITIONS) 5](#_Toc480451643)

[3.0 SCOPE OF SUPPLY 7](#_Toc480451644)

[4.0 ENVIRONMENTAL DESIGN CRITERIA 8](#_Toc480451645)

[5.0 GENERAL REQUIREMENTS 9](#_Toc480451646)

[6.0 DESIGN 11](#_Toc480451647)

[7.0 MECHANICAL REQUIREMENTS 15](#_Toc480451648)

[8.0 ADDITIONAL REQUIREMENTS FOR FLANGED GIRTH JOINTS 24](#_Toc480451649)

[9.0 MATERIALS 26](#_Toc480451650)

[10.0 FABRICATION 29](#_Toc480451651)

[11.0 INSPECTION, TESTING AND CERTIFICATION 34](#_Toc480451652)

[12.0 PAINTING AND PREPARATION FOR SHIPMENT 39](#_Toc480451653)

[13.0 SPECIFIC REQUIREMENTS FOR CLAD VESSELS 41](#_Toc480451654)

[14.0 DRAWINGS AND DATA REQUIRED 43](#_Toc480451655)

# INTRODUCTION

## GENERAL

This specification is a standard specification for Unfired Pressure Vessels and outlines the minimum requirements of the COMPANY.

.

## DEFINITION

Following definitions apply throughout this document:

|  |  |
| --- | --- |
| Company / Owner | Oil & Gas Development Company Limited (OGDCL) |
| Contractor | “Contractor” means the person or persons, firm or Proprietor whose proposal has been accepted by the Company for verification of FEED package, engineering design, procurement, inspection, supply of material and equipment, construction/ commissioning, performance testing, one year of defect liability period and training of Company’s personnel for the project and includes the Contractor's representative(s), successors and permitted assignees. |
| Vendor / Supplier | The organization, firm or agency with whom order for the supply of equipment and or material has been placed. |

## ERRORS OR OMISSIONS

Review and comment by the COMPANY of any CONTRACTOR / SUPPLIER drawings, procedures or documents shall only indicate acceptance of general requirements and shall not relieve the CONTRACTOR / SUPPLIER of its obligations to comply with the requirements of this specification and other related parts of the Contract Documents. Any errors or omissions noted by the CONTRACTOR / SUPPLIER in this Specification shall be immediately brought to the attention of COMPANY.

## DEVIATION

All deviations to this Specification, other related specifications or attachments shall be brought to the knowledge of the COMPANY in the bid. All deviations made during the procurement, design, manufacturing, testing and inspection of the Works shall be with written approval of the COMPANY prior to execution of work. Such deviations shall be shown in the documentation prepared by the COMPANY.

## CONFLICTING REQUIREMENTS

In the event of any conflict, inconsistency or ambiguity between the Contract scope of work, this Specification, Codes & Standards referenced in this Specification or any other documents, the CONTRACTOR / SUPPLIER shall refer to the COMPANY whose decision shall prevail.

## REPORTING PROCEDURE

A reporting and documentation system shall be agreed between the COMPANY and the CONTRACTOR / SUPPLIER for the status of procurement, design, manufacturing, inspection, testing and shipment of the equipment/material to be supplied under this specification. CONTRACTOR / SUPPLIER’s manufacturer shall provide reports and summaries for production performance and testing operations in conformance with a manufacturing schedule approved by COMPANY.

Weekly, monthly and run summaries of all major aspects of the production process shall be provided as reports to the COMPANY.

## UNIT RESPONSIBILITY

The CONTRACTOR / SUPPLIER shall be responsible for the complete design, manufacture supply, fabrication, installation/erection, inspection and testing of the vessels, including full compliance with all applicable design codes, and standards, including those listed in Section 2.0 of this document and with the requirements of the independent certifying authority, where applicable.

# REFERENCE CODES & STANDARDS (LATEST EDITIONS)

ASME Codes

Section VIII Division I & Division II (Pressure Vessels)

Section IX Welding Qualifications

Section V Non-destructive Examination

Section II Materials

Section II, (Part C) Welding Rods, Electrodes and Filler Materials

ANSI Standards (Latest Editions)

B16.5 Steel Pipe Flanges

B.16.20 Metallic Gasket for pipe Flanges

B16.9 Factory Made Wrought Steel Butt-Welding Fittings

B36.10 Wrought Steel Pipes

B36.19 Stainless Steel Pipes

A58.1 Building Code Requirement for Minimum Design Loads in Building and Other Structures.

MSS SP-44 or Steel pipe line flanges for dia > 24"

ANSI B16.47

Steel Structures Painting Council Specification for Surface Preparation and Painting System;

In addition to the requirements of this specification, all requirements of the governing authority, i.e. the country and/or its sub-divisions, where the vessel is to be installed shall be met;

Pressure vessels shall be fabricated in accordance with ASME code by `U’ stamp fabricator. Bidder to confirm the name of fabricator in the bid and provide his `U’ stamp certification from ASME. Waiver from this requirement must be obtained from COMPANY.

# SCOPE OF SUPPLY

## GENERAL

This specification sets forth the minimum acceptable standards governing the design, fabrication, material requirements, inspection, testing, identification and preparation for shipping of unfired pressure vessels.

## MATERIAL, WORKMANSHIP AND SUITABILITY

All materials and parts included in the construction of the specified vessel shall be new, unused and of the highest grade being free from all defects or imperfections likely to affect their performance.

# ENVIRONMENTAL CRITERIA

Environmental criteria is as per environmental conditions.

# GENERAL REQUIREMENTS

## COMPANY’s Requirements

The design life of equipment shall be 25 years.

Requests for substitutions of any kind shall be complete with all pertinent engineering information required for the COMPANY’s evaluation of the proposed substitution.

Vessel outline drawings and/or data sheet sketches submitted to the CONTRACTOR / SUPPLIER are not intended to cover complete details. The CONTRACTOR / SUPPLIER shall make detailed calculations for the design of the pressure vessels and shall prepare detailed shop drawings.

The CONTRACTOR / SUPPLIER shall concurrently submit to the COMPANY, fabrication drawings, weld procedures and detailed calculations for approval. Shop work shall not start until the CONTRACTOR / SUPPLIER have received drawings and weld procedures approved by the COMPANY. No subsequent revision may be issued to the fabrication shop unless it is approved by the COMPANY.

## EARTHING

Each vessel shall be supplied with a minimum of two earthing bosses suitable for termination of 70 sq. mm earth cable.

## TOLERANCES & DIMENSIONS

CONTRACTOR / SUPPLIER shall comply with the requirements as per ASME VIII.

## NOZZLE PROJECTION

Unless specified otherwise, the nozzle projections shall comply with the requirements as per ASME VIII.

## INSULATION

See insulation specification attached in MR.

# DESIGN

## DESIGN CONDITIONS

The design pressure shall be in accordance with the code, but shall be at least 10% above the maximum operating pressure or 1.0 barg (14.5 psig) plus maximum operating pressure, whichever the larger.

Internal pressure due to static head of liquid in columns and vessels shall be added to the internal design pressure. For vessels operating above 0°C, the design temperature shall be 13°C above the maximum continuous operating temperature, but not less than 60 °C. All vessels, regardless of operating temperature, shall be designed for a low temperature condition, which shall be the lowest of the following:

* 3°C below the minimum operating temperature
* The minimum ambient temperature
* The blow down temperature

## DESIGN LOADINGS

The Vessel(s) shall be self-supporting and designed to withstand a wind loading based on the projected area of curved surfaces. The area of ladders, platforms and pipework shall be assumed as equivalent to one and one-half times the wind loading of the insulated vessel.

Pressure vessel components, their supports and anchorages, shall be designed to withstand the results of the following combinations of loads and forces within the limits of stress set by the code, and the deflections set by Section 6.4 of this specification:

* Erection Condition (The empty weight plus the weight of any internals present during erection).
* Initial Site Test Condition (The empty weight plus weight of water to fill the vessel).
* Operating and Design Conditions (The empty weight plus the weight of all internals packing, insulation and operating liquid);
* Hot Shut down Condition (As for the Operating and Design Condition, but excluding the operating liquid);
* Transportation/Dynamic Loading Condition;
* Continuous monitoring of vessel conditions by mechanical testing during operation conducted by operating and maintenance team after start-up and handing over;
* Any other condition, which would affect the safety of the vessel e.g. cyclic loading;

## DESIGN STRESS

Allowable Stress

Shall be the maximum stresses permitted by the basic design code.

Test Condition

The allowable general membrane stress shall be the maximum of 90 percent of the minimum specified yield or proof stress of the material of construction.

Anchorages

Foundation bolts for vessels shall have a maximum allowable tensile stress of 110 N/mm2.

## DEFLECTION LIMITS DUE TO APPLIED LOADS

The static deflection of vertical vessels in the corroded condition due to the full wind load shall be limited to 1 in 200 of the vessel length. The deflection due to applied load and self weight of distributors, gratings, etc. and their supports, in the corroded condition, shall be limited to 1 in 500 of their span. Vertical vessels with a ratio of overall height to diameter exceeding 15 shall be designed for dynamic stability under wind induced vibrations.

## NOZZLE LOADING

|  |  |  |
| --- | --- | --- |
| Nozzle Size | Resultant Force (N) | Resultant Moment (RN) |
| 2” | 1435 | 380 |
| 3” | 2930 | 1140 |
| 4” | 4100 | 2080 |
| 6” | 7000 | 5230 |
| 8” | 10190 | 9800 |
| 10” | 13950 | 16510 |
| 12” | 16500 | 22820 |
| 14” | 17500 | 26110 |
| 16” | 19350 | 32310 |
| 18” | 21000 | 38310 |
| 20” | 22450 | 44260 |
| 24” – 30” | 24750 | 54880 |

The above table gives the resultant forces and moments induced from pipework systems, which are to be allowed. CONTRACTOR / SUPPLIER shall consider the force acting radially together with the moment acting either in a longitudinal or circumferential direction. The above table does not apply to equipment nozzles within packaged units where actual loading conditions should be applied. CONTRACTOR / SUPPLIER shall ensure that the above nozzle loadings will not induce unacceptable stress levels in the vessel shell or head, in compliance with the relevant vessel design code.

## DRAWINGS & CALCULATIONS

Shop details shall be complete with all dimensions, thicknesses and details of construction, including dimensional location of circumferential and longitudinal seams, and all nozzle locations and orientations. All material thicknesses shall be shown, including spherical radius and knuckle radius of heads. All welds shall be detailed or fully described by notes or weld symbols, and annotated to the relevant weld procedure specification.

The assembly drawings shall contain all pertinent information relating to the standards, codes and specifications used in the design, fabrication, inspection and testing of the vessel, including the materials used, plus the total weight of the vessel empty, operating and full of water.

A detail of the skirt, base ring and chairs for vertical vessels or saddles for horizontal vessels shall be provided, complete with all dimensions and descriptions of material, including number, diameter, and location of anchor bolt holes. If this information is furnished by the COMPANY it shall be checked by the CONTRACTOR / SUPPLIER and so noted on the appropriate drawing. Foundation loading data shall also be provided by the CONTRACTOR / SUPPLIER. CONTRACTOR / SUPPLIER shall submit detailed calculations establishing the compliance of design with the requirements of this specification, the certifying authority if applicable and all statutory regulations. Methods of calculations which are not in accordance with the relevant code or established procedures shall be subject to approval by the COMPANY for its applicability to the design.

All calculations shall be complete, giving all references and showing all working methods. Computer printouts will not be accepted without the program flow chart, input data and complete printout, and then only by prior written agreement with the COMPANY at the quotation stage. Review of drawings, calculations and other documents by the COMPANY, does not relieve the CONTRACTOR / SUPPLIER of his responsibility for the correctness of the design to suit the stated conditions.

# MECHANICAL REQUIREMENTS

## MINIMUM THICKNESS

After forming, the minimum thickness of shell and head shall, for carbon steel and low alloy steel vessels, be as follows:

|  |  |
| --- | --- |
| **Vessel I.D.** | **Min. Thickness with Corrosion Allowance** |
| 1500 mm & below | 6 mm |
| 1501 – 2500 mm | 8 mm |
| 2501 mm | 10 mm |

Minimum thickness of materials other than carbon steel shall be based on the structural stability of the vessel in addition to the requirements of pressure and other mechanical loading. However, the minimum thickness of high alloy (austenitic) steel vessels and their components shall not be less than 6mm. Minimum wall thicknesses of carbon steel and low alloy nozzle necks, including corrosion allowance, shall be the greater of the code requirement or the following:

* 2" through 6" - Sch. 80.
* 8" through 24" - Std. Wall

Skirts shall be designed for load conditions, but shall not be less than 6mm wall thickness. Minimum thickness of internal carbon steel attachments shall not be less than 6mm excluding corrosion allowance.

## CORROSION ALLOWANCE

Unless otherwise specified on the data sheet, carbon steel vessels and internals shall have 3mm corrosion allowance applied to all pressure retaining parts and all surfaces of non-removable internals exposed to the process fluid. Removable internals shall have half the specified corrosion allowance on all surfaces exposed to process fluid.

No corrosion allowance is required on stainless steel materials or materials protected by stainless steel unless otherwise specified. When corrosion allowance is provided by a corrosion resistant metallic lining, a minimum thickness of 3mm of lining material shall be used.

Vessel parts, which are subjected to erosion e.g. due to impingement by the process stream, shall be protected with wear plates, or impingement baffles. Flaked glass lining may be provided on the inner surface of inlet separator vessels to avoid erosion due to high velocity inlet fluid, which may contain abrasives/solid particles etc. and also to avoid corrosion effect in water boot section.

## HEADS

Vessel heads shall be one-piece semi-ellipsoidal (ratio 2:1) unless otherwise specified. Pressure vessels having design pressure 150 psig & above, shall have one piece hemispherical heads.

Torispherical and hemispherical heads may be used provided all pertinent dimensions and information is submitted to the COMPANY for approval before the heads are ordered.

Heads shall have straight flange of not less than 50mm or two times the thickness, whichever is greater. All heads, which have been formed cold or below final tempering temperature. Heads produced from more than one plate shall have the welds 100% radiographed after forming.

## SUPPORTS

Horizontal vessels shall be supported on two steel saddles only. Saddles shall be furnished by CONTRACTOR / SUPPLIER. There shall be two (2) ½" NPT tapped tell-tale holes at outer extremities in each saddle pad. Saddle pads shall have rounded corners. Saddles shall provide support for at least 120° arc at the circumference of vessel shell (As per ASME VIII).

Calculations shall be provided for the effect of support saddles on the vessel shell and heads. Vertical vessels shall be supported on steel skirts. Small vertical vessels less than 1200mm Inside Diameter may be supported on structural legs, or lugs, where advantageous to plant layout. Skirts are however mandatory for all vertical vessels with a height to diameter ratio greater than 5.

All vessels shall be designed to be self-supporting without benefit of guys or braces. Vessel skirts shall be of the height required to provide a clearance not less than 480mm between the bottom of the head and the deck/foundation. All vessels provided with skirts shall have a reinforced access opening of 400mm minimum diameter. Skirts for vessels smaller than 920mm nominal diameter shall be provided with at least one 200mm access opening. Desired orientation of openings shall be shown on the vessel drawing, or affixed on CONTRACTOR / SUPPLIER's approval drawings.

Vessel skirts shall be provided with 3" diameter reinforced vent holes at approximately 920mm intervals on the circumference, located as near the vessel head as permitted by insulation or other attachments. No skirts shall have less than two such vent holes. The following joint factors should be applied to vessel skirts:

* Circumferential seams - 0.7
* Skirt to shell joint - 0.55
* Skirt to base ring joint - 1.0

## MANHOLES, NOZZLES & INSPECTION OPENINGS

Manholes, handholes, cleanout openings and end flanges shall be provided as required for operation and maintenance and to meet Code requirements for inspection.

Cleanout openings shall be 4" minimum inside diameter, and shall be complete with blind flanges, bolting and gaskets and hinged, if not accessible to ground or a platform, for ease in maintenance. Where inspection openings are required the minimum size shall be 4" nominal. Trayed or packed towers shall be served by adequate internal and external access openings and shall have at least a top and bottom manhole. Packed towers shall have a manhole above the top level of the packing and below each support grid. A minimum 12" nominal opening shall be provided above each grid to permit removal of packing. Where the centreline of the lowest manhole is more than 1525mm above the vessel bottom, ladder access shall be provided to the interior vessel bottom.

Manholes shall be at least 480mm clear inside diameter, and are to be complete with blind flanges, bolting, gaskets, and davits or hinges. No bolts smaller than M 16 diameter may be used. The minimum connection size welded into a vessel shall be 2" NB, swaged if required to the specific line size and terminating with a flanged connection. Alternatively, an appropriate long welding neck forging may be used for the connection provided it has a 2" or greater diameter hub. The only exception to the above shall be nozzles for vessels in water, air and steam (if applicable) service in which the pressure does not exceed 13.50 barg and the temperature does not exceed 160°C.

Full penetration welds shall be used for all body flange, nozzle and manhole attachments. Other attachment weld details are not acceptable without specific approval of the COMPANY. All flanges for external nozzles and manholes of 24" diameter and smaller shall be in accordance with ANSI B16.5 and shall be raised face unless otherwise shown on the individual vessel data sheets and/or drawings. Pressure-temperature ratings of ANSI B16.5 shall apply for the design condition. Flanges over 24" diameter shall be in accordance with MSS Standard Practice SP-

44. Non-standard size flanges shall be calculated in accordance with ASME Code Rules. Raised face flanges for use with spiral wound or soft metal jacketed asbestos gaskets shall have a smooth finish (125 RMS). Raised face flanges for use with compressed asbestos gaskets shall have contact surfaces as follows:

* Nominal size 12" and smaller - A continuous spiral groove generated by a 1.8mm radius round-nose tool at a feed of approximately 0.9mm per revolution.
* Nominal size above 12" - A continuous spiral groove generated by a 3mm radius round-nose tool at a feed of approximately 1.3mm per revolution All nozzles shall be flush with inside of vessel wall unless otherwise indicated on vessel data sheets.

Where two or more openings are provided for installation of equipment, such as gouge glasses, level controls, etc. they shall be set with a Jig to prevent tolerance from being additive. No threaded connections shall be screwed directly into any part of the vessel except for tell-tale holes in reinforcing pads.

All bolt holes in manholes, handholes and nozzles and anchor bolts on supports shall straddle the normal vessel centerline unless otherwise specified. Pad type nozzles, handholes etc. shall not be used unless written approval is obtained from the COMPANY. Nozzles may be either integral forgings or fabricated from seamless pipe and welding neck flange joined by full penetration welds. Other type built-up nozzles are not acceptable without approval of COMPANY.

Flanges for internal non pressure piping may be slip-on-type. Set-on type nozzles shall only be used with prior agreement from the COMPANY and provided that 100% Ultrasonic Examination of the shell plate is carried out adjacent to the opening. Examination is to be in accordance with ASTM A-435 to cover a minimum of two times the opening diameter.

## REINFORCEMENT

Reinforcement of nozzles and manholes shall be designed to provide 100% compensation for the as built thickness of the shell/head, in accordance with the specified design code. The reinforcement for openings shall be provided by either self-reinforcing type nozzles or built-up, seamless pipe and WN flange with pad reinforcement as necessary.

Reinforcing pads when applied shall have a minimum width of 2" or three times the pad thickness, whichever is greater. Reinforcing pads shall be made in one piece if possible. Large reinforcing pads may be made from two pieces provided that written approval is obtained from the COMPANY. Integral reinforcement of openings shall be provided for vessels in the following categories. Reinforcing pads shall not be used in these instances:

* Vessels in lethal service;
* Vessels designed for temperatures below 0°C;
* Vessels with shell thickness exceeding 50mm;

All rectangular reinforcing pads when used for external or internal attachments shall be radi used 25mm minimum.

## INTERNAL ATTACHMENTS

The vessel fabricator shall furnish and install all internal support rings, down comer supports, bars, gratings, grating supports, tray lifting, tray leveling device, vortex breakers, piping and all other internals as and where required by the appropriate drawings. Internals shall be fixed by bolting to cups or rings for ease of maintenance.

Mitred joints shall not be used, unless otherwise specified on drawings and agreed by the COMPANY. Major internal piping shall be flanged for ease of removal through vessel manholes. All removable internals shall be fabricated so as to pass through the vessel manholes. Support and fixed internals welded to shell/head, shall be seal welded to prevent crevice corrosion. Seal and strength welds shall carry the appropriate corrosion allowance.

All internal crevices where supports and fixed internals are welded to the shell/heads shall be seal welded to exclude process fluids. Seal and strength welds shall carry the appropriate corrosion allowance.

## EXTERNAL ATTACHMENTS

Vessel fabricator shall furnish and attach all insulation support rings, external pressure stiffeners, lifting lugs, ladder and platform lugs, and pipe supports unless otherwise specified. Reinforcing pads shall be continuously welded to vessel beneath all attachments where the welding of such attachments would cause excessive concentration of stress on vessel at those points. Each pad shall contain at least one ½" NPT tapped tell-tale hole.

All vessels greater than 3600mm installed height shall be fitted with a full length ladder, Platforms for maintenance shall be provided as necessary for safe access to manholes, relief valves, control valves, controllers, etc. Sample connections, thermometers, thermowells, gauges and control instruments shall be accessible from a platform or a ladder. Tower davits shall be provided as necessary for proper maintenance. All attachments shall be continuously welded. All vessels, vertical or horizontal, shall be furnished with a minimum of two lifting lugs, which shall be designed for a load equal to two times the shipping weight.

## VIBRATION ANALYSIS

A dynamic wind analysis shall be performed for all towers taller than 100 ft (30 m) with a height-to-diameter ratio greater than 15. The following conditions shall be met:

* Vessel diameter (d) shall be the predominant outside shell diameter of the top one-third of the vessel.
* Vessel height (H) shall be the total height of vessel from base of skirt to top of head.
* The maximum single amplitude (deflection) at the top of the vessel due to dynamic wind load, including rotation of the concrete foundation or structure, shall not exceed 0.5 percent of H.

# ADDITIONAL REQUIREMENTS FOR FLANGED GIRTH JOINTS

1. Flanged girth joints shall be designed for through bolting. Proposals for alternative joint design shall be submitted to the COMPANY for approval.
2. Flanges for girth joints shall conform to the following:

* Flanges shall be according to ASME B16.5, ASME B16.47 Series B, or designed according to ASME SEC VIII D1 with allowable stresses determined according to that code.
* Welding neck flanges shall be used where the pressure-temperature design conditions require an ASME Class 300 or greater flange.
* Slip-on flanges shall not be used if any of the following conditions are exceeded:
* Pressure-temperature design conditions require an ASME Class 300 or greater flange.
* Design temperature exceeds 750°F (400°C).
* Specified corrosion allowance for the vessel is greater than 1/8 in. (3 mm).
* The vessel is in hydrogen service.
* Girth flanges larger than NPS 24 that are not in accordance with ASME B16.47 Series B shall be designed to meet the flange rigidity recommendations in ASME SEC VIII D1.
* Unless otherwise specified, gasket contacts surfaces shall have a finish in accordance with reference Codes and Standards.
* Allowable flatness tolerances of gasket contact surfaces for the appropriate service condition shall be as per reference Codes and Standards.
* For confined joint construction (peripheral gasket confined on OD):
* Nubbins, if provided, shall be located on the female (grooved) flange.
* The clearance between flanges after assembly shall be not less than 3/16 in. (5 mm). This clearance shall extend from the periphery of the flange to within the bolt circle.

# MATERIALS

## GENERAL SPECIFICATION

Materials of construction for pressure parts shall be in accordance with the design code. Alternative materials may be used if advantageous with the approval of the COMPANY. Proposed substitutions must be clearly defined:

* Vessels having design temperature below 0°C are considered as cold vessels.
* Vessels having design temperature over 0°C considered as warm vessels.

## SHELL / HEADS

Unless otherwise specified in drawings or data sheets, materials for shell/heads shall be as under:

* Material for warm service pressure vessel shell/heads shall be:

ASTM A-515 for Intermediate & High Temperature Service;

ASTM A-516 for Moderate & Lower Temperature Service;

* Material for cold service pressure vessel shell/heads shall be:

ASTM A-516 for Pressure Vessel having Design Temperature upto -46°C with impact test.

ASTM A-203 Gr. D for Pressure Vessel having Design Temperature upto -101oC with impact testing corresponding to vessel design temperature.

ASTM A-240 Gr. 304 for Pressure Vessel having Design Temperature upto -178°C without impact testing.

## SUPPORTS & MISCELLANEOUS PARTS

Any material welded directly to the pressure retaining parts shall be of similar quality as the vessel plate, including impact requirements if any, for a length measured from the vessel wall of at least 150mm. The material of such items beyond this point may be structural quality A283 Gr. C, or equal.

ASTM A-203 Gr. D or ASTM A-240 Gr. 304 shall be used for cold vessels.

## BOLTING

Bolts and nuts shall be furnished by the CONTRACTOR / SUPPLIER for all cover plates, manholes, blind flanges and bolted attachments supplied with vessels. Bolts and nuts shall be new.

External bolting shall be alloy steel stud type and selected for maximum and minimum design temperatures.

For warm vessels; all external bolting shall be cadmium plated to ASTM A-193 Gr. B7 c/w ASTM A-194 Gr. 2H nuts.

For cold vessels; all external bolting shall be cadmium plated to ASTM A-320 Gr. L7 c/w ASTM A-194 Gr. 7 nuts.

All internal bolting to be stainless steel;

Flange bolting of nominal size 1½" and above shall be subject to bolt tensioning. CONTRACTOR / SUPPLIER to supply flange stud-bolts over length by one nut thickness and complete with 3 nuts to facilitate bolt tensioning for all flanged connections for which CONTRACTOR / SUPPLIER supplies a mating flange, bolt tensioning will be carried out on site by Contractor.

## FLANGES

Flange material shall be of a similar quality to the vessel shell including impact properties where applicable. Forgings shall be supplied in the normalized condition.

For warm vessels; all flanges material shall be ASTM A-105. For cold vessels; all flanges material shall be ASTM A-182 Gr. 316 for Stainless Steel Vessels or ASTM A-350 Gr. LF2 for Carbon Steel (with impact test) Vessels.

## GASKETS

Gaskets shall be furnished by the CONTRACTOR / SUPPLIER for all bolted attachments i.e. cover-plates, manways, and blind flanges supplied with vessels. Unless otherwise specified, gaskets shall be in accordance with ANSI B16.5 as follows:

* For Flat Face, 150 LB ANSI flange: Full Face, 1.6mm thick compressed non-asbestos.
* For Raised Face, 150 LB ANSI flanges: thick compressed Spiral wound stainless steel, non-asbestos filled with spacer rings.
* For Raised Face, 300 & 600LB ANSI flanges: Spiral wound stainless steel, non-asbestos filled with spacer rings.
* For Ring Joint, 900, 1500 and 2500 LB ANSI flanges: Oval Ring per ANSI B16.20, Armco soft iron or equal. (90 Brinell Max).

Gasket material for nozzles connected to external pipework and valving shall be in accordance with the Project Specification for Piping Design and Materials.

## IMPACT TEST REQUIREMENTS

Charpy V-notch impact testing is required in accordance with the code except that this shall apply to all vessels with a design temperature below 0°C. These vessels shall meet the requirements of ASME Section 11 Part A, SA20 and Clause UG-84 of ASME VIII Division 1.

# FABRICATION

## START OF FABRICATION

No manufacture may begin until CONTRACTOR / SUPPLIER has received written approval of his detailed fabrication drawings from the COMPANY or their authorized representative.

The CONTRACTOR / SUPPLIER shall notify the COMPANY or their authorized representative in reasonable time before actual fabrication begins.

## FORMING

Shell plates shall not be formed until actual head dimensions are known. Plates shall be formed in the same direction as the final roll given in manufacture.

## WELDING

All welding shall be in accordance with the code, standard and welding specification for this project. The CONTRACTOR / SUPPLIER shall submit proposed weld procedures and weld details for the COMPANY'S review and approval prior to commencing any production welding.

Submerged arc welding is preferred on all vessel seams. For materials with yield strength exceeding 330 N/mm2 and/or thickness exceeding 20mm, consumables for manual metallic arc welding shall be of the basic low hydrogen type. CONTRACTOR / SUPPLIER shall establish a procedure for maintaining proper control of welding consumables.

Low hydrogen electrodes shall be dried or baked at the temperature level and times specified by the manufacturer, and shall be used within 8 hours when stored in quivers. Electrodes stored in quivers, but not used within the specified times, shall be restored in ovens.

No electrodes shall be left lying about the site, or in workshops. Electrodes so left shall be scrapped. Submerged arc flux shall be stored in moisture-proof containers in a dry location, at a temperature of above 20°C. Submerged arc consumables shall be withdrawn from store only when required for immediate use. Used consumables shall be returned to store on completion of the welding operation.

Submerged arc flux may be recycled but shall be free from fused flux, mill scale, dirt or other foreign matter. The CONTRACTOR / SUPPLIER shall provide proof to the satisfaction of the COMPANY’S Inspector that the welder has been using the process for which he is qualified within the previous 3 months. If not, then the welder shall be required to re-qualify. Backing rings shall be used only with approval of the COMPANY.

Adjacent longitudinal seams shall be staggered to give between seams a minimum of 60° orientation or 2000mm whichever is greater. Shell seams shall be located to miss long internal attachment welds (trays, downcomers, etc.) and all nozzles and manhole openings and their reinforcing pad.

Longitudinal and circumferential seams in shells and all seams in heads shall be full penetration single or double butt-welds of the 'V’ or 'U' type. Lap welds are not permitted. All weld procedure numbers shall be shown on drawings. All welding without subsequent postweld heat treatment is prohibited on the following:

* Materials and thickness criteria defined within the design code.
* Chrome-moly alloy steels containing more than 2% Cr or more than 0.6% Mo.

Production test plates shall be conducted on longitudinal shell seams and head seams (if any) where run-off tabs shall be used. This shall apply to vessels with a design temperature below 0°C and thickness greater than 25mm. One production test plate shall be provided per vessel for each weld procedure and shall be subject to full mechanical testing in accordance with ASME IX. Production control test plates shall be post-weld heat treated with the vessel where applicable.

The weld ligament, i.e. the distance between the edges of weld preparations for any two nozzle welds, or between nozzle welds and seam welds and attachment welds, shall be twice the shell/head thickness plus 25mm. No welding shall be allowed after PWHT. All attachments including ladder and platform clips must be welded before PWHT. All fillet welds shall be continuous.

## WELD REPAIRS

All repairs welding shall be in accordance with procedures previously approved by the COMPANY. The repaired weld shall be subjected, as a minimum requirement, to the same testing and inspection as the original weld. The cost of all repairs and subsequent inspection shall be the responsibility of the CONTRACTOR / SUPPLIER. Weld repairs shall take place before hydrotesting and care shall be taken to ensure that the wall thickness is not reduced below the specified minimum design thickness. Surface defects, and areas of weld resulting from the removal of temporary attachments shall be ground smooth and the area subjected to 100% crack detection.

## WELDING PROCEDURE QUALIFICATION RECORD (WPQR)

Each weld procedure shall be covered by a suitable procedure qualification tested in accordance with the requirements of ASME IX.

## PREHEAT REQUIREMENTS

The minimum preheat for ferritic steels shall be in accordance with Appendix R of ASME VIII DIV I. Calculations of preheat temperature to suit particular combined plate thickness, chemical composition, heat input, consumables and restraint can however be made by reference to the following:

Welding Steels without Hydrogen Cracking, international Institute of Welding 1973;

*Note: This guide is primarily suitable for carbon, carbon manganese fine grain and carbon molybdenum steel with less than 0.6% Mo.*

The required preheat temperature shall be established before commencing welding, and held until welding is complete. Preheat temperatures shall be controlled by temperature indicating crayons or contact pyrometer.

## POST WELD HEAT TREATMENT REQUIREMENTS

Vessels shall be post-weld heat treated when required by the design code depending on the combination of material, thickness and design temperature. All vessels in lethal service shall be post-weld heat treated. Post-weld heat treatment shall also be considered for vessels subjected to large amounts of welding and where pressure parts have been formed from thick plate into tight radii.

Field post-weld heat treatment procedures must be reviewed by the COMPANY. The CONTRACTOR / SUPPLIER shall include in his material sub-order(s), how many heat treatments are likely to be carried out during fabrication, and he shall ensure that he receives a guarantee from the mill that the steel supplied can be heat treated as proposed, without detrimental effect on the minimum guaranteed mechanical properties.

The use of manually operated gas torches or gas rings shall not be permitted for PWHT. During PWHT, a minimum of six thermocouples per furnace load shall be used to ensure that uniform temperature is achieved throughout the heat treatment cycle. The thermocouples shall be used to record metal skin temperature.

If welded repairs are made to a vessel, which has been heat treated, the vessel shall again be heat treated. This treatment shall form part of the repair procedure. All heat treatments shall be recorded and documented by a temperature recording chart. The welding and associated heat treatment of stainless steels shall take into account the ease with which this material can be sensitized and its corrosion resistant properties thereby impaired.

# INSPECTION, TESTING AND CERTIFICATION

## GENERAL

All non-destructive examination shall be carried out in accordance with the design code as a minimum. All personnel involved in non-destructive testing shall be qualified to a nationally recognized standard.

Inspection and testing shall be carried out at the CONTRACTOR / SUPPLIER'S works and shall be witnessed by the COMPANY'S authorized representatives and/or the certifying authority if applicable.

The responsibility for inspection rests with the COMPANY. However, the COMPANY reserves the right to inspect vessels at any time during fabrication to ensure that materials and workmanship are in accordance with this specification, and/or the approved drawings.

The CONTRACTOR / SUPPLIER shall provide a projected shop schedule with appropriate fabrication stages at the time drawings are submitted for approval, to highlight the inspection activity schedule. The approval of any work by the COMPANY or their authorized representative and the release of a vessel for shipment shall in no way relieve the CONTRACTOR / SUPPLIER of any responsibility for carrying out the provisions of this specification.

The CONTRACTOR / SUPPLIER shall inform the COMPANY at the time of placing the order of any tests, which cannot be adequately performed.

## RADIOGRAPHIC INSPECTION

Except where amplified in this specification the extent of radiography shall be in accordance with the design code. When 100% radiography is specified for all welds, including flange butt welds and nozzle to shell connecting welds, shall be fully radiographed. Where radiography is considered to be impractical ultrasonic inspection may be substituted with prior approval of the COMPANY.

For vessels requiring radiography where heat treatment is required, the radiography must be carried out after heat treatment. The CONTRACTOR / SUPPLIER may at his discretion carry out radiography prior to heat treatment. The COMPANY'S appointed inspector shall see all radiographs and shall be advised of any defects found in any welds.

## ULTRASONIC INSPECTION

Ultrasonic inspection may be substituted for radiography with prior approval of the COMPANY in areas that are inaccessible for radiography.

For vessels requiring U/T examination where heat treatment is required, the examination must be carried out after heat treatment. The CONTRACTOR / SUPPLIER may, at his discretion carry out U/T examination prior to heat treatment.

## MAGNETIC PARTICLE & DYE PENETRANT INSPECTION

All magnetic particle and Dye Penetrant inspection shall be performed in accordance with the design code.

As. a minimum, the following applies at all nozzles, manways, and reinforcing pads:

* Load bearing fillet welds shall be checked at root runs and finished welds by magnetic particle or dye penetrant method.
* All full penetration attachment welds shall be magnetic particle inspected at the bock-chipped surface and on all finished weld surfaces.

Crack detection of finished welds shall be carried out after hydrotest and PWHT (where applicable). Magnetic particle inspection is preferred particularly after post-weld heat treatment. Vessels of low chrome alloy with plates over 50mm thick shall receive this inspection of all weld seams after post-weld heat treatment.

## ACCEPTANCE CRITERIA

The acceptance standard for Non-Destructive examination of welds shall be in accordance with the design code.

## SUPPORT & REINFORCING POD INSPECTION

Welds of reinforcing pads shall be tested to 1 barg with dry air after fabrication (but prior to the hydrostatic test of the vessel) using suitable materials for the detection of leaks.

## HYDROSTATIC TESTS

Hydrostatic tests shall be carried out in presence of the COMPANY appointed inspector and a representative of the certifying authority, when applicable.

Hydrostatic testing shall be in accordance with the design code. Fresh water only shall be used for testing. For vessels manufactured from stainless steel the chloride ion content of the test water shall not exceed 30ppm. During testing the temperature of the vessel and test water shall not be lower than 7°C and not more than 25°C. Adequate support shall be provided for vertical vessels tested in the horizontal position to ensure that they are not subjected to excessive local loadings and bending stresses. Hydrotest pressure shall be held for a minimum of 60 minutes, irrespective of design code requirements.

## TEST BOLTING

After the successful completion of the hydrostatic test, the bolting used during testing shall be replaced. Service bolts; nuts and gaskets furnished by the CONTRACTOR / SUPPLIER shall not be used for testing. The test bolts shall form part of the total equipment supply.

## NAMEPLATE

### GENERAL

Each complete vessel shall be provided with a type 316 stainless steel nameplate securely attached to the vessel shell and located so that it is clearly visible after installation. Nameplates shall be rivetted to a bracket welded on the vessel and the inspection authority then overstamps one rivet. Insulated vessels shall have nameplate brackets with enough projection to clear insulation by at least 25mm

### STAMPED DATA

The following information shall be stamped on the nameplate:

* Manufacturer's Name;
* Manufacturer's Serial Number;
* Tag Number;
* Purchase Order Number;
* Equipment Title;
* Maximum allowable working pressure (Hot and Corroded) barg at °C;
* Maximum test Pressure (Corroded) in barg;
* Year Built;
* Size I.D./O.D. x T to T in mm;
* Service;
* Corrosion Allowance in mm;
* Design Code/Code Symbol showing degree of radiography and/or stress relieved and type of construction;
* Weight empty/operating/hydrotest in kg;
* Inspection authority and date of inspection;
* Code symbol showing if the unit is x-rayed and stress relieved;
* Design temperature and pressure;
* Operating temperature and pressure;

## REPORT & ACCEPTANCE CERTIFICATES

With regard to witnessed tests the CONTRACTOR / SUPPLIER shall prepare a report on the tests and the results, these shall be included in the 'Certification Data Books'. All Data Books produced shall be complete and copies submitted to the COMPANY for review not later than 4 weeks after the date of completion of the tests.

## CERTIFICATION DOCUMENTS

The COMPANY shall store in good order all material certificates, fully catalogued and indexed NDT test records, mechanical test certificates, welding qualification certificates, heat treatment certificates and hydrostatic test certificates for a minimum of 5 years after acceptance of the complete and fully certified vessel by the COMPANY.

All certificates shall be available for counter signature by the certification authority.

# PAINTING AND PREPARATION FOR SHIPMENT

## PAINTING & PROTECTIVE COATINGS

Painting, protective coatings and the procedures used for the preparation of surfaces shall be as specified in the Project Specification for Painting and Protective Coatings.

Where painting is specified, the entire vessel shall be painted, including inside of skirt, outside of bottom head, entire base ring and all skirt attachments. Nozzles shall be painted on the flange edges, inside bolt holes, and up to the gasket surface.

Fireproofed/Insulated surfaces shall be shot blasted and given one coat of primer only. The CONTRACTOR / SUPPLIER shall stencil in a prominent position in 50mm high characters the dry lifting weight of the vessel and for stress relieved vessels the words "NO WELDING PERMITTED".

## PREPARATION OF SHIPMENT

After the final hydrostatic test, the vessel shall be dried and cleaned thoroughly of all grease, loose scale, rust, flux and weld spatter, both internally and externally. All machined surfaces and threaded connections shall be protected by coating with rust preventative. Flanged openings shall be protected with steel plate covers attached by proper bolting or strapping and sealed with a plastic compound. Screwed connections shall be protected with threaded forged steel plugs.

The CONTRACTOR / SUPPLIER shall be responsible for loading and anchoring vessels to prevent any damage during shipment.

When shipped loose, all instruments, valves, parts, etc., of a vessel shall be tagged with vessel number and purchase order number to facilitate match-up with appropriate vessel in the field. Tags and wire shall be stainless steel. All such items shall be boxed and where possible attached to the inside of the skirt or saddle.

CONTRACTOR / SUPPLIER shall state in the proposal his recommendations for long term storage (up to 12 months) for both indoor and open-air storage in a marine environment.

# SPECIFIC REQUIREMENTS FOR CLAD VESSELS

## DESIGN

Design calculation shall be based on the nominal thickness of the base material i.e. shall not include any allowance for the cladding thickness. The thickness of corrosion resistant linings applied to nozzles shall not be less than the thickness specified for the vessel.

The principle shall be satisfied that the design of a cladding or lining accounts for the effect of differential thermal expansion and has sufficient ductility to accommodate any strain likely to be imposed during service.

## MATERIALS

Pressure vessel parts constructed of integrally clad plate, and vessel parts fully or partially lined by welding after forming, shall satisfy the requirements of ASME Section VIII DIV I Part UCL.

The use of linings other than those obtained by using integrally clad plate or overlay weld deposits shall be avoided and requires special approval of the COMPANY. Integrally clad plate shall be of the homogeneously clad type as obtained by roll cladding or explosive bonding. The clad plates shall conform to ASTM A-263, ASTM A-264 & ASTM A-265, as applicable, irrespective of the design calculation method used. Integrally clad plate shall be ultrasonically tested to check the quality of the bond in accordance with the requirements of ASTM A579, acceptance level S6. The branches in clad vessels shall be cut from tubing or fabricated from clad plate. Alternatively, the branches may be protected by corrosion resistance weld overlays.

Solid alloy nozzles may be offered as an alternative to clad nozzles in the smaller sizes where it is considered to be advantageous. Flange facings on clad vessels shall be provided with an overlay weld deposit protection unless otherwise specified by the COMPANY. Overlay weld deposits of austenitic stainless steel weld metal on carbon and low alloy steels shall be applied in a minimum of two layers. For the first layer type 309 weld material shall be used, and the top layer as specified.

## FABRICATION

Weld overlay deposits on clad vessels shall be performed in accordance with procedures qualified to ASME IX. The proposed procedure for relevant application shall be submitted with the bid. The procedure for PWHT shall be submitted to the COMPANY for approval. It shall be demonstrated that no deleterious effects on the corrosion resistance of the cladding or weld overlay will occur during PWHT.

## INSPECTION & TESTING

Clad plate formed into dished ends shall be ultrasonically retested for soundness after forming. Linings applied by overlay weld deposit, shall be ultrasonically examined for gross lack of fusion in accordance with ASTM A578 acceptance level S6. This also applies to clad restoring of welds in clad plate, where a bond of 50mm on each side of the weld shall be examined.

Vessels protected with a cladding or lining of stainless steel, or having stainless steel internals shall be hydrostatically tested as if they were of solid stainless steel, refer to clause No. 6 of this specification.

# DRAWINGS AND DATA REQUIRED

CONTRACTOR / SUPPLIER information shall be supplied in accordance with the COMPANY’s procurement documentation and shall include, as a minimum, the following:

* Completed data sheets;
* General arrangement and cross-sectional drawings, complete with parts list, materials and equipment description;
* Materials and thickness of principal parts, not covered by the data sheet;
* Itemized weights, including maintenance weights, plus withdrawal dimensions;
* Foundation Loading Data;
* CONTRACTOR / SUPPLIER connection drawings complete with detailed nozzle schedule;
* Itemized list of CONTRACTOR / SUPPLIER's deviations from Specification. CONTRACTOR / SUPPLIER shall advise separate prices for the following:
* Supply & installation of additional nozzles, rated as per data sheet, with and without reinforcement for the following nominal bores:

2", 3", 4", 6", 8", 10", 12", 14" & 16";

20" & 24" Manways complete with blind flanges, bolting, gasket and davit;

Per kg of all support clips and lugs;

* Proposed test procedure and erection details;
* Priced list of recommended commissioning spares;
* Priced list of spare parts for two years operation;
* Priced list of special tools;