ADNOC GROUP PROJECTS AND ENGINEERING

PRESSURE VESSEL SPECIFICATION

Specification

AGES-SP-06-002

ص ب 898، أبوظبي، الإمارات العربية المتحدة
PO Box 898, Abu Dhabi, UAE
adnoc.ae

GROUP PROJECTS & ENGINEERING / PT&CS DIRECTORATE

CUSTODIAN	Group Projects & Engineering / PT&CS
ADNOC	Specification applicable to ADNOC & ADNOC Group Companies

Group Projects & Engineering is the owner of this Specification and responsible for its custody, maintenance and periodic update.

In addition, Group Projects & Engineering is responsible for communication and distribution of any changes to this Specification and its version control.

This specification will be reviewed and updated in case of any changes affecting the activities described in this document.

INTER-RELATIONSHIPS AND STAKEHOLDERS

a) The following are inter-relationships for implementation of this Specification:

   i. ADNOC Upstream and ADNOC Downstream Directorates and

   ii. ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOG Gas Processing. ADNOC LNG, ADNOC Refining, ADNOC Fertilisers, Borouge, Al Dhafra Petroleum, Al Yasat

b) The following are stakeholders for the purpose of this Specification:

   ADNOC PT&CS Directorate.

c) This Specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group company included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance

d) Each ADNOC Group company must establish/nominate a Technical Authority responsible for compliance with this Specification.

DEFINED TERMS / ABBREVIATIONS / REFERENCES

"**ADNOC**" means Abu Dhabi National Oil Company.

"**ADNOC Group**" means ADNOC together with each company in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

"**Approving Authority**" means the decision-making body or employee with the required authority to approve Policies & Procedures or any changes to it.

"**Business Line Directorates**" or "**BLD**" means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

"**Business Support Directorates and Functions**" or "**Non- BLD**" means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

"**CEO**" means chief executive officer.

"**Group Company**" means any company within the ADNOC Group other than ADNOC.

"Specification" means this Pressure Vessel.

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TABLE OF CONTENTS

GENERAL

1. PURPOSE

This specification provides minimum requirements covering material, fabrication, inspection, testing, packing, preservation, shipping transportation that shall be applied to all pressure vessels which are intended to be constructed in accordance with ASME Section VIII Division 1 or ASME Section VIII Division 2.

2. SCOPE

This Specification gives minimum requirements for the construction of pressure vessels within process & utility packages of the following types;

a. Pressure Vessels such as Columns, Towers, Drums, Filters / Separators / Coalescers /, Pulsation Dampers, Tanks and Spheres (designed as per ASME Section VIII) and Electric heaters (excluding electrical and control components)

b. Pig Launchers and Receivers for ADNOC Offshore facilities designed as per ASME Section VIII

c. Shell and Tube Heat Exchangers, Waste Heat Boilers

d. Air Coolers

e. Plate heat exchangers

This specification, engineering standards and codes and other specification listed in Section 2 of this document, the data sheets and/or engineering drawings attached to the material requisition form part of the complete specification required for construction of pressure vessel.

3. DEFINITIONS/ ABBREVIATIONS

3.1. Definition

COMPANY: ADNOC Group of Companies.

CONCESSION REQUEST: A deviation requested by the CONTRACTOR or VENDOR, usually after receiving the contract package or purchase order. Often, it refers to an authorization to use, repair, recondition, reclaim, or release materials, components or equipment already in progress or completely manufactured but does not meet or comply with COMPANY requirements. A CONCESSION REQUEST is subject to COMPANY approval

CONTRACTOR: The party(s) who will carry out all or part of the Design Engineering, Procurement, Construction and Commissioning or Management of the Project.

CYCLIC SERVICE: Cyclic and dynamic reactions from any pressure or thermal loading source that require fatigue analysis per Part 5.5 of ASME Section VIII, Div.2.

DESIGN CODE: ASME Boiler and Pressure Vessel Code Section VIII, Division 1 or ASME Section VIII Division 2, as specified on the datasheet.

GENERAL SERVICE: Other than hydrocarbon service (e.g. Utility and non-critical services).

HYDROCARBON SERVICE: Process streams of liquid or gaseous hydrocarbon materials, including two and three phase hydrocarbon materials.

LETHAL SERVICE: Equipment contents containing a concentration of poisonous gas or liquid that is dangerous to life when inhaled, such as hydrogen sulfide. Lethal service definition shall be as per Process Design Criteria Company, Isolation, vent and Drain Philosophy and as specified in the process datasheet

GUARANTEE: The party(s) that undertake Mechanical or Process Design functions shall Guarantee Mechanical / Process / Hydraulic performance within agreed contractual parameters.

NATIONAL BOARD: The National Board of Boiler and Pressure Vessel Inspectors, an organization whose members are the jurisdictional officials responsible for enforcing and administrating the rules of the ASME Boiler and Pressure Vessel Code Section VIII division 1 and ASME Section VIII, Division 2. Vessels meeting requirements of the Code and stamped with the Code “U” or “U2” symbol, shall be registered with the National Board.

QUALITY ASSURANCE: All those planned and systematic actions (QA) necessary to ensure quality i.e. to provide adequate confidence that a product or service will be fit for its intended purpose.

QUALITY MANUAL: A Document setting out the general quality policies, procedures and practices of an organization.

QUALITY PLAN: A document prepared by the Contractor/Vendor setting out the specific quality practices, resources and activities relevant to a particular project.

QUALITY MANAGEMENT SYSTEM: The structure organization, responsibilities, activities, resources and events that together provide organized procedures and methods of implementation to ensure the capability of the organization to meet quality requirements.

SHALL and SHOULD: The word ‘Shall’ is to be understood as a mandatory and the word ‘Should’ as strongly recommended to comply with the requirements of this document.

TPA: Third Party Agency.

UTILITY SERVICE: Water, air and nitrogen services.

VESSEL: Pressure Vessel. It is a container that falls within the scope of ASME Section VIII and is subject to an internal pressure greater than 15 psi and/or with vacuum of 15psi or lower

VENDOR: The party(s), which manufactures and/or supplies equipment, technical documents/drawings and services to perform the duties specified by COMPANY/CONTRACTOR.

SUB-VENDOR: The party(s) which carries out all or part of the design, procurement, installation and testing of the System(s) as specified by the CONTRACTOR/VENDOR.

WARRANTY: The party(s) undertaking manufacture of any part of the equipment shall give warranties for workmanship and materials.

3.2. Abbreviations

Abbreviations	
ADNOC	Abu Dhabi National Oil Company
CFD	Computational Fluid Dynamics
CLR	Crack Length Ratio
CMTR	Certified Material Test Reports
COP	Code of Practice
CP	Cathodic Protection
CR	Criticality Rating
CRA	Corrosion Resistant Alloy
CS	Carbon steel
CSR	Crack Sensitivity Ratio
CTR	Crack Thickness Ratio
FEA	Finite Element Analysis
H_2S	Hydrogen Sulphide
HSE	Health, Safety and Environment
HSECES	HSECritical Equipment and Systems
IGC	Inter-Granular Corrosion
ITP	Inspection and Test Plan
LTCS	Low Temperature Carbon Steel
LWN	Long Weld Neck
MAP	Maximum Allowable Pressure
MAWP	Maximum Allowable Working Pressure
MDMT	Minimum Design Metal Temperature
MT	Magnetic Particle Testing
MTC	Material Test Certificate
NACT	Normalised accelerated cooled and Tempered
NDE	Non-Destructive Examination
NPS	Nominal Pipe Size
NPT	National Pipe Taper
OD	Outside Diameter
PMI	Positive Material Identification
PT	Dye Penetrant Testing
PTFE	Polytetrafluoroethylene
PWHT	Post Weld Heat Treatment
QA	Quality Assurance
QAS	Quality Assurance System
QC/QP	Quality Control/ Quality Plan
QMS	Quality Management Systems
RTJ	Ring Type Joint
SHDG	Spun hot dip galvanized

SS	Stainless Steel
TMCP	Thermo/mechanical controlled process
TPA	Third Party Agency
TSD	Technical Standard Documents
UDS	User Design Specification
UT	Ultrasonic Test
WFMT	Wet Fluorescent Magnetic Particle Testing
WRC	Welding Research Council

SECTION A

4. NORMATIVE REFERENCE

International Codes and Standards

The following Codes and Standards shall, to the extent specified herein, form a part of this Specification. When an edition date is not indicated for Code or Standard, the latest edition (including addenda) in force at the time of contract award shall apply.

American Petroleum Institute (API)	
API 510	Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair and Alterations
API 521	Pressure-Relieving and De-pressuring Systems
API 660	Shell and Tube Heat Exchangers
API 661	Petroleum, petrochemical and natural gas industries—Air-cooled heat exchangers
API 662	Plate Heat Exchangers for General Refinery Services: Part 1— Plate and Frame Heat Exchangers Part 2— Brazed Aluminum Plate-fin Heat Exchangers
API RP 2A-WSD	Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design
American Society of Civil Engineers (ASCE)	
ASCE Standard 7	Wind Loads Guide to Wind Load Provision of ASCE 7
ASCE Standard 7	Seismic Loads Guide to Seismic Load Provision of ASCE 7
ASCE	Task Committee report on Seismic Evaluation & Design of Petrochemical Facilities
American Society for Nondestructive Testing (ASNT)	
ASNT CP-189	Standard for Qualification and Certification of Nondestructive Testing Personnel
American Society of Mechanical Engineers (ASME)	
ASME Sec II–Part A	Ferrous Material Specifications
ASME Sec II–Part B	Non-Ferrous Material Specifications
ASME Sec II–Part C	Material Specification for Welding rods, Electrodes and Filler Metals
ASME Sec II–Part D	Material Properties
ASME Section V	Non-destructive Examination
ASME Sec VIII Div.1	Rules for Construction of Pressure Vessels
ASME Sec VIII Div. 2	Rules for Construction of Pressure Vessels (Alternative Rules)
ASME Section IX	Qualification Standard for Welding, Brazing and Fusing Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators
ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	Pipe Threads, General Purpose (Inch)
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory made Wrought Butt Welding Fittings
ASME B16.11	Forged Steel Fittings, Socket Welding and Threaded
ASME B16.20	Metallic Gaskets for Pipe Flanges-Ring-Joint, Spiral-Wound, and Jacketed

ASME B16.21	Non-metallic Flat Gaskets for Pipe Flanges
ASME B16.25	Butt-welding Ends
ASME B16.47	Large Diameter Steel Flanges NPS 26 through NPS 60
ASME B 31.3	Process Piping
ASME B 36.10M	Welded and Seamless Wrought Steel Pipe
ASME B 36.19M	Stainless Steel Pipe
ASME B46.1	Surface Texture (Surface Roughness, Waviness, And Lay)
ASME BTH-1	Design of Below-the-Hook Lifting Devices
ASME PCC-1	Guidelines for Pressure boundary bolted flange joint assembly
ASME STS-1	Steel Stacks
American Welding Society (AWS)	
AWS D1.1	Structural Welding – Steel
British Standards Institution (BSI)	
BS EN 1991-1-4	Eurocode 1 - Actions on Structures, Part 1-4: General actions -Wind actions
BS EN 10204	Metallic Products – Types of Inspection Documents.
BS EN 13121	GRP Tanks and Vessels for use above ground Part 1- Raw Materials - Specification conditions and acceptance conditions Part 2 - Composite materials - Chemical resistance Part 3 - Design and workmanship Part 4 - Delivery, installation and maintenance
PD 5500	Specification for Unfired Fusion Welded Pressure Vessels
International Organization for Standardization (ISO)	
ISO 9001	Quality Management Systems – Requirements
ISO 9004	ISO 9004 Quality management -- Quality of an organization -- Guidance to achieve sustained success
ISO 9809 Parts 1-4	Gas Cylinders - Refillable seamless steel gas cylinders - Design, construction and testing
ISO 3690	Welding and Allied Processes-Determination of hydrogen content in arc weld metal.
Abu Dhabi International Building Code	
ADIBC	Abu Dhabi International Building Code
National Association of Corrosion Engineers (NACE)	
NACE MR0175 / ISO 15156, Parts 1-3	Petroleum and Natural Gas Industries – Materials for Use in H2S Containing Environments in Oil and Gas Production: Part 1 - General Principles for the Selection of Cracking- Resistant Materials Part 2 - Cracking-Resistant Carbon and Low Alloy Steels, and the Use of Cast Irons Part 3 - Cracking-Resistant CRAs (corrosion-resistant alloys) and other alloys
NACE MR 0103	Petroleum, petrochemical and natural gas industries — Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments
NACE SP0198	The Control of Corrosion under Thermal Insulation and Fireproofing – A Systems Approach
NACE SP0387	Metallurgical and Inspection Requirements for Cast Galvanic Anodes for Offshore Applications

NACE SP0575	Internal Cathodic Protection (CP) Systems in Oil-Treating Vessels
NACE SP0590	Prevention, Detection and Correction of De-aerator Cracking
NACE SP0472	Methods and controls to prevent in-service environmental cracking of carbon steel weldments in corrosive Petroleum Refining Environment
NACE TM0177	Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H2S Environments
NACE TM0284	Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
NACE TM0103	Laboratory Test Procedure for Evaluation of SOHIC Resistance of Plate Steels Used in Wet H2S Service
The Society For Protective Coatings (SSPC)	
SSPC-SP 6/NACE No 3	Commercial Blast Cleaning
Welding Research Council (WRC)	
WRC Bulletin 297	Local Stress in Spherical and Cylindrical Shells due to External Loadings on Nozzles – Supplement to WRC Bulletin No. 107
WRC Bulletin 368	Stresses in Intersecting Cylinders subjected to pressure
WRC Bulletin 537	Precision Equations and Enhanced Diagrams for Local Stresses in Spherical and Cylindrical Shells Due to External Loadings for Implementation of WRC Bulletin 107
TEMA	
TEMA	Standards of the Tubular Exchanger Manufacturers Association
Miscellaneous	
AISC	ASDAISC Manual of Steel Construction: Allowable Stress Design
	Zick, L.P. Stresses in Large Horizontal Cylindrical Pressure Vessels on Two Saddle Supports, The Welding Journal Research Supplement, Sep. 1951
	Roark's Formulas for Stress and Strain - 8th Edition by Warren Young, Richard Budynas

5. REFERENCE DOCUMENTS

5.1. ADNOC Specifications, Standard Drawings and Other References

The following reference documents, to the extent specified herein, form a part of this specification. When an edition/revision date is not indicated for a document, the latest edition/revision in force at the time of the contract shall apply.

Structural Steel Supply, Fabrication And Erection Specification	AGES-SP-01-002
Structural Design Basis- Onshore Specification	AGES-SP-01-003
Design criteria for Static Equipment	AGES-SP-06-001
Shell and Heat Exchanger Specification	AGES-SP-06-003
Material Selection Guidelines & Specifications	AGES-SP-07-001
Specifications for Cathodic Protection	AGES-SP-07-002
Isolation, Drain and Vent Philosophy	AGES-PH-08-001
Process Design Criteria	AGES-SP-08-002
Piping Basis of Design	AGES-SP-09-001
Piping Material Specification Index	AGES-SP-09-002

5.2. ADNOC Group Companies Requirement

The following Annexures list documents providing specific ADNOC Group COMPANIES requirements to be followed in addition to the requirement in this specification.

ANNEXURE 1 ADNOC Gas Processing, Additional References and Requirements
ANNEXURE 2 ADNOC Refining, Additional References and Requirements
ANNEXURE 3 ADNOC Borouge, Additional References and Requirements
ANNEXURE 4 ADNOC Onshore, Additional References and Requirements
ANNEXURE 5 FERTIL, Additional references and Requirements
ANNEXURE 6 ADNOC Offshore, Additional References and Requirements

6. DOCUMENTS PRECEDENCE

It shall be the CONTRACTOR or VENDOR'S responsibility to be knowledgeable of the requirements of the referenced Codes and Standards.

The VENDOR shall notify the CONTRACTOR of any conflict between this Specification, the related vessel data sheets/drawings, the Codes and Standards and any other specifications noted herein.

Resolution and/or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design/manufacture.

Unless specifically stated/agreed with COMPANY, the most stringent requirements shall apply.

In case of conflict, the order of precedence shall be:

a. UAE Federal Acts and Regulations
b. Design Data Sheets
c. Project Specification
d. COMPANY Specification and Standard Drawings
e. International Codes and Standards

7. SPECIFICATION DEVIATION/CONCESSION CONTROL

This specification is complementary to requirements of certifying authority, legislative requirement, guidance note issued by any authority & documents referenced herein. Compliance with this Specification & Standards and documents referenced therein does not relieve SUPPLIER of his responsibility to furnish units of proper design, workmanship & materials to meet the specified conditions & duties required in data sheet.

Deviations to this Specification are only acceptable where the CONTRACTOR/VENDOR has listed in his quotation the requirements he cannot comply with and the COMPANY/CONTRACTOR has accepted in writing these deviations before the order is placed.

In the absence of a list of deviations, it will be assumed that the CONTRACTOR/VENDOR complies fully with the Specification.

Post Purchase order, any technical deviations to the Purchase Order and its attachments shall be sought by the CONTRACTOR/VENDOR only through Concession Request procedure and formats. All Concession Requests require the Company's review/approval, prior to the proposed technical changes being implemented.

The COMPANY decision shall be final without any cost & schedule impact to the COMPANY/project.

Technical changes implemented prior to Company approval are subject to rejection.

SECTION B

8. TECHNICAL REQUIREMENTS FOR COMPONENTS

8.1. HEADS

8.1.1. Cold forming:

The calculations shall be submitted to the CONTRACTOR for review.

All carbon / low alloy parts, which have been cold formed by more than 5% shall be subjected to an appropriate normalizing treatment and, if necessary, a tempering treatment. Pressure retaining stainless steel components shall be solution annealed as per applicable code when forming strain exceeds 10%.

8.1.2. Head Shape

ASME 2:1 semi-ellipsoidal heads are preferred. Use of ellipsoidal heads with petal construction shall be subject to COMPANY Approval.

Dished head construction shall preferably be seamless. However, due to practicalities and in agreement with the Company, heads may be made from two plates. Where heads are formed in one piece from more than one plate, weld seams shall be 100% radiographed before and after forming. Also, the width of chordal plate shall not be less than one third of the blank diameter. Heads shall not be formed by either point pressing or by hammering.

Hemispherical heads are acceptable under certain conditions; i.e. high pressure vessels.

Conical heads or transitions shall each be provided with half apex angle α equals 30° or less. When used it shall have knuckle radiused ends when the design pressure exceeds 10.4 bar or the design temperature exceeds 260 °C.

Torispherical heads shallower than 2:1 ratio may be used on equipment with a design pressure of 6.9 barg or less in utility service only,

100% MT / PT shall be carried out on the head knuckle radius after forming.

Dished heads / Conical heads shall achieve at least the minimum required thickness in all areas after forming.

Any holes in heads, required during the forming process shall be closed by welding, using an approved procedure, and shall be fully Radiographed unless the hole coincides with a nozzle location.

8.1.3. Hot Forming

Hot formed Heads shall be normalized after hot forming. Hot forming of carbon and low alloy steels are acceptable, only if allowed to cool below 260°C after forming and then subsequently normalized or quenched and tempered as necessary. Simulated coupon from raw material shall consider this additional heat treatment to confirm the material properties.

Both surfaces of the knuckles and straight flanges of ellipsoidal head shall be shown to be crack-free by a 100% MT or PT examinations. If any repair is required, it must be approved by the CONTRACTOR prior to repair being done.

Fabricated heads and transitions welded from formed pieces shall be Fully Radiographed as required by the Code.

The preliminary formed pieces shall be rolled or formed to avoid objectionable flat spots.

Final formed head surfaces shall be MT or PT examined.

8.1.4. Forged Heads

Flat heads and flanges shall not be machined from plate but shall be forgings.

8.2. SHELLS

Shells shall be fabricated from rolled plate, pipe or forgings.

Shell plate shall be rolled with plate VENDOR's serial and heat numbers on the outside of the vessel.

Each shell section shall be completely welded longitudinally and corrected for out-of-roundness to ASME VIII Div. 1 sections UG 79 & 80 and ASME VIII Div 2 sections 4.3.6 and 4.4.4 and peaking / banding of the weld seams, prior to assembly.

Weld seams minimum offset shall be as follows:

a. Adjacent long seams in pipe, the lesser of 150 mm or 90°.
b. Adjacent seams in plate, the greater of 100 mm or four (4) x plate thickness. Orientation between adjacent seams shall be minimum 60°.
c. Adjacent girth welds in pipe, 100 mm or two (2) x pipe outside diameter.

Shell seams shall be located to avoid manways, nozzles, reinforcement pads, long internal attachment welds, and areas where inspection would otherwise be difficult.

When internal coating is specified, all internal sharp edges shall be removed and the internal weld areas around nozzles shall be ground flush and radiused to smooth profile. VENDOR shall follow coating VENDOR guidelines on preparation of surfaces for coating.

Unless otherwise specified, the inside diameter of the vessel shall be constant when shell courses have different thicknesses.

Transitions shall be made with knuckle and flare if any of the following conditions apply:

a. Vessel is in cyclic or hydrogen service.
b. Section is subject to a major support reaction (for example, skirt-to-cone attachment).
c. Transition thickness or attached shell thickness is over 30 mm.
d. All loadings per ASME Section VIII Div.1 Appendix 1-5 or 1-8, whichever is applicable, are not available.

Openings and attachments (including reinforcing and support pads) shall clear weld seams by more than 2.5 *sqrt (r.t) in accordance with this specification (clearance from shell discontinuity).

8.3. VESSEL ASSEMBLY

Vessel parts that are being joined shall be fitted, aligned and retained in position during the welding operation so that the permissible tolerances are not exceeded in the complete assembly.

In all cases of nozzle internal projections, the corners of the nozzle walls shall be ground smooth. Where nozzles have been flame cut to length, the flame cut surface shall be ground smooth.

Internal and external clips shall be continuously fillet welded all around.

All removable internals shall be installed after vessel welding and heat treatment are completed.

Shop procedures for correction of alignment during fit up and assembly shall be submitted and approved, prior to the commencement of fabrication, except for normal use of fit up dogs and wedges or hydraulic means.

8.4. NOZZLES AND FLANGES

8.4.1. Nozzles

8.4.1.1. Nozzle Size and schedule

The minimum nozzle diameter permitted is 2” NPS (50.8 mm); except for Pressure Indicator and Thermowell nozzles (non-welded overlayed) may be 1 ½” NPS (40 mm).

Nozzle necks 12” NPS or larger may be seamless pipe, rolled plate, or integrally forged.

Rolled plate nozzle necks and all plate reinforcing pads shall be the same grade of material as specified for the vessel shell or head.

Nozzles carrying gauge glasses, instrument standpipes or float chambers shall be suitably strengthened by means of flat bar braces or gussets.

Minimum pipe schedule used for nozzles shall be as shown in Table below or applicable design code, whichever is greater:

Nozzle Material	Size (NPS)	Minimum pipe schedule (*)
Carbon Steel and low alloy, clad steels	1.5 and 2”	Schedule 160
	> 2”	Schedule XS
High Alloy and non-ferrous materials	1.5 and 2”	Schedule 80S
	>2”	Schedule STD
* Pipe wall thickness designations per ASME B36.10M / B36.19M		

a. Nozzles 2” NPS and below shall be provided with two stiffeners 40 x 6 mm at 90 degrees apart.

b. Nozzles with NPS of 2-½", 3-½", and 5" shall not be used.

Nozzles shall be straight, flanged with no bends/ elbows except for the bottom nozzle of vertical vessels, unless otherwise stated on the vessel data sheet.

When nozzle necks are rolled from plate, if the forming operation takes place at a temperature below the minimum PWHT temperature and the extreme fibres are stretched by more than 5%, the completed nozzle assembly shall be PWHT, except when the complete vessel is to be subsequently PWHT.

Rolled plate used as nozzle necks shall have full volumetric examination prior to attachment to other components. Acceptance criteria shall be in conformance to the design code for full NDE.

The bore of nozzle necks and welding neck flanges shall match.

All nozzle flanges, blind flanges, specialist flanges and body/girth flanges shall be forged. Flanges made from plate are not acceptable.

All fillet welds shall blend smoothly with both the vessel and the nozzle wall without any notch, sharp corner or undercut.

Nozzles not directly connected to internals shall be flush with the inside surface of the vessel wall. Hand holes and manways shall be flush with the inside of the vessel.

All sharp edges and corners rounded to a minimum radius of 3 mm unless shown otherwise on Vessel Data Sheet. Self-Reinforced Nozzles (8" and above) and Manways shall be radiused to 12mm at their inside edges.

The distance between process nozzles and vessel ends and other stress concentrating features shall be greater than 2.5√r.t (2.5 times the square root of the product of vessel mean radius and shell design thickness in corroded condition), unless supported by a discontinuity stress analysis duly approved by the Company.

8.4.1.2. Nozzle Projection

Nozzle minimum projection from the outside of the vessel wall or external insulation to the nozzle face shall be as per company standard drawing for nozzle projection.

For closed drain (sump vessels) nozzle projections shall be extended above access platform with bolt removal clearance (between nozzle flange rear side to top of grating).

Nozzles adjacent to shell girth flanges or horizontal vessel saddles shall be located with clearance such that bolt tightening equipment can be used on the girth flange bolts.

Nozzles with an internal projection shall:

a. Have a continuous fillet weld at the inside corner.
b. Not include the internal projection in reinforcement calculations

8.4.1.3. Nozzle Type

All Nozzles shall be flanged and set-in type (i.e. all nozzles and manway necks shall be attached by welding completely through the total thickness of the vessel shell, head or nozzle wall, including any reinforcement) with full penetration welds from each side. Full penetration welds from outside are only permitted when access from the inside is not possible.

Nozzles with connection of Socket Welded, Threaded Coupling, Single or double fillet welds, Screwed, Tapped or Threaded Openings, Pad Type, Built-up Type and Stubbed are Not Permitted.

8.4.1.4. Self-Reinforced Forged Nozzles

Nozzle shall be Integral set-through reinforcement type for any of following conditions:

a. Design temperature exceeds 399 ºC.
b. Design temperature exceeds 230 ºC in Hydrogen service.
c. Cyclic service.
d. Wall thickness exceeds 40mm in all services
e. Sour / Lethal service

8.4.1.5. Forged Saddle Type (Lip type) Nozzles

Forged Saddle Type (Q or Insert Lip) Self Reinforced Nozzles shall be used as shown in Figs UW-16.1 (f1), (f2), (f3) or (f4) of Div 1 and Table 4.2.13 Details 1 to 5 of Div 2 shall be provided for vessel where wall thickness exceeds 100mm in all services.

8.4.1.6. Set-on type Nozzles

Use of ‘Set-on’ nozzles is permitted only when all of the following conditions are met:

a. The Vessel Shell or Head thickness is 50mm or more.
b. The Nozzle thickness is less than half of the Shell thickness.
c. The nozzle attachment is radial (i.e. at 90°) and not tangential.
d. The Vessel is not in hydrogen service above 230°C.

Where Set-On connections are used, all of the following conditions shall be met:

a. The plate material shall meet ASTM A 770 S3 (with a minimum area reduction of 35%) or EN 10164 (Quality Class Z35)
b. 100% wet magnetic particle or liquid penetrant examination shall be carried out on the edge of openings before fit-up.
c. 100% ultrasonic examination shall be performed on a 100 mm wide band around the nozzle opening before attachment of the nozzle. Acceptance criteria shall be ASTM A 578 Level B for General service and C for hydrocarbon service. For Sour Service, Supplementary requirements S9 shall be applied.
d. 100% Volumetric NDE of attachment weld.
e. UT inspection of nozzle weld from inside of the Vessel where accessible.

8.4.2. Reinforcement Pad

Split reinforcement pads shall generally be avoided. When a split reinforcing pad cannot be avoided, the pad weld seam shall be oriented parallel to the circumference of the shell. Pad segment welds shall be 100% Radiographed. The welds of each pad or segment shall be given an air and soap solution test before pressure testing. Each pad segment shall have at least one ¼" NPT (6 mm) tell-tale hole for testing purposes. It shall be located near the lowest point of a pad with the vessel in its operating position to permit drainage.

Each Tell-tale hole shall be left open during welding of pad, PWHT (if applicable) and during hydrotest. Tell-tale holes shall not be plugged but shall be filled with grease after leak test for tightness of the welds and prior to shipment.

Reinforcing pad thickness shall not exceed 40 mm or the shell /head thickness, whichever is the lesser.

Reinforcing pads that are not circular shall have rounded corners of 50 mm minimum radius.

Nozzles in dished heads shall be positioned such that the nozzle, reinforcing pads, and attachment welds fall within the spherical portion of the head and are not within the knuckle region of the dished head.

8.4.3. Flanges

8.4.3.1. General

Flanged connection inside skirt is not acceptable

Flange design temperature shall be equal to the design temperature of the vessel.

Flanges fitted with blind flanges shall be supplied with bolting and gaskets.

8.4.3.2. Flange Type

Unless otherwise specified, flanges shall be weld neck or long weld neck type with raised face.

Slip-on Flanges are not permitted except for the following conditions.

a. Utility services up to flange ranting of 150#.
b. Vessel Internal pipework when specified on vessel data sheet.

Lap joint flanges are not permitted.

Nozzle flanges 24" (609.6 mm) and smaller shall be in accordance with ASME B16.5.

Nozzle Flanges larger than 24" (609.6 mm) shall be in accordance with ASME B16.47 Series A.

Manways and shell girth flanges larger than 24" (609.6 mm) may be in accordance with ASME B16.47 Series B, or alternatively designed and fabricated to suit maximum allowable calculated working

conditions. The VENDOR shall recalculate the flanges with the related gasket selected. For flanges outside the scope of these standards, the design shall be in accordance with the ASME Code, Section VIII, Division 1 or Division 2, as applicable.

Flange bolt holes shall be equally spaced off north/south centre lines or vertical centre lines, as applicable.

For Filters body flanges (900# rating and above), vendor specific flange design with self-centering or self-energized gaskets (lifelong gaskets) in compliance with ASME can be considered subject to company approval. In such case Vendor shall supply additional 100% gasket supply along with equipment over and above project spares.

8.4.3.3. Flange Rating

All flanges for relief valves shall be Class 300 minimum.

Thermowell / Pressure Indicator connecting flanges on vessels may require a higher flange rating if the Thermowell / Pressure Indicator flange rating is higher than the ratings for other nozzle flanges for the vessel due to different Thermowell / Pressure Indicator flange material. The ratings for Thermowell / Pressure Indicator connecting flanges and the mating flanges shall be checked and the flanges shall suit the mating Thermowell / Pressure Indicator flanges.

8.4.3.4. Flange Facing

Welding neck type flanges with raised-face shall be used as a minimum.

Flange facings shall be protected from damage during fabrication, heat treatment, and shipping.

8.4.3.5. Flange Gasket

Gaskets shall be specified on the datasheets and shall comply with Company Standard for Gaskets for Flanged joints, applicable ADNOCPiping Material Specification and the following requirements:

a. The gasket hardness and finish shall be compatible with hardness and finish of the sealing surfaces of the flanges to ensure sealing. CONTRACTOR shall define the hardness requirement of gasket and gasket seating surface of the flange in the mechanical datasheet.
b. Unless otherwise specified in datasheet, main shell body flange gaskets shall be spiral wound / metal jacketed gaskets / Octagonal Ring Gasket in accordance with ASME B 16.20. Material for spiral wound shall be austenitic steel strip type 316L (or suitable for service), non-asbestos filler with 316L (or suitable for service) inner ring and carbon steel outer ring.
c. Graphite gaskets shall not be used for seawater service.
d. Gaskets and bolting in joints which form an integral part of the equipment (i.e., manways, agitator connections, sight glass pads, etc.) and terminal joints shall be supplied by the Vessel VENDOR.

All flanges designed with spiral wound gaskets shall have considered the greater of ASME specified value or Manufacture’s specified value for gasket seating stress.

8.4.3.6. Flange Face Finish:

For Standard Flanged process nozzles conforming to ASME B16.5 / B16.47, Rating and facing of flanged nozzles shall be indicated in the datasheet and shall conform to ADNOC Piping Material Specification.

For Non-Standard flanges designed as per ASME:

a. When spiral wound and flexible graphite based gaskets are used, the gasket contact surfaces shall have concentric or spiral grooves, resulting in roughness height within the range of 3.2 – 6.3 µm Ra in accordance with ASME B46.1. Minimum gasket thickness is 3.2 mm.
b. When jacketed type gaskets, solid metallic type gasket and gasket for ring joint are used the surface finish of the gasket contact surfaces shall be 0.8-1.6 µm Ra in accordance with ASME B46.1.

Ring Type Joint (RTJ) Groove shall be harder than RTJ gaskets – 20 HB points minimum and machining shall be in accordance with ASME B46.1.

8.4.4. Inspection and Service Nozzles

All vessels shall be furnished with flanged manways and/or hand holes or inspection openings.

Minimum size of manholes shall be 24”. Smaller sizes, i.e. up to 20”, require COMPANY approval. However in no case ID shall be less than 460mm.

Vessels with outside diameters of 1220 mm and smaller shall have manholes and hand holes sized as large as practical.

When the diameter of the vessel containing internals is not sufficiently large enough to permit the use of manways or vessels having outside diameter of 914 mm and below shall be provided with body flanges instead of manways for accessibility.

CONTRACTOR shall obtain COMPANY’s approval for hand holes smaller than 8” (203.2mm) NB. Hand hole covers shall be provided with a hand grip.

Manways shall be sized and located to ensure the efficient removal of bolted internals, and to allow entry of personnel wearing breathing apparatus when this facility is required.

Manway flanges, vessel flanges and other inspection nozzle flanges shall be provided with cover, davit / hinges, gaskets, bolts and nuts.

Horizontal and vertical vessels shall be provided with a minimum of one manhole for access, subject to limitations of this section.

a. For Trayed Column, a minimum of two 610 mm (24") nominal size manways, one above the tray section and one below the tray section, at the feed tray, shall be provided on Columns with trays. Additional manways shall be provided between trays, the recommended number of trays between manways shall not exceed 15. Additional manways shall be provided as required for service conditions and maintenance.

b. The minimum tray spacing with manhole in the internal shall not be less than 760 mm. In no case spacing between the manways shall exceed 6 meters.

c. For vessels with tan to tan length less than 6 meters, one manway for access and one handhole of NPS 8 shall be provided for ventilation. The handhole shall be located at the opposite end to the manway, to permit good ventilation prior to personnel entering the vessel.

d. Horizontal Vessels of 6 meters or longer (tangent to tangent length) shall be provided with at least two manholes or more depending upon vessel specific internal arrangement. Vessels having a length of 10 m or more shall be provided with one additional access man way for every 10 m length. e.g. Vessel having 12 m length shall be provided with two manholes and vessel having 22 m length shall be provided with three access manways.

e. Manways shall be located in the heads of horizontal vessels when practicable and in the shells of vertical vessels.

For horizontal vessels with pumps installed on the top manholes, CONTRACTOR to ensure PUMP VENDOR utilizes standard flange sizes.

Top entry and side entry manway covers shall be self-supported and complete opening (180°). Tthey shall not be restricted by any fixtures of the equipment itself or their facilities.

Manways shall be provided with internal rungs and handgrip as per ADNOC Standard drawing.

Top entry and side entry manways shall be provided with a davit. Bottom entry manholes shall be provided with hinges.

All eyebolt and swing bolts shall be forged in one piece; welded bolts are not permitted. Hinge pins shall be machined from solid forged bar.

Manways orientated at an angle other than 0° or 90° from the horizontal plane shall be designed with a hinge which opens in the horizontal plane. In any case where this is not possible an arrangement for safe operation shall be agreed between the CONTRACTOR and the COMPANY.

Stops shall be provided to prevent damage to vessel shell or insulation from the over-rotation of the manway hinge or davit.

Davits for cover removal shall be provided for all nozzles NPS 300 up to and including NPS 750 and shall be provided with suitable lubrication arrangement. Davits shall comply with Company Standard Drawings.

Davit and hinge dimensions for manway sizes and (or) flange ratings not listed shall be determined and design included in calculations for COMPANY’s review.

Division plates in compartmented vessels shall be provided with bolted covers openings with bolts facing the manway side of the vessel to permit inspection or access to all parts of the equipment. Covers shall be designed such that they weigh no more than 30 kg.

8.4.5. Top Davit

A Top Davit per COMPANY standard shall be specified for vessels containing removable internals such as trays, packing and safety relief valves. Davit shall be located at the top of Vertical vessels to serve manways below. Equipment vendor shall submit the design calculations for Davit sizes outside the company standard.

8.4.6. Quick Opening Closures

Quick-actuating closures (QOC) shall be provided when specified on datasheet and designed as per ASME Section Div. 1 Paragraph UG-35.2 or ASME Section Div. 2 Paragraph 4.8 and Annex 4.B. Procedures for the operation or maintenance of quick-actuating closure shall be submitted for Company's review.

Quick opening closures (QOC) shall be quick acting type, lever or hand wheel, easily operated by one operator in approximately one minute without use of any additional devices and fitted with davit for easy operation. Screwed or threaded-type enclosure shall not be used.

Tell-tale vent or safety bleeder shall be provided near end closure for ensuring safe opening of end closure and to ensure that liquid is drained before opening the end closure.

For sour and hazardous service, Quick opening closure (QOC) shall be equipped with pressure safety device of non-bleed type and not to allow the opening of QOC in case of positive pressure.

The design of the QOC mechanism shall provide visual aid/indication for operator to see and ensure QOC mechanism fully closed, locked and aligned.

8.5. VESSEL SUPPORTS

8.5.1. Saddle Supports

Below requirements are applicable for saddle supports. In case these contradict with any specified COMPANY Standard drawing requirements, same shall be discussed and mutually agreed.

Fixed and sliding support arrangement shall be followed as per ADNOC specification, Design Criteria for Static Equipment.

When specified, bearing plates shall be provided for installation under the sliding support.

Wear plates for saddle supports shall be of the same material as the shell, be continuously welded to the shell and have 1/4" NPT (M.6) weep hole on each plate, at the lowest point. All corners of wear plates shall have a radius of at least three times the thickness of the wear plates.

Supports shall be designed so that the metal temperature of the part of the support resting on concrete will not exceed 100 °C.

For vessels with operating temperatures below ambient, COMPANY specification for Cold Insulation for Piping and Equipment shall be followed for adequate surface protection and prevention of condensate collecting areas.

8.5.2. Vertical Equipment Supports and Anchor Bolts

Skirts shall be designed to be attached to the vessel and base ring by continuous welds.

For stress relieved vessels, the top portion of skirts shall be stress relieved with the vessel.

The base plates for vertical vessels shall be preferably in one-piece construction without any weld joints. If welded construction is provided, the welds shall be ground flush and fully radiographed to ensure integrity and uniform contact (bearing) with the deck steel / foundation.

Material of top of skirt welded to head shall be the same material as that of shell for a lengthL = 2.5 sqrt (Rt) or 600 mm whichever is greater,

where R = inside radius of skirt (mm) and t = skirt plate thickness (mm).

For vertical vessel in cyclic service, skirt to head joint shall be as per ASME Section VIII Div 2, Figure 4.2.4 (e) or (f) or Table 4.2.5 Detail 7.

In either case of Forged Ring or Built-up Weld for Skirt to Head joint, the finished joint shall provide a smooth radiused configuration (minimum 25 mm radius) to avoid peak stress concentration effects and any backing ring used shall be removed after welding.

All vessels shall be provided with at least two (2) Earth connections as per COMPANY Standard Drawing.

A hot box shall be provided at the junction between the skirt and shell for vessels with a design temperature of 260°C and above to reduce the thermal gradient impact at Skirt to head joint for Vertical Vessels as per COMPANY specification for Hot Insulation for Piping and Equipment.

Leg supports shall be welded to backing pads on the cylindrical shell and shall not bear on the knuckle, crown or bottom of formed heads but conform to Company Standard Drawing for Static Equipment unless otherwise specified on data sheets.

ASME Section VIII Div.1 Vessels may be supported by lugs if vessel is not in cryogenic service. The lugs shall be attached to cylindrical shell on pads that are of same material group as that of Vessel.

8.6. INSULATION

Vessels shall be insulated in accordance with ADNOC Specifications when required by the Vessel Data Sheets/Drawings. Material type, thickness and extent of support of insulation system shall be specified on the data sheet and shall comply with the following:

1. Pins, clips and studs welded to a pressurized part shall be the same material as the component to which they are welded and shall be installed prior to any required PWHT.

2. Insulation supports shall clear vessel weld seams by minimum 50 mm (edge of weld to edge of weld).

3. Insulation supports shall be provided to suit the thickness and type of insulation material.

8.7. FIREPROOFING

For ADNOC Offshore Equipment, fireproofing requirements shall be complied as Painting is followed as per ANNEXURE-6.

When specified on the data sheets/ drawings support skirts shall be fireproofed in accordance with ADNOC Specifications / standard drawing and the following thickness:

VESSEL DIAMETER	INTERNAL THICKNESS	EXTERNAL THICKNESS
1220 mm O.D. and less	None	50 mm
Over 1220 mm O.D.	50 mm	50 mm

8.8. LADDERS, PLATFORMS AND DAVITS

Ladders, platforms, pipe supports and column davits shall be provided in accordance with ADNOC Specifications for Structural Steel Supply, Fabrication and Erection and/ or Standard drawings for Ladders and Platforms.

Ladders, platforms and relevant accessories shall be provided for all equipment where access is required to operate and maintain the equipment in service

8.9. INTERNALS

Process design of internals shall be specified in Process Design Criteria philosophy.

Unless otherwise stated on the vessel data sheet, all rings, angles, clips, bolting bars and brackets required for the support for the internals whether welded or not, shall be supplied by the vessel VENDOR.

TRAY VENDOR shall design tower attachments and submit detail drawings for use by the vessel VENDOR.

Removable internals shall be designed such a way that they can pass through the nearest manway on the vessel/column.

Materials for internal supports and clips welded to the shell or heads shall be the same material grade as shell or head.

Internal flanges shall be ASME B16.5 Class 150 rating slip-on flanges, or when specified, may be fabricated from plate. Gaskets shall be provided for all flanges.

Continuous fillet welds shall be used for all internal structures, supports and fittings welded to the vessel shell or head.

8.10. MECHANICAL ASPECTS FOR INTERNALS

Materials for internal supports and clips welded to the shell or heads shall be the same material grade as shell or head.

Unless otherwise specified, internal flanges shall have heavy hex head bolts and heavy hex nuts of the same material type as the flanges.

Removable and non-removable internal piping shall be 3.2 mm minimum thickness before corrosion allowance is added.

Internal flanges shall be ASME B16.5 Class 150 rating slip-on flanges, or when specified, may be fabricated from plate. Gaskets shall be provided for all flanges.

Internal flange bolting shall be securely tightened and tack welded at bolt head and nut. Nut shall be provided with double lock nut

Unless otherwise specified, removable internals shall pass through the vessel manhole.

Continuous fillet welds shall be used for all internal structures, supports and fittings welded to the vessel shell or head.

8.11. EXTERNAL STIFFENING RINGS

CONTRACTOR/VENDOR shall ensure all stiffening rings are correctly sized per code requirements. An increase in shell thickness may be used to eliminate some or all stiffening rings if economically attractive.

Pre-formed structural shapes directly welded to shell are not acceptable stiffening rings unless approved by COMPANY.

8.12. BOLTING

8.12.1. External Flange Bolting

External bolting for covers, blind flanges, and shell flanges shall be stud bolts, with two heavy hex nuts each.

Bolting of less than 16 mm diameter (5/8") shall not be used for flanged connections. The height of the nut shall be equal to the bolt diameter.

Bolting up to 24 mm (1") shall have UNC standard thread and bolting 30 mm (11/8") and larger shall have UN threading (8-thread series).

Bolted joints specified with non-ASME standard flanges shall be designed to meet all anticipated loading conditions of the vessel in accordance with applicable ASME Section VIII code.

For Bolt sizes over 63.5 mm (2-1/2 in), reduced diameter ("necked") stud bolts shall be used.

Except for special design considerations, flanges shall be through-bolted with stud bolts threaded full length with a removable nut on each end unless fitted with collar bolts. One full stud thread shall extend beyond each nut to indicate full engagement.

External Flange Bolting shall be specified on the datasheets and shall comply applicable ADNOC Specifications Piping Material Specification.

Flange bolting design temperature shall be equal to the vessel design temperature.

Flange bolting length shall conform to ASME B16.5 / B16.47 dimensions when bolt diameter is less than 1 ½" (38 mm).

The extent of hydraulic bolt tightening shall be recommended by the CONTRACTOR / VENDOR after liaison with gasket VENDOR to ensure adequate compressive load on the gasket is generated. Bolt pitch and flange hub details shall allow for this equipment.

Hydraulic Bolt Tensioning Equipment shall be used for bolting larger than 38 mm diameter.

Bolts for bolt tensioning shall be extended by the length of one nut and provided with a cap for protection during service.

Hydraulic Bolt Tensioning Equipment which can be used for all size of bolts greater than 38mm in the project shall be quoted and supplied by CONTRACTOR/ VENDOR if requested.

External bolting including insulated flange bolting shall be coated in accordance with ADNOC Specifications for Painting.

8.12.2. External Structural Bolting

External Bolts less than 5/8" (16 mm) nominal diameter shall not be used.

Imperial Bolts 1" diameter and smaller shall be Unified Coarse thread series (UNC). Bolts over 1" diameter shall be Unified 8 TPI Series (8-UN).

Metric Bolts shall be ISO Metric Coarse Thread.

8.12.3. Internal Bolting

Bolting for internal flanges shall be ASME B16.5 Class 150 rating equivalent sizes

Where necessary, bolting shall be accomplished using the special tools and the instructions as supplied by the approved VENDOR.

8.13. EXTERNAL ATTACHMENTS

Fabricator shall supply all clips welded to the vessel. Quantity, elevation, orientation and sizes will be specified on the detail drawings, which may not be available at the time of contract award.

Clips for ladder, platforms, and pipe supports and support brackets shall be furnished, continuously welded to the vessel and shall not be located over any vessel seams. If required by purchase order, VENDOR shall supply ladders and platforms.

Bolt holes in ladder, platform and pipe support clips or brackets on insulated vessels shall be sufficient distance from the insulation to allow installation of bolts without damage to the insulation

Earthing cleats / Bosses (Minimum 2 Nos) shall be provided as per standard drawing.

Stiffening rings and external attachments shall be designed and constructed to prevent channelling and retention of rainwater/ condensate.

All Attachments welded directly to the pressure parts shall be of same material that of the mating part unless otherwise specified. Welding structural quality material directly to pressure parts not permitted.

8.14. LIFTING ATTACHMENTS

Lifting attachment shall be as per applicable COMPANY Standard drawing

All insulated horizontal vessels shall be provided with lifting lug or trunnions to facilitate handling. Lifting lugs and trunnions shall be of the same material as the shell.

All vertical vessels shall be provided with lifting trunnions, attached by full penetration welds, or lifting lugs as specified on the vessel data sheet. Holes shall be sized to take shackle pins based on this loading. Vertical vessels having a weight greater than 20 tonnes shall have tailing a lug or lugs. The attachment welds shall be tested for cracks on completion, and the pressure parts local to the attachment shall be ultrasonically examined.

Tailing beam(s) shall be provided as necessary to satisfy the tailing analysis of vertical vessels including an increase in skirt thickness to provide necessary stiffening. (temporary local strengthening of skirt or anchor chair is not allowed unless approved by Company).

All vessels shall be designed for lifting in fully dressed conditions when specified on the Mechanical Data Sheet. Lift weight in dressed up condition shall include the weight of all components, such as trays, bundles, ladders, platforms, insulation, etc. as applicable. Thickness adequacy of vessels shall be validated for such conditions prior to selecting the shell nominal thickness.

CONTRACTOR shall select lifting lug or trunnion attachments based on calculated bending moment during lifting and providing clearance for platforms and ladders in dressed condition.

Vessel shall be designed for safe lifting operations. Necessary rigging analysis shall be performed by CONTRACTOR/ VENDOR.

8.15. ACCESSORIES

All vessel external or internal accessories shall be supplied and installed by the VENDOR unless specifically excluded on the vessel data sheets/drawings.

Tray support rings, downcomer bars, beam supports, baffles, and all other tray support parts that are welded to the vessel shall be in accordance with the TRAY VENDOR'S detail drawings, and TRAY VENDOR's load calculations.

Internal trays shall be in accordance with ADNOC Specifications.

8.16. IMPACT TESTING REQUIREMENTS

In application of the ASME curves, Figure UCS-66 and notes, the thickness of each component and weld shall be determined according to the definitions given in the ASME Code.

Each weld and component shall be individually evaluated to determine if impact testing is required. Components shall include, but not be limited to, shells, heads, nozzles, manways, reinforcing pads, flanges, tubesheets, flat cover plates and welded attachments to pressure containing components.

All base metal sampling and test procedures shall be per the ASME Code. Impact testing shall be done at the MDMT of the vessel. If LTCS material is used for vessel at temperature lower than -46 deg. C due to depressurization, then it shall be impact tested at -46 deg. C and meet ASME Code requirement.

Impact testing for bolting materials shall be in accordance with the ASME Code.

8.17. FABRICATION

Longitudinally welded joints shall not be located within the tray downcomer area or behind any plate or obstruction that prevents inspection of the weld on the inside of the vessel. Circumferentially welded joints shall clear a tray support ring weld by at least 25 mm.

Wherever possible, reinforcing pads for nozzles and other attachments shall not be located over longitudinal and circumferential welded joints.

Nozzles including the reinforcing elements (when applied) should be placed away from pressure containing welds to the greater of 50mm or 2 x t min (where t min is the Parent Component (Shell / Head) thickness on which nozzle is installed).

If this is unavoidable, the welded joint shall be ground smooth and fully radiographed (100% RT) for its entire covered length, plus 50mm on each side when measured from weld toe of nozzle or reinforcing element as applicable.

Additionally Refer to ANNEXURE-6 for ADNOC Offshore requirement.

8.18. POST WELD HEAT TREATMENT (PWHT)

PWHT shall be performed when required by the ASME Code, ADNOC Specifications, for Sour /Lethal Services and/or the Vessel Data Sheets/Drawings.

PWHT when specified shall be carried out in accordance with a CONTRACTOR approved procedure that meets the requirements of the ASME Code and ADNOC Specifications as applicable.

Welding on vessels that have been PWHT is not permitted without prior approval from the CONTRACTOR/COMPANY.

Chrome-moly material shall be post weld heat treated in all thicknesses unless otherwise specified.

When PWHT is required, the entire vessel shall be heat treated in an enclosed furnace.

When PWHT is required in the field, the procedure and requirement shall be subject to review by the CONTRACTOR/COMPANY.

Welding on a pressure part is not permitted after PWHT. This note shall be on the Vessel Fabrication Drawings, and CONTRACTOR Vessel Drawings/Data Sheets.

All acceptance NDE shall be carried out after PWHT.

8.19. WELDING AND NDE

All welding & NDE shall be in accordance with the ASME Code and meet the requirements in ADNOC Specifications as applicable.

Shell and head joints shall be full penetration, double welded butt joints. Single welded, full penetration joints utilizing consumable inserts are permitted only on the closing circumferential joint of vessels that are not provided with a manhole, except that vessels less than 609.6 mm O.D. may have two (2) closing circumferential joints with consumable inserts. Permanent backing strips are not permitted. Acceptance of single welded, full penetration joints are subject to review and acceptance of weld procedures by the CONTRACTOR.

All nozzles shall be welded to a shell or head with full penetration welds from each side. Full penetration welds from outside are only permitted when access from the inside is not possible.

100% RT can be substituted with recordable UT techniques such as TOFD or PAUT subject to COMPANY approval.

The minimum distance between two longitudinal seams in one course and between the staggered longitudinal seams of two adjacent courses shall be 200 mm or five (5) times the wall thickness, whichever is larger.

All parts which have been cold formed over 5% strain shall be subject to an appropriate normalizing treatment and, if necessary, a tempering treatment.

All nozzles shall be trimmed flush with the inside surface of the vessel unless attached to internal piping. Internal projection of manholes and handholds is not permitted.

Fabrication tolerances shall be in accordance with the ASME Code and standard drawing.

Refer to ANNEXURE-6 for ADNOC Offshore requirements for welding and NDE.

8.20. INSPECTION AND TESTING

For establishing and implementing Inspection class (Criticality Rating) and minimum shop inspection and certification requirements as per COMPANY Specification. Refer to ANNEXURE-6 for ADNOC Offshore requirement.

8.21. GENERAL

Inspection and testing shall be in accordance with design code requirements as a minimum, the requirements specified in this specification and purchase order documents and the following:

a. The responsibility for inspection rests with the CONTRACTOR in accordance with Paragraph UG-90 of the Code; however, the CONTRACTOR reserves the right to inspect at any time during fabrication to assure that vessels, materials and workmanship are in accordance with this Standard and the ASME Code.

b. Prior to start of fabrication the VENDOR will supply an “Inspection and Test Plan” (ITP) which will detail all VENDOR steps for procurement, receiving materials, fabrication, PWHT, testing and transportation. CONTRACTOR will review ITP and will be ready to identify witness and or hold points. All inspection and testing activities shall be carried out as per approved Inspection and Test Plan (ITP).

c. All welds not meeting the applicable Code requirements shall be cut out or repaired and re-examined or re-tested as specified at the VENDOR’S expense.

d. The CONTRACTOR shall have free access to all locations where and when the work covered by this specification is being carried out.

e. The VENDOR shall make available to the CONTRACTOR the quality assurance data, material certificates, test certificates, welding procedure specifications (WPS), procedure qualification records (PQR) and all other relevant documentation deemed necessary to carry out inspection.

f. Non-destructive examinations shall be performed by qualified personnel.

g. Visual and non-destructive examinations of weld preparation and welded joints shall conform to the requirements of the applicable ASME Code sections, COMPANY and project specifications.

h. Non-destructive examination procedures shall be prepared by VENDOR’s NDT Level III (ACCP ASNT/ PCN Level III) and to be submitted to COMPANY for approval after review and endorsement of, ASME AI and NDT Engineer/Consultant with ACCP ASNT/ PCN Level III.

i. Non-destructive examinations for final acceptance shall be carried out after PWHT.

j. All NDT including radiographic, ultrasonic, magnetic particle or liquid penetrant examinations shall be performed identically before and after PWHT of the vessel.

k. Welded zones of temporary fabrication attachments shall be subjected examination by both of PT/MPI and UT check by A-Scan/compression probe.

8.22. RADIOGRAPHIC WELD INSPECTION

Unless otherwise stated on the datasheet the minimum joint efficiency for pressure part calculation shall be 85% (spot radiography) in accordance with ASME VIII Div.1, UW-52.

For minimum requirements and for service conditions including Lethal, Sour & Wet H2S requiring 100% radiography refer Critical Service Requirement in this specification and ANNEXURE 6 for ADNOC Offshore

When joint efficiency of 100% (full radiography) is used in calculations, all butt welds shall be 100% radiographed, regardless of welded joint category as defined by the ASME Code.

Radiographic examination shall be used for plate thickness up to 50 mm (or 25 mm if double wall technique is used). For greater thickness, radiographic examinations shall be supplemented with full ultrasonic examination including manual UT with 0° in the case of a flush weld and the plate for 100 mm on either side of the weld, in addition to 45°, 60°, and 70° respectively .Then applying automatic ultrasonic PAUT including at least zonal discrimination, B-Scan, S-Scan and TOFD altogether in compliance with ASME Code requirements as listed in ASME VIII Div.1, VIII Div.2, ASME V, and ASME CODE CASE 2235 and ASTM E 1961. The same are applied in case of technical deviation raised to utilize UT testing in lieu of RT. Automatic ultrasonic phased array UT shall be conducted based on approved qualified procedure established based on ASME sec-V.

All joints with restoration cladding which require RT or UT testing over the area of interest shall be considered, including base material thickness and weld overlay thickness.

All nozzles fabricated from plate shall be 100% radiographed.

Fillet and butt welds that cannot be RT or UT examined shall be inspected by MT or PT examination in accordance with the method specified by the ASME Code.

Acceptance Criteria for Butt Welded Joints with Restoration Cladding shall be the same as applied section of ASME Section VIII Div.1 or Div.2.

Acceptance criteria for rounded indications for spot radiography shall be the same as for full radiography i.e. Appendix 4 of ASME Section VIII Division 1.

Refer to ANNEXURE-6 for ADNOC Offshore requirement for RT.

8.23. POSITIVE MATERIAL IDENTIFICATION (PMI)

All components, pressure and non-pressure retaining, shall be tested when required by applicable ADNOC Specification for PMI.

8.24. INTER GRANULAR CORROSION

Stainless steels 304, 304L, 316, 316L, 321,347, & 347H shall pass the Inter Granular Corrosion (IGC) test conducted by the manufacturer in accordance with ASTM A262 Practice E. For duplex stainless steel inter granular corrosion [IGC] test conducted by the manufacturer in accordance withx ISO 3651-2.

All stainless steel and alloy 825 material shall be Inter Granular Corrosion tested in accordance with ASTM A262 and G28 Method A.

Alloy 625 shall be Inter Granular Corrosion Tested in accordance with ASTM G48 and G28 Method A.

Weld overlays, welds and internals, pressure and non-pressure retaining, shall be Inter Granular Corrosion tested in accordance with ADNOC Specification for PMI.

CONTRACTOR shall ensure that the VENDOR shall furnish Material Certificates in accordance with the requirements of EN 10204. The type of certificate required “A”, “B” or “C” is determined by the inspection class assigned to the type of equipment or material.

8.25. ULTRASONIC INSPECTION

Both the UT and the acceptance criteria shall be in accordance with the Code and performed in accordance with written procedures.

Where full radiography of nozzle neck or stub to vessel welding is specified on the Vessel Data Sheet and radiographic interpretation is questionable owing to the weld configuration, then such areas shall be examined by UT.

When nozzles with reinforcement pads require UT, the weldment shall be examined prior to fitting the pads.

All forgings and plate material 50 mm and over in thickness shall be UT examined to the requirements of ASME, Section VIII, Division 2, paragraph 3.3.4.1 Test specification SA 388 is the same as the old edition of Code. In General Testing shall comply with the applied design code.

For shell and head plates if design pressure is > 50 bars the UT inspection shall be done in accordance with ASTM A 578. Level of acceptance shall be level B.

Shell and head plates of 38 mm thickness and above, even if design pressure is < 50 bars, shall be UT tested on a 75 mm square grid system. Level of acceptance shall be level B according to ASTM A 578.

All process connection openings in shell and head plates that exceed 150 mm diameter shall be UT tested for lamination when the plate thicknesses are greater than 38 mm.

Additionally, the plates shall only be considered acceptable if lamellar defects in a single plane do not exceed the following limits:

a. Maximum total defect length of 170 mm in any metre of plate edge.
b. Maximum area of any individual defect not to exceed 970 sq. mm.
c. A maximum penetration of defect into the plate of 50 mm.
d. Maximum length of any individual defect parallel to the edge does not exceed 75 mm.
e. Any defect less than 320 sq. mm. in area will not be considered in the overall assessment.

For wall thicknesses greater than 100 mm, or if the angle of the fusion edge preparation is no more than 10°, a supplementary examination shall be performed by a mechanised tandem technique with an angle of refraction of 45°.

Inspection of Heads after forming:

After forming, the inside and outside surfaces of the formed heads shall be visually examined.

When a head is constructed from more than one plate, the weld in the region of the knuckle radius shall be radiographed as a minimum requirement.

PT examination shall be conducted on all heads at the following locations:

a. All weld seams on inside and outside surfaces.
b. All weld preparations.

Defects found during the inspection of formed heads may be repaired by welding but the VENDOR shall submit the proposed rectification, for approval prior to carrying out any rectification. Any weld repairs that may be necessary shall be completed prior to final heat treatment.

Final inspection shall be carried out after the removal of all slag, mill scale, dirt, grit, weld, spatter, paint, oil or other foreign matter from the equipment (It is the VENDOR'S responsibility to offer equipment in a suitable condition for the Inspecting Engineer(s) examination which includes the provision of scaffolding/ ladders when required).

The weld profiles shall be as follows:

a. Profile of Internal and External Reinforcement
b. The weld metal shall be properly fused with the parent metal without significant undercutting or overlapping at the weld toe. Weld toes shall blend smoothly into the parent metal and the depth of local undercutting shall not exceed 5% of the plate thickness or 1 mm whichever is smaller.
c. The external weld reinforcement shall not exceed 3 mm and the internal weld reinforcement shall not exceed 2 mm. The weld shall be substantially symmetrical about the centre line of the joint.
d. Weld Surface Finish: The start and stop of each run of weld metal shall merge smoothly and show no pronounced hump or crater on the weld surface.
e. Fillet welds shall be regular in form and free from undercut.

Refer to ANNEXURE-6 for ADNOC Offshore requirement for UT.

8.26. MAGNETIC PARTICLE & LIQUID PENETRANT INSPECTION

MT examination shall be in accordance with the Code Art. 7, ASME Section V and in accordance with written procedures.

The evaluation of indications and acceptance criteria for MT shall be in accordance with the Code.

The D-C prod method shall be used prior to PWHT.

The A-C yoke or coil method shall be used after PWHT.

When MT is required the DC prod or yoke method shall be employed.

All edge preparations for plates 50 mm or thicker shall be examined by MT. Discontinuities disclosed by this examination shall be repaired and re-examined.

All root passes shall be examined by MT. This includes back gouged or chipped or ground root passes to be welded from the second side.

When MT examination is called for, PT examination may be substituted.

PT examination shall be in accordance with the Code Art. 6, ASME Section V and in accordance with written procedures.

The evaluation of indications and acceptance criteria for PT shall be in accordance with the Code.

All root passes, back-chipped, back-gouged surfaces, final welded surfaces and HAZ shall be MT examined using the DC prod DC yoke method. All cracks and linear indication shall be removed prior to continuing to weld the joint.

All areas from which temporary attachment welds have been removed and all weld repairs to base materials shall be examined for cracks by either the PT or AC yoke MT methods, after PWHT. All cracks shall be completely removed. Repairs and re-examinations are required if the thickness of the part is reduced below the Code minimum required thickness plus full corrosion allowance.

All accessible surfaces of pressure retaining welds and load bearing internal welds (e.g., catalyst bed support shall be MT examined using AC yoke method after hydrostatic test in accordance with the Code, Appendix 6). For non-magnetic materials, PT examination shall be substituted and performed in accordance with the Code, Appendix 8.

Refer to ANNEXURE-6 for ADNOC Offshore requirement for MT and PT.

8.27. HARDNESS TESTING

After final PWHT the hardness of the deposited weld metal and heat affected zone (HAZ) shall be examined. Hardness values shall not exceed 200 BHN. Heat treatment shall be performed if required to reduce hardness to the specified level, subject to review and approval by the CONTRACTOR.

On pressure vessels, hardness shall be measured in one location on each of the following welded areas:

a. Circumferential
b. Longitudinal
c. Nozzle
d. Stub
e. Attachment

CONTRACTOR shall use Vickers HV 10 measurement with a portable hardness measuring device like Equotip. Welds in sour service shall be subjected to hardness testing using Kraut Kramer Microdur MIC 20 or MIC 10 instrument or other equivalent if approved by the company.

The acceptable hardness values after heat treatment for equipment in hydrogen service shall be taken from NACE MR0103 for Onshore equipment and NACE MR0175 for Offshore Equipment.

Where required value of BHN is not achieved, the VENDOR shall perform a re-test without any heat treatment, whatsoever. If this second test fails to meet the BHN requirement, heat treatment shall be repeated. Methods and procedures for anticipated second heat treatment shall be pre-approved by the CONTRACTOR. The most critical requirements in hydrogen service at high temperature are as follows:

a. Must use low hydrogen welding electrodes
b. Must apply baking out after welding continuously.
c. Must apply strong NDE for the weldment. (e.g., 100% RT. 100% MT)

8.28. VISUAL INSPECTION / DIMENSIONAL CHECK

A Dimensional Check shall be listed in all fabrication stages of the ITP including; on receiving material e.g. check dished heads, after forming e.g. after plate rolling, after preassembly e.g. nozzle assembly, before welding including welding joint preparation check and after welding as part of the visual inspection after welding, before and after heat treatment, before and after hydrotest. Any deviation from the AFC drawings shall be reported with identification with judgment by acceptable dimensions or rejected.

Dimensional checks shall be carried out Before and After PWHT (any deformation shall be recorded and evaluated).

The final dimensional check and visual inspection shall be performed after the hydrostatic test. Tolerances shall be as per the applicable ASME CODE Sections, COMPANY specifications and Project specifications.

8.29. INTERNALS CHECK

Removable internals shall be trial fitted inside the vessel (before PWHT for vessels subject to PWHT or Hydrostatic test for non PWHT vessels). Trial fit-up shall be supervised by Internals Process Vendor Specialist and the COMPANY.

Very large vessels shipped in several sections to site, e.g. Columns or others, shall be subject to a trial fit between various sub-assemblies in the manufacturing plant. All the reference plans, reference lines, reference points shall be recorded and remain visible for further use during final site assembly.

8.30. PRESSURE TESTS

8.30.1. Hydrotest

Vessels shall be hydrostatic pressure tested at the test pressure specified on the Vessel Data Sheets/Drawings. The test procedure shall be in accordance with the ASME Code and approved by the CONTRACTOR. A minimum of two calibrated pressure gauges are to be installed. One at the topmost point and one near the test header. Chart recorders are mandatory to be used to record the hydrotest.

The test medium for hydrostatic testing shall be clean water containing a suitable wetting agent to reduce the surface tension. The pH of the water shall be kept between 6 to 8. The use of any other medium shall require approval by the CONTRACTOR.

Hydrotest water temperature shall be per ASME Code and shall be carefully monitored to avoid the possibility of brittle fracture.

After completion of the pressure test, additional welding on the pressure-containing portion of the vessel is not permitted without prior approval by the CONTRACTOR.

Test medium for hydrostatic testing of Stainless Steel Vessels shall be in accordance with para 9.1.3 of this specification.

Test medium for hydrostatic testing of CRA Clad Vessels shall be in accordance with para 9.2.5 of this specification.

After completion of the pressure test, additional welding on the pressure-containing portion of the vessel is not permitted without prior approval by the CONTRACTOR.

Hydrotest shall be carried out using same specification of gasket as service gasket.

Gaskets for inspection or access nozzles which are opened after hydrotest shall be replaced by service gaskets prior to closure for transportation.

Vessels are tested in the shop, in a position compatible with their dimensions. However, for vertical vessels, which are shop-tested in the horizontal position, the shop test pressure must be increased by the hydrostatic head corresponding to the vessel in the vertical position, in compliance with the calculation note. Vessels will only be designed for future hydrostatic test in vertical position if noted on the mechanical data sheet.

Refer to ANNEXURE-6 for ADNOC Offshore requirements for pressure tests

8.30.2. Leak Tests

A Leak test of reinforcing pads shall be performed in accordance with the ASME Code Section V. The welds of each pad or segment shall be given an air and bubble solution pressure test before the test of the vessel. The test pressure shall be at least 1.05 kg/cm2 but shall not exceed 1.4 kg/cm2. The test shall be witnessed and accepted. The test holes shall be left open for use as tell-tale holes. They shall be filled with corrosion inhibiting grease after testing of vessel. Do not install a screwed plug.

For insulated vessels, the VENDOR shall apply corrosion inhibiting grease in the end of the nipple after testing of vessel. Do not install a pipe cap.

8.31. CLEANING AND PAINTING

When indicated on Vessel Data Sheets/Drawings, vessels shall be painted in accordance with ADNOC Specifications. Internal surfaces shall be cleaned in accordance with ADNOC Specifications.

Each vessel shall be thoroughly cleaned inside and shall be free from grease, weld spatter, scale, slag, rust, and any other foreign matter. Carbon Steel Vessels shall be internally blast cleaned in accordance with SSPC-SP6.

Vessels which require painting shall have all exterior surfaces coated, including inside of skirt and bottom head, in accordance with ADNOC Specifications.

All painting shall be performed after hydrostatic testing.

Welds of high alloy steel and non-ferrous material shall be examined for oxidation.

Pickling and Passivation of welds shall be carried out where excessive oxidation is observed.

8.32. IDENTIFICATION AND MARKING

Vessels or sections of vessels shall be clearly identified by painting or dye stencilling the Purchase Order number and the Item number in a conspicuous location on the shell, head, or fixed support.

Vertical vessels shall be marked on the base and first 300 mm of skirt support welded to the pressure vessel indicating the north, south, east, and west co-ordinates. The co-ordinates shall be indicated with a painted line and letter for each, according to the orientation shown on the vessel drawings. The markings shall be made on the shell near the bottom tangent line if the vessel does not have a skirt.

Horizontal vessels shall have one head marked north, south, east, or west as identified on the vessel drawings.

The centre of gravity shall be marked on all vertical vessels by painting a continuous 75 mm wide circumferential stripe.

The letters C.G. and the shipping weight in metric tons shall be painted at 2 locations diametrically opposite and adjacent to the stripe. The location of the centre of gravity specified on vessel drawings is as fabricated; the VENDOR shall make suitable adjustment for shipping supports if they cause the centre of gravity location to move more than 150 mm.

The colour of paint for marking and lettering shall conspicuously contrast with the vessel surface and shall be compatible with the paint system.

Vessels or vessel sections that have been subjected to PWHT shall be clearly marked "Post Weld Heat Treated - Do Not Flame Cut or Weld on This Vessel." The above requirements shall be clearly marked on each side of the vessel in 75 mm high block letters with a contrasting colour and shall be clearly visible.

Vessel nameplates shall be in accordance with standard drawing. For vessels in Low- Temperature service (-29 °C or lower), the nameplate shall always show the date of the final pressure test, the design temperature/pressure and the MDMT. The nameplate shall also show the MAWP and the maximum temperature possible. Code stamp to be applied to nameplate. Additionally, the Nameplate shall indicate the Minimum Depressurization Temperature and its corresponding pressure.

All markings painted on vessel shall be clearly visible in the shipping position. Vessels that have been internally coated shall be clearly marked “Internally Coated – Do Not Flame Cut or Weld on this Vessel”.

8.33. SHIPPING AND HANDLING

Preparation for shipment shall be in accordance with the VENDOR'S standards and as noted herein. The VENDOR shall be solely responsible for the adequacy of the preparation for shipment with respect to materials and application and shall provide the vessel(s) at the destination in ex-works condition.

Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite.

Preparation for shipment and packing shall be subject to inspection and rejection by CONTRACTOR'S/COMPANY'S inspectors. All costs associated with a rejection shall be to the account of the VENDOR.

Prior to shipping, vessels shall be completely drained and thoroughly dried and cleaned from all loose scales, weld slag, dirt and debris to the satisfaction of the Inspector.

Vessels shall be strapped, securely anchored, and skid mounted when required. Bracing, supports, and rigging connections shall be provided to prevent damage during transit, lifting, or unloading. All temporary bracing/supports shall be marked "REMOVE BEFORE VESSEL COMMISSIONING AND START UP".

Flanged openings shall be protected with metal cover plates to prevent damage during shipment. Covers shall be a minimum of 6 mm thick and shall be installed with a full-width gasket using a minimum of four (4) full diameter bolts. Large diameter flanges shall have enough full diameter bolts to seat the cover all around. The cover and flange shall be taped for waterproof protection.

All loose items and all spare parts shall be boxed or crated. All boxed or crated items shall be identified by item number/service and marked with CONTRACTOR's Purchase Order number, tag number, and weight, both inside and outside of each individual box or crate. A bill of materials shall be enclosed in each box or crate.

All external unprotected areas, machined surfaces and bolting, shall be given a coating of rust inhibiting compound. Internal metal surfaces shall be sprayed or coated with a suitable rust preventative. Openings shall be suitably tagged to indicate the rust preventative name and supplier.

One complete set of installation, operation, and maintenance instructions shall be packed in the boxes or crates. This is in addition to the number called for in the Purchase Order.

The VENDOR is responsible for all support designs for on-loading, during transport, off-loading and erection at site. Local stresses developed from these local loads shall be limited to 2/3 of the yield

8.34. SHIPPING SADDLES

Attachments and tackle for securing vessel to transport shall be suitable to prevent any horizontal or rotational movement of the vessel.

Shipping saddles strength shall be suitable for being supported at each end of saddle on 1 m^2 supports during shipment and storing for up to 6-months, without causing deflection of the saddle base and locally stressing the vessel above its design limits.

The shipping saddle base shall be suitable for securing to the transporter by clamping or bolting.

Sizes of shipping saddles are dependent on method of transportation and method of lifting on to transport vehicle. Dimensions shall be agreed during design Engineering.

Typical lengths of saddle base supports are:

a. 4.9m long for 3.0m width bogie

b. 5.5m long for 3.65m width bogie

c. 6.3m long for 4.8m width bogie

d. 7.8m long for 6.2m width bogie

Saddle height to be a minimum to reduce overturning forces, but sufficient for vessel attachments projecting downwards to clear surfaces on which it is to be placed.

Vessel is to be attached securely to the shipping saddles.

Shear stops are to be fitted to prevent rotation about the shipping saddle during lifting and unloading.

Shear stops and method of attachment shall be agreed with COMPANY.

Vertical vessels shall be furnished with shipping saddles and tie downs.

Horizontal vessels shall be shipped on their own supports unless unusual nozzle projections create clearance problems.

The design criteria and regulations of the region of transport shall also be followed for delivery of the vessel by road, rail or ship.

8.35. PRESERVATION AND STORAGE

Each vessel and all loose items or spare parts shall be protected to withstand ocean transit and an extended period of storage at the jobsite. Extended period protection shall be 18 months minimum.

All items shall be protected against any adverse environments, such as: humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray, and seawater.

'Asbestos in any form shall not be used as material for any item, including the packaging'. Lifting and tailing lug shall not be used for anchoring during shipping and transit.

All items shall be preserved, and export packed in accordance with ADNOC Specifications.

Refer to ANNEXURE-6 for ADNOC Offshore requirements for Preservation and Storage.

9. ADDITIONAL REQUIREMENTS FOR CRA & INTEGRAL ALLOY CLAD VESSELS

This section is supplementary for Corrosion Resistant Alloys and Integral alloy clad (Roll bonded Clad / Explosion bonded Clad Plates) vessels and where applicable, takes precedence over Technical Requirements for CS/LTCS Vessels Corrosion Resistant Alloy Vessels.

9.1. General

The instructions and requirements presented in this section shall be applicable to pressure vessels constructed of austenitic, ferritic and duplex high alloy steel, nickel and nickel alloys.

Austenitic Stainless Steel grades shall be as specified in mechanical datasheet and meet the requirements of this specification.

9.1.1. Fabrication

Special attention shall be given to cleanliness (freedom from dirt, grease, paint, or other foreign matter) of austenitic stainless steel surfaces during all manufacturing and welding operations. Fabrication shall be carried out in a separate partitioned area (preferably a separate shop) completely segregated from that used for carbon manganese and low alloy steels to avoid contamination. The designated facility will be subject to COMPANY approval.

Equipment used for fabrication and welding shall not have been used on ferrous materials, copper alloys, aluminium or zinc coatings (paint or galvanizing). i.e. plate rollers, grinders, stainless steel wire brushes, etc.

9.1.2. Cleaning and Painting

Only stainless steel brushes, glass beads, aluminium oxide grits or Garnet shall be used for cleaning austenitic, nickel, and high nickel alloy surfaces. Grit shall be free from chlorides and zinc. Copper slag, blast furnace slag, steel grit, steel or iron shot shall not be used.

If blast cleaning is impractical or costly, a proposal to solvent or high-pressure steam clean with an alkaline detergent agent may be submitted. COMPANY/CONTRACTOR pre-approval is required before using this option provided durability of paint scheme on solvent cleaned surface is proven. The procedure shall specify how the vessel will be cleaned after solvent / alkaline detergent is used.

All austenitic, ferritic, and duplex stainless steel shall be painted in accordance with Project Specification for Painting.

Solvents used to clean or remove scale or oil shall be free of organic and inorganic chlorides.

9.1.3. Inspection and Testing

9.1.3.1. Hydrostatic test

Austenitic Stainless Steel Vessels shall be hydrostatically tested with controlled test water to prevent stress cracking. The vessel VENDOR shall provide a chemical analysis certificate of the test water for each vessel:

a. Test water shall contain less than 50 ppm chlorides.

b. Water containing more than 50 ppm chlorides but less than 200 ppm chlorides shall be treated with an inhibitor of 1.5% soda ash and 0.5% sodium nitrate to reduce the chloride content to 15 ppm or less. The chloride content of the soda ash shall not exceed 500 ppm. These percentages are by weight. An inhibitor treatment procedure shall be provided for approval by the CONTRACTOR.

Each vessel shall be drained thoroughly after hydrostatic testing. Hot air drying is not permitted.

Where complete drainage of test water is not possible, flushing with low chloride water such as condensate or demineralized water (up to 2 mg/kg chlorides) is required.

9.1.3.2. Positive Material Identification

Positive Material Identification (PMI) shall be in accordance with ADNOC Specifications.

9.1.3.3. Non Destructive Examination

Non Destructive Examination:

a. For wall thickness 50 mm and below, NDE for acceptance of the welded joints of stainless steel shell and heads of pressure vessels shall be RT.

b. For wall thickness greater than 50 mm, automated UT using shear wave technique, TOFD or phased array may be acceptable in lieu of RT. COMPANY approval is required for the particular technique to be used. ASME Code Case 2235 shall be adopted to prepare the procedure.

c. If a manually guided system using a special probe is preferred by the CONTRACTOR, it shall require COMPANY approval. ASME Code Case 2235 shall be adopted to prepare the procedure. Recorded data shall be automatically transferred to a computer.

d. For weld thickness exceeding 80 mm - Special UT technique (to be approved by the CONTRACTOR and COMPANY) in line with ASME code case 2235 shall be developed by the VENDOR to assess the weld quality including micro-cracks if any at the weld seams during qualification of WPS as well as production welds.

9.1.4. Identification and Marking

Do not use marking inks, crayons, or paints that contain carbon or harmful metals such as zinc, lead, copper or salts which may cause corrosive attack when the vessel part is heated.

a. Marking shall be in English language. Marking shall also be in an additional language if specified on the data sheets or in the CONTRACTOR'S Order Documents.

b. Marking shall be letters at least 150 mm high in contrasting colour paint.

c. The marking on vertical equipment shall be located on two opposite sides near the bottom tangent line and repeated at approximately each 3 m of height, but rotated 90°.

d. The markings on horizontal equipment shall be located on both sides near the horizontal centreline.

Temporary support components required for maintaining equipment roundness or shipping shall be painted yellow and marked:

SHIPPING/FABRICATION DEVICE. REMOVE BEFORE UNIT START UP.

The centre of gravity of the equipment shall be marked in contrasting colour paint.

Other important precautions for handling, transporting, and storing the equipment shall also be stencilled on the equipment. If the equipment has been Post Weld Heat Treated, then it shall be clearly marked with the following notice in 150 mm high letters on both sides of the equipment exterior surface, as loaded for shipment:

POST WELD HEAT TREATED. DO NOT FLAME CUT OR WELD ON THIS EQUIPMENT

If nitrogen purge is used to protect the inside of the equipment for shipment, the VENDOR shall paint the following warning in 150 mm high letters adjacent to each equipment manway:

!!! DANGER !!!

EQUIPMENT FILLED WITH NITROGEN UNDER PRESSURE.

REMOVE of ALL NITROGEN, PRIOR TO ENTRY.

Equipment with non-metallic linings shall have the following notice painted on two sides of the equipment and insulation covering, if present, in 75 mm high letters visible, as loaded for shipment:

LINED EQUIPMENT – DO NOT FLAME CUT OR WELD ON THIS EQUIPMENT

9.1.5. Preparation for Shipment

Vessels shall not be shipped as deck cargo and shall be protected from salt environment.

9.1.6. Pickling and Passivation

High Alloy steel clad or High Alloy Steel Vessels shall be passivated according to ASTM A380.The level of acceptance shall be determined as per ASTM B-117. Stainless steel surfaces which are not coated/painted shall be pickled and passivated after hydrotesting and before commissioning.

Oxidation may be removed by mechanical means. The surface shall be polished with a grinder and a smooth transition to the unpolished base material surface shall be made. The final surface roughness, Ra, shall be less than 12.5 µm.

a. Do not use grinding wheels, sanding materials or wire brushes made of iron, iron oxide, steel, zinc or other materials that may cause contamination of the stainless steel surface.

b. The use of carbide or other non-metallic tooling is recommended.

c. Grinding wheels, sanding wheels and wire brushes that have been previously used on other metals shall not be used on stainless steel.

d. Use only clean, unused abrasive such as glass beads or GARNET or Aluminium oxide for abrasive blasting.

Thorough cleaning prior to any thermal processing is critical. Stress relieving, annealing, drawing or other hot-forming process can actually draw surface contaminants deeper into the substrate, making them impossible to remove during passivation.

Care shall be taken during all thermal process to avoid the formation of oxides.

Passivation is not designed to remove decolouration and will not penetrate heavy oxide layers. In extreme situations, additional pickling and de scaling operations are required prior to passivation to remove the decolouration.

Pickling and passivation shall be carried out in acid solutions, which shall be based upon a mixture of HF/HNO3. The acid concentrations shall be controlled by means of analysis. Details on minimum and maximum concentrations (including contaminating elements such as. Fe2+, Fe3+ and other metal ions), exposure time and temperature shall be included in the pickling procedure. For final rinsing, only fresh water with a chloride ion concentration of less than 200 mg/kg shall be used.

In case of CRA clad with CS backing, adequate precautions must be taken to prevent contact between CS and pickling chemicals or acid. Alternatively, VENDOR shall recommend other suitable methods of pickling, which are subject to COMPANY approval.

After rinsing, the item shall be dried using blowers.

Pickling and passivation using pastes shall only be carried out on the outside of equipment, pipelines, pipes etc. Pastes shall be specifically produced for the purpose of oxidation removal and shall contain no halogens. Any residuals of such pastes shall be removed after cleaning by washing with copious quantities of fresh water.

9.1.7. Preservation and Storage

Any additional requirements, such as protection of internal surfaces, and Preservation and storage shall be in accordance with COMPANY Specification for Preservation of New Materials & Equipment, in addition, to the CONTRACTOR/VENDOR'S requirements.

Each equipment piece and all loose items or spare parts shall be protected to withstand ocean transit and an extended period of storage at the jobsite. Extended period protection shall be 18 months minimum. All items shall be protected against any adverse elements such as: humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray, and seawater.

Stub ends of nozzle connections shall be coated with a suitable preservative and closed with airtight plastic plugs.

Open flange faces shall be greased and covered with bolted-on airtight, gasketed protective plates.

Stud bolts shall be coated with a graphite and white lead paste before fitting.

All SS, Non-Ferrous and Clad Vessels shall be preserved using low pressure nitrogen or other Company approved preservation method.

9.2. CRA Clad or Overlayed Carbon Steel Vessels

Cladding material shall be as specified on the data sheet.

Vessels fabricated from Weld overlay or Clad plate shall use materials in accordance with Para 15 of this specification.

The instructions and requirements presented in this section are applicable to Carbon Steel Pressure Vessels with Integral Alloy Clad (Roll bonded Clad / Explosion bonded Clad) plates or weld overlayed alloy internal lining.

9.2.1. Design

Clad plate or weld overlay shall meet the following requirements:

a. Integrally clad plate or weld overlay shall be of the alloy type specified on PROJECT Vessel Data Sheets/Drawings.

b. Integrally clad plate shall be of the homogeneously clad type as obtained by roll cladding or explosive cladding. The clad plates shall conform to ASME A263, A264, and A265, as applicable.

c. All integrally clad material shall be subject to and pass UT examination in accordance with ASME SA-578, S6, Level I, except that more than 90% loss in back reflection shall be considered as total loss.

d. Minimum required thickness of base materials plus thickness of cladding shall be indicated separately in the mechanical datasheet.

e. The thickness of the material used for cladding or lining shall not be included in the computation of the required wall thickness.

f. Additional corrosion allowance is not to be applied unless otherwise specified on Vessel Data Sheet.

g. A minimum Clad thickness of 3 mm shall be considered for all Integrally Bonded Clad Vessels.

h. The minimum thickness of undiluted weld overlay shall be 2.5 mm.

9.2.2. Connections, Nozzles, and Flanges

The minimum neck thickness for nozzles, manholes, and handholes constructed of alloy clad or overlayed carbon steel shall conform to ASME Code requirements for nozzles, considering the cladding or overlay as corrosion allowance.

Weld Overlay shall be continuous through nozzle bore and shall extend across the full flange face up to the bolting line and flange gasket raised face shall be machined after WOL to achieve required gasket finish. Nozzle Internal Bore surface after WOL shall be smooth, uniform and free from any burrs or imperfections.

Nozzle construction shall conform to one of the types outlined herein. The required type for each vessel shall be specified on PROJECT Vessel Data Sheets/Drawings.

a. Acceptable types of alloy clad or weld overlayed construction shall be in accordance with Project Standard Drawings.

b. Solid alloy nozzles are not permitted unless specifically approved by the CONTRACTOR/COMPANY.

c. Manhole blinds, handhole blinds and other permanent nozzle blinds shall be protected with weld overlay. A plug and fillet welded alloy steel plate is not acceptable.

9.2.3. Clad Plate or Weld Overlayed Vessel Fabrication

Special attention shall be given to cleanliness (freedom from dirt, grease, paint, or other foreign matter) of austenitic alloy surfaces during all manufacturing and welding operations.

9.2.3..1. Weld overlay and Cladding

In case of weld overlay, to control the chemical composition, a two-layer weld overlay in which the first layer is applied with a low heat input shall be used. A single-layer weld overlay can only be used provided the VENDOR demonstrates and provides a procedure to achieve the required chemical composition at required depth for CONTRACTOR and COMPANY approval.

PQR welding of coupons and mechanical, chemical, corrosion testing shall be witnessed as per the approved inspection test plan (ITP). PQR shall be qualified with 50% overlap between weld beads of the weld overlay.

Thickness of the Weld Overlay or cladding and clad restoring shall be as specified in the equipment specific data sheet, or 3 mm (Minimum) with tolerance +2, -0 mm.

Where cladding or overlay is specified, the use of solid alloy is not allowed unless it is specifically agreed by CONTRACTOR/COMPANY.

Filler wires and electrodes intended for Inconel 625 overlay or clad shall not contain more than 1% Iron in the all-weld deposit. Maximum hardness for Inconel 625 shall be 345 (HV10).

Incoloy 825 (UNS N08825) clad material shall be welded (full joint thickness) or repaired using Inconel 625 welding consumables. The chemical composition of Inconel 625 overlay shall fully conform to UNS N06625 alloy specification.

When integrally bonded clad plate is to be welded, the lining shall be stripped back by 10 mm from each side of the weld joint prior to welding the base metal. Complete removal of the cladding / overlay shall be verified by a suitable etching test or chemical analysis of the stripped back surface. The weld in the base metal shall be ground flush, then fully covered with weld overlay.

The undiluted weld overlay thickness shall not be less than 2.5 mm from the final surface.

Cladding thickness specified shall be “finished” cladding thickness.

The weld overlay shall be applied circumferentially to the vessel and shall be relatively smooth with no notches and undercuts that would act as stress intensifiers. Flaws on the surface of the base metal that would interfere with bonding of the overlay shall be removed by grinding.

9.2.3..2. Weld Overlay and Back Cladding

Weld Overlay surface shall be as smooth as possible without grinding.

Weld overlay or back cladding thickness shall be no less than the base cladding thickness and shall have a minimum effective thickness equal to that specified for the base cladding.

Attachments to Weld overlay and Clad surfaces

Attachment welds to the cladding shall be of the same nominal composition as the cladding.

Welding attachments directly on to vessel integral cladding is only permitted when the stress in the attachment, under design loads, is less than 30 N/mm2 and the leg of the attachment welds are 10 mm or less (e.g. tray support rings). Attachments welded to cladding shall be fabricated from solid alloy of same material as the cladding. Prior to making such attachments and following completion of all forming, the entire area within 50mm of the required attachment weld shall be subject to UT examination.

Internals for clad construction shall not be welded directly to cladding unless a satisfactory result on PMI check can be achieved. Alternatively, weld overlay on the heat-affected zone shall be applied to meet the acceptable limits of iron dilution levels mentioned in this specification. Attachments to the cladding may be considered only after consultation with the CONTRACTOR/COMPANY.

Vessel attachments other than those above (e.g. bed supports) shall be welded directly to the base metal. The cladding shall be removed from base material at attachment area, for a minimum distance of three times cladding thickness from toe of the attachment welds. After attachment is completed, the exposed areas shall be replaced with weld overlay to match cladding and UT examined.

Continuous fillet welds shall be used for all internal structures, supports and fittings welded to the vessel shell or head.

Welded internals shall be installed before PWHT.

9.2.4. Removable Internals

Unless otherwise specified, internal flanges shall have heavy hex head bolts and heavy hex nuts of the same type material as the flanges.

Removable and non-removable CRA internal piping shall be 3.2 mm minimum thickness before corrosion allowance is added.

Internal flanges shall be ASME B16.5 Class 150 rating slip-on flanges, or when specified, may be fabricated from plate. Gaskets shall be provided for all flanges.

Internal flange bolting shall be securely tightened and tack welded at bolt head and nut or secured using double lock nuts when specified on the data sheet.

Unless otherwise specified, removable internals shall pass through vessel manhole.

9.2.5. Inspection and Testing

Production testing of the weld overlay shall be carried out at the minimum qualified overlay thickness (min. depth of 2.5 mm from the working surface). The chemical composition of the weld deposit at the minimum qualified overlay thickness shall meet the requirements of the WPS and the UNS alloy designation.

Alloy clad or overlayed vessels shall be hydrostatically tested with controlled test water to prevent the risk of stress corrosion cracking.

Test water shall contain less than 50 ppm chlorides.

Water containing more than 50 ppm chlorides, but less than 200 ppm chlorides shall be treated with an inhibitor of 1.5% soda ash and 0.5% nitrate to reduce the chloride content to 15 ppm or less. The chloride content of the soda ash shall not exceed 500 ppm. These percentages are by weight. An inhibitor treatment procedure shall be provided for approval by the CONTRACTOR.

Each vessel shall be drained thoroughly after hydrostatic testing. Hot air drying is not permitted.

Where complete drainage of test water is not possible, flushing with low chloride water such as condensate or demineralized water (up to 2 mg/kg chlorides) is required.

9.2.6. Non-Destructive Examination

Weld overlay deposits and clad restoration on welds shall be 100% PT examined.

If PWHT is required, this inspection shall be done after PWHT.

Acceptance criteria for NDE examination is after PWHT

Heads formed with clad plates shall be UT tested for soundness of bonding after forming. Any indication which produces a total loss of back reflection and extending for 25 mm or more in any direction shall be considered unacceptable

PT materials used for non-destructive examinations shall be free of organic and inorganic chlorides.

When used on nickel alloys, the liquid penetrant materials shall also be sulfur free.

9.2.7. Destructive Testing

On weld overlaps drill samples shall be taken from the weld surface for chemical analysis. The chemical composition shall comply with specification 2.5 mm below surface. Samples shall be taken at random and especially where local clad restoration has been applied around the nozzles.

9.2.8. Cleaning and Painting

Special attention shall be given to cleanliness (freedom from dirt, grease, paint, or other foreign matter) of austenitic, nickel, and high nickel alloy surfaces during all manufacturing and welding operations.

Only stainless steel brushes, ceramic, or stainless steel grit shall be used for cleaning austenitic stainless steel surfaces. All weld flux shall be completely removed. Sand materials are not permitted for surface preparation and cleaning.

Solvents used to clean or remove scale or oil shall be free of organic or inorganic chlorides.

9.2.9. Identification and Marking

Do not use marking inks, crayons, or paint that contain carbon or harmful metals such as zinc, lead, copper, or salts which may cause corrosive attack when the vessel section is heated.

10. ADDITIONAL SPECIFIC REQUIREMENTS

10.1. Additional Requirements for Low Temperature Services

These requirements are applicable to pressure vessels constructed of steel materials having MDMT of -29 °C and below where choices of material are affected by fracture toughness considerations.

10.1.1. VENDOR shall submit to CONTRACTOR the following engineering data for review:

1. Procedure for Impact Testing, detailing the following:

    a. Type and model of machine used.
    b. Dimensions, orientation and identification of specimens.
    c. Temperature of the specimen.
    d. Number of specimens failing to break.
    e. Date of test.
    f. Heat and lot number of materials tested and relation of specimen identification numbers to material heat number. The energy actually absorbed by each specimen in breaking, reported in total joules.
    g. Lateral expansion of each specimen.
    h. Appearance of fractured surface (percent shear fracture) of each specimen. This data is reported for information only.

10.1.2. Brittle Fracture

To prevent in-service brittle fracture, fabrication, testing and inspection requirements shall be in accordance with ADNOC Specifications. The requirements shall be applied under any of the following conditions:

a. The vessel may attain, due to internal or external influences, a metal temperature of -29°C or below
b. The vessel will not attain a MDMT (Minimum design metal temperature) Colder than -46°C in normal operating case and -105 °C for depressurization case.
c. The vessel is not constructed from rimming steel.
d. The vessel is not constructed from ferritic high strength steel having a specified minimum tensile stress at room temperature which exceeds 425 N/mm2 (with the exception of 5% nickel steel, 9% nickel steel, and bolting).

Other vessels outside these boundaries may have other special requirements and shall be specified on Project Vessel Data Sheets/Drawings.

10.1.3. Stress Concentrations

Design details which will produce local areas of high stress shall not be used, e.g. lugs or gussets. Welded stiffeners, reinforcements and supports must be designed with care, to avoid producing severe stress concentrations. Stiffeners shall not be attached by discontinuous welding. Sharp edges of fillet welds shall be rounded.

10.1.4. Low Temperature Materials

Materials of construction shall be as shown on the Project Vessel Data Sheets/Drawings, except as provided in para 15 of this specification

a. All Low temperature Materials selected shall be impact tested Irrespective of code requirements.
b. Materials for internal supports and clips welded to the shell or heads shall be the same material grade as shell or head. The material shall be subjected to the same restrictions as the critical components to which they are being attached.
c. Attachments which transmit negligible or no loads may be attached to pressure retaining components via intermediate parts which shall be subject to the same restrictions as the pressure parts.
d. The intermediate part shall extend the greater of 2 times its thickness or 50 mm, from the attached part. This rule is not applicable to internal support trays.

10.1.5. Fabrication

When attaching and removing temporary clips, etc., care shall be taken to prevent damage to the surface of the vessel material. After removal of such items, any remaining weld metal protrusions shall be ground flush with the surface, and a crack detection test shall be carried out by MT for ferritic materials or low alloys and PT for stainless steel.

All plates made from ferrite steels which have been hot-formed or which have been cold-formed by dishing, flanging or rolling to an internal radius less than 10 times the plate thickness (no more than 5% deformation) shall be given a normalizing heat treatment.

PWHT for low temperature requirements shall be in accordance with Code.

10.1.6. Inspection and Testing

a. All material used selected for low temperature service shall be impact tested.
b. The pressure test conditions must be included when considering the risk of brittle fracture. Test water and metal minimum temperature shall be as per ASME Code.
c. Charpy V-notch impact tests are required for the weld metal and heat-affected zone (HAZ) if impact tests are applicable for base metal. The test temperature and acceptance criteria shall be the same as for the base metal and shall be in accordance with main specification
d. The selection of impact test specimens, procedure, and general provisions for impact testing shall be in accordance with the ASME Code.
e. Impact test specimens shall be stamped for identification on each end of the specimen.
f. Specimens shall be identified by a number relating to the material identification and by a symbol to indicate orientation: “L” for longitudinal and “T” for transverse.
g. Attachment fillet welds to pressure parts shall be ground smooth, radiused and 100% MT examination carried out.

10.1.7. Fatigue

Cyclic and other dynamic loadings may cause, otherwise non-critical defects to grow and become critical through fatigue. Therefore, any dynamic operation shall be considered during the design.

11. LINED VESSELS AND STORAGE TANKS

11.1. REFRACTORY

The CONTRACTOR shall specify refractory lining on the mechanical datasheet with the following information:

a. The extent of coverage, design density and total weight of the refractory lining.
b. The supports and protection required for internal refractory materials (i.e. anchor type, locations, materials, welding requirements.

11.2. NON METALLIC CORROSION RESISTANT LINING

For vessels where non-metallic internal lining specified all nozzles including flange raised face shall be extended with metallic weld over lay (SS 316L / Alloy 625) to eliminate the non-metallic coating damage at flange faces.

For details of surface preparation, lining application, curing, inspection and testing, see reference specification on Mechanical Data Sheet.

12. STORAGE SPHERES

12.1. INTRODUCTION

This section outlines the minimum additional design requirements for field fabricated non-refrigerated pressure storage spheres. Spheres shall be designed, fabricated, erected, inspected, tested, cleaned, registered and stamped in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Division I or II as specified on Sphere data sheet/drawing.

12.2. HANDLING

Packaging and Shipping

a. Preparation for shipment of materials to the jobsite shall be in accordance with the VENDOR's standards and as noted herein. VENDOR shall be solely responsible for the adequacy of the preparation for shipment provisions with respect to materials and application, and to provide equipment at the destination in ex-works condition when handled by commercial carriers.
b. Adequate protection shall be provided to prevent mechanical damage and atmospheric corrosion in transit and at the jobsite. High humidity, rain, dust, sand, salt air, and salt water are some of the adverse conditions to be allowed for at the jobsite.

Preservation

For preservation of material, ADNOC Specifications shall be followed.

12.3. DESIGN

a. In addition to the general requirements of this specification, the VENDOR is to carry out checks to verify the minimum thickness specified on Sphere Data Sheet and increase where necessary to suit his calculations based on design data.
b. All pressures shown are (g) gauge unless otherwise specified.
c. Design pressure and temperature shall be as shown on Project Sphere data sheets/drawings and to the general requirements of this specification.
d. The corrosion allowance to be used in the design shall be indicated on Project Sphere data sheets/drawings and to the general requirements of this specification.
e. The corrosion allowance provided shall be at least 1.6 mm.
f. VENDOR shall include in his design for minimum nozzle loads as shown in the general requirements of this specification.
g. Separate calculation of extreme fiber elongation shall be made for each segment (excluding spherical crown) using ASME Code formulas based on greatest measured thickness and smallest radius of curvature after forming. Accordingly necessary heat treatment shall be applied by VENDOR subject to CONTRACTOR approval.
h. Sphere support column shall be designed and evaluated using industry acceptable Finite element analysis (FEA) approach to sustain all combined loading/s, including dead weight, design pressure, weight of stored liquid head, wind / seismic loads and attachment loads due to piping reactions to account to evaluate overall stresses in support system and specifically localized stresses at junction of column support to shell junction. Similar to above, FEA shall be performed to evaluate thermal stresses produced during PWHT conditions to account for differential thermal expansion between support columns and shell.

12.4. SUPPORTS

a. Spheres, for capacities exceeding 400 m3, shall have tubular steel leg supports connected to the shell.
b. Supports shall be capable for all load combination including Hydrostatic test load of carrying the vessel full of water. The vessels shall be properly anchored to the foundation.
c. Whenever possible, supports shall be attached to equatorial zones by reinforcing plates to ensure even distribution of loads.

12.5. FIREPROOFING

Skirts and tubular leg supports of vertical vessels and spheres shall be fireproofed up to the shell of the vessel irrespective of its height, as indicated on the Project Sphere data sheets/drawings. A rain deflector installed on top of the fireproofing shall prevent ingress of moisture.

12.6. PREFABRICATION

All connections shall be prefabricated and welded to the shell plates, e.g. manholes, nozzles, supports, column stubs and major structural attachments. These parts shall be post-weld heat-treated as a subassembly. This also applies to vessels that have to be totally post-weld heat-treated at site.

Tolerance shall be in accordance with Specification requirements.

12.7. CONNECTIONS

a. Storage spheres shall have only one bottom process connection, which may be used for filling, discharge and draining. It shall be flush with the inner side of the vessel bottom.
b. All other connections to the vessel shall be positioned above the maximum liquid level.
c. Gussets and lugs welded to the vessel shall have a circular pad plate of material equal to the shell plate concerned.
d. If the entire vessel is to be post-weld heat-treated all gussets and lugs shall be welded before the heat treatment.
e. Nozzle connections shall be provided as indicated on Project Sphere data sheets/drawings and per ADNOC Specifications.

12.8. DESIGN OF FOUNDATIONS

The VENDOR shall submit within two weeks of the order acceptance a loading diagram for the foundation design. This shall include loads on the foundations, dimensions and location of baseplates and holding-down bolts. Loading data and load combinations shall be as indicated in CONTRACTOR instructions.

12.9. MATERIALS

Materials of construction shall be as shown on the Project Sphere data sheets/drawings and per ADNOC Specifications.

Materials for all parts of a pressurized Liquefied Petroleum Gases (LPG) spheres, including those directly welded to that vessel, shall meet the additional requirements of ADNOC Specifications.

12.10. WELDING

a. Spheres shall be welded in accordance with ADNOC Specifications.
b. Spheres shall be designed on the basis that pressure-holding seams shall be full penetration, double-welded butt joints. Single-welded butt joints with or without backing strips are not to be used.
c. The VENDOR shall locate all weld seams so they do not interfere with welded attachments such as nozzles, manways, supports, stiffening rings, insulation supports, etc. Location of all weld seams shall be indicated on VENDOR's sphere drawings.
d. Nozzles welded to sphere shall have full penetration welds through the sphere shell and reinforcing pad.
e. Before proceeding with any repair of plate or forging defects, or heat treatment to reduce hardness, the VENDOR'S proposed procedures shall be submitted for review and acceptance by CONTRACTOR.

12.11. POST WELD HEAT TREATMENT

The VENDOR shall submit detailed specifications for PWHT of field fabricated spheres for CONTRACTOR's approval. PWHT shall be carried out in accordance with the requirements of the ASME Code, and ADNOC Specifications. Further welding on spheres that have received PWHT is not permitted without prior approval from CONTRACTOR/COMPANY.

12.12. STAIRWAYS AND PLATFORMS

a. Stairways and platforms shall be provided in accordance with ADNOC Specifications to allow access to operating valves and instruments. Auxiliary structures to service instruments, connections, and access openings at the bottom of the sphere shall be specified.
b. A stairway with handrails shall be provided from grade to the top of the sphere.
c. Railings and toe plates shall enclose all attachments located on the top of the sphere.
d. Platform flooring and stair treads shall be grating per ADNOC Specifications.

12.13. FIELD CONSTRUCTION

a. During erection, guys or other methods shall be provided to secure incomplete spheres against damage during windy conditions.
b. All necessary protection to be provided around sphere location to ensure safety of job site, equipment and personnel working in vicinity.
c. Suitable protection shall be provided for spheres to ensure coating and painting are not affected by adverse weather.
d. All un-blanked nozzles and openings shall be protected with a blank cover to prevent ingress of foreign matter.
e. Inspection of foundations shall be carried out by VENDOR prior to erection commencing to ensure they are complete and acceptable as fit for purpose.
f. VENDOR shall check and record settlements during hydrotest filling, holding and emptying, at 25, 50, 75 and 100% full and after emptying. Check to be carried out at all support leg locations.
g. Water filling of the sphere should be suspended when the differential settlement of the support legs outside the planar tilt of the foundation is greater than 15 mm and until the settlement ceases for all practical purposes.

12.14. INSPECTION AND TESTING

For General Inspection and Testing requirements as specified in this Specification.

12.15. NON-DESTRUCTIVE TESTING AT WORKS

a. Welds attaching manholes, nozzles and major structural parts shall be fully inspected by the MT method and UT tested. The inspection shall be after the PWHT.
b. Plates over 15-mm thickness shall be 100% UT tested in accordance with ASME Code Section V, article 5 with acceptance criteria in accordance with ASME Code Section VIII Division 1 or 2 (whichever is applicable). .
c. Weld edges of plates shall be 100% UT tested over a width of 50 mm in accordance with ASME Code Section V, article 5 with acceptance criteria in accordance with ASME Code Section VIII Division 1 or 2 (whichever is applicable).

12.16. NON-DESTRUCTIVE TESTING AT SITE

All butt-welded seams in the pressure-containing part of the vessel shall be 100% radiographed (RT).

In addition, all butt-welded seams including nozzle and attachment welds shall be 100% examined by magnetic particle (MT) and ultrasonically (UT) inspected at the following stages:

When no PWHT applies to vessel	If PWHT applies to the vessel
RT + MT*	RT + MT*
↓	↓
Hydro	PWHT
↓	↓
UT	UT + MT*
	↓
	Hydro
	↓
	UT

*MT to be applied to the inside and the outside of the vessel

12.17. HYDROSTATIC PRESSURE TEST

All storage spheres shall be fully hydrostatically pressure tested in accordance with paragraph 8.28 of this specification.

12.18. CLEANING AND PAINTING

Cleaning: Each sphere shall be thoroughly cleaned inside and outside and shall be free from grease, weld spatter, scale, slag, rust, and any other foreign matter.

Painting: The painting shall be in accordance with ADNOC Specifications, unless specifically stated otherwise. Painting shall be carried out after completion and acceptance of hydrostatic test and any NDE that has to be performed after hydrotest.

12.19. SPHERE CALIBRATION (GAUGING)

The VENDOR shall furnish gauging tables in accordance with API 2552 as required by CONTRACTOR's Purchase Order. VENDOR shall submit his procedure for carrying out sphere measurements and calibration. Copies of calibration tables and data, together with records of checks carried out, are to be provided to COMPANY for record purposes.

12.20. IDENTIFICATION AND MARKING

Nameplate shall be located at the minimum elevation possible in a position that is readable from the spiral stairway.

SECTION C

13. QUALITY ASSURANCE / QUALITY CONTROL

13.1. Quality Assurance/Management System

VENDORS's Quality Management Systems shall comply with all the requirements of ISO 9001 "Quality Management Systems – Requirements" and ISO 9004 "Quality management - Quality of an organization - Guidance to achieve sustained success".

To ensure that all work is being performed consistently and accurately and to the requirements of the Project Specifications, CONTRACTOR shall ensure that the VENDOR shall have in effect, at all times, a QA program which clearly establishes the authorities and responsibilities of those responsible for the Quality System. Persons performing Quality functions shall have sufficient and well-defined authority to enforce Quality requirements that they initiate or identify and to recommend and provide solutions for Quality problems and thereafter verify the effectiveness of the corrective action.

Quality System and Quality Control requirements shall be identified and included in the CONTRACTOR's Purchase Documentation. Based on these requirements the VENDOR will develop a QA/QC program which shall be submitted to the CONTRACTOR for review and approval. The VENDOR's QA/QC program shall extend to SUB-CONTRACTORS and SUB-VENDORS.

On request, the VENDOR shall provide objective evidence of QA/QC surveillance for all levels of the VENDOR activity.

COMPANY/ CONTRACTOR reserves the right to inspect materials and workmanship at all stages of manufacture and to witness any or all tests. The VENDOR shall provide the CONTRACTOR with a copy of its manufacturing Inspection and Test Plan and with copies of all related/ referenced procedures for review and approval in accordance with the agreed document schedule.

The Inspection and Test Plan will also be reviewed for inclusion of any mandatory COMPANY/ CONTRACTOR witness or hold points."

13.2. Quality Plan

The CONTRACTOR'S Quality Manual shall provide details for the preparation of a Quality Plan, which shall include provisions for the QA/QC of services activities. The Quality Plan shall be submitted to ADNOC for approval. Moreover, in case of any revision in the Quality Plan due to change in Quality Management System, then the revised QP shall be submitted for ADNOC approval before initiating any service activities.

The level of detail required in the Quality Plan shall be commensurate with the scope of services provided.

During services/activities, Quality Assurance/Quality Control issues are the responsibility of the VENDOR and shall be approved and certified by the Third party Authority (TPA).

All Conflicts among CONTRACTOR, VENDOR & TPA shall be reported in writing to ADNOC for resolution.

13.3. Inspection and Certification Requirements

The ADNOC Specification for Minimum Shop Inspection and Certification Requirements describes the minimum inspection and certification requirements to be performed by CONTRACTOR on the equipment and materials for the ADNOC facilities which shall be subject to inspection, testing and witnessing, at source of supply.

The complete listing of inspection, tests, material certification requirements and parties involved shall be agreed to in the COMPANY approved VENDOR Inspection and Test Plans (ITP) as required by the procurement documents.

These minimum inspection requirements are in addition to any and all code requirements.

Inspection and certification requirements for material shall be in accordance to BS EN 10204 and respective COMPANY specifications in addition to requirements specified in this specification. If Insurance Inspection is specified, all documents are to be certified by the Insurance Authority and are to be countersigned by the Inspecting Engineer.

Records of compliance with the requirements of material specifications shall be submitted by the VENDOR to the COMPANY. Original Certificates of Compliance with complete steel analysis shall be required from the VENDOR and shall include reports or test results as required by the material specification or Purchase Order.

14. CATHODIC PROTECTION

Cathodic Protection for Pressure Vessels, if specified on the datasheet as required, shall be in accordance with Company Specification for Cathodic Protection.

15. MATERIAL SELECTION

15.1. MATERIALS FOR GENERAL SERVICE

15.1.1. General Material Selection Notes

All materials shall be new and unused. The use of reclaimed materials is prohibited.

Only those materials specified on the Vessel Data Sheets/Drawings shall be used for construction, except as provided in substitution paragraph below. Plate material of skirt shall be the same as that of pressure vessel.

Castings shall not be used without specific approval.

Substitution of material shall have the written approval of the CONTRACTOR before being used in construction. A request by the VENDOR for substitution of materials must be accompanied by the ASME designation or complete chemical and mechanical properties including proposed thickness and code cases.

Typical Materials for Major Vessel Components for CS/LTCS/SS material

MATERIAL	LTCS	CARBON STEEL	STAINLESS STEEL
Vessel Component	**(Note 1,2,3,4,11)**	**(Note 1,3,4,11)**	**(Note 1,10)**
Shell / Head	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70	SA 240 TP 316L
Weld Overlay / Cladding / of Shell / Head / Nozzle / Manway etc.	(Note 5,6)	(Note 5,6)	(Note 5,6)
Reinforcing Pads	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70	SA 240 TP 316L
Jacket	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70	SA 240 TP 316L
Nozzle Pipe	SA 333 Gr. 6	SA 106 Gr. B	SA 312 TP 316L
Nozzle Plate	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70	SA 240 TP 316L
Nozzle Forging	SA 350 LF 2 Cl.1 SA 765 Gr.II (Note 7)	SA 105 SA 266 Gr.2 (Note 8)	SA 182 F 316L SA 336 F 316L (Note 9)
Nozzle Flanges, Body Flanges, Blind Flanges (STD ASME Flange)	SA 350 LF2 Cl.1	SA 105	SA 182 F 316L

MATERIAL	LTCS	CARBON STEEL	STAINLESS STEEL
Vessel Component	**(Note 1,2,3,4,11)**	**(Note 1,3,4,11)**	**(Note 1,10)**
Nozzle Flanges, Body Flanges, Blind Flanges (Non Standard-ASME)	SA 765 Gr.II	SA 266 Gr.2	SA 336 F 316L
Welding Pipe Fittings	SA 420 WPL6	SA 234-WPB	SA 403 WP 316L
External Welded Attachment - Reinforcing Rings, Insulation Support, Platform Cleat etc.	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70	SA 240 TP 316L
Welded Internal Parts – Tray Support Rings, Downcomer Supports, Cleats, Baffles etc.	Un-Clad Vessel – SA 516 Gr. 60/65/70 Clad Vessel – Same as Cladding or weld overlaid or solid CRA	Un-Clad Vessel – SA 516 Gr. 60/65/70 Clad Vessel – Same as Cladding or weld overlaid or solid CRA	SA 240 TP 316L
Removable Internals	Un-Clad Vessel – (Note 4) Clad Vessel – Same as Cladding	Un-Clad Vessel – (Note 4) Clad Vessel – Same as Cladding	SA 240 TP 316L
Internal Piping, Flanges, Fittings, Bolts, Nuts	Clad Vessel – Same as Cladding	Clad Vessel – Same as Cladding	SA 240 TP 316L
Stud Bolts External	SA 320 Gr. L7 (Note 11)	SA 193 Gr. B7 (Note 11)	SA 193 Gr. B8M Cl. 2
Nuts External	SA 194 Gr. 7 (Note 11)	SA 194 Gr. 2H (Note 11)	SA 194 Gr. 8M
Gaskets External	Per ADNOC Pipe Material Spec	Per ADNOC Pipe Material Spec	Per ADNOC Pipe Material Spec
Demister Supports	(Note 6)	(Note 6)	(Note 6)

MATERIAL	LTCS	CARBON STEEL	STAINLESS STEEL
Vessel Component	**(Note 1,2,3,4,11)**	**(Note 1,3,4,11)**	**(Note 1,10)**
Skirt	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70 SA 285 Gr C and SA 283 Gr C	SA 240 TP 316L / SA 516 Gr. 60/65/70 (Note 10)
Skirt Base Ring, Bolt Chairs	SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 15)	SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 15)	SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 10,15)
Saddle Wrapper Plate	SA 516 Gr. 60/65/70	SA 516 Gr. 60/65/70	SA 240 TP 316L
Saddle Web, Ribs	SA 283 Gr. C SA 285 Gr. C	SA 283 Gr. C SA 285 Gr. C	SA 240 TP 316L SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 15)
Saddle Base Plate	SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 15)	SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 15)	SA 240 TP 316L SA 283 Gr. C SA 285 Gr. C SA 516 Gr.60/65/70 (Note 15)
Support legs / base plates	SA 36 SA 283 Gr. C	SA 36 SA 283 Gr. C	SA 240 TP 316L
Anchor Bolts - LT (Note 14)	SA 320 L7	SA 36	SA 320 L7
Anchor Bolts – Normal Temp (Note 14)	SA 36	SA 36	SA 36

Material Table Notes:

1. Carbon or carbon manganese steels shall not be used if the design temperature exceeds 425°C (800°F). Above 400°C (750°F) such steels shall be fully killed. For vessels having a design temperature exceeding 425°C (800°F), materials shall be 1 Cr ½ Mo or higher alloy steel.

2. For Low Temperature Carbon steel, Charpy impact requirements shall meet the requirements of this specification.

3. For equipment, which requires PWHT, simulated coupon from raw material shall be subjected to one extra cycle of PWHT for future modification/repair by the COMPANY. Required heat treatment for plate, heads, PWHT for the equipment, repair by the VENDOR shall be considered extra. These simulated coupons shall be tested and shall retain the material strength and its properties after all Simulated PWHT cycles. Combining of PWHT cycles are not permitted. Coupons shall be taken from plate from with highest carbon equivalent.

4. For equipment in Sour Service, HIC testing of carbon steel material and welds metals Charpy impact requirements shall meet the requirement of ADNOC Specifications. Specific OPCO requirements for Sour service shall be complied with as specified in Annexures.

5. Deleted

6. Material of Cladding/Weld Overlay on vessel internal and material of removable internals shall be as indicated in MSD (Material selection Diagram).

7. Deleted

8. Deleted

9. Deleted

10. Material of top of skirt welded to head shall be same material as that of shell for a minimum height as per Cl.8.5.2 of this specification.

11. Grade M bolts and nuts to be used in sour service (e.g. SA 320 Gr. L7M, SA 193 Gr. B7M, SA 194 Gr. 7M, SA 194 Gr. 2HM)

12. SS 316,316L and 321 are acceptable grade and ferrite control (2-8%) are required for welded items.

13. Refer Company Standard Drawing for Anchor bolts details. Use of High Strength Anchor bolts is not recommended and shall be subject to COMPANY Approval.

14. Vessel supports constructed of SA-283-C materials should be limited to a maximum thickness of 15mm and a minimum temperature of 0°C.

15.1.2. Carbon Steel Materials – CS/LTCS

The selection of Carbon Steel (CS)/ Low Temperature Carbon Steel (LTCS) shall be as follows:

Carbon content of carbon and carbon-manganese steels shall not exceed 0.23%, except for forgings, where this may be relaxed to 0.25%. Carbon equivalents shall not exceed:

Ceq = % C + % Mn/6 ≤ 0.42 % if material standard specifies C and Mn only

Ceq = % C + % Mn/6 + (% Cr + % Mo + % V)/5 + (% Cu + % Ni)/15 ≤ 0.43 % for all other steels

All carbon steel pressure parts (Plates, Pipes, Flanges, Fittings, etc) in low temperature service (MDMT is -29 °C and below) shall be supplied in normalized condition.

1. For Minimum Design Metal temperature (MDMT) of -29 °C and above CS material shall be used meeting ASME Code requirements in respect of impact testing based on steel grade and thickness. All CS plate material shall be normalized.

2. For MDMT of -46 °C and below -29 °C LTCS material shall be used. All material shall be normalized and impact tested at MDMT per code.

3. For MDMT < -46 °C up to -105 °C Impact tested LTCS material can be used provided all below criteria are met:

   a. MDMT is governed by depressurization temperature.
   b. It is in accordance with ASME Code.
   c. Primary membrane stresses due to corresponding pressure at depressurization temperature of -46 °C, do not exceed allowable membrane stress values of ASME Code for Coincident ratio requirement.
   d. All material shall be impact tested at -46 °C with minimum impact values per code
   e. When it can be positively ensured by proper operating procedure and instrumented protective system (IPS) that re-pressurization is prevented until vessel wall temperature reaches -46 °C. Detail procedure and IPS for the same shall be submitted to COMPANY for review/approval before the use of material.

4. For MDMT < -46 °C. If MDMT is governed by continuous operating temperature Stainless Steel materials shall be used.

15.2. CORROSION RESISTANT ALLOY (CRA) MATERIAL

The classification "austenitic, ferritic and duplex high alloy steel, nickel and nickel alloys" applies to materials designated by the following ASME Code P, Numbers for welding: P-8, P10H, P10I, P41, P42, P43, P44 & P45. Only those materials specified on the PROJECT Vessel Data Sheets/Drawings shall be used for construction.

The selection of Corrosion Resistant Alloy (CRA) covering additional requirements for stainless steels (304L, 316L, 321, 347, 347H, 254 SMO, etc.), and Nickel Alloy 825. shall be as follows:

15.2.1. Skirts for Vertical Vessels in CRA Material

The top section of skirts shall be fabricated from the same material as the section of vessel shell to which it is attached for a minimum distance as per Cl.8.5.2 of this specification.

15.2.2. Dual Grade

When SS 316L material is indicated, use of dual grade stainless steel material SA 240 SS316L/316 material with allowable stress value of SS 316 is acceptable

15.2.3. Additional Requirements for Austenitic Stainless Steel

This section covers additional requirements for stainless steels (304L, 316L, 321, 347, 347H and 254 SMO):

1. Higher allowable stress values, as specified in Table 1A of ASME Code Section II Part D, may be used for design of shell and heads, but the lower allowable stresses specified shall be used for flanges and other components subject to distortion.

2. As microstructure segregation at the plate edges is an area of concern for thicker austenitic stainless steel plates. Shell wall thickness shall be restricted to 80 mm. In case of thickness exceeds 80mm during detailed engineering phase; the plates shall be proven that segregation does not exist. In any case, if there was segregated section found, the edges shall be trimmed to remove the segregated section.

3. Seamless stainless steel pipe shall be in accordance with SA312 and stainless steel plate shall be in accordance with SA240 with the following supplementary requirements. These requirements shall be applied to each heat lot of the material:

    a. Grain size shall be determined in accordance with ASTM E112 and shall be 5 or finer for material under 38-mm thickness. For material, 38-50-mm thick, grain size 3½ or finer is required and for material over 50-mm thick, grain size 2½ is required. Grain size shall be determined after all fabrication and all heat treatment.

    b. After forming or drawing, all 304L, 316L, 321, 347 and 347H components shall be solution annealed at a temperature as per ASME Code, then cooled by water quenching. The VENDOR'S procedures for intermediate and final heat treatment(s) and repair welding are required prior to manufacturing. Heat treatments used to produce large grains is not to be performed on this material purchase. Any distortion during solution annealing treatment shall be the responsibility of the VENDOR.

    c. All 300 series stainless steel materials to be used in applications with operating temperatures above 425°C shall be given a stabilization heat treatment at 900°C to 950°C after solution heat treatments.

    d. All UNS S31254 (254 SMO) shall be solution heat treated temperature as per ASME and immediately water quenched or rapidly cooled.

4. Forged flanges shall be in accordance with SA182 with the supplementary requirements:

    a. S2, Heat Treatment Details
    b. S3. Material for Optimum Resistance to Stress-Corrosion Cracking
    c. S5. Special Filler Metal
    d. S8, Heat Treatment of Austenitic Forgings

5. Micro structural requirements for Standard Duplex & Super duplex stainless steel:

    a. The microstructure shall be examined and classified for detrimental phases in accordance with ASTM A923 Method A.
    b. The volume fraction ferrite content shall be determined in accordance with ASTM E562

15.2.4. CRA Clad or Overlayed Carbon Steel Material

CRA Clad (Roll bonded Clad / Explosion Bonded Clad Plates) or Weld Overlayed Carbon Steel Plate material shall meet the following requirements:

1. Integrally clad plate or weld overlay shall be of the alloy type specified on PROJECT Vessel Data Sheets/Drawings.

2. Weld overlaid /clad/ lined plate material shall be suitable for service conditions and NACE MR0175/ISO 15156-3 or NACE MR 0103 compliant.

3. Integrally clad plate shall be of the homogeneously clad type as obtained by roll cladding or explosive cladding. The clad plates shall conform to ASME A263, A264, or A265, as applicable, irrespective of the design calculation method used. Integrally clad material shall pass a minimum bond shear test as per Code.

4. All integrally clad material shall be subject to and pass UT examination in accordance with ASME SA-578, S6, Level I, except that more than 90% loss in back reflection shall be considered as total loss.

5. Materials for welded internals in clad vessels shall be of same material as base metal with required thickness of cladding or weld overlay applied, or from solid metal of same material as cladding.

6. When internal lining is specified, only over lay-welding or integrally bonded cladding shall be used for all pressure part/wetted part materials inclusive of nozzles. Strip lining or loose lining shall not be used. Loose lining or Strip Cladding is not acceptable.

15.2.5. Alloy 825 Material

Material Requirements:

1. Plate shall be in accordance with SB424 UNS N08825.

2. Seamless fittings shall be in accordance with ASTM B423 UNS N08825.

3. All material shall have a minimum PREN of 31. The formula for determining the PREN shall be:
   PREN = wt% Cr + 3.3 x wt% Mo + 30 x wt% N

4. All material except previously heat treated, rolled and welded plate, shall receive a finishing heat treatment at a temperature as per Code for approximately one hour 25 mm of thickness. Cooling after heat treatment shall be forced air or water quench. Materials with thickness exceeding 32 mm must be water quenched only.

5. Materials, less than 19 mm thick which have not been manufactured with a minimum PREN of 31 may still be used if it passes intergranular corrosion test per ASTM A262 Practice C. For acceptance, corrosion rate shall be 0.25 mm per month or 3 mm maximum (120 mpy) applied to the average of the five readings required by the test procedure.

6. Weld filler metal shall have PREN value higher than base metal being welded by at least a value of 10 to retain the corrosion resistance. Procedures shall be submitted to the COMPANY for approval and authorization.

7. Filler metal is required to be used in all weld passes made in all materials. Procedures for thin sheet gauge weldments shall be reviewed for authorization based on application.

8. Fittings for pipe manufactured from machined and drilled rods or round bar stock shall not be used if over 3” diameter initially.

15.3. MATERIAL TEST REPORTS (MTRS)

Certified Material Test Reports (CMTR’s) are required. MTR’s shall include the following additional information:

1. Grain Size.

2. Corrosion test results as specified in this supplement.

3. Heat treatment and cooling method as a minimum for acceptance as required by this supplement.

4. Modified MTR’s must be accompanied by written explanation for any change. Each MTR must be signed by the Manager of Quality Assurance and dated. The addition of “missing” information to comply with the current requirements of this specification is not permitted.

5. Simulated PWHT Test record and resulting material properties

15.4. VESSEL SHELL THICKNESS 50MM OR GREATER

All pressure retaining parts fabricated from plate or custom forged materials only that are 50 mm thickness or over, shall meet the following requirements:

1. All carbon plate steels for pressure parts shall be fully killed, vacuum degassed or better (e.g., electroslag re-melted) and examined in accordance with SA 435 on a 229 mm (9”) square grid .

2. The carbon content of all plates shall be 0.23% maximum and for forgings it shall be limited to 0.25% maximum.

3. Hot-formed carbon steel pressure parts shall be normalized after hot forming. Hot forming at normalizing temperatures shall not be considered as normalizing. Hot forming of carbon or low alloy steel is acceptable only if allowed to cool below 250°C after forming then subsequently normalized or quenched or tempered as necessary.

4. All cut edges of pressure containing base materials shall be MT examined by ASME, Section VIII, Division 2, paragraph AF 112.1. Discontinuities disclosed by this examination shall be repaired and re-examined as required to AF 112.1.1, before welding.

5. MT and PT examinations, when required shall be performed in accordance with written procedures.

15.5. BOLTING

1. Bolting material SA 193-B7 and SA 194-2H shall be restricted to design temperatures up to and including 450°C. For design temperatures above 450°C and up to 525°C, SA 193-B16 and SA 194-4 shall be used.

2. Low alloy steel bolting SA 193-B7 and SA 194-2H or SA 193-B16 and SA 194-4 used to connect stainless steel flanges shall be limited to the operating temperature of 400°C. For flanges operating above 400°C, SA 453 shall be used, when stainless steel bolting SA 193-B7 and SA 194-8 cannot provide required torque loads.

3. Bolt material for sour service shall be SA 193 - B7M and SA 194 - 2HM. If added strength and corrosion resistance are required studs shall be SA 453 grade 660.

4. Bolt material for design temperatures below -29°C bolts shall be SA-320 Grade L7 with SA-194 Grade 7 nuts.

5. Material of Internal Bolting shall same as that of material for removable internals.

16. CRITICAL SERVICE REQUIREMENTS

ADNOC Specification for Critical Service including sour services shall be complied for equipment in applicable service. Following additional requirements shall be followed if not specified in the other ADNOC specifications.

16.1. SOUR, WET H2S AND HYDROGEN SERVICE

For Sour, Wet H2S & Hydrocarbon service requirements for ADNOC Offshore, please refer to ANNEXURE-6

16.1.1. Specific Definitions:

H2S content: H2S content of the water means the sum of the dissolved (molecular) H2S, bisulfide ion (HS-1) and sulfide ion(s-2) concentrations in the water phase, that result from the presence of H2S in the process stream.

Cyanide Content: Cyanide content of water means the concentration of free cyanide [CN Free], expressed in ppmw, in the sour water that results from the presence of HCN and CN- in the process stream. [CN Free] is the sum of dissolved (molecular) HCN and cyanide ion (CN-) concentrations in water phase.

Carbonate Content: The carbonate ion (CO3-2) concentration used to determine the susceptibility to carbonate cracking means the actual carbonate ion concentration in the water phase.

16.1.2. Technical Definitions

SEVERE SERVICE — Any of the following process environments:

a. Wet H2S (as defined in this Section)
b. Sour Service (as defined in this Section)
c. Amine Services any concentration
d. Caustic Services with any concentration
e. Ammonium Bi Sulfide NH4HS with concentration > 2 wt%

Note that this definition applies to carbon steels and not to other metallic materials.

SOUR SERVICE — Fluid(s) containing water as a liquid and hydrogen sulfide exceeding the limits given in NACE MR0103, Paragraphs 1.3.5.1 / ISO 17945 Paragraph 6.3.5

All systems with 10 mole % or more of H2S shall be regarded as SOUR SERVICE. In process streams where the H2S content varies, peak values shall be used unless approved otherwise by COMPANY. Note that this definition applies to all metallic materials and is not limited to carbon steels.

WET H2S — Free water containing equal to or greater than 50 ppmw dissolved hydrogen sulphide. Note that this definition applies to all metallic materials.

16.1.3. Process Severity Categories:

Carbon steel susceptibility to each different cracking mechanism is determined by the process environment (like presence of water, [H2S], [CNFree], [CO3-2], amine, and caustic.) and material properties (Chemistry, mechanical properties and thermal history). The most probable cracking mechanism for carbon steel in severe service is listed down below:

a. Sulfide Stress Cracking [SSC]
b. Hydrogen Blistering, Hydrogen Induced Cracking [HIC]/ Stress Oriented Hydrogen Induced Cracking [SOHIC]
c. Alkaline Carbonate Stress Corrosion Cracking [ACSCC]
d. Amine Stress Corrosion Cracking. [ASCC]
e. Caustic Stress Corrosion Cracking [CSCC]

Process Severity category:

a. One of three categories shall be defined for each mechanism for the purposes of setting the material and fabrication requirements. These categories are:

    i. Low Severity Service [LSS]
    ii. Moderate Severity Service [MSS]
    iii. High Severity service [HSS]

b. All severe service [as defined in Technical definition] process environment shall be assessed the severity of the process environment as applicable to the type of damage mechanism being considered. When using these tables, the primary environment being considered is the environment present during normal operations.

c. Transient conditions (start-up, shutdown, pre-sulfiding, process upsets, etc.) shall also be considered because some damage mechanisms can occur rapidly, while others result from accumulated damage over numerous transient periods during equipment service life.

d. If transient conditions increase the environmental severity category, then the potential for rapid or cumulative damage such transients shall be considered for material specification.

e. Potential mechanisms are not exclusive, i.e., if there is more than one mechanism active, the materials and PWHT requirements shall be combined to address the severity of more than one environment.

f. In high pH streams containing 50ppmw or more H2S and carbonate ions, an assessment of the process severity for carbonate cracking shall be conducted.

The environmental severity for SSC shall be assessed in accordance with **Table. 1a.**

Table 1a SSC Severity Categories					
pH of Water	**Cyanide Content [mg/kg (ppmw)]**	**H2S content of water [mg/kg (ppnw)]**			
		< 50	**50 to 1000**	**1000 to 10,000**	**>10,000**
< 4.0	*	Moderate	High	High	High
4.0 to 5.4	*	Low	Moderate	High	High
5.5 to 7.5	*	Low		Moderate	Moderate
7.6 to 7.9	≤ 20	Low	Moderate	High	High
7.6 to 7.9	≥ 20	Moderate	High	High	High
≥ 8.0	< 20	Low	Moderate	High	High
≥ 8.0	≥ 20	Moderate	High	High	High
*The level of Cyanide has no significance at pH 7.5 and below					

The environmental severity for HIC/SOHIC shall be assessed in accordance with **Table. 1b**.

Table 1b HIC/SOHIC Severity Categories					
pH of Water	**Cyanide Content [mg/kg (ppmw)]**	**H2S content of water [mg/kg (ppnw)]**			
		< 50	**50 to 1000**	**1000 to 10,000**	**>10,000**
7.6 to 7.9	< 20	Low	Moderate	Moderate	Moderate
7.6 to 7.9	≤ 20	Moderate	Moderate	High	High
≥ 8.0	< 20	Low	Moderate	High	High
≥ 8.0	≥ 20	Low	High	High	High
*The level of Cyanide has no significance at pH 7.5 and below					

The environmental severity for ACSCC shall be assessed in accordance with **Table. 1.c**

Table 1.c. Carbonate Cracking Severity Categories		
pH of Water	**CO3-2 content of water**	
	10 to 100	**> 1000**
≥ 7.5 to 8.0	Low	Moderate
≥ 8.0 to 9.0	Low	High
≥ 9.0	High	High

The environmental severity for all amine and caustic service for any concentration shall be categorized as high.

The following severe services are not covered within the scope of the remainder of this document but shall meet the indicated special requirements:

a. Hydrofluoric Acid Service - The special requirements will be included in the purchase documents to be approved by the COMPANY.
b. Thinning mechanism due to Ammonium Bisulfide - Special requirements will be included in the purchase documents to be approved by the COMPANY.
c. Deaerators - Special requirements will be included in the purchase documents to be approved by the COMPANY.
d. Pressure Swing Absorbers (PSA) - Special requirements will be included in the purchase documents to be approved by the COMPANY.

16.1.4. Materials

1. For unclad carbon steel vessels, material shall be in the normalised condition unless approval is given for the steel to be supplied quenched and tempered (Q+T) or made by thermomechanical controlled process (TMCP). In addition:

    a. The specified minimum tensile strength of carbon and C Mn steels shall not exceed 585 MPa (85 000 psi).

    b. Vessels shall be stress relieved.

    c. As a minimum, Z quality plate, see A.6.1, shall be used for carbon steel. Under conditions of severe hydrogen charging (e.g. sour water containing cyanides), as specified by the CONTRACTOR, the plate shall be to A.6.2 to include testing to confirm resistance to HIC.

        If a SOHIC (stress orientated hydrogen induced cracking) or soft zone cracking (SZC) test is specified in addition to the HIC test, unless otherwise agreed with the CONTRACTOR, a NACE Standard Tensile Test shall be carried out to TM0177 using Method A and Test Solution A. The material shall pass this test and un-failed test samples, shall be evaluated for acceptance by one of two methods:

        i. At least two metallographic sections shall be taken parallel to the sample axis. There shall be no ladder-like cracks > 0,5 mm in length in the through-thickness direction, or

        ii. The remaining tensile strength (after hydrogen degassing at 150°C (302°F)) shall be ≥ 80% of the original actual tensile strength of the material.

    d. For refinery applications, hardness of carbon steal HAZ, as measured in the weld procedure test, shall not exceed 248 Hv10 (Brinell 237 HBW) as per NACE RP0472. Acceptable hardness values for other materials shall be as given in NACE MR0103.

2. Unless specified otherwise in other project specifications, a minimum of EN 10204 3.1 certification is required for all welding consumables. All such certification shall be original or red stamped verified copies by CONTRACTOR approved inspectors.

3. Chemical composition and carbon equivalent requirements shall be based on product analysis of the material.

4. All materials shall be made in a basic oxygen or electric arc furnace and shall be killed.

5. All materials, except castings and materials in amine service that do not meet the wet H2S or sour service definitions, shall be supplied in the normalized or normalized and tempered condition. Normalizing shall be carried out as a separate heat treatment. The acceptability of hot finished material shall be subject to COMPANY approval.

6. Where ASME materials (SA) are specified, the equivalent ASTM material specifications are acceptable when appropriate.

16.1.5. Plate Material

1. Plate shall comply with SA-516, and supplementary requirements defined herein.

2. All plates shall have tensile strength of less than 550Mpa (80,000psi).

3. Carbon content shall be 0.2% maximum.

4. The carbon equivalent (CE) shall be 0.41 maximum. The following formula shall be used to calculate the CE:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Cu + \%Ni}{15}$$

5. SA-20 Supplementary Requirements S19 and S21 shall apply with the following limits on analysis:

Boron (B)	0.0008% max
Copper (Cu)	0.35 % max (Note 1)
Nickel (Ni)	0.25 % max (Note 1)
Chromium (Cr)	0.25 % max (Note 1)
Molybdenum (Mo)	0.08 % max (Note 1)
Vanadium (V)	0.02 % max (Notes 1, 2)
Columbium (Cb)	0.02% max (Notes 1, 2)
Sulphur (S)	0.008% max
Phosphorus (P)	0.01% max

(Note 1) The sum of these elements shall not exceed 0.7%.
(Note 2) The sum of these elements shall not exceed 0.03%.

6. Analysis shall be based on product analysis. Any such work shall be done before material is purchased

7. The VENDOR shall purchase material with simulated PWHT in accordance SA-20 Supplementary Requirement S3.

8. All plates shall meet ASTM A770-S3 with a minimum area reduction of 35 percent.

9. Plates produced from coils are not permitted.

16.2. HYDROGEN SERVICE

1. Materials used in this service shall be annealed, normalized or normalized and tempered. Quenched and tempered or cold worked steels shall not be used. When hydrogen partial pressure is higher than 7 Kg/cm2 at any temperature then material selection shall satisfy Nelson Chart. Max. Carbon content shall not exceed 0.22% and max. Carbo equivalent (long formula) shall be limited to 0.45%. HIC resistant materials shall be used unless otherwise accepted by COMPANY/CONTRACTOR.

2. Threaded connections shall not be used.

3. Carbon steel and low alloy castings (P numbers 1, 3, 4, and 5 materials) shall be 100% MT and RT examined. Examination and acceptance criteria shall be as follows:

   a. MT in accordance with ASME VIII Div 1, Appendix 7, except Type IV and V indications shall be based on the results of RT examination.

   b. RT in accordance with ASME VIII Div 1, Appendix 7, except that casting less than 25 mm thick need only meet the acceptance criteria of castings 25 mm to 50 mm thick. RT quality level shall be 2-2T.

4. All pressure retaining plates and heads shall be 100% scanned by UT examination to ASME SA 435 supplementary requirement S1. All areas of total loss of back reflection shall be excavated, weld repaired, and re-inspected.

5. All internal welded attachments shall be through thickness welded plus fillet. All external welded attachments such as clips, if not through thickness welded, shall have a 12 mm gap in the continuous fillet weld at a low point to vent any migratory hydrogen.

6. All welds in materials P1, P3, P4, P5, P10A, P10C, P11A and P11B shall be PWHT.

16.3. WET HYDROGEN SULPHIDE SERVICE

1. If H2S is present at high temperature without hydrogen, the following shall be used: solid 5 Cr ½ Mo; solid 9 Cr 1 Mo; 12 Cr clad steel (Type 405 or 410S); or an ASS clad steel.

2. Si-killed C Mn steel may be used at lower temperatures, where corrosion rates are lower.

3. If the concentration of H2S is greater than 0,02 mol % and the design temperature is above 260°C (500°F), stabilised ASS (austenitic stainless steel) (Type 321 or 347) shall be used.

4. Heads and shell plates shall be UT examined as per ASME, Section V, Article 23, SA 435, with the following additional requirements:

5. Scan continuously along parallel paths transverse to the major axis on nominal 100 mm centres.

6. Scan an additional path within 50 mm of plate edges, including nozzle cut out edges after weld bevel preparation, but prior to welding.

7. Where welding is involved, hardness testing using a machine in compliance with paragraph 8.27 shall be performed on base metal, weld metal and HAZ. The hardness shall be checked for each welding process, filler metal and technique used, for one test of circumferential weld, one test of longitudinal weld and one test of nozzle attachment. Hardness values shall not exceed those specified in the specification. Test shall be inside and outside.

8. All vessel category weld joints A, B and D shall be full penetration welds. After completion of all welding, carbon and low alloy steel pressure vessels shall be PWHT.

9. Stud bolts when insulated or covered and exposed to H2S, including trace quantities, shall not be used if the yield strength exceeds 627 MPa (91,000 psi) or the hardness exceeds 237 BHN. Then bolting used shall be SA 193 B7M and SA 194 2Hm. External pressure bolting, when not insulated or otherwise covered, shall be SA 193 B7 and SA 194 2H.

10. Materials subject to manufacturing processes resulting in permanent fibre deformation greater than 5% shall be PWHT.

11. All vessel components designed for this service shall be subject to notch toughness requirements.

12. Other than austenitic stainless steel, all welds shall be PWHT. The exemption granted by the Code is not permitted.

13. All materials subject to this specification shall meet the requirements as per NACE Standard MR 01-75, latest edition, as a minimum requirement. Max. Carbon content shall not exceed 0.23% and max. Carbon equivalent (long formula) shall be limited to 0.42%. HIC resistant materials shall be used unless otherwise accepted by COMPANY/CONTRACTOR.

14. Copper and copper alloys shall not be used.

15. When the material is non-magnetic or the geometry does not allow for MT examination, PT examination shall be used.

16.4. CAUSTIC, POTASSIUM CARBONATE AND AMINE SERVICES

All welded carbon and low alloy steel pressure vessels and components shall be PWHT in accordance with paragraphs UW 40, 49 and UCS 56 of ASME VIII Div 1. Exemptions provided by Tables UCS 56 are not permitted. Minimum holding time at the full PWHT temperature shall be 30 minutes. For MDEA service Licensor does not require PWHT as the medium is uncritical. Therefore for CO_2 Removal equipment in the BASF MDEA process PWHT shall not be considered.

16.5. WELDING REQUIREMENTS

1. The following supplementary specifications apply in Critical Services:

2. Longitudinal and circumferential butt welds shall receive full volumetric NDE after any PWHT.

3. All welds, including external and internal non-pressure containing welds, shall be subject to 100% surface inspection by MP or DP after any PWHT.

4. After PWHT, weldments shall be subject to blasting of surface to SSPC SP 5/NACE No. 1 and tested by WFMT.

5. Full penetration welds shall be provided on pressure boundary parts to internal attachments such as downcomer bolting bars and segments, bed support beam seats, or any load-carrying attachments that have the long axis parallel to the longitudinal axis of the vessel. This requirement for full penetration welds does not extend to tray support rings or other circumferentially oriented attachments.

16.6. PRODUCTION TEST PLATES

1. Production test pieces for welds shall be provided under the following provisions:

   a. Any pressure vessels subjected to PWHT
   b. Pressure vessels in low temperature services (MDMT less than -29°C)
   c. Welding of Production control test plates shall be required for P1 materials whenever impact testing is required for the shell and dish materials

2. Fabrication coupons include two test pieces using the same welding procedures as those used for the assembly of the main seams of the vessel and the same materials (basic metal and filler metals), at the same time. There must be one set of two fabrication coupons for each WPS used either on circular or longitudinal welds. The thicknesses of the test pieces must match the thickness of the thickest wall, not including any reinforcements. These test pieces must furthermore undergo the same heat treatments as the vessel itself, in the same furnace and at the same time.

3. Laboratory testing for production test pieces are identical to the required tests done for relevant PQR qualification including; mechanical tests, chemical, corrosion etc (as applicable), all tests shall be witnessed by COMPANY. Tests results must satisfy the same criteria; in addition, all results must be certified by ASME AI and CONTRACTOR representative, and to be reported to COMPANY.

16.7. POST WELD HEAT TREATMENT REQUIREMENTS

1. PWHT shall be performed when required by the ASME Code, Design General Specifications and/or the Vessel Data Sheets/Drawings.

2. PWHT when specified shall be carried out in accordance with a CONTRACTOR approved procedure that meets the requirements of the ASME Code and Design

3. Group COMPANY Specifications Welding and NDT for Pressure Vessel and Heat Exchanger and/or Material for Sour Service, Materials and Fabrication Requirements for Carbon Steel Piping and Equipment in Severe Services and Group COMPANY ANNEXURE as applicable shall be complied for vessels containing caustic, amine or chlorine solutions.

4. Welding on vessels that have been PWHT is not permitted without prior approval from the CONTRACTOR/COMPANY.

5. When PWHT is required, the entire vessel shall be heat treated in an enclosed furnace. When heat treating the entire vessel in an enclosed furnace is not feasible, the procedure and requirement shall be approved by the CONTRACTOR/COMPANY.

6. When PWHT is required in the field, the procedure and requirement shall be subject to review by the CONTRACTOR/COMPANY.

7. Welding on a pressure part is not permitted after PWHT. This note shall be on the Vessel Fabrication Drawings, and CONTRACTOR Vessel Drawings/Datasheets.

8. All acceptance NDE shall be carried out after PWHT

9. Flange faces and other machined or threaded surfaces shall be adequately protected against oxidation during heat treatment.

10. Vessels and components shall be inspected for cleanliness prior to heat treatment. Oil and grease shall be removed completely.

11. PWHT and stress relieving procedures shall be submitted for review.

12. Cr-Mo Steel shall be post weld heat treated in all thicknesses unless otherwise specified.

13. No welding or thermal cutting is permitted on stress relieved vessels after completion of final PWHT. Add this note on vessel fabrication drawings, and CONTRACTOR drawings and/or Data Sheets. The vessel shall be clearly marked "POSTWELD HEAT TREATED. DO NOT BURN, WELD OR HAMMER."

17. LETHAL SERVICE REQUIREMENTS

17.1. DEFINITION

Lethal service definition shall be as per Process Design Criteria requirement and as specified in the process datasheet.

Lethal Service Additional Requirements

Pressure vessels in lethal service as identified in the Mechanical Datasheets shall comply with the following additional requirements:

1. Name plate for Division 1 & 2 vessels shall include an item called “service” which should be filled up as “lethal”.

2. If the vessel is under “lethal” service, it shall be specified on the User’s Design Specification (for Division 2 items) with “Professional Engineer” signature included in Data Reports.

3. Plates used for fabricating pressure retaining components shall be UT examined irrespective of thickness. Forgings above 50 mm thickness for Division 1 & 2 vessel shall be UT examined.

4. Reinforcement pad for nozzle opening is not permitted. All nozzles shall be integrally reinforced.

5. Lap joint flanges and Slip on flanges are not allowed.

6. Rigidity Index (J) of 0.85 shall be used in the design of non-standard flange.

7. All Category A, B, C joints shall be of butt welded Type No 1 of Table UW-12 and fully (100%) radiographed after PWHT for Division 1 and 2 vessels. The nozzle to shell or head weld joint (Category D) shall be 100% UT tested.

8. For carbon steel and low alloy steels, PWHT shall be specified for Division 1 and Division 2 vessels irrespective of thickness.

9. All pressure retaining seams shall be sufficient distance from external and internal appurtenances to allow full accessibility in order to monitor their integrity by NDE in the field.

18. MANUFACTURING DATA REPORTS & VENDOR DATA REQUIREMENTS

18.1. GENERAL

This Specification describes requirements for the compilation and submittal of a Manufacturing Data Report & VENDOR Data Requirements / VENDOR Responsibilities for each pressure vessel built in accordance with the ASME Code Sec. VIII, Division 1 OR Division 2.

The Manufacturing Data Report(s) shall be provided by the vessel VENDOR.

This specification gives minimum requirements for the compilation of a manufacturing data report and VENDOR Data Requirements for each pressure vessel.

18.2. MDR Submittal Requirements

As part of the as-built documentation deliverables, the following approved documents shall be submitted to the COMPANY in the electronic format (two sets of CD-ROM's) in addition to the hard copies:

a. Manufacturing procedure specification for the shell & dish plate materials and procedures for HIC and SSC testing (where applicable) by the plate mill Inspection & Test Plans (ITP) for the shell & dish plate materials by the plate mill Inspection & Test Plans (ITP) for the manufacture of pressure vessels.

b. Welding procedures (WPS's & PQR's) with an index showing the application of each WPS Procedures for PWHT, non-destructive testing, hardness testing, pressure testing, results of production coupon tests, where applicable.

c. VENDOR Manufacturer's Data Reports (MDR's) and Manufacturer's Certificate of Compliance duly completed (scanned image is acceptable).

The Manufacturing Data Report for each vessel shall be compiled in accordance with the following requirements and the applicable Codes. Documents that are common to more than one pressure vessel shall be duplicated in each package.

The CONTRACTOR'S Purchase Order Number, Vessel Tag Number and Vessel Service shall be shown on each page of the Data Report.

All documents shall be in legible, reproducible form, A-4 size paper or folded to A-4 size paper.

The number of Manufacturing Data Reports supplied shall be specified in the Material Requisition and Purchase Order.

All documents shall be written in English.

The contents of the Manufacturing Data Report shall reflect in detail the fabrication history of the pressure vessel(s). It shall provide all information necessary to demonstrate that quality procedures have been followed and all applicable Codes, Standards and Specifications have been adhered to.

As fabrication of the vessel(s) progresses, the VENDOR shall compile the Manufacturing Data Report with the original manufacturing documents and shall keep it up-to-date. It shall be presented to the CONTRACTOR or his nominee upon request.

The Manufacturing Data Report, after sign-off by the VENDOR'S inspector, shall be submitted to the CONTRACTOR. The original and the required number of copies shall be forwarded to the CONTRACTOR in accordance with the terms and conditions of the Purchase Order. If the order is subject to inspection by the CONTRACTOR, the release for the acceptance of the vessel(s) shall only be issued when the Manufacturing Data Report, including the required number of copies, is presented to the CONTRACTOR. Final acceptance of the Manufacturing Data Report by CONTRACTOR is subject to inclusion of all required final documents and his relevant comments. Final acceptance of documents, other than those required to travel with goods, shall not delay shipment of equipment.

18.2.1. Manufacturing Report Documents

The Manufacturing Report shall be provided in loose-leaf form with numbered pages. The VENDOR shall supply document and manuals as per project requirements. The following documents shall be provided as a minimum:

18.2.1..1. Cover Sheet

Each report shall have a cover sheet indicating the following:

1. Name of the Project/Plant and Unit
2. VENDOR's Name and Address
3. CONTRACTOR'S Purchase Order Number
4. Vessel Tag Number, Service and Unit Number
5. Year of Manufacture

18.2.1..2. Table of Contents

The table of contents shall contain the following:

1. Name and Address of the VENDOR
2. CONTRACTOR'S Complete Purchase Order Number
3. Vessel Tag Number, Service and Unit Number
4. VENDOR'S Shop Order Number
5. Name and address of the Approved Inspection Organization
6. Name and Signature of the VENDOR'S Inspector
7. List of sections and description of associated Attachments

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18.2.1..3. Attachments

a. Each page of attachments, for example, (certificates, repair reports, sketches, deviations and concessions), etc., shall be attached immediately behind the relevant section sheets and shall be clearly marked with:

   i. Name of Project/Plant and Unit

ii. CONTRACTOR'S Purchase Order Number
iii. Vessel Number, Service and Unit Number
iv. Relevant Section Letter and Page Number

b. Certificates for a part of a vessel shall show the name of the relevant part, its Purchase Order Number and item numbers, for example, (shell, channel, head, nozzle A-2, tubes, flanges, bolts, internals), etc.

If material mill certificates are applicable only to certain parts of the vessel, the applicable items shall be marked with an arrow and numbered on a marked copy of the original certificate. A cross-reference of this certificate number shall be included in as built drawings, alongside appropriate parts.

All documents incorporated are to contain signatures of the applicable review/approval authorities.

c. Copy of inspection release note.

d. ASME Requirements:

i. Manufacturer's Data Report or Manufacturer's Partial Data Report as applicable in accordance with the ASME Code, Section VIII.
ii. Manufacturer's Certificate of Compliance on Form U-3 covering any vessel stamped with the UM symbol in accordance with the ASME Code Section VIII, Division 1.
iii. Certified Manufacturer's Design report for each vessel in accordance with the ASME Code Section VIII, Division 2.

e. Certificate of conformance-design. The certificate of conformance (design) shall be issued for review and accepted by:

i. The CONTRACTOR for Division 1 vessels prior to the start of fabrication.
ii. The registered Professional Engineer and the CONTRACTOR and COMPANY for Division 2 vessels prior to the start of fabrication.

f. Certificate of conformance-fabrication and testing. The certificate of conformance (fabrication and testing) shall be issued for review and accepted by the CONTRACTOR or its Third Party inspection Authority (TPA) and the COMPANY prior to release for shipment.

g. List of authorized deviations and/or concessions. Evidence of authorized approvals shall be attached to this list, for example, (copy of letter or fax).

h. Material Records - The following requirements for material identification and traceability shall be provided on the VENDOR Primary Material Record:

i. Provide an outline sketch of the pressure vessel showing the location of pressure components for which the ASME Code Section VIII requires traceability to a Material Test Report or Certificate of Compliance as provided for in the ASME Material Specification in Section II of the ASME Code. As a minimum, this sketch shall include shell rings, heads and conical reducing sections fabricated of plate. Nozzle reinforcing pads and rolled plate

nozzle neck locations do not have to be shown on the outline sketch; however, these components must be included in the tabulated Primary Material Record.

ii. Complete the tabulated Primary Material Record on components noted in paragraph above. Also include any non-pressure component (for example, support, skirt, wear plate, or internal or external attachment) that is required to conform to the material specification of a shell ring, head, or conical section to which it is attached.

iii. Provide a Material Test Report or certificate of Compliance for every item included in the tabulated Primary Material Record. Material Test Reports shall include, but shall not be limited to, the results of a chemical analysis, results of mechanical testing to establish the material's physical properties, heat treatments performed, repairs performed, and NDE (Non-Destructive Examination) performed. Reports or certificates shall be the originals. Where photocopies are issued, these shall be authenticated and attested true copies. True copies are defined as copies of the original certificates which have been over-stamped and countersigned by an inspector approved by the CONTRACTOR, an independent third-party representative, such as a recognized certifying authority or when specifically agreed by COMPANY, an independent QC department representative of the VENDOR.

iv. NOTE: If seamless shell sections, heads or other pressure boundary parts of carbon steel have been cold formed by other than the Pressure Vessel VENDOR and used in the fabrication of vessels certified in accordance with the ASME Code Section VIII, Division I, the required certification for the part shall also indicate whether the requirements of UCS-79(d) have been satisfied.

v. The materials of construction used for miscellaneous components of the pressure vessel that are not listed in the Primary Material Record shall be tabulated and signed by a representative of the Pressure Vessel VENDOR'S quality control department; this representative's authority and responsibility shall be clearly defined in the VENDOR'S Quality Control System. This representative shall be a person who performs quality control functions and has sufficient and well-defined responsibility, authority, and the organizational freedom to identify quality control problems and to initiate, recommend, and provide solutions.

vi. PMI reports per ADNOC Specification

i. Welding Procedures and Procedure Qualification Records. Weld map to be included.

j. List of welders and welder approval test record.

k. Radiography certificates (not films). Radiography map to be included.

l. Other NDE reports. NDE map to be included.

m. Dimensional checks:

i. Thickness measurements - all pressure components.
ii. Nozzle orientation and location check.
iii. Circularity/straightness/misalignment.

n. Report on repairs (locations to be shown on as-built drawings, report to include additional NDE and re-heat treatment if applicable).

o. Heat treatment certificate and charts.

p. Hydrostatic test certificate and chart. Hydrostatic test certificate shall include water analysis and details of the chemical treatment (if any).

q. Painting and coating system:

i. Painting/coating systems details.
ii. Surface preparation.
iii. The conditions of humidity during application of various layers.
iv. Satisfactory adhesion/cohesion has been demonstrated by means of testing samples.

r. “Rubbing” or photocopy of the ASME Code stamped nameplate attached to the vessel. Photography may be also acceptable.

s. As-built general assembly drawing (certified and signed).

t. Inspection & Test Plan specific for each item with signatures of applicable inspection authorities at designated inspection points.

u. Design Calculations

Calculation notes with design stress values stated for all parts of equipment. Calculation notes shall be certified by a third party inspection. A certificate is acceptable.

v. Procedures:

i. Manufacturing/Fabrication Procedure
ii. NDE Procedures
iii. Heat Treatment Procedures (Including PWHT)
iv. Hardness Test Procedure
v. Impact Test Procedure
vi. Positive Material Identification (PMI) Procedure
vii. Hydrostatic / Pneumatic Test Procedures
viii. Surface Preparation, Painting & Coating Schedule
ix. Packing and Transportation procedure
x. Rigging Procedure and Plan
xi. Inspection and Test Procedures

18.3. VENDOR Data Requirements

The VENDOR shall comply with the Documentation requirements specified in the Purchase order documentation, this Specification and its referenced documents and the following paragraphs.

All documents shall be in reproducible form. The quality shall be acceptable for microfilming and/or electronic scanning without loss of clarity. All documents shall be signed as checked prior to submittal. Unchecked data will not be accepted for review. VENDOR shall not proceed with fabrication until authorized by CONTRACTOR.

VENDOR'S drawings, calculations, and engineering data shall be in the English language and in metric units.

The VENDOR shall submit to the CONTRACTOR the following engineering data for review:

1. Drawings:

   All drawings required for the complete fabrication of a pressure vessel including those of other VENDORS of component parts. The drawings shall be complete and shall include as a minimum the following information:

   a. Item number and Purchase Order number.
   b. National Board number.
   c. External design pressure and temperature.
   d. Internal design pressure and temperature.
   e. Minimum design metal temperature.
   f. MAWP (maximum allowable working pressure) based on the nominal thickness, in the corroded condition at maximum temperature and limiting part.
   g. Weld joint efficiencies.
   h. Corrosion allowances and cladding thickness.
   i. Shop hydrostatic test pressure and test water temperature.
   j. Field hydrostatic test pressure in the corroded condition.
   k. Basis for hydrostatic test pressure and limiting part.
   l. Identification of welds using standard welding symbols.
   m. Requirements for radiographic examination.
   n. Requirements for PWHT.
   o. Fabrication, inspection, and all non-destructive examination requirements for each component part.
   p. Thickness of all components.
   q. Material specifications for all components.
   r. Estimated weight of vessel, shipping, empty, operating and full of water.
   s. Cleaning, surface preparation, painting, and marking requirements.
   t. Pertinent dimensions, including location of weld seams, nozzle location and projection, location of vessel supports, insulation supports, and other information necessary for a complete description of the vessel.
   u. All external clip attachment details and locations.
   v. Tray supports, downcomer bolting bars, baffles and other internals.
   w. All nozzles numbered and/or lettered as indicated on vessel data sheets/drawings.
   x. Transport/shipping saddles, location and details.
   y. Vessel lifting lugs and locations.
   z. Center of gravity.
   aa. Criticality rating.
   bb. Foundation / Support loading for all load cases at each support location.

2. Calculations:

    a. All design calculations according to the ASME Code
    b. Support, Nozzle Stress Analysis, Wind Analysis, Seismic Analysis, Hydrotest calculation, lifting condition calculation, Transportation calculation, Fatigue Analysis (as required).

3. All inspection and testing records.

4. Weld MAP, Welding procedures and PQR's.

5. Manufacturing Data Report in accordance with section 12.2 of this specification.

6. Electronic files of all certified detail, fabrication and erection drawings.

7. Procedures for:

    a. Fabrication
    b. Non-Destructive Examination
    c. Heat Treatment
    d. Forming
    e. Insulation and Fireproofing
    f. Lifting & Transportation
    g. Pickling & Passivation (if applicable)
    h. PMI
    i. Painting and surface preparation
    j. Preservation and export packing
    k. Hydrotest

18.4. VENDOR'S DATA REPORT:

1. The Vendor shall submit to the contractor in a labelled folder the following documents, Marked with the Purchaser's Order number and Plant Item Number.

2. These documents shall be forwarded not later than 14 days after acceptance of the equipment. Vendors Data Report shall be complete with the following documents (latest revisions approved by Company):

3. The certificate of conformance (design) shall be issued, reviewed and accepted by Company prior to commencement of manufacture.

4. The certificate of conformance (manufacture assembly and testing) shall be issued for review and acceptance by Company or nominee prior to release for shipment. This shall include:

    a. Company Project Title and Number.
    b. Purchaser's Purchase Order Number
    c. Plant Equipment Item Number
    d. Vendor's Equipment Number (if any)
    e. Name of Vessel
    f. Plant
    g. Date of Acceptance

5. All deviations and concessions shall be listed and described. Evidence of authorized approvals shall be attached to this sheet, e.g. copy of telex or letter.

6. All construction materials shall be listed. This shall include as a minimum:

   a. Shell and Head Materials
   b. Nozzle and Flange Materials

7. Reports of all repairs and related heat treatments including thermographs for all post-weld heat treatment cycles. Locations of repairs shall be shown on the as-built drawings. The results of additional NDE shall be reported.

8. In case of re-heat treatment due to repair, The re-heat treatment details shall also be enclosed.

9. Hydrostatic test report.

10. A drawing showing all dimensions indicating the actual deviations and acceptable tolerance specified in this specification

11. Record of the painting/coating systems details, both specified and actual. Provision is made to verify:

    a. That surface preparation is to a referenced code/standard.
    b. The conditions of humidity during various layer applications.
    c. That continuity of painting/coating, the method used and results, have been checked.
    d. That satisfactory adhesion/cohesion has been demonstrated by means of test samples.

12. A copy of the final release note.

13. Heat treatment report including thermographs of post-weld heat treatment

14. As-built drawing. It shall be certified and signed by the Vendor.

15. A copy of the Vendor's accepted Quality Control plan to be incorporated.

16. Certified material record report, including chemical analysis, mechanical properties, heat and charge numbers for all pressure part materials.

17. Results of production control weld test plate.

18. Welding procedures and results of welding procedure qualification tests.

19. Inspection and test plan duly signed and certified by all parties concerned.

20. Copies of all Welders or Operator qualification certificates.

21. Radiographic interpretation report together with sketch showing location of films.

22. Ultrasonic test report indicating technique used, also testing location, extent and type of defects found.

23. Dye-penetrant examination report.

24. Hardness test results, if any.

25. A sketch showing actual readings as measured for out-of-roundness, straightness and length.

26. Pressure Test Certificate (including air test on compensating rings).

27. Pickling and passivation report and Positive Material Identification Report (PMI) where these are applicable.

28. In addition to the reporting required by NACE TM0284 the following information shall be provided for HIC testing:

    a. Location and dimensions of specimens
    b. Full chemical analysis of material tested including analysis for micro-alloying elements
    c. Mechanical properties of materials tested after a simulated PWHT cycle.
    d. Results of cracking evaluation indicating individual CLR, CTR and CSR for each section and also averaged over 3 sections, and pass/fail
    e. Photomicrographs of the specimens showing cracking and/or blistering, together with photomicrographs of adjacent material structures and photomicrographs of the bulk material structure (samples) used to assess microstructure banding: - Unetched (showing the type of inclusions in the steel), Etched (showing the parent material microstructure) and assessment of microstructure banding according to ASTM E 1268.

29. Fire protection documentation as per applicable Company Specification

18.5. VENDOR Records

The VENDOR shall retain complete engineering records for each vessel for at least ten (10) years. The VENDOR shall notify the COMPANY at least 60 days before destroying any original copies of records, data and drawings.

18.6. Documentation

The VENDOR shall submit the type and quantity of drawings and documentation for CONTRACTOR'S approval or information as listed in the individual Material Requisitions and Purchase Orders.

Mutual agreement on scheduled submittal of drawings and engineering data shall be an integral part of any formal Purchase Order.

Comments made by the CONTRACTOR on drawing submittals shall not relieve the VENDOR of any responsibility in meeting the requirements of the specifications. Such comments shall not be

construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is reached and confirmed in writing.

Each drawing shall be provided with a title block in the bottom right-hand corner incorporating the following information:

a. Official trade name of the company manufacturing the Vessel.
b. VENDOR'S name and drawing number.
c. Drawing title giving the description of contents whereby the drawing can be identified.
d. A symbol or letter indicating the latest issue or revision.
e. Purchase Order number and item tag numbers.
f. Designation and signature of originator, checker and approver Company drawing/ document number

Revisions to each drawing shall be identified with symbols adjacent to the alterations, a brief description in tabular form of each revision shall be given, and if applicable, the authority and date of the revision shall be listed. The term "Latest Revision" shall not be used.

18.7. Sub-Contractors / Sub-VENDORs

The VENDOR shall give warranty and guarantees for the workmanship, materials and mechanical design of the pressure vessel. When specified, the guarantees shall also include process / hydraulic / thermal design and performance.

The VENDOR shall transmit all relevant Purchase Order documents including specifications to his SUB-VENDORS and SUB-CONTRACTORS.

It is the VENDOR'S responsibility to enforce all Purchase Order and Specification requirements on his SUB-VENDORS and SUB-CONTRACTORS.

The VENDOR shall submit all relevant SUB-VENDOR and SUB-CONTRACTOR drawings and engineering data to the CONTRACTOR.

The VENDOR shall obtain and transmit all SUB-VENDOR and SUB-CONTRACTOR warranties to the CONTRACTOR / COMPANY, in addition to the system warranty.

The VENDOR shall at all times be responsible for review and correction of SUB-VENDOR’s drawing and documents prior to submittal to COMPANY / CONTRACTOR for approval.

18.8. Definition of Responsibilities

18.8.1. COMPANY/CONTRACTOR Responsibilities

COMPANY/CONTRACTOR main responsibilities include but are not limited to the following:

a. Providing process & mechanical data sheets with operating/design conditions, materials, performance requirements, etc. Process and hydraulic design shall be included as required.
b. Finalizing the nozzle orientation and drawing as soon as possible after placement of the order.

18.8.2. VENDOR'S Responsibilities

The VENDOR shall assume mechanical responsibility and overall guarantee for the pressure vessel(s) and associated equipment. The VENDOR shall transmit all relevant Purchase Order documents including specifications to his Sub-VENDORs and Sub-Contractors. It is the VENDOR'S responsibility to enforce all Purchase Order and Specification requirements on his SUB-VENDORS and Sub-Contractors. The VENDOR shall submit all relevant SUB-VENDOR and Sub-Contractor drawings and engineering data to the CONTRACTOR. THE VENDOR shall obtain and transmit all SUB-VENDOR and Sub-Contractor warranties to the CONTRACTOR/COMPANY, in addition to the system warranty.

The VENDOR'S main responsibilities include but are not limited to the following:

1. The mechanical design (including process and hydraulic design if specified in the Contract), provision of materials, fabrication, inspection, testing, code stamping and quality of workmanship of vessels which shall be provided in conformance to this specification and the following:

    a. Comply with all applicable HSE regulations and local jurisdictional requirements.
    b. Vessel Design Code.
    c. Other codes and standards referenced in this Specification.
    d. Additional requirements listed on the data sheets.

2. The VENDOR shall provide vessel design, component and material that has been installed and operated satisfactorily in previous services similar to the conditions specified on data sheets.

3. Pressure Vessels shall be ASME stamped, "U" or "U2" certified and registered with the National Board.

4. The Code stamp certificate shall be provided in the Manufacturer's Data Book. VENDOR shall be responsible for obtaining all the necessary certification from an Insurance authority or other appropriate authority including ASME stamping and "U" or "U2" certification covering the design, fabrication, inspection and pressure testing of vessels, and shall also perform the tasks defined in the Fabrication Code and related documents.

5. The following does not relieve the VENDOR of their responsibility to supply and conform to the requirements of this specification and other purchase order documents or to supply vessels suited to meet the specified service conditions and/or local codes governing Health and Safety:

    a. Design of vessel, furnished by Company or Company's review of VENDOR documentation
    b. Compliance by the VENDOR with this specification and other purchase order documents.
    c. Release for shipment by Company inspector

6. COMPANY shall be allowed shop access, including workshop of Sub-VENDORs, for inspecting materials and activities during vessel fabrication for conformance to this specification. Also, VENDOR shall furnish the Inspecting Engineer(s) with all reasonable facilities to satisfy themselves that the equipment is manufactured and tested in accordance with the Fabrication Code and this specification. VENDOR shall afford the Inspecting Engineer(s) the opportunity to carry out or witness all or some of the quality control checks listed below. The details shall be

mutually agreed between the COMPANY/CONTRACTOR'S Inspecting Engineer(s) and the VENDOR prior to the commencement of fabrication. (e.g.: Inspection and test plan)

a. Identification and stamping of all test plates.
b. Welding procedure and operator qualification work.
c. Identification of materials against Mill Test Certificates, including welding consumables.
d. Examination of rolled and welded shells.
e. Visual and dimensional check of the dished ends (knuckle and crown radii, thickness, outside diameter, ovality and straight flange).
f. Welding examination (joints profile, alignment, root pass, intermediate passes and final).
g. Examination of radiographic films.
h. UT examination.
i. PT examination.
j. Hardness testing.
k. Positive material identification for alloys except Carbon steel.
l. Mechanical tests on weld test coupon plate.
m. Review of heat treatment charts.
n. Internal and external examination of vessels.
o. Pressure or leak tests.
p. Final dimensional check (straightness, diametrical difference, length, nozzle orientation/elevations/ projection/squareness and all internals).
q. Examination after shot blasting or cleaning.
r. Examination after painting and preparation for dispatch.
s. Verification of Code and Identification plate details.
t. Review and signature of VENDOR's Fabrication Dossiers.

7. VENDOR shall convey in writing to the Inspecting Engineer and the certifying authority all defects, discrepancies and alterations prior to rectification.

8. Work or materials not conforming shall be cause for rejection. The rejected material or items shall be clearly marked as rejected items and to be segregated in a specific designated area.

9. Any approvals given by the Inspecting Engineer, the insurance authority, the State Authority or any other body acting on behalf of the Company or the Company do not relieve the VENDOR of any responsibility regarding guarantees, workmanship or compliance with the Fabrication Code and this specification.

10. Data sheets, calculations, drawings, quality control records and other items which assist in determining the acceptability of vessel for inspection shall be made available for Company review. All related approved concessions to be attached and provided along with engineering and other VENDOR’S deliverables.

11. The VENDOR shall be responsible for assuring that subcontracted fabrication work is in conformance to this specification and purchase order documents. Sub-VENDOR shall be selected from the Company latest approved list of Manufacturers/VENDORs/service providers. However, no portion of vessel construction, such as plate forming, welding, heat treatment, non-destructive examination, painting, etc. shall be sub-contracted without prior written agreement from Company.

12. While all efforts have been made to make this specification complete & unambiguous, it shall be VENDOR'S responsibility to ask for missing information, ensure completeness of specification, to bring out any contradictory/ conflicting requirement in different sections of the specification and within a section itself to the notice of the Company and to seek any clarification on specification requirement. In absence of any such clarifications, in case of any contradictory requirement, the more stringent requirement as per interpretation of Company shall prevail and shall be complied by the VENDOR without any implication to the Company.

13. In this specification, language indicating that the Company accepts, agrees, reviews, or approves a VENDOR's design, work process, manufacturing action, etc., shall not limit or relieve the VENDOR's responsibility to conform to applicable industry design and safety standards and codes, project specifications and drawings and professional workmanship.

14. VENDOR shall submit a complete material specification with the proposal as per code.

15. Unless otherwise specified in the PO, VENDOR shall furnish all labour, tools, equipment, supplies, materials, utilities, storage and personnel services necessary for and reasonably incidental to, the delivery of materials to the site, the construction of the vessel, inspection and testing and the removal of surplus and scrap materials from the job site. VENDOR shall dispose of the water for hydro-testing from the vessel to the tie-in points as permitted by Company.

16. For equipment such as heat exchangers, air coolers, filters, coalescers and vessels with internals, where VENDOR must also meet process requirements, VENDOR shall provide a process guarantee.

18.8.3. VENDOR'S Scope of Services

The following is the VENDOR'S Scope of Services as a minimum:

1. Process and hydraulic design as required.
2. Mechanical design and engineering.
3. Complete design of vessel (including anchor bolts), attachments and supports.
4. Fabrication, assembly and welding.
5. PWHT as required by Code/Specifications/Datasheets.
6. Inspection of vessel.
7. Non-destructive testing.
8. Hydrostatic testing and drying of vessel after hydrotest.
9. Material inspection, testing and certification.
10. PMI.
11. Code stamping and national board registration.
12. Surface preparation and external painting.
13. Pickling and passivation.
14. Packing, marking and protection for transportation and site storage.
15. Documentation in accordance with these requirements specified in this document.
16. Mechanical Guarantees for design, material and workmanship.
17. Process and hydraulic guarantees for performance.

18.8.4. VENDOR'S Scope of Supply

For ADNOC Offshore requirements, see ANNEXURE-6

The following is the VENDOR'S Scope of supply as a minimum:

1. All vessels shall be furnished complete as shown on data sheets/drawings, or as required by the Purchase Order and as herein noted and shall supply of all materials.
2. Complete vessel along with covers, all nozzles, nozzles reinforcement, nozzle flanges, blind flanges, vessel supports and appurtenances in accordance with the data sheets.
3. Clips for ladders, platforms, pipe supports and guides.
4. Sockets and guides for davits.
5. Lifting devices for erection.
6. Insulation supports and welding studs or blank nuts for fireproofing.
7. Earthing lugs and other special brackets as detailed.
8. Special tools required for testing, installation, commissioning and maintenance.
9. Warning plate with respect to PWHT of the vessel.
10. Jackscrews, eyebolts, locking studs, as required for installation/dismantling.
11. VENDOR's and Code Stamp name plates and nameplate brackets.
12. Temporary blinds, gaskets and bolting for testing.
13. Temporary covers, gaskets and bolting for shipment.
14. Shipping/transportation supports.
15. Spares for start-up and commissioning.
16. List of recommended spares for 2 years maintenance and operation*

* VENDOR shall quote for the spare parts separately. Spare parts shall be designed and manufactured as Original part.

18.8.5. The VENDOR shall provide the following minimum Commissioning Spares for each vessel. For ADNOC Offshore, the quantity of Spares shall be as per ANNEXURE-6. :

1. 10% of bolting or minimum of 2 sets of each type
2. 200% gaskets, including gasket for manholes, hand holes and other flanged nozzles where a blind/companion flange is used. The above gaskets shall be suitably packaged to prevent damage in transit, clearly marked with the Purchase Order number and item number and shipped with the vessel. The gasket used for the hydrostatic test shall be identical to the service gasket and shall remain in place for shipment.

18.8.6. The VENDOR shall provide all internals as specified on data sheet. These shall include supports for trays, demister and packing, vortex breaker, distributors and baffles. Tray supports shall comply with specification, Vessel Trays and Internals - General.

18.8.7. After acceptance of his support design calculations, the VENDOR shall provide a base plate template for vertical vessel anchor bolts. Template to be 10 mm minimum thick and shipped to site to suit construction schedule. Upper surface of template shall be marked with reference north, equipment number, Project Title and, where supplied in multiple pieces, match marks. For templates provided in multiple pieces, clips to be provided for joining in field. Where the construction schedule requires the template to be shipped before fabrication of the vessel is complete, then base plate and template may be fabricated together. Alternatively, a duplicate spare template may be fabricated and retained in works for later fabrication of base plate.

18.8.8. Spare Parts and Special Tools

VENDOR shall prepare/propose spares list (Spare Parts Interchangeability Record) for COMPANY review and approval in line with ADNOC Specification for Spare Parts and Maintenance Data .

Spares list shall include as minimum:

1. One set of Gaskets for blind flanges, girth flanges, Manways and special cover flanges,
2. 10% of bolting (minimum 5 pieces of bolts and nuts) required for blind connections, manways, special flanges and Internals,
3. One complete set of Gaskets for Internals Parts/connections,
4. One set of Filter/Coalescer elements, if applicable,
5. When required, one set of gaskets or tapes for trays, shall be supplied by the tray vendor

A List of special tools shall be submitted by VENDOR for Company review. VENDOR shall supply the listed special tools and tackles required for the equipment for operation and/or maintenance. These are the tools which are not freely available in the market or non-standard tools or the tools developed by the VENDOR.

Hydraulic bolt tensioning device requirement shall be checked by VENDOR and if required by COMPANY, it shall be supplied by VENDOR.

If a design calls for a non-standard flange, the companion flange and its fasteners including any spares shall be in the VENDOR'S scope of supply.

18.8.9. General

VENDOR shall submit the type and quantity of drawings and documentation for CONTRACTOR'S authorization or information as listed in the individual Material Requisitions and Purchase Orders.

Mutual agreement on scheduled submittal of drawings and engineering data shall be an integral part of any formal Purchase Order.

Comments made by CONTRACTOR on drawing submittal shall not relieve VENDOR or SUB-VENDORS of any responsibility in meeting the requirements of the specifications. Such comments shall not be construed as permission to deviate from requirements of the Purchase Order unless specific and mutual agreement is reached and confirmed in writing.

Each drawing shall be provided with a block in the bottom right-hand corner incorporating the following information:

1. Official trade name of the VENDOR.
2. VENDOR'S drawing number.
3. Drawing title giving the description of contents whereby the drawing can be identified.
4. A symbol or letter indicating the latest issue or revision.
5. PO number and item tag numbers.

Revisions to drawing shall be identified with symbols adjacent to the alterations, a brief description in tabular form of each revision shall be given, and if applicable, the authority and date of the revision shall be listed. The term "Latest Revision" shall not be used.

SECTION D

Standard Drawing:

Applicable Standard Drawings indicated in group COMPANY ANNEXURE shall be followed

SECTION E

ANNEXURE 1 - ADNOC GAS PROCESSING ADDITIONAL REFERENCES AND REQUIREMENTS

The following reference documents, form a part of this specification and are additional requirements to be followed for all Static Equipment to be procured/installed in ADNOC Gas Processing facilities. Latest Revision as time of contract shall be followed. CONTRACTOR shall advise COMPANY of any changes to Reference Documents after the EFFECTIVE DATE. CONTRACTOR shall comply with COMPANY instruction to comply with any changed Referenced Documents. CONTRACTOR shall advise of conflict among any Reference Documents and any technical specification, and COMPANY will determine which shall govern.

Specifications

DGS 0000-001	Positive Material Identification Of Equipment And Piping
DGS 0000-002	Material for sour environment
DGS 0000-003	Minimum Shop Inspection and Certification Requirements
DGS 0000-004	Criticality Rating System
DGS 0570-001	Vessel Trays and Internals
DGS 6300-003	Welding and NDE of Pressure Vessels and Heat Exchangers
DGS 6600-010	Painting
DGS 6710-001	Preservation and Export Packing
DGS 6500-010	Hot Insulation for Piping and Equipment
DGS 6500-020	Cold Insulation for Piping and Equipment
DGS 6531-010	Fireproofing
DGS 6600-020	Internal Lining
DGS 0710-001	Air Cooled Heat Exchanger Amendments And Supplements To API Std. 661
DGS 0710-002	Air Cooled Heat Exchanger - Design Criteria
DGS 0660-001	Plate And Frame Heat Exchangers

Standard Drawings

STANDARD DRAWINGS

STD - 0400 - 101	Tolerances - Vertical Vessels
STD - 0400 - 102	Tolerances - Horizontal Vessels
STD - 0400 - 104	Manufacturer Nameplate
STD - 0400 - 106-1	Nameplates Mounting Bracket
STD - 0400 - 201	Manholes
STD - 0400 - 202	Projection of Nozzles
STD - 0400 - 203	Typical Details of Clad Plate Weld Joint Preparation
STD - 0400 - 204	Typical Detail of Weld Overlay and Alloy Clad Nozzles
STD - 0400 - 301	Skirts - Access Holes - Vents
STD - 0400 - 302	Support Legs for Vertical Vessels
STD - 0400 - 303	Support Saddle for Horizontal Vessels
STD - 0400 - 304	Anchor Chairs
STD - 0400 - 401	Flanges for Removable Internal Piping
STD - 0400 - 402	Internal Arrangement of Vessels
STD - 0400 - 403	Stilling Well for Displacement Type Level Instruments
STD - 0400 - 404	Typical Details of Demisters

STD - 0400 - 405	Typical Details of Demister Attachments
STD - 0400 - 406	Typical Details of Demister Supports
STD - 0400 - 501-1	Hot Insulation Supports (Vertical Vessels)
STD - 0400 - 501-2	Hot Insulation Supports (Hor. Vessels)
STD - 0400 - 502	Fire Proofing Supports
STD - 0400 - 503	Cold Insulation Supports
STD - 0400 - 505	Earth Connection
STD - 0400 - 506	Lifting Trunnions
STD - 0400 - 507	Lifting Lugs
STD - 0400 - 508	Tail Lugs
STD - 0400 - 509	Standard for Templates
STD - 0400 - 512	Schedule - AC/SS/CLAD
STD - 0400 - 905	Reinforcement Standard
STD-1881-002-001	Brackets for Platforms CI2-CU2-L<-1300
STD-1881-002-002	Brackets for Platforms CI1-CU1-L<-1300
STD-1881-002-003	Brackets for Platforms CI2-CU2 On Cold Vessels <-20 In Operation L<-1300
STD-1881-002-004	Brackets for Platforms CI1-CU1 On Cold Vessels <-20 In Operation L<-1300
STD-1881-002-005	CL3 Brackets for Platforms On Vessels
STD-1881-002-006	CL3 Brackets for Platforms On Cold Vessels <-20 In Operation
STD-1881-003-001	Davit With Tackle (PA) With Pulley (PL)
STD-1781-002-001	Anchor Bolts – Materials – Fabrication – Marking

ANNEXURE 2 - ADNOC REFINING ADDITIONAL REFERENCES AND REQUIREMENTS

The following reference documents, form a part of this specification and are additional requirements to be followed for all Static Equipment to be procured/installed in ADNOC REFINING facilities. Latest Revision as time of contract shall be followed. CONTRACTOR shall advise COMPANY of any changes to Reference Documents after the EFFECTIVE DATE. CONTRACTOR shall comply with COMPANY instruction to comply with any changed Referenced Documents. CONTRACTOR shall advise of conflict among any Reference Documents and any technical specification, and COMPANY will determine which shall govern.

Design General Specifications

DGS-CU-010	Concrete Construction Formwork and Coatings
DGS-MD-006	Vessel Trays – General
DGS-MN-001	Insulation
DGS-MU-002	Preservation and Export Packing
DGS-MU-003	Specification for Spare Parts
DGS-MU-013	Criticality Rating System
DGS-MU-014	Minimum Shop Inspection and Certification Requirements
DGS-MU-200	Fire Protection Design Philosophy
DGS-MU-201	Fire Protection Spray Systems
DGS-MW-001	Welding, NDE and Prevention of Brittle Fracture of Pressure Vessels and Heat Exchangers
DGS-MW-004	Materials and Fabrication Requirements for Carbon Steel Piping and Equipment in Severe Services
DGS-MW-005	Materials and Fabrication Requirements for Cr-Mo/Cr-Mo-V Steel Equipment for Higher Temperature, High Pressure Hydrogen Services
DGS-MW-006	Positive Materials Identification of Equipment and Piping
DGS-MW-008	Metallic Materials
DGS-MX-001	Painting
DGS-MX-002	Galvanizing
DGS-MX-004	Internal Lining
DGS-PE-012	Basic Engineering Design Data for Ruwais Refinery-West (RRW)

Standard Drawings

Standard drawings listed below shall be used as referenced herein or on vessel Data Sheets/drawings:

STD-M01-001	Hot Insulation Support (Vertical Vessel)
STD-M01-002-01	Equipment Support Saddles Up To 3000 mm Diameter
STD-M01-002-02	Equipment Support Saddles Greater Than 3000mm Diameter
STD-M01-003	Anchor Bolt Ring Or Lugs And Base Plate Detail For Vertical Vessel
STD-M01-004	Skirts Cylindrical And Conical
STD-M01-005	Support Legs and Base Plate Details
STD-M01-006	Vortex Breakers
STD-M01-007	Bolting Non-Standard Flange With Unified Inch Screw Threads
STD-M01-008	Stilling Well For Displacement Type Level Instruments
STD-M01-009	Davit For ANSI Or BS Blind Flanges Nom Size 12"-24" And Classes 150-600 Incl
STD-M01-010	Equipment Nozzles
STD-M01-011	Typical Details of Bush Lined, Overlay Welded and Clad Steel Nozzles
STD-M01-012	Hatch Way Covers
STD-M01-013	Nameplate With Bracket For Vessel And Heat Exchanger Equipment
STD-M01-014	Internal Ladder Rung Details

STD-M01-015	Typical Details of Demisters
STD-M01-016	Typical Details of Demister Attachments
STD-M01-017	Typical Details of Demister Supports
STD-M01-018	General Arrangement & Details Of Davit For Columns
STD-M01-019	Vessel Piping Support and Guide Details
STD-M01-020-01	Structural Steelwork Standards - Typical Vessel Ladder And Platform Details(vertical)
STD-M01-021-001	Tolerance - Vertical Vessels
STD-M01-021-02	Tolerance - Horizontal Vessels
STD-M01-022	Flange Bolt Hole Orientation
STD-M01-023	Tray Support Tolerance
STD-M01-024	Tray Tolerances
STD-M01-020-02	Structural Steelwork Standards - Typical Vessel Ladder And Platform Details(vertical)
STD-M01-020-03	Structural Steelwork Standards - Typical Vessel Ladder And Platform Details(vertical)
STD-M01-025	Earth Connection For Tanks, Vessels And Support Structures
STD-M01-026	Internal Pipe Support Details
STD-M01-027-01	Reflux Nozzle Details
STD-M01-027-02	Reflux Nozzle Details
STD-M01-027-03	Reflux Nozzle Details
STD-M01-028-01	Feed Nozzle Details
STD-M01-028-02	Feed Nozzle Details
STD-M01-028-03	Feed Nozzle Details
STD-M01-029	Flash Feed Details
STD-M01-030	Liquid Draw-off and Vapor Outlet Details
STD-M01-031	Side Reboiler Draw and Return Details
STD-M01-032	Tray Support Ring Details
STD-M04-001	Obstruction Lights for Steel Stack
STD-M02-005	Warning Nameplate

ANNEXURE 3 - BOROUGE ADDITIONAL REFERENCES AND REQUIREMENTS

The following reference documents, form a part of this specification and are additional requirements to be followed for all Static Equipment to be procured/installed in Borouge facilities. Latest Revision as time of contract shall be followed. CONTRACTOR shall advise COMPANY of any changes to Reference Documents after the EFFECTIVE DATE. CONTRACTOR shall comply with COMPANY instruction to comply with any changed Referenced Documents. CONTRACTOR shall advise of conflict among any Reference Documents and any technical specification, and COMPANY will determine which shall govern.

Specifications

BGS-CU-010	Concrete Construction Formwork and Coatings
BGS-IU-001	Instrumentation and control
BGS-MD-006	Vessel Trays - General
BGS-MN-100	Thermal Hot Service Insulation
BGS-MU-002	Preservation and Export Packing
BGS-MU-013	Criticality Rating System
BGS-MU-014	Minimum Shop Inspection and Certification Requirements
BGS-MU-200	Fire Protection Design Philosophy
BGS-MU-201	Fire Protection Spray Systems
BGS-MW-001	Welding, NDE and Prevention of Brittle Fracture of Pressure Vessels and Heat Exchangers
BGS-MW-004	Materials and Fabrication Requirements for Carbon Steel Piping and Equipment in Severe Services
BGS-MW-005	Materials and Fabrication Requirements for Cr-Mo Alloy Steel High Pressure Equipment
BGS-MW-006	Positive Materials Identification of Equipment and Piping
BGS-MX-001	Painting
BGS-MX-002	Galvanizing

Standard Drawing

BTD-MD-00011	Supports for Hot Insulation and Fireproofing
BTD-MD-00012	Saddle Details for Horizontal Vessels
BTD-MD-00013	Vertical Vessel Skirt Base Details
BTD-MD-00014	Skirts, Cylindrical and Conical
BTD-MD-00015	Support Legs and Base Plated Details
BTD-MD-00016	Vortex Breakers
BTD-MD-00017	Bolting for Non-Standard Flanges with Unified Inch Screw Threads
BTD-MD-00018	Stilling Well for Displacement-Type Level Instruments
BTD-MD-00019	Davit for ANSI or BS Flanges Nom. Size 12-24 Inch Inclusive Classes 150-600 Inclusive
BTD-MD-00020	Nozzles to Apparatus
BTD-MD-00022	Typical Details of Bush Lined, Overlay Welded and Clad Steel Nozzles
BTD-MD-00023	Internal Baffle Hatchway Cover Details
BTD-MD-00024	Nameplate with Bracket for Vessel and Heat Exchange Equipment
BTD-MD-00025	Internal Ladder Rung Details
BTD-MD-00026	Typical Details of Demisters
BTD-MD-00027	Typical Details of Demister Attachments
BTD-MD-00028	Typical Details of Demister Supports
BTD-MD-00029	Davit for Column, General Arrangement & Typical Details

BTD-MD-00030	Vessel Piping Support and Guide Details
BTD-MD-00031	Typical Vessel Ladder and Platforms, Sheet 1
BTD-MD-00032	Vessel Tolerances
BTD-MD-00033	Flange Bolt Hole Orientation
BTD-MD-00034	Tray Support Tolerances
BTD-MD-00035	Tray Tolerances
BTD-MD-00036	Typical Vessel Ladders and Platform Details, Sheet 2
BTD-MD-00037	Typical Vessel Ladders and Platform Details, Sheet 3
BTD-MD-00038	Obstruction Lights for Steel Stack
BTD-MD-00040	Earthing Clips for Tanks, Vessels and Supporting Structures
BTD-MD-00041	Warning Nameplate
BTD-MD-00042	Internal Pipe Support Details
BTD-MD-00043	Reflux Nozzle Details, Sheet 1
BTD-MD-00044	Reflux Nozzle Details, Sheet 2
BTD-MD-00045	Reflux Nozzle Details, Sheet 3
BTD-MD-00046	Feed Nozzle Details, Sheet 1
BTD-MD-00047	Feed Nozzle Details, Sheet 2
BTD-MD-00048	Feed Nozzle Details, Sheet 3
BTD-MD-00049	Flash Feed Details
BTD-MD-00050	Liquid Draw-off and Vapor Outlet Details
BTD-MD-00051	Side Reboiler Draw and Return Details
BTD-MD-00052	Tray Support Ring Details

ANNEXURE 4 - ADNOC ONSHORE ADDITIONAL REFERENCES AND REQUIREMENTS

The following reference documents, form a part of this specification and are additional requirements to be followed for all Static Equipment to be procured/installed in ADNOC ONSHORE facilities. Latest Revision as time of contract shall be followed. CONTRACTOR shall advise COMPANY of any changes to Reference Documents after the EFFECTIVE DATE. CONTRACTOR shall comply with COMPANY instruction to comply with any changed Referenced Documents. CONTRACTOR shall advise of conflict among any Reference Documents and any technical specification, and COMPANY will determine which shall govern.

COMPANY PROCEDURES, STANDARDS AND AMENDMENTS TO SHELL DEP

EP 30.99.90.0024	Preparation of Supplier's/Vendor's Engineering Drawings and Documents.
EM 30.99.95.0006	Guidelines for Submission of Electronic Documentation.
EP 30.99.90.0001	Drawing Design and Numbering Systems.
EP 30.99.00.0001	Engineering Specification for Tag Plates for Field & Indoor Equipment
EP 30.99.90.0002	Procedure for project drawing as built mark-up and master drawing
ES 30.99.00.0102	Corrosion control and Material selection Philosophy
ES 30.99.37.0013	Specification for Painting & Coating of New Equipment
EP 30.99.97.0006.1	Project Quality System Requirements

Shell DEP's Standards

31.22.00.30-Gen February 2017 Equipment Criticality for use in pressure vessel design

ANNEXURE 5 – FERTIL ADDITIONAL REFERENCES AND REQUIREMENTS

The following reference documents, form a part of this specification and are additional requirements to be followed for all Static Equipment to be procured/installed in FERTIL facilities. Latest Revision as time of contract shall be followed. CONTRACTOR shall advise COMPANY of any changes to Reference Documents after the EFFECTIVE DATE. CONTRACTOR shall comply with COMPANY instruction to comply with any changed Referenced Documents. CONTRACTOR shall advise of conflict among any Reference Documents and any technical specification, and COMPANY will determine which shall govern.

Standard Specifications
Standard specifications listed below shall be used as referenced herein or on Project vessel Data Sheets/drawings:

F2-00-MS-SPC-1001	Painting
F2-00-MS-SPC-1002	Insulation
F2-00-MS-SPC-1004	Supports For Pressure Vessel
F2-00-MS-SPC-1005	Hydrogen and/or Sour Gas Service
F2-00-MS-SPC-1006	Surface Treatment of Austenitic SS after Welding
F2-00-MS-SPC-1007	Non-destructive Testing (NDT)
F2-00-MS-SPC-1010	Preservation
F2-00-MS-SPC-1010	Material Identification Programme
F2-00-MS-SPC-1010	Welding
F2-00-PI -SPC- 0001	Piping Material Specification

Standard Drawings
Standard drawings listed below shall be used as referenced herein or on vessel Data Sheets/drawings:

F2-00-ST-SDG-0001	Standard Drawing General Notes(1/2)
F2-00-ST-SDG-0002	Standard Drawing General Notes(2/2)
F2-00-ST-SDG-0008	Standard Drawing Anchor Bolts Detail
F2-00-ST-SDG-0009	Standard Drawing Base Plate - Hinge Support
F2-00-ST-SDG-0021	Standard Drawing Steel Stair Detail
F2-00-ST-SDG-0022	Standard Drawing Ladders & Safety Gate Detail
F2-00-ST-SDG-0023	Standard Drawing Handrail Detail
F2-00-ST-SDG-0024	Standard Drawing Grating, Floor Plates & Joist Detail

ANNEXURE 6 - ADNOC OFFSHORE ADDITIONAL REFERENCES AND REQUIREMENTS

In addition to the requirements given in the main body of this specification, the following additions are specific to ADNOC Offshore Pressure Vessels and shall assume priority over and above the requirements covered in other parts of this document.

1. GENERAL

Pressure vessels supplied as part of a Vendor's off-the-shelf standard design in package units may not comply with the requirements of this specification provided that all of the below mentioned requirements are satisfied:

a. The vessel is ASME Code stamped. For the application of alternate code, CONTRACTOR/VENDOR shall obtain Company's approval.

b. Full penetration welds joints are used for weld category A, B, C & D in accordance with ASME Section VIII Div.1 Sec UW-9.

c. The vessel is mechanically protected against overpressure conditions

User Design Specification (UDS) shall be prepared by Contractor/Consultant for pressure vessels designed in accordance with ASME Section VIII Division 2.

2. VESSEL COMPONENTS AND DETAILS

2.1. Nozzles and Manways

a. Nozzles

1. Nozzles shall be straight flanged with no bends/ elbows except for the bottom nozzle of vertical vessels, unless otherwise stated on the vessel data sheet.

2. Following Nozzle welding details shall not be used:

ASME Section VIII Div.1, Fig. UG-40 details (a1), (a2), (a3), (a4), (b-1), (b-2), (b-3), (c), (j), (k), (l), (m), (n) and (o); ASME Section VIII Div.2, Table 4.2.11, Table 4.2.12, and Table 4.2.14 details.

3. The design of the vessel shall allow for complete venting, draining and access to carry out unrestricted in-service inspections on all areas of the vessel. Vessel should have minimum one utility nozzle and one vent nozzle. Vendor to highlight area where this is impracticable for Company approval.

4. Vents shall be provided at the highest point and drains at the lowest point of a vessel or compartment. Where process connections are positioned at these points, they shall be used for test purposes. Operational vents and drains will then be incorporated as part of the piping, unless otherwise stated on the vessel data sheet.

b. Nozzle Flanges & Gaskets

1. Class 150 flanges are not permitted for design temperatures above 371°C or for pressure relief valve connections.

2. For vessels supported on a skirt, the flanges of nozzles in bottom head shall be located outside the skirt.

3. Unless otherwise approved by the Company, raised-face shall be used except for high pressure rating nozzle (rating class ≥ 600) where RTJ is required as per Company Piping Material Specification for applicable piping classes. However, for steam service, only raised face flanges shall be used for all ratings.

4. Bolt holes in all fixed flanges shall straddle the natural centerlines of the vessel.

5. Flange Face Finish shall be as follow:

   i. Unless noted otherwise, face finish for ferrous flanges shall be as per the relevant flange code and Company Piping Material Specification.

   ii. Flanges for non-pressure internal connections shall be of the flat faced type plate construction with full faced compressed fibre gaskets.

   iii. Flange face finish abbreviations shall be in accordance with ASME B46.1.

   iv. Flange facings shall be protected from damage during fabrication, heat treatment, and shipping.

   v. On all vessels which will be protected with internal coating or cladding for sour or other corrosive services, flange face including the nozzles shall be protected with Inconel 625 or specified clad material weld overlay and machined, based on the corrosion study report. For internally coated vessels, this overlay shall also extend upto 50 mm inside the nozzle bore and coating to be applied on the overlaid area within the nozzle bore, but not on the flange face.

c. Manways and Handholes

1. When the diameter of the vessel containing internals is not sufficiently large enough to permit the use of manways or vessels having outside diameter of 914 mm and below shall be provided with body flanges instead of manways for accessibility.

2. Manways shall be located in the heads of horizontal vessels when practicable and in the shells of vertical vessels.

3. Division plates in compartmented vessels shall be provided with bolted covers openings with bolts facing the manhole side of the vessel to permit inspection or access to all parts of the equipment. Covers shall be designed such that they weigh no more than 30 kg.

d. Covers, Davits and Closures

Vessels provided with quick opening closures shall comply with requirements pertaining to quick opening closures stated in Company Specification for Pig Launchers and Receivers. Quick opening closures shall be designed per ASME Section Div. 1 Paragraph UG-35.2 or ASME Section Div. 2 Paragraph 4.8 and Annex 4-B as applicable. Procedures for the operation or maintenance of quick opening closure shall be submitted for Company's review.

2.2. Vessel Internals

a. Internals shall be retained and supported by alloy steel bolts of suitable corrosion resistance for the application.

b. All internal bolted attachments shall be secured with double nuts system.

c. All internal equipment which is specified to be welded in place shall be installed before stress relieving. All internal equipment which is to be bolted, screwed or clamped in place shall be installed by the vessel fabricator before shipment unless otherwise specified, and suitably supported for transport.

d. Supports for internals shall be easily identifiable for removal by site contractor before commissioning.

e. Flimsy internals such as process trays, mesh pad mist extractors and the vanes of vane type mist extractors shall not be installed until after the post weld heat treatment and/ hydrostatic test of the vessel.

2.3. Equipment Davit

A davit for the lifting of equipment internals shall be specified for vessels containing removable internals such as trays, packing, internal & safety relief valves. Davit might be located on the top of Vertical vessels or on the top platform for Horizontal Vessels.

2.4. Vessel Supports

2.4.1. Skirt Supports

The upper part of the skirts of alloy steel vessels shall be supplied in the same grade of material as the adjacent head of the supported vessel as per Cl.8.5.2 of this specification.

Skirts shall be designed to be attached to the vessel and base ring by continuous welds. Skirts shall be welded to bottom head, mean diameter of skirt coinciding with the mean diameter of vessel in the corroded condition. The weld profile shall be smoothly blended into the head profile.

For stress relieved vessels, the top portion of skirts shall be stress relieved with the vessel.

Vessel skirts shall be provided with pipe opening for bottom head nozzles, access openings and vents, per Company "Standard Drawings for Static Equipment". Skirt openings for piping shall have a 13 mm maximum clearance between the pipe outside diameter, including insulation, and skirt opening if inside of skirt is not fireproofed.

Half skirts shall not be used for vessels with fire proofing or for vessels connected to piping that is prone to vibration.

Unless specified otherwise on data sheets, a minimum of two 50 mm radius semi-circular drain holes 180 degrees apart shall be located at the vessel skirt to base ring attachment weld. The drain holes shall be staggered 90 degrees from the skirt vent holes. In applications where the inside of the skirt will be open or grated, the drain opening shall be omitted.

The base plates for vertical vessels shall be preferably in one-piece construction without any weld joints. If welded construction is provided, the welds shall be ground flush and fully radiographed to ensure integrity and uniform contact (bearing) with the deck steel / foundation.

When it is not practical to cut a full circular manhole in vessel skirt, a half round cut extended to base plate can be made instead.

Vertical vessels shall be supported by skirt, legs or lugs, with the following recommendations:

Leg supports shall not be used in high vibration, shock, cyclic service or where the vessel is attached to reciprocating equipment.
Leg supports shall not be used where either of the following criteria are applicable, unless otherwise stated on the vessel data sheet:

The overall equipment height to outer diameter ratio exceeds 5.

Vessels greater than 1,524 mm outer diameter or 6 100 mm tan to tan length.

Support lugs shall not be considered for vessels designed to ASME Section VIII, Division 2.

Vertical vessels installed on offshore platform (except vessels in packaged equipment) shall be anchored by welding the equipment support using continuous fillet welds with the deck/deck beam. Supplier to ensure that fillet weld sizes are adequate for the load conditions as per their design. The design of equipment supports and their welds to the deck plate shall disallow accumulation of moisture or water (due to rain, sea spray, condensation or wetting).

2.4.2. Saddle Supports

Horizontal vessels installed on offshore platforms shall have saddle base plate on fixed side rounded to a minimum 13 mm radius to allow fillet welds between fixed saddle base plate and the deck beam “wrap” around at the corners.

Each saddle pad shall have a 1/4" NPT vent hole tapped at its lowest point and plugged with plastic sealant prior to shipment.

The saddle base plate on the sliding end shall be welded with a slide plate assembly as described in Design criteria for Static Equipment.

2.5. Vessel Markings and Nameplates

a. Vessel shall be fitted with nameplate(s) as per Company “Standard Drawings for Static Equipment”.

b. ASME Code nameplate shall be provided as per design code requirements.

c. Nameplate brackets shall be located near a manway or handhole and shall not be obstructed if the manway or handhole is open.

d. For vessels, which are divided into separate compartments, require a Code and Manufacturer's nameplate for each compartment; the location of the nameplates is indicated on the vessel drawings. The data for a jacket or coil, when fitted to a vessel, shall be included on the Vessel Code Nameplate.

e. The nameplates shall be marked before being fixed to the vessel. The CONTRACTOR and VENDOR shall ensure that the nameplate with the correct marking has been applied to the proper vessel, and the Inspector shall satisfy himself that this has been done.

f. Nameplate rub-off shall be submitted to the Company as part of Manufacturer's Databook.

3. CRITICALITY RATING

A Criticality Rating (CR) shall be assigned to each pressure vessel and shall be indicated on the Equipment Data Sheets/Drawings by Contractor/Engineer. Criticality Rating (CR) requirements shall be as specified in A0-Q-PQ-CP-001 "Code of Practice for Project Procurement Inspection". The calculation procedure for criticality assessment shall be as per "Code of Practice for Project Procurement Inspection".

4. MATERIALS AND CORROSION REQUIREMENTS

4.1. GENERAL REQUIREMENTS

a. ASME specification shall be considered for code stamped equipment and ASTM specification may be used for non- pressure parts not directly welded to pressure parts. European equivalents to those of the Design Code materials shall only be used with the specific approval of the Company.

b. Carbon and Low alloy steel nuts/bolts/fasteners/external bolting including washers shall be SHDG (Spun hot dip galvanized) and stainless steels shall be PTFE (Composite Fluoropolymer) coated in accordance with A0-IG-P-SP-003.

c. The Vendor shall clearly define on their documents the materials by reference to the relevant specifications and standards. Where these specifications and standards allow a choice (i.e. grade of steel, extent of acceptance tests) it shall be indicated on the material lists.

d. Records of compliance with the requirements of material specifications shall be submitted by the VENDOR to the Company. Original Certificates of compliance with complete steel analysis shall be required from the VENDOR and shall include reports or test results as required by the material specification or Purchase Order.

e. Carbon steel materials SA-36 and SA-283 shall not be used for pressure parts.

f. All internals or externals welded to the Vessel shall be of compatible material to the material to which it is welded, and shall be installed prior to post-weld heat treatment.

g. Bolting materials and gaskets used for connecting piping to vessel nozzles shall be in accordance with applicable Company Piping Material Specification.

h. Bolting material for internal bolting shall be compatible with gasket and flange material ensuring protection against galvanic corrosion. However, if in absence of galvanic coupling, the bolting material selection shall be as follows:

- Bolting of K500 and Marinel material shall not be used for seawater service.
- Bolting material, where no toughness testing is involved, shall be to SA 193 Grade B7M, SA 194 Grade 2HM or 7M.
- Bolting material shall be to SA 320 Grade L7M, SA 194 Grade 2HM/S3 or Grade 7M/S3 for low temperature service down to –73 °C.
- Bolting material shall be to Alloy 625 for low temperature service down to -196°C.

i. Flat heads and flanges shall not be machined from plate, but shall be forgings

j. For pressure vessel plate where more than one thickness may be rolled from the same heat, tests shall be performed on both the thickest and thinnest plates produced from each heat.

k. Supplementary or special requirements, in addition to the requirements of the material specification, as required by the Purchase Order shall be included on the certified material test reports (CMTR).

l. The specification of the material being represented, year of issue and material heat number shall be included on the CMTR.

m. All such documents shall identify the applicable material specification and shall be identified to the material represented.

4.2. ADDITIONAL REQUIREMENTS FOR HYDROCARBON SERVICE

a. All pressure part/wetted part including base plate of clad or weld overlaid materials shall be fully compliant with NACE MR 0175/ISO 15156-1/ISO 15156-2/ISO 15156-3 in addition to the requirements specified in this Annexure to meet the mechanical and corrosion resistance properties required for sour service unless otherwise specified in the data sheet. The materials shall be in accordance with material selection report, drawings /data sheets, other applicable Company specifications. The discrepancy between different documents, if any, shall be brought to the Company's notice for reconfirmation.

b. H2S content and fluid composition shall be as specified in the Process Datasheet. Materials shall be chosen with consideration to operating, design and upset conditions of the Vessel in addition to H2S partial pressure and Chloride content. The following shall also be taken into account for selection of material:

i. Specific characteristics of materials, which may require additional precautions during welding and/or heat treatment.

ii. Economy resulting from the choice of material.

iii. Combinations of dissimilar materials likely to promote galvanic corrosion shall be avoided unless proper precautions are taken such as insulating gaskets, bolt sleeving, insulating washers and other suitable barriers.

c. No pressure part/wetted part materials shall be selected which has a specified minimum ultimate tensile strength more than 485 Mpa. Alternatively clad or solid alloy materials may be proposed for Company's approval.

d. All carbon steel plate materials excluding base plate of clad or weld over laid materials for pressure part/wetted part shall be HIC, SSC and SOHIC resistant. These materials shall be checked and qualified in accordance with NACE standard TM 0284 with test solution A for HIC and clause B.4 of ISO 15156-2 for SOHIC test with test solution A of TM0177.

e. The acceptance criteria for SOHIC testing shall be in accordance with NACE MR 0175/ISO 15156-2 clause B 4.2.2 or B 4.2.3 as applicable. The test condition shall be as per table B.1.

f. Plate material shall be HIC and SOHIC tested in a simulated PWHT condition.

g. Plate materials shall be subjected to HIC testing at a frequency of one test per heat.

h. The plate materials shall be vacuum-treated, fully deoxidised, desulphurised and dephosphorised. The manufacturing/rolling process shall be such that a homogeneous microstructure is obtained, i.e. the structure shall be free of any significant ferrite/pearlite banding. The degree of banding according to ASTM E 1268 shall be carried out. Calcium treatment shall be applied for inclusion shape control. If sulphur level>0.001%, the calcium content shall not exceed 3 times the sulphur content. Inclusion content rating shall be carried out in accordance with ASTM E-45 and reported. Alternative methods of inclusion shape control shall be subject to the approval of the Company.

i. In order to ensure effective resistance to HIC and SSC, the chemical composition (product analysis) of carbon steel materials shall be restricted as follows, except where the standard material specification is more restrictive:

Table 3: Chemical composition (product analysis) of carbon steel materials

Single Elements	Maximum wt.%
Carbon (C)	0.20
Manganese (Mn)	1.30
Phosphorous (P)	0.01
Sulphur	0.002*
Silicon (Si)	0.40
Copper (Cu)	0.4
Nickel (Ni)	0.4
Chromium (Cr)	0.3
Molybdenum (Mo)	0.12
Vanadium (V)	0.015
Niobium (Nb)	0.015
Titanium (Ti)	0.02

Boron (B)	0.0005
Multiple Elements	
Cr + Mo	0.3
Ni + Cu + Cr + Mo	0.7
V + Nb	0.02
Carbon Equivalent	0.43

*The sulphur content indicated in the material chemistry is indicative only and the material supplier shall confirm its suitability for the sour service with the indicated percentage of H_2S and CO_2 or its partial pressures and operating temperature .The supplier may revert with the lowest level of sulphur required to make the material HIC resistant for company's approval with supporting test results for the specific operating conditions envisaged for the project.

j. Carbon Equivalent (CE) shall be calculated using the following formula:

$$CE = C + \frac{Mn}{6} + \frac{(Ni + Cu)}{15} + \frac{(Cr + Mo + V)}{5}$$

k. The micro-alloying elements boron (B), titanium (Ti), niobium (Nb) and vanadium (V) shall not be intentionally added to the steel unless the Company has given prior approval.

l. Plate materials shall be subjected to an ultrasonic lamination check in accordance with ASTM A 578 Level B. Generally, only seamless pipe and fittings shall be used for vessel nozzles. Where this is impractical, welded pipe and fittings of sizes above NPS 16 manufactured from plates for pressure/wetted part complying with this specification shall be used. Welding of such fittings shall be done using welding procedures complying with this specification.

m. The acceptance criteria for HIC testing shall be as per table B.3 of NACE MR0175/ISO 15156- 2 (NACE TM 0284, solution A (ph3), CLR<=15%, CTR<=5%, CSR<=2%,Where CLR, CTR and CSR values are averages of the three sections of HIC-Specimen) The maximum individual crack length on any section shall not exceed 5 mm. If any specimen fails to meet the acceptance criteria, the whole material represented by the heat of the specimen used in the test shall be rejected.

n. All carbon steel plate materials other than wetted/pressure part materials (e.g. clips, skirts, etc.) need not be HIC tested but shall be SA 516 or steel grades according to EN 10028-3 with the following chemical composition (product analysis), except where the standard material specification is more restrictive.

Table 1: Chemical composition (product analysis) of SA 516 or steel grades according to EN 10028-3

Single Elements	Maximum wt.%
Carbon (C)	0.20
Sulphur (S)	0.01

Multiple Elements	
Vanadium (V) + Niobium (Nb)	0.02
Carbon Equivalent	0.43

o. Carbon steel Forgings (e.g. Flanges etc.) shall be in accordance with SA 105N or SA 350-LF2 with a maximum carbon content of 0.25 wt.% max., carbon equivalent of 0.43 max. and sulphur content of 0.025% max. All non-standard forgings shall be UT examined as per SA 388 and DP/MP tested after machining.

p. Carbon steel Seamless pipes (e.g. for nozzles) shall be in accordance SA 106 Grade B or SA 333 Grade 6 with a maximum carbon content of 0.23 wt.% max., carbon equivalent of 0.43 max. and sulphur content of 0.008% max. Electric resistance welded ESW pipe material shall not be used for any pressure part / wetted part.

q. Carbon steel fittings shall be in accordance SA 234 Gr WPB/WPC or SA 420 Gr WPL6 with a maximum carbon content of 0.23 wt.% max., carbon equivalent of 0.43 max. and sulphur content of 0.008% max.

4.3. REQUIREMENTS FOR CLAD/ OVERLAYED MATERIALS

a. When internal lining is specified, only over lay-welding or integral cladding shall be used for all pressure part/wetted part materials inclusive of nozzles. Strip lining or loose lining shall not be used.

b. Weld overlaid /clad/ lined plate material shall be suitable for service conditions and NACE MR0175/ISO 15156-3 compliant for hydrocarbon servive.

c. Solid alloy nozzles are not recommended for clad or weld overlay clad vessels.

d. When envisaged, integrally clad plate shall be homogeneously clad type only as obtained by roll cladding or explosive cladding. The clad plates shall conform to SA 263, SA 264 or SA 265, as applicable, irrespective of the design calculation method used. These shall meet the minimum shear strength and shear test requirements stipulated in these specifications.

e. Internals of the vessel shall be of the same alloy or of the same alloy lined material in case of alloy-lined vessels.

f. Chemical analysis for Corrosion Resistant Alloy (CRA) materials / weld overlays:

   i. Certified chemical analysis of all automatic weld wire is required. Check analysis (Product analysis) shall be performed by the vessel fabricator to confirm the alloy content.

   ii. Vendor shall prove that in the as-built condition material grades actually used for the construction shall comply with the requirements of the purchase order/Company approved drawings. For this purpose, a non-destructive positive alloy material identification shall be carried out by “X-ray fluorescence analysis” in accordance with ASTM E-572. Any portable X-ray emission analyser, such as Texas Nuclear analyser Model 9266 or equivalent with

computerised read-out, is acceptable. The maximum allowed iron dilution shall be limited to 10%.

iii. Samples of completed shell, head, and nozzle weld shall be analysed to confirm required alloy content. Samples to be taken from the inside weld surface.

iv. Two samples of the weld deposit overlay shall be taken from each overlaid shell section and each head and analysed to confirm required analysis. Each manual weld overlay, such as those on girth seams and nozzles, shall also be sampled. Analysis to a depth of 2.5 mm from the surface shall confirm to the chemistry requirements for the alloy specified on the project specifications. Specific approval of Company shall be obtained for the proposed material, manufacturing process, fabrication procedure etc. Where automatic weld deposit overlay is applied by more than one welding operator, samples shall include deposits made by each operator.

5. SOUR SERVICE REQUIRMENTS

a. Materials shall comply with the requirements for Hydrocarbon service as per above Clause. Additionally, materials shall meet the requirements of NACE MR0175/ISO 15156 parts 1 and 2 and API 5L/ISO 3183 Annex H and K.

b. Longitudinal and circumferential butt welds shall receive full volumetric NDE after any PWHT.

c. All welds, including external and internal non-pressure containing welds, shall be subject to 100% surface inspection by MP or DP after any PWHT.

d. Materials specified shall be purchased and fabricated in order to be resistant to environmental cracking in sour service, and ISO 15156 for upstream applications and for downstream (refinery) applications to NACE MR0103.

e. Material shall be in the normalised condition unless agreement is given for the pressure part/wetted part steel materials to be heat treated by quenching and tempering or by TMCP or NACT, to improve microstructure homogeneity and enhance HIC resistance, as specified in data sheets and the following:
   i. Normalised plate shall conform to EN 10028-3 or ASTM A516/A516M.
   ii. Quenched and tempered plates shall conform to EN 10028-6.
   iii. TMCP plates shall conform to EN 10028-5 or ASTM A841/A841M.

f. The vessel shall be PWHT.

g. Z quality and HIC plate shall be used for carbon steel. Z-quality steel plate shall be designated as one of the following:
   i. EN 10028-3 Grade P275NH + EN 10164, Z35.
   ii. ASME SA-516/SA-516M Grade 70 (or equivalent) + ASTM A770/A770M with S3 at 35%.

h. The plate shall meet EN 10028-3 or equivalent steel grades and shall be made by a low sulphur and low phosphorus refining process, for example, in an electric furnace with double de-slagging or in the basic oxygen furnace. The steel shall be vacuum degassed while molten.

i. Plate shall be ultrasonically examined and meet EN 10160 quality classes S1/E1 or equivalent.

j. Through-thickness tensile test
   i. Each plate shall conform to acceptance class Z35 of EN 10164 or equivalent.
   ii. Company may agree to a retest after consideration of information supplied. The through-thickness test shall be made after the completion of all heat treatments.
   iii. In addition to the above, the tests required by the material specification shall be carried out.

k. Plate shall not be weld repaired without agreement and shall be subject to an agreed repair procedure before repair.

l. The following additional requirements shall apply if data sheets specify that HIC resistant plate shall be used.
   i. Plates shall meet one of the following:
      - EN 10028-3/ASME SA-516/SA-516M (normalised).
      - EN 10028-6 (Quench + Tempered).
      - ASME SA-841/SA-841M (TMCP)/EN 10028-5.
   ii. For low temperature applications (down to -46°C) the impact tested carbon steel plates meeting ASTM A516/A516M Grades 60, 65, 70 or EN 10028-3 grades P275 (NL2) and P355 (NL2) shall be used.
   iii. Steels shall be made by a low sulphur and low phosphorus refining process, for example in an electric furnace with double de-slagging or in the basic oxygen furnace. The steel shall be vacuum degassed while molten.
   iv. Plates shall be in the normalised, Quench + Tempered, or TMCP condition as specified in data sheets.
   v. Plate shall be ultrasonically examined and meet EN 10160 quality classes S1/E1 or equivalent.
   vi. Plate shall not be weld repaired.
   vii. HIC test
      - Tests shall be made in conformance to NACE TM0284, in the NACE TM0284 Test Solution A (i.e., 5 wt.% NaCl + 0,5 wt.% glacial acetic acid).
      - One set of 3 specimens shall be tested from each thickness of plate from each heat.
      - Following exposure, the test coupons shall be ultrasonically tested for evidence of hydrogen-induced cracking and stepwise cracking before sectioning. Additional sections for microscopic examination shall be prepared through any suspect locations, agreed by Company.
      - The acceptance criteria shall be all of the following:
         1) Less than 5,0% CLR (crack length ratio).
         2) Less than 1,5% CTR (crack thickness ratio).
         3) Less than 0,5% CSR (crack sensitivity ratio).
   viii. A NACE Standard Tensile Test shall be carried out to NACE TM0177 using Method A and Test Solution A if a SOHIC or SZC test is specified in addition to the HIC test. The material test samples which pass this test shall be evaluated for acceptance by one of two methods:
      - At least two metallographic sections shall be taken parallel to the sample axis. There shall be no ladder-like cracks > 0,5 mm in length in the through-thickness direction.

- The remaining tensile strength (after hydrogen degassing at 150°C (302°F)) shall be ≥ 80% of the original actual tensile strength of the material.

m. Hardness of carbon steel HAZ for downstream applications, as measured in the weld procedure test, shall not exceed 248 Hv10 (Brinell 237 HBW) as given in NACE SP0472. Hardness values for other materials shall be as given in NACE MR0103. Hardness checks on the weld deposit of the completed vessel shall conform to NACE SP0472, which specifies a maximum hardness of Brinell 200 HBW in the weld metal.

n. Hardness in the weldment on cracking resistant carbon and low alloy steels for upstream applications, measured in the weld procedure test, shall conform to ISO 15156-2, which specifies a maximum hardness of 250 Hv10 for the weld root area and a minimum temperature for PWHT of 620°C (1 150°F).

o. After PWHT, weldments shall be subject to blasting of surface to SSPC SP 5/NACE No. 1 and tested by WFMT.

p. Vessels clad with a corrosion resistant lining or fabricated from solid corrosion resistant alloys for Upstream environments shall conform to ISO 15156-3. The conditions of acceptability for each of the material classes given in Annex A in ISO 15156-3 shall be met. For Downstream environments, the material requirements given in NACE MR0103 shall be met.

q. Full penetration welds shall be provided on pressure boundary parts to internal attachments such as downcomer bolting bars and segments, bed support beam seats, or any load-carrying attachments that have the long axis parallel to the longitudinal axis of the vessel. This requirement for full penetration welds does not extend to tray support rings or other circumferentially oriented attachments.

r. External bolting shall comply with sour service requirement regardless of vessel being insulated or not.

6. FABRICATION REQUIREMENTS

6.1 Fabrication activities, welding requirements, chemistry requirements, hardness requirements and heat treatment requirements shall be in full compliance with code and this specification unless more stringent requirements are specified elsewhere.

6.2 Prior to start of fabrication, Manufacturer shall submit quality plan to the Contractor and Company. The quality plan shall include the following:

a. Approval of Subcontractors and Manufacturers.
b. Approval of drawings, design data, procedures, and calculations.
c. Updating and control of latest issues or revisions of drawings and specifications.
d. Qualification of welders and non-destructive testing (NDT) operators.
e. Documentation of approvals, clarifications, and quality related activities.

6.3 All welds shall be continuous unless otherwise specified.

6.4 The restoration of mechanical properties by a heat treatment operation after hot or cold forming, prior to further fabrication is governed by the requirements of the material specification. (i.e. normalised and tempered or annealed material). If tempering is required, it shall be completed after the fabrication of the vessel during the final post-weld heat treatment.

6.5 Shell sections shall be rolled/ formed such that the rolling direction (i.e. longitudinal axis) is transverse to the central axis of the shell.

6.6 Materials that may cause corrosive attack when the equipment part is heated shall not be used, including the following:

a. Marking inks (containing halogens).
b. Lubricants.
c. Crayons.
d. Adhesives.
e. Tapes (e.g., duct tape).
f. Coatings to prevent adhesion of weld spatter.
g. Paints containing sulfur.
h. Chlorine and other halogen compounds (e.g., chlorine compounds that might decompose to hydrogen chloride).
i. Materials causing carbon pick-up.
j. Harmful metal or metal salts such as zinc, lead, mercury, cadmium, or copper.

6.7 Hot forming:

a. The hot working temperature range shall be in accordance with that recommended in the relevant material specification.
b. The furnace thermal cycle shall be automatically recorded using sufficient number of thermocouples to indicate uniform furnace temperature. For all materials that are hot formed, or subsequently received an intermediate heat treatment, the thermal history charts produced shall be presented in the final data folder. The thermocouples may be attached to the equipment by any means in order to achieve accurate metal temperatures.
c. During all hot working operations, the furnace atmosphere shall be controlled to avoid excessive scaling, carburization and decarburization.
d. After hot working, for CS/LAS materials, the plates shall be allowed to cool in still air. For other materials, Code requirements shall be complied.
e. Prior to further fabrication all hot-formed heads shall be descaled.
f. Hot-formed head plates originally supplied in the annealed condition will not normally require heat treatment prior to further fabrication.
g. Normalizing of carbon steel components and base materials shall be performed separately, not as part of the hot-forming operation, unless the finishing hot-forming temperature is in the normalizing temperature range as per relevant material specification. In both cases, the temperature shall be recorded and documented by a temperature-recording chart.

6.8 Cold forming:

a. All carbon / low alloy parts, which have been cold formed by more than 5% shall be subjected to an appropriate normalizing treatment and, if necessary, a tempering treatment. Pressure retaining stainless steel components shall be solution annealed as per applicable code when forming strain exceeds 10%.

b. The Vendor's sub-order to the mill shall specify those head plates that are required for cold forming.

c. Sectional dishing and flanging of heads shall only be used with specific Company approval.

6.9 Fabrication:

a. The minimum distance between the edges of any attachment weld of a pressure or non–pressure part to the edge of another pressure weld of the vessel shall be 50 mm or twice the thickness of the pressure part, whichever is the greater. However, if this is not possible the attachment weld shall cross the pressure weld completely by a length of at least 50 mm or twice the wall thickness (whichever is the greater) in order to avoid stress concentration. Before the attachment weld is made, 100% NDE in accordance with the applicable code shall be performed on the adjacent pressure weld in the area where the attachment weld will cross. In case of nozzle openings, the vessel weld seam shall be subjected to 100% RT for a distance of $1.8 \sqrt{(D \times t_{min})}$ from the toe of the nozzle weld, where D is the OD of the nozzle and t_{min} is the minimum of nozzle and shell thicknesses. The pressure weld shall be ground flush prior to welding attachment.

b. The minimum distance between the staggered longitudinal seams of two adjacent courses shall be 200 mm or five times the wall thickness, whichever is the greater. However, where this cannot be achieved, the last 300 mm of the adjacent longitudinal seams shall be subjected to 100% NDE in accordance with the applicable code.

c. Longitudinal seams of two adjacent shell belts shall be preferably offset by at least 60° for Vessels up to 6 m I.D. or at least 45° for vessels exceeding 6 m I.D.

d. Longitudinal seams of horizontal cylindrical vessels shall be preferably situated only in upper part of shell extending from apex down (on each side) to 30° below horizontal plane.

e. Where liquid-tight baffles, tray support rings and down comer bolting bars cross vessel weld seams, these must be continuously welded. All other attachments shall be notched to clear the seams.

f. When tail lugs are fitted, the base ring needs to be checked for requirement of internal strengthening and strengthened as required.

g. Cleats for ladders and platforms, insulation support rings and clips for steam tracing or other piping shall be fabricated in trapezium form to avoid corrosion under insulation.

h. Sharp discontinuities located in regions subjected to operational cycle thermal stresses shall be avoided to prevent cracking due to thermal fatigue.

i. Only full penetration welds are allowed. Double sided welds with crevice in between, are not allowed in the primary pressure boundary or for nozzle attachments to the shell.

j. All welding shall be carried out in the Vendors shop before hydro test. No welding on vessels shall be scheduled at site.

k. Details (c),(e),(f),(h),(i),(n),(o),(q),(r) and (s) given in UG-34 of ASME Section VIII Division 1 shall not be used for Hydrocarbon /sour service. For General service, these may be used only with the approval of the Company on a case-to-case basis.

l. All types (except Types 1, 7 and 8) mentioned in Table UW-12 of ASME Section VIII Division 1 or Type 2 joints mentioned in Table 4.2.4 of ASME Section VIII Division 2 is not permitted to be used in the fabrication.

m. Double fillet constructions are not permitted for hydrocarbon /sour service. For General service, if permitted, these are applicable only in secondary pressure boundaries (e.g. slip-on flanges).

n. Socket welds and plug welds are not allowed.

o. Following weld details of ASME Section VIII Division 1 shall not be used.
   - Details (a),(b),(c),(d),(e) and (i) of FIG.UW –13.1
   - Details (d),(e-1) with backing strip, (g),(h) with backing strip, (i),(l),(m) with backing strip of FIG.UW –13.2
   - Details (a-2),(a-3),(c),(h) up to and including (z-2),(aa) and(bb) of FIG.UW-16.1 ; Additionally, detail (a-1) is not permitted for hydrocarbon / sour service.
   - Details (a) up to and including (c) and (e) up to and including (k) of FIG.UW-16.2 for General service. For hydrocarbon /sour service, details of FIG.UW-16.2 shall not be used.

p. Plate cutting, weld preparations and openings shall be made by one of the following methods:
   - Machining methods: milling, planing, grinding, chipping and shearing.
   - Thermal methods: oxy-fuel gas, arc-air.
   - Plasma cutting shall be used for high-alloy steels and clad steels.
   - For plates less than 25 mm thick, cold shearing may be used.
   - The arc-air method shall only be used for back gouging.
   - In general, thermal cutting and/or gouging shall be limited to carbon and carbon manganese steels only.

q. Low alloy ferritic steels may be cut and/or gouged using a thermal process provided the plate area to be cut is pre-heated. After the cutting operation a minimum of 1.5 mm shall be machined or ground from the cut face.

r. Stiffening rings shall be attached to shell by continuous welds on both sides of the stiffener.

s. When integrally bonded clad plate is to be welded, the lining shall be cut back at all seams to permit back welding of the base metal. The metal shall be ground flush and fully covered with weld overlay. The weld deposit overlay thickness shall meet minimum undiluted thickness specified elsewhere in this specification.

t. For weld overlay type of construction, the undiluted weld overlay thickness shall not be less than 2.5 mm from the final surface.

u. Cladding thickness specified shall be “finished” cladding thickness.

v. The weld overlay shall be applied circumferentially to the vessel and shall be relatively smooth with no notches and undercuts that would act as stress intensifiers. Flaws on the surface of the base metal that would interfere with bonding of the overlay shall be removed by grinding.

w. Weld Overlay and Back Cladding:
   - Overlay surface shall be as smooth as possible without grinding.

- Weld overlay or back cladding thickness shall be no less than the base cladding thickness and shall have a minimum effective thickness equal to that specified for the base cladding.

x. Attachment welds to the cladding shall be of the same nominal composition as the cladding.

y. Internals for clad construction shall not be welded direct to cladding unless a satisfactory result on PMI check can be achieved. Alternatively, weld overlay on the heat-affected zone shall be done to meet the acceptable limits of iron dilution levels mentioned in this specification. If internal coating permits the operating temperature and service media of the vessel, internal coating may substitute weld overlay. Attachments to the cladding may be considered only after consultation with the Company.

z. Straightening of material shall be done by pressing or other non-injurious methods before the material is laid out or worked on in any way.

aa. Materials shall not be hammered.

bb. The edges of plates may be sheared, machined, or cut with a machine-operated gas torch. Shearing shall be limited to plates 10 mm or less in thickness.

cc. When the edges of plates are cut with a torch, the resulting surface shall be uniform and smooth and shall be free from scale and slag accumulations before welding. A remaining fine film of rust adhering to cut or sheared edges after wire brushing need not be removed before welding.

dd. After the edges have been prepared for welding, they shall be thoroughly examined for any defects such as cracks, slag inclusions, etc. Visual inspection will generally be considered acceptable for this purpose.

6.10 Tolerances:

a. The maximum deviation of the shell from a straight line shall not exceed 0.3%, either of the total cylindrical length or of any individual 5 m length of the vessel.

b. Tolerance on overall length measured between the tangent lines for a total tangent to tangent length of 1,000 mm and below shall be shall be ±2.0 mm.

c. Tolerance on overall length measured between the tangent lines for a total tangent to tangent length above 1,000 mm up to 4,000mm shall be shall be ±4.0 mm.

d. Tolerance on overall length measured between the tangent lines for a total tangent to tangent length above 4,000 mm up to 10,000mm shall be shall be ±8.0 mm.

e. Tolerance on overall length measured between the tangent lines for a total tangent to tangent length above 10,000 mm and for vessel wall thickness above 70 mm shall be shall be ±13.0 mm. (Note:-Tangent lines shall be punch-marked on the dished heads, both externally and internally at the intersection of the knuckle with the cylindrical section).

f. Tolerance for process nozzle elevation with reference to tangent line ±6.0 mm. (Dimension “a” in the attached Figure 1).

g. Tolerance for process nozzle projection for nozzles on shell measured from shell curvature, and for nozzles on domes measured from tangent line shall be ±6.0 mm. (Dimension “b” in the attached Figure 1).

h. Tolerance for alignment of process nozzle flange face with the indicated plane shall be a maximum of 0.5° in any direction. (Dimension “c” in the attached Figure 1).

i. Tolerance for radial orientation of process nozzles, measured from reference centre line to centre line of nozzle shall be ±1°, with a maximum circumferential tolerance of 15 mm. (Dimension “d” in the attached Figure 1).

j. Bolthole orientation of process nozzles shall not exceed a maximum rotation 1.5 mm measured at bolt circle. (Dimension “e” in the attached Figure 1).

k. Tolerance of nozzle centre line in head shall not exceed 3 mm. (Dimension “f” in the attached Figure 1).

l. Tolerance of nozzle centre-to-centre distance for level instrument nozzles shall be ±1.5 mm. (Dimension “g” in the attached Figure 1).

m. Tolerance of nozzle projection difference for each pair of level instrument nozzle flanges, measured from shell curvature shall be 1.0 mm. (Dimension “h” in the attached Figure 1).

n. Tolerance for alignment of level instrument nozzle flange face with the indicated plane shall be a maximum of 0.25° in any direction. (Dimension “i” in the attached Figure 1).

o. Tolerance for inspection/manhole opening elevation with reference to tangent line shall be ±12 mm. (Dimension “j” in the attached Figure 1).

p. Tolerance for inspection/manhole opening height measured from shell curvature shall be ±12 mm. (Dimension “k” in the attached Figure 1).

q. Tolerance for alignment of inspection/manhole opening flange face with the indicated plane shall be a maximum of 1° in any direction. (Dimension “l” in the attached Figure 1).

r. Tolerance on support height measured from lower head tangent line to base for a height of 1,000 mm and below shall be ±2.0mm. (Dimension “m” in the attached Figure 1).

s. Tolerance on support height measured from lower head tangent line to base for a height above 1,000 mm up to 4,000mm shall be ±4.0mm. (Dimension “m” in the attached Figure 1).

t. Tolerance on support height measured from lower head tangent line to base for a height above 4,000 mm up to 10,000mm shall be ±8.0mm. (Dimension “m” in the attached Figure 1).

u. Base ring or support out of level ness shall be limited to 0.2% of nominal diameter with a maximum of 12 mm. (Dimension “n” in the attached Figure 1).

v. Tolerance on foundation bolt pitch circle shall be limited to ±3 mm for vessels with inside diameter of 2,100 mm and below but to ±6 mm in other cases. (Dimension “p” in the attached Figure 1).

w. Tolerance on distance between saddle supports shall be limited to ±3 mm. (Dimension “q” in the attached Figure 1).

x. Tolerance on height of saddle supports shall be limited to ±5 mm. (Dimension “r” in the attached Figure 1).

y. Tray support ring level ness, measured as greatest difference all around shall be ±0.15% of the outside tray diameter, with a maximum of 4 mm. (Dimension “s” in the attached Figure 1).

z. Tray support ring elevation - distance of tray support ring to lower tangent line shall be ±6 mm. (Dimension “t” in the attached Figure 1).

aa. Tolerance on distance between two adjacent tray support rings (and from tray support ring to centre of adjacent nozzle or instrument connection) shall be ±3 mm, except for the distance of a draw-off tray support ring to the centre of the corresponding nozzle, for which the tolerance is ±2 mm.(Dimension “u” in the attached Figure 1).

bb. Tolerance on distance of vertical down comer plate to vessel axis shall be ±3 mm. (Dimension “v” in the attached Figure 1).

cc. Tolerance on height of fixed weir above tray support ring shall be ±3 mm. (Dimension "w" in the attached Figure 1).

dd. Tolerance on distance from down comer bottom to tray support shall be ±3 mm. (Dimension "y" in Figure 1).

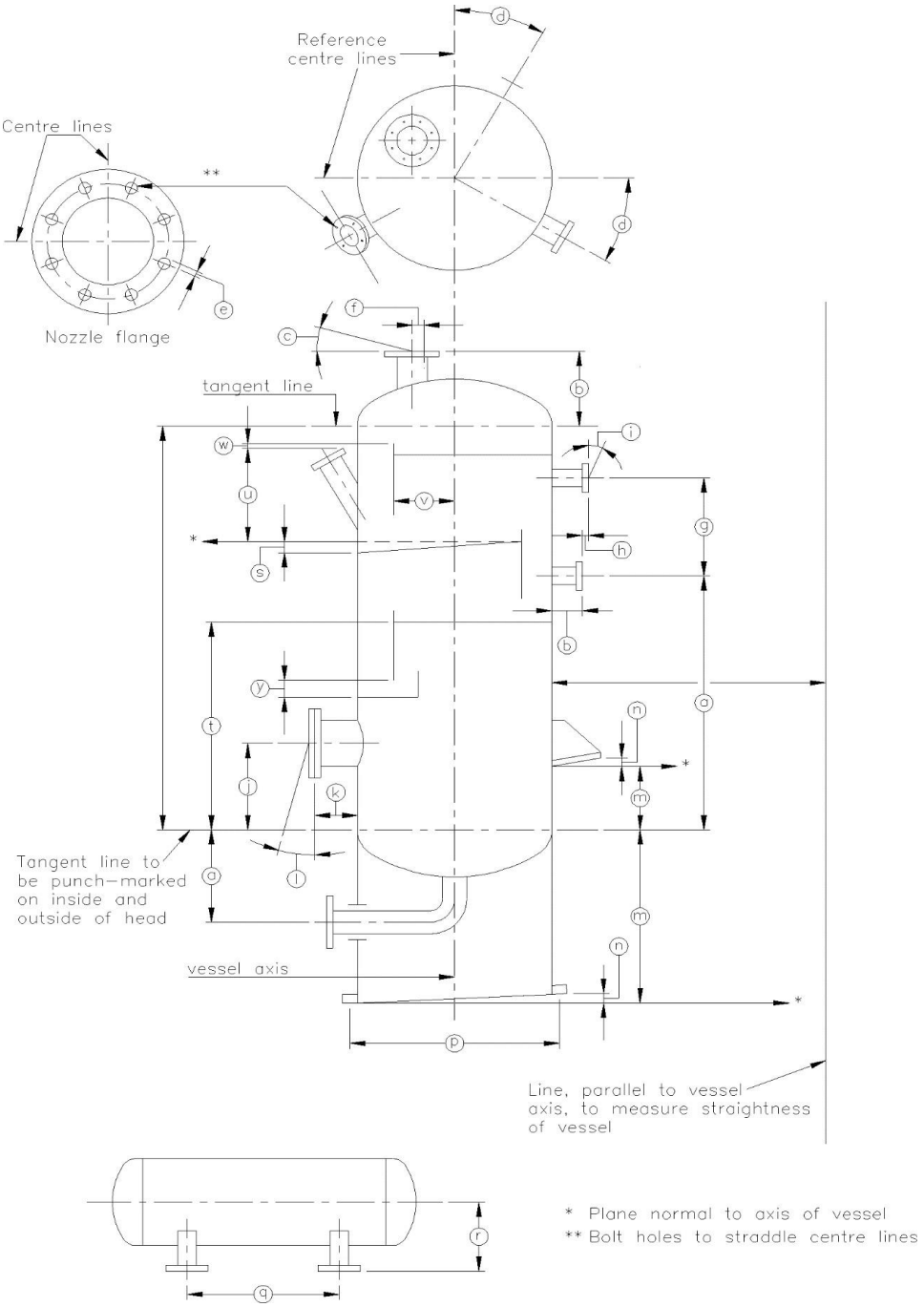

Figure 1: Tolerances - Alphabetic coding

6.11 Welding Processes and Consumables:

a. All welding requirements, chemistry requirements, hardness requirements and Heat treatment requirements shall be in full compliance with NACE Standard SP0472 unless more stringent requirements are specified elsewhere.

b. The following welding processes can be used:

- Manual Welding Processes:
  - i. Shielded Metal Arc Welding (SMAW).
  - ii. Tungsten inert gas (T.I.G / GTAW).
- Semi-automated Welding Process,
  - i. Gas Metal Arc Welding (GMAW) or Submerged-Arc Welding (SAW).
- Automatic Welding Process,
  - i. Automatic M.I.G. process and submerged arc process.

c. Flux Cored Arc Welding (FCAW) shall not be used for pressure part/wetted part materials with the exception for structural welding which is not to any pressure part/wetted part material.

d. Oxy fuel gas welding shall not be used.

e. Submerged Arc Welding (SAW) shall not be used up to 6 mm base plate thickness. However this can be used for weld overlay of Stainless steel material (P8) up to an overlay thickness of 6 mm. This process shall not be used for root pass on material with P numbers P-5 to P-8.

f. SMAW shall not be used for base plate thickness up to 3 mm.

g. Gas Metal Arc Welding (GMAW) (Short–circuit Arc) shall not be used.

h. Gas Metal Arc Welding (GMAW) (Pulsed Arc) shall be used only for Fill and Cap passes in case of material with material thickness up to 15 mm with P number P1 and with material thickness up to 6 mm in case of material with P number P2 to P7.

i. Gas Metal Arc Welding (GMAW) when envisaged for butt-welding of carbon steel pipe, the pipe size shall be minimum NPS 4 or above unless the welding is performed in 1 G-rolled position.

j. Carbon di-oxide shall not be used as shielding gas with the exception for structural welding which is not to any pressure part/wetted part material.

k. There shall be no hydrogen in the shielding gas or backing gas.

l. Electrodes, filler wire, wire/flux combinations and fusible inserts shall be selected in such a way that they will match the composition and mechanical properties of the parent plate material.

m. Only Basic Coated Electrodes (low Hydrogen type) shall be used. Rutile and Cellulosic coated electrodes shall not be used. The diffusible Hydrogen limit in the weld metal shall be 4 ml /100 g max and needs to be indicated in the MTC.

n. Welding consumables shall be approved by an appropriate official authority e.g. Lloyds Register of Shipping.

o. The addition of alloying elements to the weld pool by means of the flux shall not be used.

p. Low alloy, high strength weld materials shall not be used unless the vessel is required to be post weld heat treated (PWHT).

q. Electrodes and fluxes shall be stored under the conditions recommended by the consumable manufacturer. Batches of low hydrogen type electrodes shall be kept in a suitable portable heater, when out of the stores or on the shop floor.

r. Welding consumables from approved batches only shall be used. Each batch of electrodes/filler wire shall be approved by certificate to ensure compliance with ASME Section II Part C.

s. Welding consumables shall be distributed on a daily basis and the remainder shall subsequently be returned to the electrode store at the end of each working shift.

t. The maximum diameter of electrodes for welding plates in the flat position shall be 5 mm, and 4 mm maximum diameter for other positions.

u. Upon approval of the welding procedures the Vendor shall order all the necessary welding consumables for completion of the vessel. However if this is not possible a certificate of approval will be required for each batch number of electrodes/wire etc.

v. The storage, baking, issue and return of welding consumables shall be controlled by procedures with documented records.

w. Basic low-hydrogen electrodes and fluxes shall give a weld metal deposit with a diffusible hydrogen content which shall not exceed 4 ml/100 g weld metal.

x. The level of hydrogen shall be tested using the procedure in ISO 3690 if there is any doubt as to the welding consumable control level or if extra moisture resistance needs to be confirmed.

y. No electrodes shall be left lying on the site or in workshops. Electrodes so left shall be scrapped, as in the case of electrodes, which have damaged flux coatings.

z. Submerged arc flux shall be supplied clearly identified in moisture-proof containers and shall be stored in a dry location at a temperature above 20 °C. The identification shall be in compliance with the relevant consumable standard.

aa. Submerged arc and gas metal arc wire shall be clearly identified and shall be stored in a dry location at a temperature above 20 °C. The identification shall be in compliance with the relevant consumable standard. Unidentifiable and/or rusty wire shall not be used.

bb. Submerged arc and gas metal arc consumables shall be withdrawn from store only when required for immediate use. Unused consumables shall be returned to store on completion of the welding operation. Batch numbers shall be recorded on issue. After issue from storage, agglomerated fluxes shall be held in a heated condition as per manufacturer's recommendation.

cc. Unless otherwise stipulated by the Manufacturer of the flux, submerged arc flux may be recycled but shall be free from fused flux, slag particles, mill scale, dirt or other foreign matter. Before re-use, the flux shall be re-baked in accordance with the Manufacturer's instructions.

6.12 Lowest Permissible Temperature for Welding:

a. If the tensile strength of carbon and carbon manganese steels is $\leq$ 460 MPa.
   - Ambient temperatures between 0°C and -10°C. The metal shall be heated to 20°C even if pre-heating is not specified on the welding procedure. Precautions, such as local heating, and 'Lagging shall be taken to avoid rapid cooling after welding.
   - If the ambient temperature is below -10°C no welding shall be conducted.

b. If the tensile strength of carbon, carbon-manganese, carbon-molybdenum, or other low alloy steels exceeds 460 MPa, the above requirements shall apply except that no welding shall be conducted if the ambient temperature is below 0°C.

c. No welding shall be carried out when the parts to be welded are wet.

d. All welding shall be carried out under cover against wind, rain, sand and snow.

6.13 Main Seams:

a. Where because of practical difficulties welding from one side only is proposed, GTAW process shall be used for root and hot pass to ensure complete fusion. Whenever possible, the root shall be dressed smooth by grinding prior to radiography.
b. At least two runs of weld deposit shall always be used.

6.14 Tack Welds:

a. If tack welds are employed for the alignment of the parts being welded, the tack welds shall be confined to the root of the bevel.
b. Tack welding using pieces of bar in the groove is prohibited.
c. Temporary tack welds shall be removed by grinding or chipping and the area ground smooth without reduction of wall thickness, followed by MT or PT inspection to confirm the absence of linear indications.
d. Tack welds shall be carried out by qualified welders using approved electrodes and pre-heat, as specified on the welding procedure.
e. Defective tack welds shall be removed by grinding before welding the root pass.

6.15 Fillet Welds:

a. Fillet welds shall be such as to ensure proper fusion, and penetration of weld metal at the root of the joint.
b. A minimum of two runs of weld deposit shall be used for the attachment of all pressure fittings; one pass will be acceptable for non-pressure fittings.
c. Fillet welds shall be carried out by qualified welders using approved electrodes and pre-heat, as specified on the welding procedure.
d. Fillet weld dimensions shall be in accordance with the vessel drawings/applicable code.
e. All fillet welds shall blend gradually into the parent plate and be free from marked irregularities and undercut.
f. Unless detailed on approved drawings all fillet welds welded directly to the shell shall be continuous.
g. All attachment welds shall be welded all around to avoid crevice corrosion of base metal.

6.16 Welding Procedure Qualification records:

a. When the proposed welding procedures have been approved and at a convenient time prior to the commencement of production welding, procedure qualification tests shall be carried out under the surveillance of the Inspecting Engineers and the certifying Authority.
b. Separate welding procedure qualification is required for each welding process and procedure including automatic process as per ASME Section IX AWS standard welding procedure specifications are not acceptable.
c. Any change of consumable classification or consumable brand name (when corrosion testing or impact testing is required) shall call for a new qualification.
d. Where austenitic stainless steel internals are welded to vessel before PWHT, respective welding procedure shall be qualified by suitable corrosion tests after test coupons are subjected to a sensitizing heat treatment as per SA262.
e. The welding procedure qualification test for main seams shall consist of a butt weld of sufficient length to permit the full set of test pieces to be removed in addition to retaining a sufficient length of weld for possible re-tests. The carbon and carbon manganese steel test welds shall be examined by Visual inspection and full radiographic examination.

f. Material purchased for the contract, or equivalent material (i.e., specification, grade, CE and chemistry controls), shall be used for all welding procedure qualification records (WPQR's).

g. In addition to the standard mechanical tests, for hardness testing, each WPQR shall include a macro section and hardness traverses in accordance with BS EN ISO 9015-1. The series of readings shall extend from unaffected base material on one side, across the weld to unaffected base metal on the other side. Three traverses shall be made: one 2 mm below the outer surface, one 2 mm below the inner surface and one across the centre. The distance between measurements across the weld shall not exceed 2 mm. No part of the weld, HAZ or base metal shall exceed 248 HV 10. WPQR hardness testing shall be performed by the Vickers method. Requirements of NACE MR0175/ ISO 15156-2, Clause 7.3.3.3 shall also be complied.

h. The carbon steel & low alloy steel weld metal deposit shall not contain more than 1.00% nickel.

i. In case of clad material, the welding procedure shall be qualified in accordance with ASME IX, QW-217.

   i. The weld overlay of the finished production welds at a depth of 2.5 mm shall be chemically analysed by PMI machine to the following extent:

      - One analysis per course;
      - One analysis per head;
      - One analysis per each nozzle size.

      In addition to the above each finished production weld shall be chemically analysed by PMI machine. The material composition shall comply with the specification of chemical requirements for the original clad material. The WPS shall indicate the minimum deposit thickness qualified and the minimum number of layers required.

   ii. The ferrite content of the austenitic stainless steel weld overlay of the production welds shall be determined to the following extent:

      - One analysis per course;
      - One analysis per head;
      - One analysis per each nozzle size.

      The ferrite content shall be between 3% and 8%. Ferrite content shall be checked by Ferritiscope or other approved testing equipment/gauges.

j. Liquid penetrant examination shall be performed over the entire weld overlay surface. The acceptance criterion shall be zero indications of cracks.

k. The weld deposit overlay procedure shall be qualified on base metal of the same composition as the vessel and thickness of one-half of the vessel thickness, or 2 inches, whichever is less.

l. The Manufacturer shall demonstrate that he is able to control the chemical composition of the weld overlay within agreed values, either by using a normal multi-layer technique in which the first layer is applied with a low heat input, or by a proven single-layer mechanised welding process. The latter is subject to approval by the Company.

m. For all processes and layers, the heat input specified on the WPS shall not exceed the heat input recorded on the PQR by more than 10%.

n. Welds in the base materials shall be non-destructively examined, depending on the inspection percentage, before any overlay weld is deposited. Ultrasonic examination for final acceptance purposes shall be on finished welds (including weld overlay, clad restoring and PWHT).

o. The tests detailed above shall be conducted after any Post weld heat treatment or surface dressing that may be required.

6.17 Welder's Performance Qualification Tests:

a. All welders and welding operators shall be qualified in accordance with ASME IX and welding procedure prior to the commencement of production welding.
b. Welders and welding operator qualification tests shall be witnessed by the nominated certifying agency. Previously endorsed qualification certificates shall be approved by the certifying agency prior to production welding.
c. Vendor shall demonstrate that the welder qualifications are valid at all times and maintain record for the welders for welding in the specific process since last qualification.
d. In the event of "special welding task", the Inspection Engineer can request that the welder be qualified specifically for this task.

6.18 Identification of Welders:

a. All welders qualified for the work shall be assigned identification numbers.
b. Records showing the date and the results of qualification tests conducted by each welder and the identification mark assigned to him shall at all time be available for scrutiny.

6.19 Production Control Weld Test Plates:

a. Production control test plates shall be provided (when required as per fabrication code) at the rate of two test plates per 100 m of butt weld or part thereof (circumferential plus longitudinal) and shall represent the welding on the vessel or on a group of similar vessels made of the same material, ordered to the same specification and with the same welding procedure/welder/welding operator qualification.
b. The test plates shall be made at an early stage of production welding with a thickness equal to the thickness of the shell.
c. In the case of spherical vessels, the test plates shall be welded separately and they shall represent each type of seam and welding position.
d. For site-constructed vessels, the test plates shall be welded at the construction site.
e. Half the total number of plates (minimum one plate) shall be selected and tested at an early stage. The required tests shall be in accordance with those required for Welding Procedure Qualification as described in ASME IX.
f. If the vessel will be post-weld heat treated, then these test plates shall be given a simulated heat treatment before testing, and time/temperature record shall be retained by the Vendor. The test plate’s results shall be considered valid if the eventual vessel post-weld heat treatment is performed within the specified time/temperature range. The other test plates shall be placed inside the vessel during its post-weld heat treatment, and shall be retained in case later testing may be required.
g. Transverse weld hardness testing of production welds shall be carried out using a portable Vickers or Rockwell tester in accordance with ASTM E 110 or by another method capable of detecting a hard HAZ in a reliable and repeatable manner (e.g., Equotip, Microdur or other equivalent if approved by the Company).
h. Whenever possible, tests shall be made on the inside (process-wetted side) of the vessel.
i. Tests shall be made on properly ground surfaces.

j. One set of hardness measurements shall be carried out for each welding procedure qualification applied and for each 10 m of finished weld (with a minimum of one test).
k. For each set of hardness measurements required, the average of three measurements on the weld and on each HAZ shall be reported.
l. No part of the weld, HAZ or base metal shall exceed 248 HV 10.

6.20 Continuity of Welding:

a. Main seam welds shall not be allowed to cool to ambient temperatures until the thickness of the weld deposit exceeds one-third of the final weld thickness or at least two passes whichever is the greater. If this does occur, the Company shall be informed.
b. In the case of Cr-Mo materials, if there is a delay period between completion of the welds and the post-weld treatment operation, the weld shall be heated to a minimum temperature of 300°C and held for one hour per 25 mm of thickness, prior to cooling in still air.

6.21 Rectification Work:

No repairs shall be made without the agreement of the nominated certifying agency. Any damage to the vessel walls incurred during fabrication, i.e. broken off bridge pieces, arc strikes etc., shall be rectified. If this involves welding, the work shall be carried out using the pre- and post-weld heat treatment cycles and consumables used to qualify the butt-welding procedure.

6.22 Weld Repairs:

a. Weld defects shall not be rectified without the consent of the Inspection Engineer /certifying agency. The weld repair procedure shall be submitted for Company review/ approval.
b. SAW (Submerged arc welding) shall not be used for repair welding of pressure vessels
c. Weld defects shall be removed by arc-air gouging, chipping or grinding. If arc-air gouging or chipping is used, the resulting cavity shall be dressed by grinding prior to welding. In case of repair in weld overlay, removal of defects shall not reduce the base metal thickness below the minimum design thickness.
d. The repaired weld and adjacent area shall be subjected, as a minimum requirement, to the same testing and inspection requirements as the original weld.
e. The cost of all repairs and subsequent inspection shall be the responsibility of the Vendor.

6.23 Pre- and Post Weld Heat Treatment

a. Vessels shall be given PWHT if required by Code / data sheet for General services or if the service is hydrocarbon /sour /lethal. PWHT requirements shall be in accordance with the equipment design code, Company specification for Pre and Post Weld Heat Treatment of Ferrous Materials, and the requirements specified herein. The PWHT procedure shall clearly indicate the type and location of calibrated thermocouples to be used. These details form part of the heat treatment procedure to be submitted for approval.
b. The post-weld heat treatment procedure and requirement shall be subject to review by the Contractor and Company, when it is required in the field.
c. A post-weld heat treatment certificate/chart stating actual temperature/time parameters shall be included in the Manufacturer's report. The original temperature/time indicator recorder charts may be retained by the Manufacturer.

d. In the case of Cr-Mo steels, if the final required heat treatment is not performed directly after welding for fabrication reasons, a post-weld soaking heat treatment shall be performed at a temperature of 350 °C for 3 hours, without cooling down below the preheat temperature, prior to cooling down to ambient temperature. However, nozzle welds shall receive an intermediate post-weld heat treatment.

e. Controlled atmosphere furnaces are required for all thermal processes to reduce airborne contamination and prevent oxides developing. Neutral to slightly reducing atmosphere is required.

f. Pre-heat temperatures shall be controlled by temperature indicating crayons or contact pyrometer.

g. During gas/air pre- heating, care shall be taken to ensure that carbon deposition does not occur.

h. Flange facings must be protected against oxidation during heat treatment.

i. Post-weld heat treatment shall be achieved by one of the following methods, care being taken to ensure that the stipulated temperature is attained throughout the wall thickness.
   - Heating in a stationary furnace.
   - Electrical resistance heating coils.
   - Induction coils.

j. The use of manually operated gas torches, gas rings or exothermic processes shall not be used for post weld heat treatment.

k. Where local pre- or post-weld heat treatment is applied, it shall be carried out as per Welding Research Council (WRC) Bulletin 452,June-2000, “Recommended practices for local heating of welds in Pressure vessels”.

l. During post-weld heat treatment, a minimum of six thermocouples per furnace load shall be used to ensure that a uniform temperature is achieved throughout the heat treatment cycle, and that sharp thermal gradients do not occur. The thermocouple location shall be approved by the Inspection Engineer /certifying agency prior to heat treatment.

m. The thermocouples may be attached to the equipment by any means in order to achieve accurate metal temperatures.

n. It is permissible with large vessels that cannot be completely contained within the furnace to stress relieve a section of the vessel with the protruding section being suitably insulated against undesirable thermal gradients. The vessel can then be turned round to stress relieve the other section, having an overlap as per the requirement of Welding Research Council (WRC) Bulletin 452,June-2000, “Recommended practices for local heating of welds in Pressure vessels”.

o. No welding shall be conducted after final post weld heat treatment, except with particular agreement of the Company.

6.24 Pickling and Passivation

a. High alloy steel clad or high alloy steel vessels need to be passivated according to ASTM A 380.The level of acceptance shall be determined as per ASTM B-117. Stainless steel surfaces which are not coated/painted shall be pickled and passivated after hydrotesting and before commissioning.

b. Oxidation may be removed by mechanical means. The surface shall be polished with a grinder and a smooth transition to the unpolished base material surface shall be made. The final surface roughness, Ra, shall be less than 12.5 micrometers.

c. Never use grinding wheels, sanding materials or wire brushes made of iron, iron oxide, steel, zinc or other undesirable materials that may cause contamination of the stainless steel surface.
d. The use of carbide or other non-metallic tooling is recommended.
e. Grinding wheels, sanding wheels and wire brushes that have been previously used on other metals shall not be used on stainless steel.
f. Never use steel shot, grit or abrasives that have been used to blast other materials.
g. Use only clean, unused abrasive such as glass beads or GARNET or Aluminium oxide for abrasive blasting.
h. Thorough cleaning prior to any thermal processing is critical. Stress relieving, annealing, drawing or other hot-forming process can actually draw surface contaminants deeper into the substrate, making them impossible to remove during passivation.
i. Care shall be taken during all thermal process to avoid the formation of oxides.
j. Passivation is not designed to remove decolouration and will not penetrate heavy oxide layers. In extreme situations, additional pickling and de scaling operations are required prior to passivation to remove the decolouration.
k. Pickling and passivation shall be carried out in acid solutions, which shall be based upon a mixture of HF/HNO3. The acid concentrations shall be controlled by means of analysis. Details on minimum and maximum concentrations (including contaminating elements such as. Fe2+, Fe3+ and other metal ions), exposure time and temperature shall be included in the pickling procedure. For final rinsing, only fresh water with a chloride ion concentration of less than 200 mg/kg shall be used.
l. In case of CRA clad with CS backing, adequate precaution must be taken to prevent CS in contact with pickling chemicals / acid. Alternatively, manufacturer shall recommend other suitable methods of pickling, which are subject to COMPANY approval.
m. After rinsing, the item shall be dried using blowers.
n. Pickling and passivation using pastes shall only be carried out on the outside of equipment, pipelines, pipes etc. Pastes shall be specifically produced for the purpose of oxidation removal and shall contain no halogens. Any residuals of such pastes shall be removed after cleaning by washing with copious quantities of fresh water.

7. INSPECTION REQUIREMENTS

7.1 Vessels shall be inspected in accordance with design code requirements as a minimum and the requirements specified in this specification and purchase order documents.

7.2 The final non-destructive examination of welds for acceptance purposes shall be carried out after completion of PWHT, if any. At the Vendor's option, automated ultrasonic examination may be performed before PWHT, in which case radiography shall be performed after PWHT for acceptance purposes. Automated ultrasonic examination may be performed in lieu of radiography if agreed by the Company.

7.3 Surface irregularities, including weld reinforcement, inhibiting accurate interpretation of the specified method of nondestructive examination shall be ground smooth.

7.4 Examination of all welds shall include a band of base metal at least one inch wide on each side of the weld.

7.5 All non-destructive examination personnel shall be qualified to minimum PCN level 2 or ASNT level 2 and shall have minimum 3 years of experience in respective test methods. Company reserves the right to request to demonstrate the ability of the personnel to prove his/her knowledge, skill and experience.

7.6 All General service vessels shall be spot radiographed as a minimum. Extent of NDE for internal flaws shall be as specified in data sheet / Code whichever is more stringent. All pressure and non-pressure welds shall be visually inspected where accessible. All segments of longitudinal, circumferential or built-up head pressure weld seams covered or rendered inaccessible by internals, lifting lugs or other attachments shall be fully radiographed over the entire affected length plus 25 cm (10 inches) either side prior to installation of the attachment. In case radiography is not feasible, ultrasonic examination shall be performed.

7.7 In hydrocarbon/ sour/ lethal services, for examination of internal flaws, the full length of all categories of welds (A, B, & C) shall be examined 100% by radiographic or ultrasonic methods (in case radiography is not feasible).

7.8 For examination of internal flaws in category D welds on nozzles, ultrasonic examination shall be performed.

7.9 Radiography shall be used for butt welds for thickness up to 75 mm (or 38 mm if the double-wall technique is used). For a plate thickness greater than 75 mm, PAUT (Phased Array Ultrasonic Testing) or TOFD (Time of Flight Diffraction) ultrasonic inspection technique shall be used which is capable of producing hard copy inspection results.

7.10 If PAUT & TOFD techniques are applied, approval of technique, technicians, equipment and the acceptance criteria shall be based on prequalification.

7.11 For examination of surface flaws, the full length of all categories of welds (A, B, C and D), and internal attachment welds, shall be examined by the wet magnetic particle or liquid penetrant method.

7.12 On equipment operating below 0 °C, there shall not be any undercut.

7.13 100% visual inspection shall be performed for all weld joints.

7.14 Full penetration tee or corner-type joints including nozzle attachment welds shall be non-destructively examined by either radiography (preferred) or ultrasonic.

7.15 The pad eyes attached to Vessels shall be subjected to self-weight lift / load test followed by 100% PT/MPI before transportation. Load test shall be witnessed and certified by Company approved Third party inspection agency. Upon successful completion, the pad eyes shall be colour coded according to current Company practice.

7.16 Inspection of Formed Heads

a. Pre-forming inspection:

- All process connection openings in shell and head plates that exceed 150 mm diameter shall be ultrasonically tested for lamination when the plate thicknesses are $>$ 38 mm.

- In addition to the requirements of the acceptance standards, the plates shall be considered acceptable only if lamellar defects in a single plane do not exceed the following limits:
    - Maximum total defect length of 170 mm in any metre of plate edge.
    - Maximum area of any individual defect not to exceed 970 sq. mm.
    - A maximum penetration of defect into the plate of 50 mm.
    - Maximum length of 75 mm for any individual defect parallel to the edge.
    - Any defect less than 320 sq. mm in area will not be considered in the overall assessment.
- For wall thicknesses greater than 100 mm, or if the angle of the fusion edge preparation is no more than 10°, a supplementary examination shall be performed by a mechanised tandem technique with an angle of refraction of 45°.

b. After forming inspection

- After forming, the inside and outside surfaces of the formed heads shall be visually examined.
- When a head is constructed from more than one plate, the weld in the region of the knuckle radius shall be radiographed as a minimum requirement.
- 100% MT / PT examination shall be conducted on all heads at the following locations
    - All weld seams on inside and outside surfaces.
    - All weld preparations.
- Defects found during the inspection of formed heads may be repaired by welding but the Vendor shall submit the proposed rectification, for approval prior to carrying out any rectification. Any weld repairs that may be necessary shall be completed prior to final heat treatment.

7.17 Visual inspection

a. Final inspection shall be carried out after the removal of all slag, mill scale, dirt, grit, weld, spatter, paint, oil or other foreign matter from the equipment (It is the Vendor's responsibility to offer equipment in a suitable condition for the Inspecting Engineer(s) examination which includes the provision of scaffolding/ ladders when required).

b. Surface Finish for Flange Face shall be judged by visual comparison with surface finish roughness standards conforming to ANSI B 46.1.

c. The weld profiles shall be as follows:

i. Profile of Internal and External Reinforcement: The weld metal shall be properly fused with the parent metal without significant undercutting or overlapping at the weld toe. Weld toes shall blend smoothly into the parent metal and the depth of local undercutting shall not exceed 5 % of the plate thickness or 1 mm whichever is smaller. The external weld reinforcement shall not exceed 3 mm and the internal weld reinforcement shall not exceed 2 mm. The weld shall be substantially symmetrical about the centre line of the joint.

ii. Weld Surface Finish: The stop and start of each run of weld metal shall merge smoothly and show no pronounced hump or crater on the weld surface.

iii. Fillet welds shall be regular in form and free from undercut.

7.18 Radiographic Inspection

a. Radiographic examination of main seams shall be conducted using either an X-ray or gamma ray techniques.

b. Radiographs shall be identified numerically along each seam and an overlap of 75 mm minimum per exposure shall be employed.
c. The Vendor shall adopt a radiographic procedure, which is capable of producing films within the required density range and with good contrast and definition.
d. The film sensitivity, as established by the penetrameter, shall be at least 2 percent. Suitable isotope such as Se-75 should be used for radiographic examination of weld thickness less than 8 mm to achieve required sensitivity.
e. A minimum film density of 2.0. is required.
f. D.I.N/ASTM type penetrameters shall be used that have similar radiation absorption properties to the material being radio graphed.
g. The penetrameters shall be positioned across or adjacent to the weld, on the source side of the section being radio graphed.
h. One penetrameter per film is required except when a complete seam is radio graphed in one exposure (i.e. panoramic technique of circumferential seams four penetrameters at 90° will be acceptable).
i. When spot radiography is specified, a minimum of 10 percent of the main seams shall be radio-graphed in addition to all weld junctions. The location of the spots shall be selected by the Inspecting Engineer(s).
j. When unacceptable defects are found by spot radiography, at least two additional r radiographs shall be taken of the weld seam. If no further unacceptable defects are found, the defects revealed by the first radiograph shall be repaired and re-radio-graphed. If the check radiographs reveal further unacceptable defects, the Vendor, after agreement with the Inspecting Engineer(s), shall be responsible for either:

- Cutting out, rewelding and re-subjecting the whole weld seam to spot radiography.
  Or
- Radiographing the whole weld seam and repairing the defective areas. Radiography, after repairs, shall confirm the elimination of defects.

7.19 Ultrasonic Examination of Welds

a. Ultrasonic methods of inspection may in some cases be used to supplement radiography subject to agreement.
b. 100 % ultrasonic weld examination is required in the following cases:
   i. Where plates having a tensile strength in excess of 460 MPa are welded by any manual arc process.
   ii. All seams in plates welded by a semi- or fully automatic welding process.
c. However ultrasonic weld examination may be waived if any of the three conditions below are met:
   i. Thickness <10 mm.
   ii. Design pressure $\leq$ 0.4 MPa and design temperature between 0 and 120°C.
   iii. Tensile strength of the plates is $\leq$ 420MPa and the thickness of the plates $\leq$ 25 mm and the submerged arc welding process is used.
d. Integrally clad plate and linings applied by overlay weld deposit, and products formed from these materials, shall be ultrasonically examined for a minimum of 10% of the clad surface, including no less than 1 square foot in each 10 square feet or fraction thereof for the lack of bond after forming. Un-bonded areas that cannot be encompassed by a 3-inch diameter circle shall be repaired by weld deposit overlay. When repairs exceed 5% of the total area examined, the whole vessel shall be examined for 100%. Repaired areas and weld deposit overlay at weld seams shall be examined by 100% liquid dye penetrant examination in accordance with ASTM E

165.Ultrasonic examination shall be in accordance with the requirements of SA263/ SA264/ SA265 as applicable.

e. Integrally clad plate and linings applied by overlay weld depositing, and products formed from these materials, shall be ultrasonically examined to check the quality of the bond in accordance with the requirements of SA263/ SA264/ SA265 as applicable. In addition, the following requirements shall be fulfilled:
    i. Any unbonded area shall be smaller than 10 cm2;
    ii. The total of the unbonded areas shall not exceed 100 cm2 per 1 m2 area of plate (areas less than 1.0 cm2 shall be ignored).

   This also applies to clad restoring of welds in clad plate where a band of 50 mm wide on each side of the weld shall be examined.
f. In the event of the Company requiring ultrasonic weld examination; the Vendor shall produce a test report, outlining the technique employed and the findings. The report shall contain sufficient information to permit duplication of the examination at a later date.
g. Ultrasonic examination of welds shall be carried out only by a qualified technician (PCN / ASNT Level 2) who can prove his ability by production of a certificate endorsed by a recognised organisation (i.e. Welding Institute etc.).
h. Dye-penetrant inspection shall be conducted after post weld heat treatment, where this is required.
i. All weld areas which are to be subjected to dye-penetrant inspection shall be sufficiently smooth to avoid false defect indications, particularly from irregular weld surfaces and undercutting or overlapping at the toes of the weld.
j. All weld deposit overlay, whether by manual or automatic procedures, shall be 100% liquid dye penetrant (PT) examined in accordance with the methods described in ASTM E 165. When the overlay involves multiple passes (layers) and the procedure uses an intermediate heat treatment with cooling to room temperature prior to applying the second layer each layer shall be 100% PT examined. Weld deposit overlay machined surfaces shall be 100% PT examined after final heat treatment. Weld deposit overlay shall be spot PT examined (a minimum of 10% of the surface including no less than 1 square foot in each 10 square feet or fraction thereof) after final heat treatment and shop hydrostatic testing. Flange facings need not be included in the spot examination after hydro test. The finished weld deposit overlay shall be spot ultrasonically examined (a minimum of 10% of the surface including no less than 1 square foot in each 10 square feet or fraction thereof) before final heat treatment. Unbonded areas that cannot be encompassed by a 1 in diameter circle shall be repaired by removing and re-welding. When repairs in excess of 5 % of the total examined area are required, the vessel shall be 100 % ultrasonic examined, with acceptance criteria in accordance with SA263/ SA264/ SA265 as applicable.
k. Areas on the equipment surface which have been rectified by welding shall be subjected to dye-penetrant examination.
l. All cracks and fissures and circular defects greater than 1/16-inch (1.5mm) diameter in weld deposit overlay shall be removed. Repaired areas shall be 100% re inspected by-liquid-dye-penetrant.
m. The weld deposit overlay procedure shall be qualified on base metal of the same composition as the vessel and thickness of one-half of the vessel thickness, or 2 inches, whichever is less.
n. Nozzles in alloy-lined portions of vessels shall be alloy lined and faced. The facing shall be made with weld deposit which is at least as thick as the lining when properly machined and of the same alloy as the lining. When nozzles are lined with ferritic type 405 or 410S stainless steel linings, the facing weld deposit shall be made with type 309 welding electrode. The facing weld deposit for austenitic stainless steel linings

shall be made with type 309 welding electrode for the first pass, and the welding electrode for the second pass shall be of the same or similar analysis as the lining.

o. The method of lining large nozzles and manways shall be by integrally bonded cladding or weld deposit overlay.

p. Welds shall be considered acceptable if found free from all linear defect and if porosity levels are within the permissible limits specified by the Fabrication Code.

8. TESTING REQUIREMENTS

8.1 Vessels shall be tested in accordance with design code requirements as a minimum and the requirements specified in this specification and purchase order documents.

8.2 Testing requirements shall be as specified in the Company Standard Procedure for pressure testing of pressure vessels. All inspection and testing activities shall be carried out as per approved Inspection and Test Plan (ITP).

8.3 It is the Vendor's responsibility to carry out the hydrostatic pressure tests on the vessels at the pressure specified on the drawing or data sheets, in the presence of the Inspecting Engineer, the certifying authority as specified. When the test pressure is not indicated, the Vendor shall calculate it in accordance with the requirements of the Fabrication Code, Company Specifications and Company Standard Procedure for pressure testing of pressure vessels.

8.4 Test pressure gauges shall be of the direct-reading type and shall be periodically calibrated (minimum every 6 months). The certificate for calibration will be presented to the Inspecting Engineer prior to the commencement of tests.

8.5 Test pressure gauges and pressure recording chart shall be connected directly to the vessel. The test gauge shall be visible to the operator.

8.6 Prior to carrying out the final pressure test, all reinforcement plates shall be leak tested using air (via a 'tell tale' hole) at a pressure of 25 Psi with soap water.

8.7 No type of preservative or paint shall be allowed to cover any joint, mechanical or welded, before the pressure test is completed.

8.8 The water quality to be used for hydrostatic testing depends on the material(s) of construction of the vessel. Whatever the source of the hydrotest water, it shall be filtered through a 10 μm filter when filling the system. Water analysis report shall be submitted for Company’s approval.

8.9 Generally, test water at a minimum temperature of 7°C will be satisfactory. In instances where the ductile to brittle transition temperature of the steel is above 7°C, then it is the Vendor's responsibility to heat the water to a desired temperature such that the vessel wall temperature is never allowed to fall below the transition temperature plus 5°C. Code requirement of maintaining a minimum metal temperature of “MDMT of the Vessel plus 17 °C” during the test shall govern if the value is higher than 7 °C. It is the Vendor's responsibility to submit a procedure of such hydraulic tests in writing for approval.

8.10 The test pressure shall be maintained for a sufficient length of time to permit a thorough examination to be made of all welds and joints. The test pressure shall be held for at least 1 hour per 25 mm vessel wall thickness (excluding inspection time).

8.11 During this test, the hydraulic pump shall be disconnected and the pressure as shown on the pressure gauges shall not decrease.

8.12 Gaskets in joints which form an integral part of the equipment (e.g. blank connections) are to be of the correct service type for pressure test-purposes.

8.13 If the Vendor wishes to use alternative test methods, or fluids in the case of hydraulic testing, such proposals must be submitted in writing for discussion and agreement by Company is mandatory.

8.14 In order to determine whether any permanent set has occurred, measurements of the vessel shall be taken before filling for pressure test and after the vessel has been drained.

8.15 Permanent set on cylindrical portions of the vessel shall be determined by circumferential measurements taken at intervals not exceeding 600 mm (24") throughout the length of the vessel. Suitable measurement of the ends according to the shape shall also be made. In the case of jacketed vessels, measurements shall also be taken of the internal diameter of the body whilst the jacket is being pressure tested. In the event of any permanent set being observed this shall be recorded, and brought to the attention of the Company. The same steel tape shall be used for all measurements.

8.16 Hydro testing of vessels shall be monitored/recorded using a pressure recorder chart. The maximum range of pressure recorder shall preferably be over a range of about double the intended test pressure. This requirement is in addition to the pressure gauges used while testing.

8.17 Vessel manufactured from carbon steel or low-alloy steel may be hydrostatically tested with potable, brackish or salt water as available. If potable water is not used, the test water shall be completely drained and the equipment flushed with potable water immediately after testing and thoroughly dried with hot air or steam. If potable water is used for the hydro-test, the maximum Chloride content of test water shall be 200-ppm (sanitized with Chlorine). If this is not practicable, great care shall be taken with the treatment of the water to avoid any chance of oxygen corrosion or microbiological activity, with oxygen controlled to < 10 ppb and suitable bactericide added for control of bacteria for the time period that the hydrotest water will remain in the vessel.

8.18 Vessel manufactured from austenitic stainless steel /high nickel / corrosion-resistant alloys, the water used for hydrostatic testing shall not contain a concentration of chlorides more than 30 ppm, either present originally or resulting from evaporation, that may precipitate stress corrosion cracking or pitting. If biological components are left in systems or introduced with the testing water, there is also the possibility of Microbiologically Induced Corrosion. The Vessel shall be tested with condensate, boiler feed water or demineralised water. Alternatively, it may be tested with potable water provided that it is either drained or mechanically dried immediately after the testing, or flushed with condensate; boiler feed water or demineralised water immediately after the testing. This flushing media should not contain more than 2 ppm chloride content.

8.19 Duplex stainless steel is highly susceptible to crevice corrosion when in contact with oxygen-containing water. The preferred hydrostatic testing method is to use potable water and to carefully rinse the equipment immediately after the pressure test with condensate, boiler feed water or demineralised water, followed by thorough drying or dewatering of the equipment and filling with nitrogen in such a way that all oxygen is removed from the system.

8.20 When hydrostatically testing equipment manufactured from or containing 9% Ni steel, the water used shall be of a neutral pH value, clear and free from sulphides, which may otherwise precipitate stress cracking of the equipment. Complete and thorough draining and drying of the equipment is required after the removal of the test water.

8.21 The Vendor shall ensure that vessels are completely drained and dry prior to blanking for transportation.

9. FIREPROOFING & INSULATION

a. When specified on the data sheets/ drawings support skirts shall be fireproofed in accordance with COMPANY Specification for Passive Fire Protection.

b. Uninsulated vessels supported on skirts which are to be fireproofed, shall be fitted with a fireproofing capping ring. Insulated vessels shall have fireproofing capping rings incorporated with bottom insulation support. The fireproofing shall be in accordance with the requirements specified in the vessel data sheet.

c. The thickness, extent, and method of support of external insulation shall be detailed in the in the Project Specifications and Standard Drawings by the Purchaser/ Contractor/Engineer.

d. Insulation supports shall be welded to vertical vessels in the fabricator's shop.

e. Insulation supports shall not be provided for horizontal vessels unless otherwise stated in data sheet.

f. Personnel protection shall be provided on an accessible section of a pipe and/or equipment; transmitting and/or holding fluid whose normal operating temperature is greater than 65°C.

10. SPARE PARTS AND SPECIAL TOOLS

a. Contractor/Engineer shall prepare/propose spares list for Company review and approval in line with Company Specification for Vendor Document and Data requirement for Spare Parts.

b. Pre-commissioning, commissioning, Start-up Spares:

i. Spares shall be included in Equipment Manufacturer scope
ii. Spares list shall include as minimum:
1) One set of Gaskets for blind flanges, girth flanges, Manways and special cover flanges,

2) 10% of bolting (minimum 5 pieces of bolts and nuts) required for blind connections, manways, special flanges and Internals,
3) One complete set of Gaskets for Internals Parts/connections,
4) One set of Filter/Coalescer elements, if applicable,
5) Special tools for internals installations.

c. Contractor/Engineer shall prepare and develop list of recommended spares for 2 years operation. List of 2 years operation spares per unit should include the following as minimum:

i. Two sets of Gaskets for blind flanges, Manways and special cover flanges.
ii. 20% of bolting (minimum 10 pieces of bolts and nuts) required for blind connections, manways, special flanges and Internals.
iii. One complete set of Gaskets for Internals Parts/connections.
iv. One set of Filter/Coalescer elements, if applicable.

d. List of special tools shall be submitted by Contractor/Vendor for Company review. Manufacturer shall supply the listed special tools and tackles required for the equipment for operation and/or maintenance. These are the tools which are not freely available in the market or non-standard tools or the tools developed by the Manufacturer.

e. Requirement of hydraulic bolt tensioning device shall be checked by Contractor/Vendor and If required by Purchaser, it shall be supplied by Contractor/Vendor.

f. If design calls for a non-standard flange, the companion flange and its fasteners including the spares shall be in the Supplier's scope of supply

11. PRESERVATION AND STORAGE

a. Any additional requirements, such as protection of internal surfaces, and Preservation and storage shall be in accordance with Company Specification for Preservation of New Materials & Equipment, in addition, to the Contractor/Manufacturer's requirements.

b. Each equipment and all loose items or spare parts shall be protected to withstand ocean transit and an extended period of storage at the jobsite. Extended period protection shall be 18 month minimum. All items shall be protected against any adverse environments, such as: humidity, moisture, rain, dust, dirt, sand, mud, salt air, salt spray, and seawater.

c. Stub ends of nozzle connections shall be coated with a suitable preservative and closed with airtight plastic plugs.

d. Open flange faces shall be greased and covered with bolted-on airtight, gasketed protective plates.

e. Stud bolts shall be coated with a graphite and white lead paste before fitting.

f. All SS, Non-ferrous and Clad vessels shall be preserved using low pressure nitrogen or other Company approved preservation method.

12. ADNOC OFFSHORE REFERENCE DOCUMENTS

Designation	Title
ADNOC	
ADNOC COP V2-03	Code of Practice on Environmental Protection
ADNOC COP V6-01	Identification and Integrity Assurance of HSE Critical Equipment and Systems
Company	
A0-ENG-N-SL-001	Status List for ADNOC Offshore Technical Standard Documents
A0-ENG-V-STD-001	Standard Drawings for Static Equipment
A0-ENG-EMS-PRO-009	Procedure for Energy Efficient Design
A0-ENG-R-GR-001	General Requirements for Packaged Equipment
A0-ENG-P-SP-001	Specification for Small Bore Piping Connections
A0-ENG-S-SP-004	Specification for Structural Design of Equipment Skids
A0-ENG-S-STD-001	Design Criteria for Fixed Offshore Structures
A0-IG-C-SP-010	Cathodic Protection Specification for Tanks and Vessels Internal Surfaces
A0-IG-L-MS-001	Lifting Integrity Management System
A0-IG-P-SP-003	Specification for Spun Hot Dip Galvanization & Polytetrafluoroethylene (PTFE) Coating of Nuts/Bolts and Fasteners
A0-IG-P-SP-004	Coating Specification for New & Existing Constructions of Offshore and Onshore Structures
A0-IG-J-CP-001	Inspection & Testing requirements for new Equipment & materials in manufacture
A0-OP-R-PRO-001	Procedure for Nitrogen/Helium Leak Test
A0-Q-PQ-CP-001	Code of Practice for Project Procurement Inspection
A0-Q-PQ-SP-001	EPC Contractor Quality Personnel Requirements
A0-Q-PQ-SP-002	Requirements for Contractors Quality Systems on Major Projects
A0-Q-PQ-SP-003	Quality Assurance and Quality control requirements for construction works
CP-00	Code of Practices for Plant Design
A0-IG-Z-CP-001	Code of Practice for Integrity Assurance in Projects
A0-IG-W-CP-001	Code of Practice for Symbols for Welding and Non-Destructive Testing
A0-IG-F-CP-001	Code of Practice for Inspection and Testing of Plant In Service: Static Mechanical Equipment & Lifting Appliances
CP-108	Minimum Recommended Spacing For Welded Connections
DST-003 Part 1	Data Sheets for Computerized Maintenance Management System of Mechanical Equipment
GD-STD-000-001	e-Manual Standard
GDL-008	Guideline for Spare Parts Management
GDL-009	Project Deliverables
GDL-012	Material Selection
GDL-015	Guideline for Operations, Maintenance & Integrity Philosophy for Projects
A0-IG-C-GDL-002	Preservation of Production & Process Facilities
GDL-040	Concession Request
A0-ENG-Z-PRO-002	Management of Change (MOC - Applications)
Z0000-PB-STD-G-001	Numbering Procedure for Engineering Drawings
A0-IG-F-PRO-001	Procedure for Magnetic Particle Inspection
A0-IG-F-PRO-002	Procedure for Liquid Penetrant Inspection

PRO 110 Part 2	Procedure of Pressure Testing of Pressure Vessels
A0-OP-R-PRO-001	Procedure for Nitrogen/Helium Leak Test and Purging
PRO-151	Procedure for Material Preservation
HSE 102	Health, Safety and Environment Regulations
Z0000-PB-GEN-N-121	HSECS Identification and Performance Standards Procedure
SP-1000	Specification for Materials for Sour Services
SP-1002	Preservation of new Materials & Equipment
SP-1021	Water Quality for Hydrostatic Test
A0-IG-P-SP-006	Thermal Insulation (Hot & Cold) of Piping and Equipment
A0-IG-P-SP-007	Specification for Passive Fire Protection
A0-IG-W-SP-002	Pre and Post Weld Heat Treatment of Ferrous Materials
A0-OP-M-SP-001	Specification for Operating Manuals and Operating Procedures (OPERGUID)
A0-ENG-P-SP-004	Specification For Stress Analysis
A0-IG-Z-SP-001	Integrity Requirements for Baseline Survey of New Equipment in Projects
A0-ENG-S-SP-102	Specification for Weight Control of Offshore Structures
SP-1131	Specification for Piping Classification
SP-1149	Specification for Sour Services Application for Offshore and Onshore Facilities
SP-1162	Specification for Duplex and Super Duplex Material
STD-00 Part-1	Measurement Units
STD-00 Part-2	Site Condition and Data
STD-100	Approval of Materials of Manufacture Mechanical Equipment
STD-103	Approval of Welding Procedures and Welder Performance
A0-ENG-P-STD-001	Standard for Flanges
A0-ENG-P-STD-006	Bolting for Piping
A0-ENG-P-STD-007	Standard for Gasket
A0-ENG-P-STD-002	Piping Fittings
STR-001	Maintenance Strategy
STR-002	Corrosion Management Strategy
STR-07	Strategy for Records Management
Z0000-GL-GEN-N-011-062	Noise
Z0-TS-M-01020	Noise Design Requirements for Plant & Equipment
Z0-TS-M-01040	Quality Assurance and Control of Pressure Vessels, Heat Exchangers and Packaged Equipment
Z0-TS-P-05010	Piping material specification
Z0-TS-Y-02030	Specification for Ceramic Coated for High Temperature Exposure
Z0-TS-Y-03010	Thermal Insulation-Hot Services for Piping and Equipment
Z0-TS-Y-03020	Thermal Insulation-Cold Services for Piping & Equipment
Z0-TS-Z-01010	General Environmental data at ZADCO Onshore & Offshore Facilities
Z0-TS-Z-02010	Vendor Document and Data Requirement for Mechanical Equipment Packages
Z0-TS-Z-02040	Vendor Document and Data Requirement for Spare Parts