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Technical Specification for Pressure Vessels



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1	X	X	X					41	X						
2	X	X	X					42	X						
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1. GENERAL

1-1 Introduction

This project involves the engineering and construction of a new mineral processing facility, designated as “Phase 3,” dedicated to copper and molybdenum concentration as a primary and byproduct recovery operation.

The facility is engineered to process mineral ore with the following operational capacity parameters:

- Nominal Capacity: 2,340 dry tonnes per hour (dtph) of fresh ore feed.
- Design Capacity: 2,700 dry tonnes per hour (dtph) of fresh ore feed.

The plant design configuration incorporates sufficient operational flexibility and redundancy to ensure reliable performance under “Maximum” throughput conditions, adhering to the specified design capacity requirements.

1-2 Scope

This specification defines the minimum requirements for the design, manufacture, inspection and testing of Pressure Vessels in Phase III & IV Copper-Moly concentrate plant project. if some item of this specification is not applicable, VENDOR shall specify, a list of any specific exclusion to this specification, otherwise any claims for extras arising out of non-compliance with this specification will not be considered. Compliance by the manufacturer with the provisions of this specification does not relieve him of the responsibility of furnishing Pressure Vessels and relevant accessories of proper design, mechanically suited to meet operating guarantees at the specified service conditions.

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In addition to requirements of this criteria, work shall be done in accordance with recognized and accepted theories, methods, codes, standards and good engineering practice. It should be noted that all Engineering (Detail Design), Procurement and Construction activities must be done by Contractor, based on Project Design Criteria, Specifications and engineering documents approved by Employer.

No deviations or exceptions from this specification shall be permitted without written approval of the Contractor. All activities must be done base on contract documents by contractor and should be submitted to Employer for review and approval. Contractor should be assured about using last revision of all documents.

Supplier shall follow requirements of this specification together with all its due referred approved documents (such as P&ID, data sheets, material requisition, welding procedure specification, surface preparation and painting specification, etc.) as well as latest available edition of all specified international codes and standards which most of them are mentioned in following section.

1-3 Regulations

The work shall be done in accordance with the national and local laws and regulations. For subjects not covered by regulations or specifications, the design and construction shall be based on good engineering and working practice and shall be subject to approval by EMPLOYER in written.

The contractor shall inform the EMPLOYER in case of any deviation from the requirements of this specification, which is considered necessary, in order to comply with national/local regulations.

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1-4 Reference Codes and Standards

The latest revision and edition of the following codes and standards shall constitute minimum requirements of this specification, where applicable. In any case of discrepancy between the codes and standards and specifications, the requirements shall be considered according to EMPLOYER written approval.

ASME SEC VIII Div.1 & 2	Rules for Construction of Pressure Vessels
ASME SEC.II	Material Specification
ASME SEC.V	Non-Destructive Examination
ASME SEC.IX	Welding & Brazing Qualification
ASME B16.20	Metallic Gaskets for Pipe Flanges
ASME B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
ASME B16.47	Large Diameter Steel Flanges NPS 26 through NPS 60
ASME B16.5	Pipe Flanges and. Flanged Fittings
ASME B16.9	Factory-Made Wrought Steel Butt Welding Fittings
ASME B16.30	Unfired Pressure Vessel Flange Dimensions
ASME B 36.10	Welded and Seamless Wrought Steel Pipe
ASME B 36.19	Stainless Steel Pipe
ASME B 31.3	Piping-Process Piping
ASTM A-388/A-388M	Standard Practice for Ultrasonic Examination of Heavy Steel Forging)
ASTM A-435/A-435M	Standard Specification for Straight Beam Ultrasonic Examination of Steel Plates
BS EN 10204	Metallic Products-Types of Inspection Documents

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ISO 9001:2000	Quality Management Systems Requirements
ISO 9001:1994	Quality Systems-Model for Quality Assurance in Design/Development, Production Installation and Servicing
ANSI	American National Standards Institute (For flange connections, couplings, fasteners, etc.)
DIN	Deutsches Institut fur Normung (German Institute for Standardization)
AWS	American Welding Society
ISA	Instrument Society of America
ISO	International Organization for Standardization Including:
ISO 12944	Paints and varnishes — Corrosion protection of steel structures by protective paint system
ISO 2768	General tolerances
OSHA	US Occupational Safety and Health Administration
ASTM	American Society for Testing and Materials
NACE	National Association of Corrosion Engineering
UBC 97	Uniform Building Code

Notwithstanding the above, it is VENDOR 'S responsibility to bring to the notice any conflict between the above documents.

The design of vessel and equipment parts, which are not covered by the specified code or this specification, shall be carried out according to VENDOR 'S standard and shall be agreed with the CONSULTANT.

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1-5 Occupational Health and Safety

The Contractor shall adopt safe systems of work which minimise the risk to health and safety. All persons working on the site shall be competent to carry out their tasks and duties safely and in a manner that will not endanger their own health nor the health of others. Persons, when first employed on the site, shall be subject to appropriate pre-employment occupational health checks, instructed on the hazards inherent in the site, precautions to be taken, the form of construction, and emergency procedures and fire safety. Such instructions shall be given whenever there is a material change in the working arrangements. The Contractor shall maintain a record of all persons instructed and each person shall be required to sign such record confirming that instruction has been received. No person shall be permitted on site without being inducted as set out above. The Contractor shall prepare a written statement of Safe Systems of Working which shall be issued to all persons at site.

1-6 Quality Management and Records

- The project shall be administered using an accredited Quality Management System conforming.
- References to the agreement of materials, workmanship, methods, etc. throughout this Specification shall be interpreted as requiring the agreement of the Employer.
- The Contractor shall maintain all records necessary under this Specification, including quality records as appropriate.
- Copies of all site records shall be available to the Employer.
- The Contractor shall supply the Engineer with all information necessary for the Health and Safety File including as-built drawings and records, maintenance schedules, operation and maintenance manuals, within the time

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specified in the contract, after substantial completion of the Works.
Information shall be provided in the agreed format.

1-7 Language

All drawing design information, Documentation, Operation, and Maintenance Instructions & Correspondence shall be in English.

2. Design Data

2-1 General

VENDOR is responsible for design calculations for all pressure and structural parts of the vessel, for ensuring that the equipment design is adequate to withstand all internal and external loads, and for meeting the relevant code requirements for design, fabrication, testing and certification.

Pressure vessels shall be designed for combined loads applicable to the transportation, erection, operation, shutdown and test conditions. These shall, as a minimum, include loads due to wind, erection, dead weight, static pressure, moments from piping, platforms and ladders, temperature gradients and transportation Where possible VENDOR shall design Columns to be "Fully Dressed" for transport from VENDOR'S works to the site and for lifting in fully dressed condition from horizontal to vertical position at site, this shall include attachment of platforms, ladders etc. This shall be agreed with the CONSULTANT.

Design and operating temperatures and pressures and corrosion allowances shall be as specified on the equipment data sheet. The stated design pressure is the pressure at the top of the vessel. The mechanical design shall take into account the most arduous combination of temperature and

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pressure to which the vessel may be subjected, during normal operation, servicing and testing.

All vessels shall be designed for the maximum allowable working pressure. The maximum allowable working pressure for each vessel, at the coincident design temperature, shall be determined by calculations utilizing the new metal thickness minus the corrosion allowance, and shall be stated on VENDOR 'S drawings, together with limiting element. Nozzle necks, nozzle reinforcement and flanges shall not be limiting elements in the determination of maximum allowable working pressure. If nozzle necks, nozzle reinforcement or flanges prove to be limiting elements, the MAWP shall be limited to the design pressure.

If VENDOR identifies design or fabrication problems in meeting the requirements of the applicable code or the specifications and/or data sheets, the CONTRACTOR shall be consulted before the work is commenced.

Vertical vessels shall be designed to permit hydrostatic testing as erected in the fully corroded condition with the test pressure applied at the top of the vessel.

Internal diametral baffles which are welded to the shell and offer restraint to natural expansion/contraction shall be the subject of special consideration and calculations shall be submitted to the CONTRACTOR to verify their integrity. Where strakes differ in thickness the inside diameter of the vessel shall be constant.

VENDOR shall check the suitability of the standard drawings, included in Specification for Standard Details for Static Equipment, prior to use, and provide calculations to verify that the design is appropriate for the intended purpose.

All calculations should be based on the output of PV Elite software.

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2-2 Site Condition

For Site Condition Refer to Document no. 12002-D-PR-DOC-303-GNL-001.

2-3 Materials

- VENDOR shall use materials as specified on the approved vessel data sheets. VENDOR shall confirm the suitability of these, and any other proposed materials, for the specified service, operating and design conditions.
- VENDOR may propose alternative materials, which are equal to or better than those specified, subject to written approval from the CONSULTANT.
- Materials of construction shall be identified with the applicable ASME material specification, including material grade. When no such designation is available, the material specification giving physical properties, chemical composition, and test requirements shall be included.
- All materials for pressure parts and welded attachments to pressure parts shall have full chemical analysis and mechanical test certification to BS EN 10204 - 3.1C for material greater than 50mm thick and 3.1B for the remainder.
- All materials shall be new and of first quality and of the type and grade specified on the individual vessel data sheet.
- All carbon steels shall be fully killed and, unless otherwise agreed, be made to fine grain practice. Chemical content of materials shall conform to the material specification stated except that carbon content for any welded component shall not exceed 0.23%. The maximum carbon equivalent shall be 0.45% based on the formula:

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$$C_{eq} = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

based on ladle analysis.

For carbon, carbon manganese and low alloy steels, the maximum allowable phosphorous and sulphur content shall not exceed 0.025% each in the ladle analysis.

Carbon steel plates, pipes and forgings (excluding the following forged components: flanges, blank covers, blocking rings and support rings) of thickness 40mm or more, shall be checked by ultrasonic techniques to ensure freedom from laminations as indicated below:

Plates and generally pipes shall be tested in accordance with ASTM A-435/A 435M with acceptance criteria stated therein. Forgings shall be tested in accordance with either ASTM A-388/A-388M, with acceptance criteria to ASME VIII DIV2 Paragraph AM 203.2. Additionally, all prepared edges of plate, pipes and forgings in these thicknesses, including holes for nozzles, manholes, etc, shall be subject to 100% ultrasonic examination in VENDOR'S works on a band extending 75mm into the component from the edge of the weld preparation. Maximum acceptable individual defect length (parallel to material edge) and width (perpendicular to material edge) shall be 25mm and 12mm respectively. Maximum individual defect area shall be 300mm². Maximum total defect length shall be 75mm in any 1m of material edge with a minimum separation between defects of 225mm. Average total length of defects shall not be greater than 30 mm per 1m of material edge. Probe size selected shall be suitable for detection of defect sizes specified, but shall be within the range of sizes recommended by ASTM A-435/A-435M. Test requirements and acceptance criteria for materials in excess of 75mm thick

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shall be subject to agreement with the CONTRACTOR. For plates less than 40mm thick, ultrasonic testing requirements, if required, shall be specified by the CONSULTANT.

VENDOR shall provide an ultrasonic examination report for each item of material containing the following information:

- Item number.
- Identification of material.
- Description of probe, including type and dimensions of crystal and test frequencies.
- Inspection technique and scanning pattern.
- Surface conditions at time of test e.g. as rolled, heat-treated.
- Scale drawing indicating areas examined and stating nozzle and manhole
- designations, if applicable, showing shape, position, depth, orientation and nature of any flaws.
- Identification of operator who carried out each inspection or part thereof, if performed in VENDOR 'S works.
- Description and results of any confirmatory tests obtained by other methods of NDT.
- A record of repaired areas and results of re-examination of the repaired areas.

This report shall form part of the data dossier.

- Structural quality steels and cast iron are not acceptable for pressure retaining parts.
- Reinforcing pads shall be of the same material as the component to which they are attached.

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- Non-pressure parts attached to pressure parts by welding shall be of the same material specification, including impact requirements, as the shell to which they are attached. For skirt supports, this welded on element shall extend for a minimum length of 400mm.
- Should any materials prove unsatisfactory during fabrication they shall be rejected notwithstanding any previous certification of satisfactory examination or tests.
- Nuts and bolts shall be made of different types of steel or, if made of the same grade of steel, they should have a different hardness. The difference between the two hardness values shall not be less than 15 HB.
- Any steel stamping shall be done with "Low Stress" stamps.
- Cast iron is not acceptable.
- Internal support rings and lugs welded to the shell or head shall be of the same materials as the pressure retaining parts. For other steel vessels, the following materials may be used:
 - Plates: ASTM A283 Gr.C or equivalent
 - Pipe: ASTM A106 or A53 or equivalent

2-4 Design Weight Classification

The following weights are to be determined and incorporated in all design calculations and general arrangement drawings. VENDOR shall compute fabricated weights based on the finalized design of the vessel from which empty, operating, and test weights can then be more accurately established.

- Fabricated Weight shall be the weight of the vessel including vessel supporting elements, nozzles, internal and external fixed attachments, and all other non-removable

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appurtenances, excluding insulation

- Shop Test Weight shall be the fabricated weight plus weight of water in vessel.
- Erected Weight shall be the fabricated weight plus trays, packing, grids, and other removable internal components, plus the weight of platforms, ladders, piping supported from vessel, insulation and all other removable external appurtenances.
- Operating Weight shall be the erected weight plus operating liquid including tray liquid or packing entrained liquid and bottom liquid, plus weight of piping liquid supported from the vessel.
- Weight Full of Water shall be the erected weight plus weight of water in vessel and piping supported from vessel.
- Weight Full of Operating Liquid shall be the erected weight plus weight of operating liquid in vessel when flooded and weight of operating liquid in piping supported from vessel when flooded.

2-5 Wind, Weight and Seismic Loadings

Vessels shall be self-supporting (i.e. without additional bracing or guys) and designed to withstand the design wind load based on the maximum vertical projection of exposed surfaces, which shall include insulation, platforms (1m² at each manway), ladders (150mm wide for vessel height), pipework and other equipment associated with the vessel.

- Wind speed specified on the vessel data sheet shall be used for design.

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- Wind loads shall be determined in accordance with the requirements of the Uniform Building Code.
- Vessels shall be designed for seismic loads as specified on the vessel data sheets.
- Eccentric moments induced by the weight of equipment supported from the vessel and attached piping, together with resultant moments due to piping thrusts, shall be additive to wind moments.
- The vessel shall be designed to withstand the following combined loadings:
 - Totaled bending moment, internal design pressure, and empty weight at the coincident design temperature with the vessel in the corroded condition.
 - Totaled bending moment and operating weight at the coincident design temperature (pressure shutdown) with the vessel in the corroded condition.
 - 30% of wind moment plus eccentric moments and hydrostatic test pressure with the vessel in the corroded condition. Coincident wind and earthquake loadings shall not be considered.
- Vessel supports shall be designed for the following conditions of loading:
 - Wind or earthquake moment, whichever are the greater, plus other moment loading, if applicable, and the operating weight for design of the support and its attachment weld to the vessel.
 - Vessel full of test water assuming that site testing is not

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carried out in high winds but allowing 30 percent of the total wind moment.

- Vertical vessels with a height to diameter ratio of 15 or greater shall be checked and designed as required for dynamic loading. Where calculations indicate that vibrations are critical the vessel shall be stepped in thickness to withstand the dynamic effect. In certain cases, helical spoilers may be considered to dampen dynamic vibrations.
- The maximum static deflection allowed shall be 1:200 of length when the vessel is subject to the design wind loading.

3. Lifting

- Vessels shall be provided with all required lifting and tailing lugs, to facilitate handling during transportation and erection at site.
- Where possible, lifting attachments shall be positioned and orientated so that equipment can be lifted from a single point, without the aid of a spreader beam. Attachments shall be suitably positioned such that slings do not foul any part of the vessel.
- A vertical load factor of 2.0 and a lateral load factor of 0.05 shall be used when designing lifting and tailing lugs.
- Where spreader beams are required, VENDOR shall be responsible for their supply, design and certification. The lift weight shall be factored by 2.0 for design of spreader beams. Where spreader beams or frames are used, they shall be proof tested in accordance with a recognized code. All lifting equipment shall be proof tested (witnessed) by a recognized "Third Party" competent authority. The maximum lifting capacity shall be marked on the spreader beam.

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- Sling angles shall preferably be not less than 60 degrees to the horizontal, but shall never be less than 45 degrees.
- The lift weight shall include allowances for all temporary items that may be present during lift. The lift point design force shall be determined by factoring the lift weight by 2.0, apportioning the result to the lift points according to the location of the center of gravity and resolving along the line of the sling.
- Lifting lugs and their attachment welds shall be designed to resist the lift point design force. Where a spreader beam is used, the horizontal force shall be 10% of the sling force.
- The safe working load of slings and shackles shall be not less than the lift point design force.
- The lifting lugs and their attachment welds shall be detailed such that no-load path crosses the through-thickness direction of the plate/section. Welds shall be loaded in shear rather than in tension. In extreme cases where the above is not strictly adhered to due to practical reasons, plate with proven through thickness (Z) properties shall be adopted.
- VENDOR shall also check stresses generated in the vessel wall by the lifting lug.
- Temporary steelwork for transportation, lift etc. shall be identified by color coding. Removal instructions shall be provided by VENDOR.

3-1 Local Loading

VENDOR shall also be responsible for ensuring that the design of shells and heads shall sustain any forces and moments that may be applied by piping, platforms and ladders which are supported from the vessel.

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4. Corrosion Allowance

- The corrosion allowance stated on the vessel data sheet shall be provided on all pressure parts including manways, nozzles, covers, and welds in contact with process media.
- Non-removable internals shall have the full specified corrosion allowance applied to both sides to ensure the element can withstand design loadings in the fully corroded condition.
- One half of the specified corrosion allowance shall be applied to each exposed surface of non-corrosion resistant, removable internals.
- Corrosion allowance shall not be applied to flange gasket faces.
- Designs shall avoid all features likely to promote crevice corrosion.
- Combinations of materials, which are prone to promote galvanic corrosion, shall be avoided unless proper precautions are taken.

5. Construction

5-1 Heads

Ratios of major to minor axes of elliptical or approximately elliptical shapes shall be as near to 2:1 as possible.

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5-2 Nozzles

- Nozzle flanges 24" and smaller shall comply with ASME B16.5 in all respects unless otherwise stated. Nozzles 26" and larger shall comply with ASME B16.47, Series 'A'.
- Welding neck hub thickness shall not be less than the thickness of the nozzle neck to which it is welded. Plate flanges are unacceptable. Hub flanges shall not be manufactured by machining plate.
- Nozzles shall be constructed using seamless pipe and forged welding neck flanges, unless otherwise stated on the vessel data sheet. For vessels with wall thickness greater than 40mm, integrally reinforced nozzles and manways shall be used. Reinforcing pads are not permitted. Alternatively, nozzles may be integrally forged long welding necks, which include the nozzle neck and flange in one forging. For 16" NPS and larger sizes, nozzle necks may be constructed using butt-welded rolled plate (with same material specification as shell/head), provided the weld is fully radiographed.
- The minimum permitted size of flanged nozzles is 2" NPS. All 2" NPS nozzles shall be provided with 2 off bracing gussets positioned at 90° to each other. All nozzle pipe necks 2" NPS and less shall be a minimum of Sch 160 thick.
- Set-through nozzles are preferred. Where these are not practical, set-on nozzles may be used, subject to written agreement by the CONSULTANT. The edges of the holes, in this case, shall be checked for laminar defects by ultrasonic and shall also be examined by magnetic particle crack detection or dye penetrant inspection for surface cracks. After welding, the inside surface of the hole in the plate shall again be examined for surface cracks and defects by magnetic particle or dye penetrant inspection.

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- Bolt holes for flanges shall straddle the horizontal and vertical center-line in elevation, and the North/South center lines in plan, unless otherwise stated.
- Reinforcing pads shall be of the same material as the shell plates. A 6mm NPT threaded tell-tale hole shall be provided in each section of the pad, and used for air testing the attachment welds. Before dispatch the hole shall be filled with grease only, to prevent ingress of moisture. For insulated vessels, telltale holes shall be provided with vent pipes protruding beyond insulation. Where insulation is for cold service vent pipes shall not be fitted.
- Studded connections are not permitted unless specified by the CONTRACTOR and approved by CONSULTANT.
- Bottom nozzles on vertical vessels, with skirts, shall be connected to an elbow and pipe extended beyond the skirt, and the first flange shall be located outside the skirt. The complete branch to the first flange shall be designed to pressure vessel requirements, with a double corrosion allowance. Cases where this will necessitate pipes of greater thickness than is available shall be referred to the CONTRACTOR.
- Where relatively long branches are unavoidable and particularly on thin walled vessels, the design shall incorporate suitable stiffening.
- Branches which are thick relative to the vessel wall shall be avoided, and the thickness of the branch shall not be greater than the shell to which it is attached by more than 50%. Further reinforcement may be provided by means of a reinforcing pad or preferably by either increasing the shell thickness or by use of a butt-welded forged branch as details f-2 and f-3 of figure UW-16.1 of ASME VIII Div.

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- When vessels are in Cyclic Service the inside edge of all nozzles shall be rounded off to a minimum radius of 3mm.

5-3 Manholes and Handholes

- Horizontal vessels up to 6000mm tan/tan should have one manhole located in the end opposite to the vessel vent. Horizontal vessels greater than 6000mm tan/tan should have one manhole in the top and one manhole in the side or end located at opposite end. These requirements are to promote airflow through the vessel during maintenance activities.
- Vertical vessels less than 1000mm diameter should be flanged (where removable internals are specified) or have two off 10" inspection openings. Vertical vessels between 1000mm to 1400mm diameter shall have 18" minimum diameter manholes. Vessels greater than 1400mm diameter shall have 24" minimum diameter manholes.
- For all manhole and handhole covers and blind flanges weighing in excess of 25kg, davits shall be furnished. Covers of 25kg and less shall be supplied with two handles. VENDOR shall provide calculations and proof loading certificate for davit. Safe working load shall be stamped on davit.
- Handgrips at manholes shall be provided where entry is made horizontally. For manholes more than 1500mm from the bottom of the vessel, an internal ladder or rungs shall be provided.
- Manhole and inspection opening necks shall have inside sharp edges rounded off to a minimum radius of 3 mm. All internal welds on manholes and inspection openings shall be ground smooth.

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- A manhole shall be provided in any large division plate, unless otherwise stated, to permit access to all parts of the interior of the vessel.

5-4 Bolting

- Stud bolts complete with nuts and gaskets shall be furnished by VENDOR for all cover plates, manways, blind flanges and bolted attachments supplied with the vessel.
- Stud bolts shall have a full continuous thread and be long enough to extend by two threads beyond each nut. Thread shall be metric series. All nuts shall be heavy series.
- All bolts shall be treated with graphite base lubricant.
- Hydraulic bolt tensioners shall be used for the following cases:
 - All joints with nominal bolt diameter 50mm and over.
 - Joints class 600 and over, with nominal bolt diameter 38mm and over.

5-5 Internals

- Provision shall be made for the self-draining of all internals.
- All baffles, support beams or other internals spanning a chord or diameter of the vessel shall be provided with a means of allowing for differential expansion between the part and the vessel shell.
- The design shall ensure that internal fittings cannot be loosened by vibration.
- Flanges for internal non-pressure piping may be fabricated from plate. When flanges are made from plate, the facing and drilling shall

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comply with the relevant code to accommodate standard size gaskets and bolts.

- Internal pressure piping shall be fabricated from forged flanges and pipe to the same specification as the external connected pipe.
- All internals (fixed and removable) shall be supplied and installed by VENDOR, unless otherwise stated. Removable internals shall be designed to pass through the vessel manhole(s).
- The design of fixed internals shall take into account the effect of differential strains which may arise due to transient temperature/pressure conditions in service, during post weld heat treatment or due to hydrotest conditions. the greater of the following:

Thickness for strength + (2 x Corrosion Allowance) Exp: 3 mm + (2 x Corrosion Allowance) 6 mm

- Internal fitments shall, where necessary, be supported by temporary stiffeners to prevent damage during transportation and erection. These shall not be welded to the vessel unless agreed by CONTRACTOR.
- Removable internals shall be installed after any post-weld heat treatment has been carried out.

5-6 Supports

- Supports and wrapper plates shall be continuously welded to the shell. Each saddle wrapper plate or section thereof shall have one air release hole 10mm diameter, which shall be filled with grease before dispatch.
- Supports and wrapper plates must not straddle any circumferential or longitudinal weld seams of pressure retaining parts.

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- When a vertical vessel has been designed for dynamic loading the skirt shall, as a minimum, be the same thickness as the bottom shell course.
- The thickness of a skirt at the bottom portion, containing the anchor bolt chairs, shall be designed to withstand the effects of the bolt chair reaction.
- All openings in the skirt shall be reinforced as may be required to compensate for loss of material at these points.
- The minimum number of anchor bolts for vertical vessels supported on skirts shall be four and thereafter in multiples of four. Anchor bolts shall be metric thread with a minimum size of M24. The maximum allowable anchor bolt stress shall be 103 N/mm² calculated on the root area of the bolt. See “Standard Drawing for Static Equipment”, for full details which is located in the appendix 3.
- The minimum size of anchor bolts for vertical vessels supported on legs and horizontal vessels supported on saddles shall be as shown on “Standard Drawing for Static Equipment”, which is located in the appendix 3. The maximum allowable anchor bolt stress shall be 103 N/mm² calculated on the root area of the bolt.
- Baseplate design shall be based on an allowable bearing pressure of 4.51 N/mm² resting on concrete. Where resting on steelwork, the appropriate bearing pressure shall be agreed between the CONTRACTOR and VENDOR.

5-7 Stiffeners

Where stiffening rings are required by the pressure vessel code for vacuum vessels, or large diameter vessels, these shall be both continuous and external. The rings shall be positioned at least 100mm clear of

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circumferential seams, vessel branches and other permanent attachments unless otherwise agreed by the CONTRACTOR.

6. Attachments

VENDOR shall furnish and attach all insulation support rings, external pressure stiffeners, lifting lugs, ladder and platform clips, pipe supports and all other attachments as required. Doublers plates shall be continuously welded to the vessel beneath all attachments where the welding of such attachments would cause excessive concentration of stresses on the vessel at those points. Corners of doubler plates shall be rounded to a radius of not less than 50 mm. Each plate, or sealed section thereof, shall have one air release hole 10mm diameter, which shall be filled with grease before despatch.

VENDOR shall refer to Civil & Structural Design Criteria and Specification for Design, Supply, Fabrication and Erection of Structural Steel for design and details of platforms and ladders.

7. Fabrication

7-1 Forming

- Formed heads fabricated from more than one plate, or heads built up from formed sections, shall be fully radiographed and stress-relieved after completion of all welding and forming, before welding to shells. If the vessel is to be post weld heat treated, the head need only be radiographed before welding to the shell.

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- Hot spun heads shall, on completion, be stress relieved unless the vessel is fully stress relieved. Heat treatment of hot-pressed heads is not required.

The assessment of the metallurgical condition of formed heads shall be based on the materials of construction, and the selection of heat treatment requirements shall be based on the need to:

- Develop adequate strength
- Develop adequate resistance to fracture (i.e. toughness)
- Avoid formation of any undesirable metallurgical structures

7-2 Cutting and Welding

- Plates and other stock may be cut by machining, flame cutting or shearing.
- Any materials which are cut by burning must be dressed back by grinding or machining by at least 3 mm.
- Shearing may only be used on plate less than 25 mm thick, and enough extra material shall be left on the edge to permit machining, grinding or chipping to a depth of at least 50% of the thickness for stainless steels, or 25% for carbon and low alloy steels.
- All weld preparations shall be checked for flaws, cracks, and laminations by 100% MPI or DPI techniques.
- All pressure containing welds, nozzle attachment welds, main seams in skirts, and attachment welds to the pressure containing elements shall be full penetration type and continuous.

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- All welding shall be in accordance with the latest edition of the relevant design code unless otherwise stated. Only qualified procedures shall be used.
- Welding procedures intended for use on pressure vessels shall be submitted for CONSULTANT review prior to commencement of fabrication. Welding procedures and qualifications shall comply fully with the code requirements. Welding procedure qualifications shall include impact testing requirements as parent material.
- Only welders who are qualified, in accordance with code requirements, in the accepted welding procedures shall be employed on the subject vessel.
- Welding electrodes shall deposit a composition compatible with the material being welded. Full details of electrodes i.e. chemical composition and physical properties together with specification must be included in the welding procedures.
- When the ambient temperature is 0°C or below, the base metal shall be preheated to 15°C minimum before welding unless a higher pre-heat temperature is dictated by the code.
- VENDOR shall determine the degree of pre-heating required, if any, other than as dictated by the code to prevent cold cracking, excessive hardness in the heat affected zone and excessive distortion.
- Seams in supporting skirts shall be double-butt welded.
- Size of welds for all internal attachments shall include the corrosion allowance specified on the vessel data sheets.
- Longitudinal welds in separate strakes of a vessel shell and meridional or chordal welds of heads joining the shell must not be aligned with one another, but must be staggered by a distance at

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least equal to three times the thickness of the thickest plate with a minimum displacement of 100 mm.

- When welding heads from several plates, welds located on a chord shall not be more than 0.2 of the head diameter away from the center line of the head.
- The position of longitudinal welds in horizontal vessels shall be in the upper 220 degrees of the vessel cross section.
- All vessel seams shall be located to clear nozzles and manholes and, where practical, their reinforcement. Where in isolated cases reinforcing pads cover vessel seams, these shall be ground flush and fully radiographed for a distance of 150mm measured each side of the covered weld area prior to the attachment of the pad. Vessel seams shall also be located to clear lengthy internal attachment welds and any obstructions preventing examination of welds, such as saddle wrapper plates, support brackets, etc. Where this is not possible the affected seams shall be treated as for seams covered by reinforcing pads.
- The minimum distance between the edges of attachment welds and main seams, or between the edges of adjacent attachment welds shall be the greater of 50mm or three times the thickness of the main component (e.g. the shell).
- All main seam welds shall be full penetration and, where possible, shall be double sided. The second side of seams welded from both sides shall be cleaned back to sound metal before depositing weld metal at the second side. When it is proposed to use arc air gouging on plate having a minimum specified tensile strength greater than 431 N/mm², the procedure shall be submitted to the CONTRACTOR for review. The procedure shall include pre-heating where

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appropriate and conditions for grinding after gouging. Arc air gouging on stainless steel is not permitted.

- When sound back-welding is not feasible due to inaccessibility, single welded joints which utilize a gas tungsten arc welded or gas metal arc welded root pass, shall be used.
- Weld backing rings shall not be used except where internal access is not possible for a final closing seam and where prior agreement has been obtained from the CONTRACTOR.
- The maximum weld deposit for any pass shall not exceed 6.5mm.
- All welding, both externally and internally, shall be completed prior to any post weld heat treatment unless otherwise agreed with VENDOR.
- The reinforcement (i.e. height of weld cap) of weld seams of vessels and equipment shall not exceed the following values:
 - For metal thickness up to 12 mm: 1.5 mm
 - For metal thickness from 12 to 25mm: 2.5 mm
 - For metal thickness from 25 to 50mm: 3.5 mm
 - For metal thickness over 50mm: 5.0 mm
- Sharp transfers in weld joints are not permissible. Edges of joints shall have a smooth transfer to base metal.
- Vessels subject to cyclic loading shall have all full penetration butt welds ground smooth internally and externally and, all other welds ground so as to blend smoothly into the parent material.

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7-3 Non-Destructive Examination

- The extent of non-destructive testing (NDT) shall be as stated on the vessel data sheet, and in accordance with the Code. All non-destructive testing for code/process (i.e. vessels in sour service) acceptance purposes shall be performed after any post weld heat treatment.
- The following abbreviations are used throughout this section:
 - Magnetic Particle Inspection (Wet) MPI
 - Dye Penetrant Inspection DPI
 - Ultrasonic Inspection UT
 - Radiographic Testing RT
- Notwithstanding the code, the minimum extent of NDT shall be as follows, unless stated otherwise on the vessel data sheet:
 - UT as described in Section 5.1.2.8.
 - MPI or DPI as described in Section 5.3.2.4.
 - UT, and MPI or DPI, as described in Section 5.2.2.5.
 - When preheat is interrupted: 100% MPI or DPI.
 - Second side of welds after grinding back: 100% MPI or DPI.
 - Tack welds after grinding: 100% MPI or DPI.
 - 100% visual examination (both sides of the weld, where practical).
 - Spot radiography of main seams.
 - 100% MPI or DPI (inside and out) of all butt welds, nozzle

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and attachment welds.

- Arc strikes after dressing: 100% MPI or DPI plus chemical etch to ensure no hard spots.
- Temporary attachments: 100% MPI or DPI of affected area after removal and dressing smooth.
- Attachments (e.g. lifting lugs, internal baffles) producing restraint or transmitting loading likely to produce high through thickness stress: The area of plate under the attachment shall be subjected to 100% UT prior to and after welding (no planar defects allowable).
- Special forgings after machining: 100% MPI or DPI, with acceptance criteria in accordance with ASME VIII Div 1 Appendix 6, Clause 6 -4.
- Set-through nozzles made from rolled plate and with a wall thickness in excess of 19mm shall be examined for laminations along the line of the weld prior to welding: 100% UT.
- Lifting Lug and Tailing Lug attachment welds shall be 100% UT and 100% MPI or DPI.
- Skirt attachment weld to vessel head shall be 100% UT and 100% MPI/DPI examined.
- For all vessels in sour service and ASME Section VIII Division 2 vessels the nozzle/manhole/handhole to shell/head welds shall be subject to 100% UT.

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- Longitudinal and circumferential seams made by single pass automatic welds shall be fully radiographed for all plate materials and thicknesses. Seams made by one pass automatic welding one side with manual welds on the other side are classified as single pass automatic welds.
- The NDT techniques employed and defect acceptance levels shall meet the requirements of the relevant codes.
- Any defects found during inspection shall be reported to the CONTRACTOR and CONSULTANT. Where defects are to be repaired, the repair shall be to a procedure which has been approved by the CONSULTANT. Re-examination shall include any additional radiographs or tests required by the applicable codes.
- Radiographic examination shall be by means of X-ray equipment unless the use of isotopes is specifically agreed with the CONSULTANT.
- The use of UT in lieu of X-ray shall be subject to agreement by the CONSULTANT.
- NDE operator/supervisor levels shall be based on the requirements of ASME Section VIII Division 1 UW.51 and shall be finalized and agreed by the CONTRACTOR in VENDOR 'S quality plan.

7-4 Stress Relieving

- Stress relieving shall be carried out strictly in accordance with the code requirements. Additional requirements for stress relieving shall be in accordance with any specific request and as stated in this specification.

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- During heat treatment, metal temperatures shall be recorded and copies of the chart(s) submitted to the CONTRACTOR in the certification dossier.
- All nozzles and manholes of built up construction having a wall thickness of 20mm and thicker shall be stress relieved before the gasket facing is machined and the component is welded to the vessel.
- All vessels shall be stress relieved as a complete unit where this is practicable. The top portion of supporting skirts at least shall be welded to the shell before stress relief.
- If local stress relief is required such as for a main seam, the heated band width of the local stress relief portion of the vessel shall not be less than code requirements or $2.5\sqrt{Rt}$ each side of the seam whichever is greater. The temperature at the weld shall be maintained at the required stress relief temperature while the temperature at the edge of the heated band shall not be less than half the stress relief temperature. The vessel shall be insulated locally over a band width of $5\sqrt{Rt}$ either side of the seam. If local stress relief of a branch or other welded attachment is required, the heated band shall extend around the entire circumference of the vessel. It shall have a width as above but measured in each direction from the edge of the weld which connects the nozzle or attachment to the vessel. If, due to the location of the nozzle or attachment, this requirement cannot be strictly applied the method shall be agreed with the CONSULTANT.
- R = Vessel inside radius in mm.
- t = Vessel thickness in mm.

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- All flange faces shall be suitably protected against oxidation during heat treatment.
- On vessels requiring full stress relief, all welding must be carried out before heat treatment.
- Vessels fabricated wholly from stainless steel shall not be stress relieved.

7-5 Tolerances

Fabrication tolerances shall be the more stringent of those specified on Codes, Standard & Drawings.

8. Inspection and Testing

- The CONTRACTOR'S inspector and the third-party inspector shall have free access to those portions of VENDOR 'S facilities, and any sub-VENDOR'S facilities that are utilized in any manner for construction of vessels under this specification.
- VENDOR shall include in his scope of supply the provision of all documentation required by the third-party inspector. VENDOR shall provide documentation, notification and access to his appointed inspector, to enable him to perform inspections and surveillance as necessary to satisfy code requirements.
- The CONTRACTOR'S inspector and the third-party inspector shall also have access and right of review of all records, logs, reports, certificates, etc. connected or concerned in any manner with construction of vessels under this standard.
- The CONTRACTOR'S inspector and the third-party inspector shall have the right to inspect and/or witness at any time VENDOR'S

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activities and/or operations in connection with this specification and to reject any work, material, or procedure deemed defective or sub-standard.

- The extent and stages of work at which inspection shall be carried out shall be as specified in VENDOR'S quality plan which shall be subject to agreement by the CONTRACTOR and CONSULTANT /the third-party inspector, prior to commencement of manufacture.
- VENDOR shall provide, at his own expense, all appropriate equipment and facilities required to perform the required inspection and testing.
- Inspection and witnessed tests by the CONTRACTOR and/or the third-party inspector shall not relieve VENDOR of any guarantees, responsibilities or obligations to provide satisfactory equipment. The approval of release for shipment by any inspector or representative of the CONSULTANT shall not relieve VENDOR / CONTRACTOR of the responsibility for the supply under the terms of the order, or of any guarantee.
- It is the responsibility of VENDOR to advise the CONTRACTOR and the third-party inspector when the equipment will be ready for stage inspection. VENDOR shall give notice to the CONTRACTOR and the third-party inspector as specified in the requisition.
- No goods shall be packed, sealed or dispatched prior to receipt of a written release note by the CONTRACTOR or his appointed agent.

8-1 Testing

- VENDOR is required to calculate both the new and cold, and cold and corroded test pressures. For vertical vessels VENDOR shall calculate stated test pressures in the vertical position with pressure

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applied at the top of the vessel, and additionally the new and cold shop test pressure in the horizontal position.

- Before hydrostatic testing, all internal surfaces of the vessel shall be cleaned by sweeping, vacuum cleaning, or other methods, so that the vessel is free of any loose scale, dirt, welding slag and flux, weld rod stubs and other debris. Cleaning agents shall be compatible with the materials of construction, and shall be neutralized, if required.
- Fresh water shall be used for all testing. For vessels of stainless-steel construction, or of partly stainless-steel construction, the test fluid shall not contain more than 30 ppm chlorides.
- The specified test pressure shall be held for one hour per 25mm of shell thickness, with a minimum time of one hour.
- For carbon and low alloy steels, the temperature of the test fluid for the duration of the test shall be as follows:
 - For vessels not fully post weld heat treated and not fabricated from steel with guaranteed or certified Charpy V impact properties, the minimum temperature shall be not less than the greater of the following:
 - minimum temperature required by the applicable design code or;
 - 7 °c for reference thickness* up to 18 mm or;
 - 7 °c plus 1 °c per mm of reference thickness* above 18 mm with a maximum of 20°c.
 - For pressure vessels where the thickness of any component is 75mm or greater, the test temperature shall be subject to the prior agreement of the CONSULTANT.

*Reference thickness shall be taken as the greater of:

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- actual shell or head thickness
 - 25% of thickness of any flange tube sheet or flat cover;
 - actual nozzle neck thickness
- As soon as possible after completion of the hydrotest, the vessel shall be drained and dried throughout.
 - All reinforcing pads shall be pneumatically tested at a minimum pressure of 1 Barg, using soap-suds solution, before stress relief and/or hydrotest.
 - All tests are to be carried out in the presence of the CONTRACTOR'S inspector and third-party inspector.
 - Test gaskets shall be of the same material as service gaskets. Joints which are not broken down at a later stage, may be tested with service gaskets fitted, otherwise, test gaskets shall be replaced by service gaskets. Service bolts, other than austenitic, may be used for shop testing.

8-2 Quality Plan

- VENDOR shall provide a quality/inspection and test control plan, which sets out specific quality practices and activities relevant to his entire scope of supply. The requirements regarding the format and content of the quality plan shall be agreed with the CONSULTANT. It shall include as a minimum; inspection and test activities, procedure references, acceptance criteria, documentation and certification to be provided. The above shall also apply to major sub-VENDORS.
- The final inspection and test plan will be developed jointly between VENDOR, CONTRACTOR and the CONSULTANT/third-party inspector. They will define the extent of their participation on the plan.

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- The CONTRACTOR'S, VENDOR'S and CONSULTANT/third-party inspector's representatives shall confirm compliance with the inspection and test plan by initialing and dating against completed activities, before shipment of the package. The plan may be supplemented by other inspection checklists and outstanding work lists.
- The requirements for dossier compilation shall be agreed with the CONSULTANT.

8-3 Certification

- VENDOR shall provide quality records appropriate to all inspection and test activities. The records shall be referenced against appropriate activities within the inspection and test plan.
- VENDOR shall collate all such quality records and certification for submission to the CONTRACTOR as a certification dossier. Note that, where necessary, certificates shall be stamped as approved by the third-party inspector.
- All mill test certificates shall be provided.

9. Guarantee

- VENDOR shall guarantee the mechanical design.
- VENDOR shall guarantee the suitability of the materials of construction for the duties required, even if the CONTRACTOR has specified the type and grade of material to be used.
- VENDOR shall guarantee the suitability of fabrication.

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10. Site Services

10-1 protection and Painting

- VENDOR shall submit details of his standards and procedures for any necessary temporary corrosion protection to the CONTRACTOR / CONSULTANT for review. Equipment may be stored at site for up to 12 months.
- All interior and exterior surfaces of vessels shall be thoroughly cleaned to remove all loose mill scale, rust, grease, dirt, weld spatter or other foreign matter.
- Vessels shall be externally painted in accordance with Paint Specification.
- Machined surfaces shall be left unpainted.
- For Air tank in compressed air circuit, all paintings can be done in workshop before shipment. Also, the interior painting of tank should be done with electrostatic painting. This painting procedure should be approved by consultant.

10-2 Spares

VENDOR shall provide two spare sets of gaskets and 10% spare bolting (minimum of 2 for each size) for all blanked nozzles, manways, body flanges and where specified on the vessel data sheet, as two years spare part.

10-3 Preparation for Shipment

- A black "mounting line" 50mm wide x 900mm long shall be painted on the outside of vertical vessels to indicate the plant north.

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- The equipment number shall be prominently stenciled in black letters on each side of the vessel. Letter size to be 100mm min. Size to be agreed by CONTRACTOR
- Vessels that have been post-weld heat-treated shall have prominently stenciled in black letters "Stress relieved vessel - no welding permitted". Letter size to be 50mm min. Size to be agreed by CONTRACTOR.
- Vessels partly fabricated and/or liable to suffer distortion during transit and erection shall be suitable braced. Open ends shall be covered to keep out dirt and other foreign matter.
- Telltale holes in reinforcing pads shall be plugged with heavy grease.
- All nozzle flange faces and/or machined surfaces shall be coated with easily removable rust preventative/grease, and shall be further protected with wooden or metal covers bolted in place. Screwed connections shall be protected with suitable thread protectors. The vessel shall be shipped with manway covers in position.
- Equipment shall be packed so as to be capable of withstanding an acceleration of 0.8g in any direction during sea transportation, and 0.3g longitudinally and 0.1g in the vertical and transverse sections during road transport. Suitable supports shall be provided for internal parts which may be damaged during shipment. All parts not installed on the vessel during shipment shall be boxed and tagged separately and despatched in the same consignment as the vessel.
- All spare stud bolts, nuts, gaskets, and any other loose items shall be boxed separately.
- All boxes or crates shall be clearly marked in English to indicate the contents, the vessel order number and the equipment number to which the contents relate.

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- VENDOR shall provide details of his protection and packaging specifications and methods to the CONSULTANT for approval.
- Galvanized wire, strip, bolts or other zinc elements shall not be used in association with equipment either on a temporary or permanent basis when the equipment is entirely or partly of stainless-steel construction.

10-4 Documentation

- Relevant drawings and documentation shall be provided by VENDOR in accordance with the requirements of the "VENDOR Documentation Requirement Schedule" (VDRS), contained in the Material Requisition.
- The documentation shall be submitted strictly in accordance with the timings indicated on the VDRS.
- VENDOR document type catalogue, which forms part of the VDRS, describes specific requirements regarding content, format and submission details for drawings, data sheets and manuals etc.
- Review of VENDOR'S drawings, calculations and other documents by the CONTRACTOR does not relieve VENDOR/CONTRACTOR of the responsibility for correctness under the terms of the order.

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11. **APPENDIX 1 (MINIMUM NOZZLE THICKNESS AND STANDARD DIMENSION OF REINFORCING PAD)**

Nozzle size NPS	Reinforcing Pad DIA. mm	Nozzle neck thick. for corrosion allowance		
		1.5 mm SCH	3.0 mm SCH	5.0 mm SCH
2"	-	LWN	LWN	LWN
3"	190	80	160	LWN
4"	220	80	160	160
6"	300	80	80	160
8"	400	80	80	160
10"	500	80	80	160
12"	600	80	80	80

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14"	680	40	80	80
16"	780	40	80	80
18"	870	40	40	80
20"	970	40	40	80
24"	1160	40	40	40

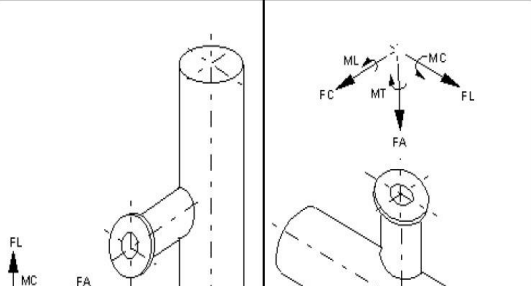
12. APPENDIX 2 (NOZZLE ALLOWABLE LODAS AND MOMENTS)

NOZ ZLES SIZE	OUT SIDE DIAMETE R	VESSEL AND SHELL & TUBE HEAT EXCHANGER ALLOWABLE FORCES & MOMENTS FOR ASME VIII DIV.1 or 2																							
		150LB & 300LB FLANGE RATING						600LB FLANGE RATING						900LB FLANGE RATING						1500LB FLANGE RATING					
		FORC ES KN			MOMEN TS KNm			FORC ES KN			MOMENTS KNm			FORCES KN			MOMENTS KNm			FORCES KN			MOMENTS KNm		
IN.	mm	FL	FA	FC	MC	MT	ML	FL	FA	FC	MC	MT	ML	FL	FA	FC	MC	MT	ML	FL	FA	FC	MC	MT	ML
2	60.33	3.3	3.3	2.5	0.4	0.6	0.5	3.8	3.8	2.9	0.5	0.7	0.6	4.3	4.3	3.2	0.5	0.8	0.7	4.8	4.8	3.6	0.6	0.8	0.7
3	88.90	4.9	4.9	3.7	0.9	1.3	1.1	5.6	5.6	4.2	1.0	1.5	1.3	6.3	6.3	4.7	1.1	1.7	1.4	7.0	7.0	5.3	1.2	1.8	1.6
4	114.30	6.3	6.3	4.7	1.4	2.1	1.8	7.2	7.2	5.4	1.6	2.4	2.1	8.1	8.1	6.1	1.8	2.7	2.4	9.0	9.0	6.8	2.0	3.0	2.6
6	168.28	9.3	9.3	7.0	3.1	4.6	4.0	10.6	10.6	8.0	3.5	5.3	4.6	11.9	11.9	8.9	4.0	5.9	5.1	13.3	13.3	9.9	4.4	6.6	5.7
8	219.08	12.1	12.1	9.1	5.2	7.8	6.8	13.8	13.8	10.4	6.0	8.9	7.7	15.5	15.5	11.6	6.7	10.0	8.7	17.3	17.3	12.9	7.4	11.2	9.7
10	273.05	15.1	15.1	11.3	8.1	12.1	10.5	17.2	17.2	12.9	9.2	13.9	12.0	19.4	19.4	14.5	10.4	15.6	13.5	21.5	21.5	16.1	11.6	17.3	15.0
12	323.85	17.9	17.9	13.4	11.4	17.1	14.8	20.4	20.4	15.3	13.0	19.5	16.9	23.0	23.0	17.2	14.6	21.9	19.0	25.5	25.5	19.1	16.3	24.4	21.1
14	355.60	19.6	19.6	14.7	13.7	20.6	17.8	22.4	22.4	16.8	15.7	23.5	20.4	25.2	25.2	18.9	17.6	26.5	22.9	28.0	28.0	21.0	19.6	29.4	25.5
16	406.40	22.4	22.4	16.8	17.9	26.9	23.3	25.6	25.6	19.2	20.5	30.7	26.6	28.8	28.8	21.6	23.0	34.6	30.0	32.0	32.0	24.0	25.6	38.4	33.3
18	457.20	25.2	25.2	18.9	22.7	34.0	29.5	28.8	28.8	21.6	25.9	38.9	33.7	32.4	32.4	24.3	29.2	43.7	37.9	36.0	36.0	27.0	32.4	48.6	42.1
20	508.00	28.0	28.0	21.0	28.0	42.0	36.4	32.0	32.0	24.0	32.0	48.0	41.6	36.0	36.0	27.0	36.0	54.0	46.8	40.0	40.0	30.0	40.0	60.0	52.0
24	609.60	33.6	33.6	25.2	40.3	60.5	52.4	38.4	38.4	28.8	46.1	69.1	59.9	43.2	43.2	32.4	51.8	77.8	67.4	48.0	48.0	36.0	57.6	86.4	74.9
26	660.40	36.4	36.4	27.3	47.3	71.0	61.5	41.6	41.6	31.2	54.1	81.1	70.3	46.8	46.8	35.1	60.8	91.3	79.1	52.0	52.0	39.0	67.6	101.4	87.9
28	711.20	39.2	39.2	29.4	54.9	82.3	71.3	44.8	44.8	33.6	62.7	94.1	81.5	50.4	50.4	37.8	70.6	105.8	91.7	56.0	56.0	42.0	78.4	117.6	101.9
30	762.00	42.0	42.0	31.5	63.0	94.5	81.9	48.0	48.0	36.0	72.0	108.0	93.6	54.0	54.0	40.5	81.0	121.5	105.3	60.0	60.0	45.0	90.0	135.0	117.0
32	812.80	44.8	44.8	33.6	71.7	107.5	93.2	51.2	51.2	38.4	81.9	122.9	106.5	57.6	57.6	43.2	92.2	138.2	119.8	64.0	64.0	48.0	102.4	153.6	133.1
34	863.60	47.6	47.6	35.7	80.9	121.4	105.2	54.4	54.4	40.8	92.5	138.7	120.2	61.2	61.2	45.9	104.0	156.1	135.3	68.0	68.0	51.0	115.6	173.4	150.3
36	914.40	50.4	50.4	37.8	90.7	136.1	117.9	57.6	57.6	43.2	103.7	155.5	134.8	64.8	64.8	48.6	116.6	175.0	151.6	72.0	72.0	54.0	129.6	194.4	168.5

NOTES

1. All forces and moments in the above table are positive and sign notation is as per WRC bulletin 107.
The most stringent case caused by axial load FA acting inward or outward shall be considered.
2. The supplier shall ensure that all process nozzles shall be suitable for the nozzle loads shown in the above table and provide the necessary local calculations in accordance with WRC bulletin 107 and ASME code.
3. All forces and moments act on the intersection of the axis with the mid-thickness of the shell or head plates.
4. The supplier shall notify the Purchaser of cases where calculations require an increase in thickness of the reinforcing greater than

6. LOADING NOMENCLATURE
Forces: FL=Longitudinal
FA=Axial
FC=Circumferential
Moments: ML=Longitudinal
MT=Torsional
MC=Circumferential
7. For spheres and heads
Resultant shear force: $F = (FL^2 + FC^2)$
Resultant bending moment: $M = (ML^2 + MC^2)$



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13. APPENDIX 3 (STANDARD DRAWING FOR STATIC EQUIPMENT)