

F.1 GENERAL ENGINEERING REQUIREMENTS**F.1.1 Language**

All documentation and drawings shall be in the English language, but where required by other authorities, another language may be used, but the English translation shall also be given alongside.

F.1.2 Corrosion allowance

All pressure retaining parts and internals welded into the vessel shall have the corrosion allowance added to each surface in contact with the process medium, unless instructed otherwise by a Purchaser design standard or the vessel drawing.

F.1.3 Welding

Welding procedures and welders for pressure parts shall be qualified in accordance with ASME section IX. Welding for non-pressure parts may be performed not according to ASME section IX, but performed by qualified welders and general welding procedures that shall be reviewed / approved by purchaser.

F.1.4 Native files

In addition to the Vendor document submission to Purchaser for review and approval during the design, procurement, fabrication and inspection stages, Vendor shall supply the native files of the Vendor Documents upon Purchaser's request. If supplied as a pdf file, the search function should be enabled.

F.1.5 Lifting plan

For heavy lifting and heavy equipment transportation, Vendor shall provide details of a lifting and transportation plan for review and comment.

When lifting devices are to be provided by Vendor, Vendor shall submit the related strength calculation, welding details and shop test certificate with the lifting plan.

For other shipping requirements, Vendor shall follow the instructions and requirements for shipping and packing in the procedures enclosed in the Commercial section and relevant specification attached in this MR.

F.1.6 Wind load

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| Code | ASCE7-2005 |
| Basic Wind Velocity | 53m/s |
| Exposure Category | C |
| Importance Factor I | 1.15 |

KBC 2016 calculation also shall be submitted and severe calculation result shall be applied in comparison with ASCE7-2005.

F.1.7 Earthquake load

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| Code | UBC-1997 |
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| Seismic Zone | 2A |
| Importance Factor I | 1.25 |
| Factor Z | 0.15 |
| Soil Profile | Sd |

KBC 2016 calculation also shall be submitted (Soil profile : Sd), and severe calculation result shall be applied in comparison with UBC-1997. (Soil profile : Sd)

F.2 SPECIFIC ENGINEERING REQUIREMENTS FOR PROCESS

F.2.1 Site conditions and Available utilities

Site conditions and Available utilities shall be referred to Basic Engineering Design Data (PE-3100_Rev.0).

F.2.2 Measuring units

The measuring units shall be based on the MKS units except dimensions of piping and equipment nozzles, which shall be designed according to ASME standards and sized by the English/American units, i.e. : inch system. For details, refer to Basic Engineering Design Data (PE-3100_Rev.0).

F.3 SPECIFIC ENGINEERING REQUIREMENTS FOR MECHANICAL

F.3.1 General

- a) FCAW welding process is not allowed for all pressure parts.
- b) Equipment shall be fabricated in accordance with ESS-40110, ESS-40111, PVM-SU-4750-H and PVM-SU-5290-A.
- c) All plates and forgings shall be produced with a fine grain practice and vacuum degassed.
- d) Entire surface of forgings and plates 2-inch thick and greater shall be ultrasonically examined with 100% scanning
- e) Entire surface of forgings, regardless of thickness, shall be magnetic particle examined after finish machining
- f) Entire surface of forgings, regardless of thickness, shall be magnetic particle examined after finish machining
- g) All equipment shall be hydrotested as per project specification and Code rules, and any other means such as pneumatic test are not allowed. Also hydro test shall be performed by 1.3 X MAP (New & Cold).
- h) Reinforcement of nozzles shall not limit either the maximum allowable working or test pressure.
- i) All internal flange connections shall be fastened with double nuts.

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- j) All indicated thickness in the mechanical data sheet shall be applied as minimum and, if specified minimum thickness has not enough strength as a result of detail strength calculation, vendor shall increase and verify all used thickness considering all design condition including wind / seismic condition.
- k) The deflection under wind load conditions shall be limited to maximum $H/200$ for operation conditions (H : total height of vessel from base). The corrosion allowance shall be excluded in the evaluating deflection.
- l) Nozzle elevation shown on the data sheets is preliminary. Purchaser will have the right to finalize them by fabrication drawing approval
- m) Vendor's welding procedures shall be submitted to purchaser for review and approval prior to start of welding fabrication. A weld map for each vessel, and/or parts thereof shall be submitted with weld procedures locating and identifying each weld procedure number
- n) Development drawing showing all nozzle, weld seam location, internal & external attachments, etc. shall be provided
- o) The materials directly welded on pressure retaining components shall be of the same material as that used for the shell and heads.
- p) Pickling and passivation for all Stainless Steel surface shall be done. (Clad or weld overlay surface shall be carried as per ASTM A380)
- q) ASME B16.47 Series "B" standard should be applied for nozzle flanges larger than 24" nominal size and analyzed per Appendix-2 of ASME Section VIII Div.1 taking care of all external loading.
- r) Attachments used for erection of the vessel shall be designed with an impact factor of 1.5
- s) Flange surface finishes shall be 125-250 AARH for spiral wound gaskets and 63~125 AARH for ring joint gasket. Finishes shall be judged by visual comparison with surface finish roughness standards confirming to ANSI B46.1.
- t) 1.5 mm corrosion allowance shall be considered for skirt design
- u) Unless otherwise specified, all flanges shall be welding neck type and long welding neck shall be used for 2" and under size.
- v) When full radiographic examination of the nozzle attachment weld is required, the attachment shall be a butt weld similar to details shown in ASME Section VIII, Division 1, Figures UW-16.1 (f-1), (f-2), (f-3), or (f-4).
- w) Full penetration welds shall be used for internal attachments as follows;
 - Vessels in hydrogen service
 - Major load bearing attachments in alloy clad vessels
 - Any attachment in alloy clad vessels
- x) Each reinforcing pad or segment shall be provided with a 1/4 inch NPT treaded "tell-

tale" hole. All tell-tale holes shall be plugged with grease after pressure test.

- y) All internals shall be fabricated in sections to permit easy removal through 24 inch diameter manhole.
- z) External flange bolting shall be full-threaded studs that conform to ANSI B1.1 or ISO-261, Class 2A or 2B, Thread Series. Nominal diameters 1" and smaller shall be of the coarse thread series while nominal diameters 1-1/8" and larger shall be of the 8-pitch thread series. Nuts shall be heavy hex type.
- aa) Vendor shall consider the external primary mechanical loads to perform the equipment design in accordance with WRC (Weld Research Council) bulletin for nozzles, clips etc. Where the local stress check is out of range by WRC, the local stress should be evaluated by Finite Element Analysis or approved equivalent.
- bb) Preparation and paint application shall be performed in accordance with the paint specification, ESS-82110.
- cc) All austenitic stainless steel for internals shall be in solution annealed condition.
- dd) Bolts and nuts, with nominal diameter 1-3/8" and larger, shall be designed for bolt tensioner application, and shall be coated with anti-seize compound.
- ee) For the bolts which are required special bolting practice, including nozzle mating flanges, required torque values and/or bolt loads shall be calculated by vendor and Vendor shall provide relevant procedure for bolt tightening.
- ff) For carbon steel and low alloy steel, the RTJ grooves shall be overlaid with TP309L before final PWHT and Alloy 625 after final PWHT. For solid stainless steel flange, the RTJ grooves shall be overlaid with Alloy 625 after PWHT.
- gg) All RTJ gasket grooves on nozzles shall be applied with 5.0mm minimum undiluted Alloy 625 weld overlay.
- hh) All nozzles and manways (whether flanged or with studding outlets) and not covered in ANSI B16.5 shall be designed with RTJ facing and furnished by the fabricator. Design of such openings shall satisfy code design requirements for pressure & temperature.
- ii) Thermal analysis of hot box design for DS-V4300 shall meet the requirement of PVM-SU-5004-I para.5.5.3, 5.5.4 and 6.10.1.

F.3.2 Alloy lined (Clad/WOL) vessel

- a) Additional Requirements for Alloy Lined Pressure Vessels (ESS-40112) shall be applied. ASME SA363/264/264 and PVM-SU-1322.H.1 shall be applied.
- b) Vendor shall specify weld overlay thickness, numbers of layer and weld processes for each part per item on their Technical Proposal.
- c) The ferrite content of austenitic stainless steel weld overlay should be between 3 FN and 10 FN, as determined in accordance with WRC Bulletin 342, prior to any PWHT except that the minimum ferrite content for Type 347 should be 5 FN (in accordance

with API 582.

- d) Clad plate which has major load bearing attachments welded to the cladding shall be subject to a shear strength test per ASME Section VIII, Division 1, Paragraph UCL-11(c).
- e) The method of lining large nozzles and manways shall be by integrally bonded cladding or weld deposit overlay.
- f) Nozzle of clad shell parts shall either be clad or weld overlay. Solid alloy nozzle and sleeve type is not allowed.
- g) Unless otherwise specified, lugs and rings for internal supports in lined portions of vessels may be welded directly to the lining only if the vessel is lined with integrally bonded lining or weld deposit overlay meeting the requirements of paragraph UCL-11(a) and (c), Section VIII, Division 1 of the ASME Code. Welds between austenitic stainless steel internal supports and stainless steel lining shall be full penetration.
- h) All weld deposit overlay, whether by manual or automatic procedures, shall be 100 percent liquid dye penetrant (PT) examined in accordance with the methods described in ASTM E165.
- i) When integrally bonded clad plate is used, it shall be ultrasonically tested at the mill to SA-578. Unbonded areas shall be repaired in accordance with the supplementary requirements S6, Level B of SA-578.
- j) Production weld overlay deposits shall be verified by check analysis to a depth of 3/4 of the required overlay thickness and shall conform to the chemistry requirements for the alloy specified. Where automatic weld deposit overlay is applied by more than one welding operator, samples shall include deposits made by each operator.
- k) Two samples of the weld deposit overlay shall be taken from each overlaid shell section and each head to confirm required analysis. Each manual weld overlay, such as those on girth seams and nozzles, shall also be sampled.
- l) Minimum two layer with TP309L (first layer) and TP304L (subsequent layer, material shall be the same as data sheet) weld overlay shall be applied to the inside of the vessel. If one layer instead of two layers except all high stress portions, such as corner radius of nozzle to shell/head, RTJ gasket grooves, attachment welded area, the vendor shall submit their commercial experience list.
- m) Single layer weld overlay cladding may be used provided the chemistry of the 3.0mm minimum thickness from the surface meets the requirements of TP304L (material shall be the same as data sheet)
- n) If vendor would apply single layer weld overlay cladding, vendor shall submit the experience list and the cost and delivery impact as an option in case of single layer weld overlay cladding. But, in any case, all nozzles and high stress portion such as

nozzle corner radius, and weld overlay restoring area, etc. shall be deposited with multiple layer (first layer of TP309L and subsequent layer of TP304L, subsequent material shall be the same as data sheet) weld overlay that covers the base metal.

- o) The chemistry of weld overlay shall be met with TP304L (material shall be the same as data sheet) chemistry on the required undiluted overlay thickness of 3.0 mm.
- p) Weld overlay disbonding test shall be performed as followed.
 - The manufacturer shall demonstrate the resistance of the weld overlay to hydrogen induced disbanding by autoclave tests in accordance with ASTM G 146.
 - Results of disbonding tests should be available, prior to fabrication, for each welding procedure to be used on the vessel shell rings and heads. Previously qualified disbonding test results can be submitted for review by the purchaser if representative of the proposed WPS and operating conditions.
 - The test specimens shall be maximum PWHT Condition.
 - The test shall be performed at the highest operating temperature and highest hydrogen partial pressure.
 - Cooling rate from the test temperature shall be as given in API RP 934-A, Table 3 & 4.

F.3.3 Vessel under wet H₂S service

- a) All materials and manufacturing process shall meet the requirements of NACE MR-0103 and Project specification (ESS-40110 Attachment #1).
- b) All pressure retaining welds in wet H₂S service shall be double butt, full penetration.
- c) Vessels in wet H₂S service shall be post weld heat treated at a temperature in accordance with the requirements stated in specification ESS-40100.
- d) Following PWHT of equipment, all internal welds shall be abrasive blasted or high-pressure water jetted and wet fluorescent magnetic particle tested (WFMT) utilizing the AC yoke method for at least one inch on each side of the toe of the weld in accordance with ASME Section V, Article 7. Acceptance Criteria shall be in accordance with ASME Section VIII, DIV 1, Appendix 6 or ASME Section VIII, Div. 2, Appendix 9, Article 9-1, whichever is applicable.
- e) For severe service, HIC testing is required on one plate from each plate thickness produced from each heat of steel in accordance with NACE Standard TM-02-84 utilizing the A per NACE Standard TM-01-77. The average crack length ratio (CLR) shall be 5% maximum for each plate tested. Also, crack thickness ratio(CTR) and crack sensitivity ratio(CSR) shall be included in mill sheet in accordance with NACE Standard TM-02-84 for reference.
- f) For conditions where the tracer could overheat vessels containing acid, caustic, amine, phenolic water, sour water (concentration of NH₄SH is 10wt% and higher) or other chemicals, insulation spacer blocks shall be installed between tracer and pipe.

(as per ST-50600)

F.3.4 Heavy wall ($t \geq 50\text{mm}$)

- a) Additional Requirements for Heavy Wall Pressure Vessels (ESS-40111) shall be applied.
- b) Carbon and low alloy steels shall be satisfied with the toughness requirements (Impact test) when the thickness exceeds 50 mm. The specimens shall exhibit minimum average impact energy of 20 Ft-lbs at test temperature with no single specimens having impact energy less than 15 Ft-lbs.
- c) Integrally reinforced nozzles shall be used in vessels with a shell thickness 50mm and above.
- d) All nozzles 3" or smaller shall be long welding neck flanges.
- e) Integrally reinforced nozzle with lip shall be used in vessel with a shell thickness over 65mm.
- f) Forging ratio shall be not less than 1:6.
- g) All main pressure welds on vessels over 76 mm thick shall be ultrasonically examined after PWHT in accordance with ASME Section VIII, Division 1, Appendix 12.
- h) All plates shall be ultrasonically examined in accordance with the requirements of SA-578. The acceptance criteria shall be in accordance with Level II. Scanning shall be on 230mm grid.
- i) All nozzles, including 1 1/2", and 2", shall be fully self-reinforcing with no reinforcement pads allowed. Except with specific written company approval, as when design thickness are established by compressive stresses, reinforcement shall not limit the hydrostatic test pressure of the part.
- j) The detail stress at the following portions of the vessel at design, operation and hydrostatic condition shall be analyzed by FEM considering all loads, thermal conditions and their configurations.
 - Support skirt connection to bottom head

k)

F.3.5 Platform & ladder

- a) All material should be ASME / ASTM designated materials except grating and vendor should provide following material.
 - Support structural members & clips: A36, A283-Gr.C, A285-Gr.C, A53-B
 - Grating should be Hot Dip Galvanized.
- b) Unless otherwise specified, Unified screw thread for bolts shall be used in accordance with Metric. All bolts shall be full thread types.
- c) All platform frame and grating shall be delivered under assembling condition

completely.

- d) The bearing bar of grating shall be arranged only to radial direction for circular platform, and to long span direction for rectangular platform.
- e) Each piece of grating shall be adequately supported by beam.
- f) Side step ladders shall be used wherever is possible.

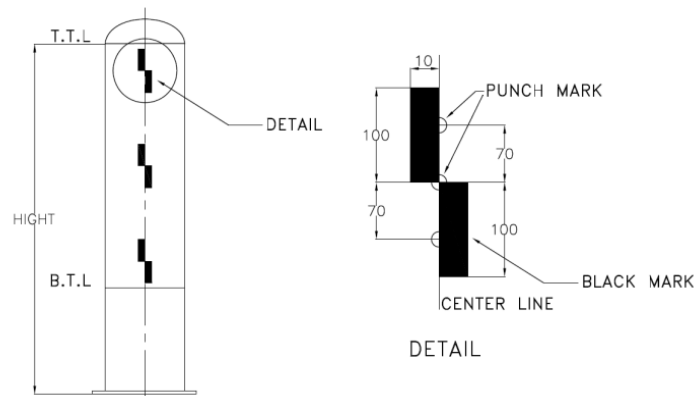
F.3.6 Shipment

- a) After pressure testing, vessels shall be completely drained and cleaned.
- b) Spare parts shall be separately packed with marking.
- c) All shop fabricated items and their internals shall be supported and/or braced to prevent damage during handling and transporting.
- d) All openings should be sealed with a steel cover and gasket, and the vessel should be filled with a minimum 0.5 kg/cm²g pressure of dry nitrogen gas. The nitrogen pressure should be maintained during transportation, erection and pre-commissioning.

F.3.7 Marking

- a) Vessels shall be clearly identified by painting or stenciling on the purchase order number, equipment item no, etc. according to purchase's instructions.
- b) All temporary items such as covers, bracing, supports, or bolting, shall be painted orange.
- c) Installation marks shall be provided in four (4) directions 0, 90, 180 and 270 degree near the top and the bottom tangent lines of equipment 20m and smaller in height as shown in Fig.1
- d) For equipment larger than 20 m in height, these installation markings shall be provided in the middle between the top and bottom tangent lines in addition to those near the tangent lines.
- e) Orientations (0, 90, 180, 270 degree) shall be indicated at easily visible points near the top of the skirt for supported vessels. For leg or lug supported vessels the orientations shall be indicated above the installation marks near the bottom tangent line.

Fig. 1 Installation Marking for Vertical Vessels

**F.4 SPECIFIC ENGINEERING REQUIREMENTS FOR PIPING****F.4.1 Nozzle force and Moment**

Allowable nozzle force and moment in ATTACHMENT J shall be applied to all process nozzles. And each process nozzle shall be designed enough to withstand at least 150% of the allowable nozzle force and moment.

F.5 SPECIFIC ENGINEERING REQUIREMENTS FOR ELECTRICAL**F.5.1 Grounding connection**

Vendor shall supply the earth lug in accordance with PEMD-B074 in ATTACHMENT G.

F.6 SPECIFIC ENGINEERING REQUIREMENTS FOR INSTRUMENT AND CONTROL

N/A

F.7 SPECIFIC ENGINEERING REQUIREMENTS FOR CIVIL AND ARCHITECTUREAL**F.7.1 Anchor bolts**

Vendor shall design the anchor bolts and nuts in accordance with ATTACHMENT G.

Anchor bolts subject to vibration or tension are to be provided with two nuts, one of which will serve as a lock nut.

Anchor bolts shall be designed in accordance following design guide;

- Minimum nominal diameter : 20mm
- Corrosion allowance : 1.5mm unless otherwise specified.
- Material : A307
- Allowable stress : 1,265kg/cm²

F.7.2 Compressive strength for concrete

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28-day compressive strength shall be 210 kg/cm² (3000 psi) for vessel foundation design.

F.8 SPECIFIC ENGINEERING REQUIREMENTS FOR INSPECTION

F.8.1 SIP (Source Inspection Plan)

Vendor shall meet the requirement of SIP which be provided by Contractor's commercial section. And it shall be developed by Vendor and approved by Purchaser.

F.8.2 Vendor shall be responsible for arranging all types of inspection, which are specified in the approved inspection plan and procedure.

F.8.3 Pre-inspection meeting (PIM) will be held at the vendor's shop or sub-vendor's shop prior to commencement of fabrication in accordance with project requirement.

F.8.4 Inspection Notices

Vendor shall submit Inspection Notification to Contractor for all witness and hold points of Contractor and Employer as specified in the approved ITP. Inspection Notification is required to be submitted 23 calendar days in advance and changing Inspection Notification is required to be submitted 5 working days if the scheduled/notified witness inspection date is changed. They shall include the following items;

- Purchase Order number
- Item numbers of Equipment / Materials
- Place of inspection
- Date of inspection
- Type of inspection to be performed (for instance, hydrotest, final inspection etc.)

Vendor is advised that failure to provide such notice will result in inspection being delayed.

F.8.5 Vendor shall perform the test and inspection as per Source Inspection Plan and Test & Inspection Procedure, which is developed by vendor and approved by purchaser.

F.8.6 For the hydrostatic test water, it shall not contain more than 50 ppm chlorides. The metal temperature during hydrostatic test shall be maintained at least 17°C above the minimum design metal temperature. Test water shall be heated to at least 16 °C.

F.8.7 For all pressure vessels in process service where the base material is C.S or Low alloy made in accordance with ASME Sec.8 Div.1, 10% of extent specified by code or SK engineering specification shall be additionally examined by recordable UT, PAUT or TOFD as follows:

a) One of the following NDE methods shall be applied.

- Recordable UT or PAUT

ASME section 5 article 4 T-472.1.3

The examination should be performed only on the weld with or without weld reinforcement. The weld cap shall be prepared enough to inspect by machining or

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flat grinding or smooth grinding, etc.

- TOFD (Time of flight diffraction)

b) Acceptance criteria

At least one weld seam shall be fully examined in each category (A/B/C/D) and the welding procedure.

If any defect observed, all weld seam shall be fully examined.

- c) Qualification for the inspector shall be submitted and approved.
- d) Inspection records shall be kept as documentations and submitted.
- e) Beam plan of inspection procedures shall be submitted and approved.
- f) Calibration set drawings for the inspection shall be submitted and approved.