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Heavy Plates & Vessels Plant
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INVITATION TO TENDER

Ref.: OS/21-22/2440/PV-LG/25/031 Date: 12.02.2022

Sub: **Fabrication of Regenerator Column against S.O. 2440 at Lovagarden site of BHEL-HPVP, Visakhapatnam**

Dear Sir,

Sealed tenders are invited for the subject work in **two-part bid** system from bidders who are experienced in fabrication of similar jobs/works and fulfil the eligibility criteria specified below at clause-1. Scope of work and techno-commercial terms and conditions are as follows.

1. ELIGIBILITY CRITERIA:

1.1 Bidders must have an experience in successful completion of similar jobs/works i.e. Columns/Pressure Vessels for process industries during the past 7 Years as on 31.01.2022 for a minimum of one project. Bidders shall enclose Work Order, Work Completion Certificate and all other relevant documents in support of the same.

1.2 Bidders shall also have to enclose the documents of Registration of Firm/ Factory License/ Certificate of Incorporation, EPF, ESI, PAN, GSTIN, MSME Registration (if registered with MSME) etc.

1.3 The works executed in own name of the individual / firm of the tenderer will only be considered for eligibility criteria.

2. LOCATION OF WORK SPOT:

2.1 The fabrication work is to be carried out at Lovagarden Site-2 (a Sea Front facility of BHEL - HPVP near Hindustan Shipyard Limited - OPF Site), Visakhapatnam, Andhra Pradesh.

3. SCOPE OF WORK: Detailed scope of the fabrication work will be as follows:

Details of the Column to be fabricated is as follows:

Regenerator Column (CS with SS Clad) - Tag No. 06-CC-102: 1 No. @ 109 MT

It may be noted that the weight indicated above is tentative and may vary on both sides due to revision in the drawings, if any.

3.1 Complete fabrication of the Column which consists of Shell, Top & Bottom Dished ends, Skirt, Internals & External attachments, Platforms, Ladders, Handrails etc., including NDT, Local SR, Hydro-test, Pickling & Passivation, Blasting & Painting, Stage wise & Final Inspection etc., as per the approved drawings, QAP / ITP, WPS, Procedures, Specifications & Standards and loading of the column sections onto the trailers. It includes the following activities but not limited to the same:

3.1.1 Main Shell including Skirt, Top & Bottom Dished Ends:

3.1.1.1 Collection and transportation of all the Shell plates, Pressed segments of Skirt Section-I, Formed individual Skirt Sections-II, III & IV, formed Dished ends, Raw materials like Plates (full/off-cuts), Pipes & Tubes, Round Bars, Structural items, BOCs like Fittings, Nozzles, Flanges, Fasteners, Gaskets etc., as per GMS from BHEL-HPVP shop/ stores to Lovagarden site including unloading at Site.

3.1.1.2 Rolling of shell segments of the column as per drawings & approved QAP.

3.1.1.3 Profile of the rolled segments shall be maintained by temporary spiders / profile plates. Raw materials for the same will be Free Issue by BHEL-HPVP.

3.1.1.4 Dished Ends will be supplied by BHEL-HPVP in Formed condition. Height marking, extra height cutting, edge preparation including clad removal of Top & Bottom Dished ends as per drawings is in Vendor Scope.

3.1.1.5 Main shell of the Column is to be fabricated in two sections (Section-I and Section-II) with welding of L-seams and C-seams so as to accommodate the same in the Furnace at Lovagarden site-1 for carrying out PWHT. PWHT of these both sections is in the scope of HPVP. However, assistance required for the Stress Relieving of the Column like Handling, Shifting & Placing the column on Saddles, Rotation of the equipment, Welding of Thermocouples etc. as per the requirements of SR Agency are to be carried out by the vendor.

3.1.1.6 **Transportation of Column Shell sections -I & II and Top & Bottom Dished Ends from LG-2 site to LG-1 site for PWHT and back to LG-2 site after PWHT is in the scope of Vendor**. Arrangement for loading and unloading of column sections and Dished Ends on/from trailer is in the scope of Vendor.

3.1.1.7 Assembly and welding of C-Seam of Column Shell Section-I with Section-II including Marking, Cutting, Edge Preparation, clad restoration, NDT, Local SR etc., as per drawings, approved QAP & WPS.

3.1.1.8 Assembly, Fit-up, welding, NDT of L-seams of Shell sections as per drawings, approved QAP / ITP, WPS along with Production Test Coupons.

3.1.1.9 Assembly, Fit-up, welding, NDT of C-seams of Shell to Shell, Shell to Top & Bottom Dished ends as per drawings & approved QAP / ITP, WPS.

3.1.1.10 100% PT on chipped back L-seam & C-seam Welds of Shell to Shell and C-seam welds of Shell to Dished ends as per approved QAP.

3.1.1.11 100% RT of C-seam Welds, L-seam Welds and Production Test Coupons as per approved QAP / Drawings.

3.1.1.12 Clad Restoration on L-seam & C-seam welds and 100% PT on Clad restoration / Weld Overlay of each layer as per approved QAP/ Procedures.

3.1.1.13 CuSO4 solution test after clad removal, Chemical Analysis of samples of Clad restoration of Dished End, Main Shell and shell to Dished end, Nozzle assemblies as per approved QAP.

3.1.1.14 Ferrite check of clad overlay with a calibrated equipment as per approved QAP.

3.1.1.15 UT shall be carried out on Rolled sections of clad and Weld Overlay as per approved QAP/ Procedures.

3.1.1.16 **Fabrication of Skirt section-I (MOC: SA516 Gr.60).** P**ressed / Formed segments for the same shall be supplied by HPVP**. However, Edge preparation of L-seams & C-seams, Assembly, Fit-up, welding, NDT of Skirt Section-I, Skirt section-I with Bottom Dished end including **Rail Shield** as per drawings, approved QAP, WPS.

3.1.1.17 **Forming of individual Skirt sections-II, III & IV is in HPVP scope**. Skirt section-II, III & IV (MOC: IS 2062) will be supplied by HPVP in three sections with L-seams welded & NDT done. Edge preparation of C-seams, Assembly, Fit-up, welding, NDT of Skirt Sections as per drawings, approved QAP / ITP, WPS including fabrication of base ring, compression ring, Ribs, Trailing Lugs, Earthing Lugs, Ladder Rungs, Hand Grip etc., to be done by vendor.

3.1.1.18 **Transportation of the Column will be done in Two Units. (Total column + Skirt Sections-I & II as one unit and Skirt sections-III+IV with Base ring as other unit).** Edge preparation of Site Weld C-seam between Skirt sections-II & III, Provision of temporary spiders / profile plates at the open ends of both Units for which raw materials will be provided by BHEL as Free Issue, Trial assembly of both the units, Match marking, Inspection clearance for despatch is in the vendor's scope.

3.1.1.19 Offering the job for stage wise inspection and obtaining stage wise inspection clearance, Final Inspection clearance from HPVP (QC) / TPIA / EIL as per approved QAP.

3.1.1.20 All NDT activities like DPT, MPT, RT, UT, etc., shall be carried out as per approved QAP/ drawings by NDT personnel qualified by BHEL as per BHEL Procedure No. BHEL: NDE: WP01.

3.1.1.21 NDT agency engaged by fabrication contractors shall have to ensure that their NDE personnel are qualified by BHEL in advance before starting of the job.

3.1.1.22 PMI Check for Clad Weld Overlay as per approved QAP / Procedures.

3.1.1.23 Handing over of Production Test Coupons for PWHT / SR along with the Column.

3.1.1.24 Production Test Coupons after RT & PWHT to be tested as per approved QAP / Procedures.

3.1.2 Internals & External Attachments and Structure:

3.1.2.1 Collection and transportation of Raw materials like Plates (full / off-cuts), Pipes & Tubes, Round Bars, Structural items, BOCs like Fittings, Nozzles, Flanges, Fasteners, Gaskets etc., as per GMS from BHEL-HPVP shop/ stores to Lovagarden site including unloading at Site.

3.1.2.2 Fabrication, Marking, cutting, Assembly, Welding and NDT of Structure consisting of Platforms,

Ladders, Handrails etc., External & Internal attachments like Tray Support Rings, Bolting Bars, Vortex breaker, Insulation & Fire proofing supports, Manway / Pipe Davits, Manhole doors, Stiffener rings, Platform and Pipe supports, Lifting Trunions, Ladder rungs, Earthing Lugs, Nozzle assemblies with pipes & pipe fittings, Hand grip, Manholes, Saddles, Lifting trunnions, Instrument Tappings, RF Pads, Insert Plates, Transportation Saddles etc.**,** as per approved drawings, QAP & NDE Procedures.

3.1.3 Nozzles Assemblies:

3.1.3.1 **For sizes up to 6"dia., Bore cladding of Pipes will be done by BHEL-HPVP. Also, Weld overlay and Machining of Flanges/ Fittings of these Nozzles up to 6"dia. will be done by BHEL-HPVP.** However, for Nozzle sizes greater than 6"dia., Nozzles are to be formed from clad plates including Rolling of the clad plates, L-seam & C-seam welding and welding of the nozzle pipe with flanges along with Weld overlay & Machining on Flanges / fittings are to be done by the Vendor.

3.1.3.2 **Nozzles formed from Plates**: For plate formed nozzles with dia. less than 6" only, rolling of the plates to form Nozzles will be done in BHEL-HPVP shop. However, fit up, assembly, welding of L-seams & C-seams, NDT etc., are to be carried out by the Vendor. For Nozzle sizes greater than 6"dia., Nozzles are to be formed from clad plates including Rolling of the clad plates, L-seam & C-seam welding and welding of the nozzle pipe with flanges along with Weld overlay & Machining on Flanges / fittings are to be done by the Vendor.

3.1.3.3 Fabrication of Nozzle Sub-assemblies involving Fit up & Welding of C-seams of Pipes, Elbows, Flanges, Nozzles including DPT of Weld Edges after root run & final weld, on weld overlay after each layer and RT on C-seam & L-seam welds, clad restoration on welds, chemical analysis of weld overlay, Ferrite check of weld overlay as per approved drawings & QAP.

3.1.3.4 100% UT where attachments are welded directly to the cladding as per approved QAP / NDE procedure.

3.1.3.5 Marking & opening of Nozzles and Access / Man way openings on Shell & Dished end as per approved drawings & QAP.

3.1.3.6 Fit up & Welding of Nozzles / Sub-Assemblies on Shell & Dished ends including PT on Weld edges, on Root Run & on Final Welds, on chipped back welds & on weld overlay after each pass, clad restoration on welds, chemical analysis & ferrite check of weld overlay as per approved drawings, QAP / NDE Procedure.

3.1.3.7 100% UT on the seam of Nozzle to Shell, Pipes & Dished ends as per approved QAP / NDE Procedure.

3.1.3.8 Fabrication of RF pads including Rolling / Pressing, Assembly & Welding with the Column and Pneumatic Test as per approved drawings, QAP / NDE Procedure.

3.1.3.9 Fabrication of Temporary Saddles for Stress Relieving of column sections, if required, and Transportation Saddles and Stools for Loading & Unloading of Finished column on / from trailers required for transportation of column as per approved drawings.

3.1.4 Hardness shall be checked for all pressure joints on Welds / Heat Affected Zone / Parent Metal after PWHT as per approved QAP / NDE procedure.

3.1.5 100% UT on Pressure retaining welds after PWHT as per approved QAP / NDE procedure.

3.1.6 Spot PT on all the internal & external welds after PWHT as per approved QAP / NDE procedure.

3.1.7 PMI check for SS & Alloy steel components, Final Dimensional inspection after PWHT as per approved QAP / NDE procedure.

3.1.8 Testing of Water Samples at NABL approved laboratory for its suitability for Hydro-test.

3.1.9 Hydro-testing of Column at Test pressure specified in the drawing followed by Draining, Drying & Cleaning. Water will be made available at one point and laying of necessary piping for filling has to be arranged by Vendor.

3.1.10 Arranging of all the accessories required for the Hydro-test like Filling Pump, Pressurizing Pump, Calibrated Pressure Gauges including fabrication of Stems for Fixing of Pressure Gauges, Non-Return Valves etc. **Water available at Lovagarden site is to be tested for its suitability for Hydro-test to meet the Specifications and if not suitable the required water has to be arranged by the Vendor in Tankers**.

3.1.11 Pickling & Passivation of Clad Surface of Shells, dished ends & weldments and Weld Overlays of Nozzles including cleaning & drying as per standards, approved procedure & QAP after Hydro testing of vessel. **An approved specialized agency shall be engaged by the Vendor for the Pickling & Passivation job. Specialized agency shall be identified in advance and credentials of agency & procedure for Pickling &**

Passivation to be submitted to BHEL for approval. After according of approval only by BHEL, the agency is to be engaged for Pickling & Passivation job.

3.1.12 Surface preparation by Blast Cleaning to Specification SSPC-SP-10 and Coating of Primer & Finish Paints as per approved Painting Schedule. All tests like Salt Contamination Test, Profile Gauge Check, Tape Adhesion Test, Holiday Check, Peel-off Test etc., required as per Job Specifications and BHEL Painting Procedure No**. SIP:H: PP:22**, Rev.0. shall be carried out by a qualified agency for testing of painting and obtaining stage wise inspection clearance from HPVP (QC) / TPIA / EIL as per approved QAP.

3.1.13 Painting is to be carried out only by Painters qualified by HPVP as per standard format.

3.1.14 All the nozzle openings shall be closed with suitable steel blind covers supplied by BHEL.

3.1.15 Letter painting of Dispatch particulars in a prescribed / specified format on the column.

3.1.16 **Transportation of the Column will be done in Two units. (Total column + Skirt Sections-I & II as one unit and Skirt Sections- III+IV with Base Ring as other unit). Transportation will be done through Hydraulic trailer with Stool Up & Down position.** Vendor to provide all the assistance to Transportation contractor for loading of the Column sections on the Hydraulic Trailers like placing & fixing steel / wooden saddles, stools, fixing of temporary supports, if required, on the trailer etc.

3.2 Work Instruction/ Procedures to be followed during fabrication:

3.2.1 Welding is to be carried out by ASME qualified welders only. Vendor shall arrange for Qualification of Welders at their own cost. However, Test Coupons shall be provided by BHEL as free issue.

3.2.2 The consumables like gases, grinding wheels etc., required for fabrication are in the scope of the Vendor except Welding consumables. **All Electrodes & Filler wires are Free Issue by BHEL-HPVP.** Any wastage or excess usage beyond BHEL assessed quantity shall be justified by the Vendor. Otherwise, the same shall be charged to the vendor's account at BHEL recovery rates.

3.2.3 Experienced Site-in-charge and Qualified Engineers & Supervisors shall be deployed for proper co-ordination of the job.

3.2.4 Vendors should deploy Experienced & Qualified QC personnel for carrying out the inspection activities in coordination with BHEL QC inspector / TPIA / EIL. **Non-deployment will attract penalty @ rate decided by BHEL and same will be deducted in RA Bills.**

3.2.5 Vendors should deploy Qualified NDT personnel (Level III / Level II) at site for carrying out the NDT inspection activities in coordination with BHEL QC –NDT / TPIA / EIL. Vendors shall have to engage sufficient man power and resources for fabrication to meet HPVP delivery schedules. **Non-deployment will attract penalty @rate decided by BHEL and same will be deducted in RA Bills.**

3.2.6 Vendor shall deploy sufficient no. of calibrated Welding machines, Main Ovens & Portable Ovens required for baking of electrodes etc., at site. All relevant documents shall also be made available for verification & approval by BHEL - HPVP (QC) / TPIA.

3.2.7 Vendor shall deploy suitable up to 20 MT cap. for handling of the raw materials, shell segments required during the fabrication. **However, for heavy components other than which can't be handled by 20 MT crane BHEL will be deploying one no. of 75 T Crawler crane for handling of shell sections. Diesel required for the operation of BHEL cranes will be Free Issue by BHEL. However, transportation of the same from BHEL-HPVP to Lovagarden site has to be arranged by Vendor.**

3.2.8 Sufficient No. of Rollers & Idlers required for fabrication of Column have to be arranged by the vendor. **Non-deployment in specified time will attract penalty @rate decided by BHEL and same will be deducted in RA Bills.**

3.2.9 Required tools & tackles like Measuring instruments like Tape, Fillet & Butt Weld Gauges, Plumb bobs with magnets, Thermal Chalks / Pyrometer etc., shall be calibrated and valid calibration certificates must be presented, if required.

3.2.10 All the Scaffolding materials like Pipes, Clamps, Jallies etc., for temporary platform works required during the complete course of the fabrication are to be arranged by the Vendor.

3.2.11 Gate passes for the entry of Manpower, Materials, Cranes, Trailers etc., inside Lovagarden site are to be taken care by the contractor.

3.2.12 Any modification work due to revision of drawings during fabrication is to be carried out by the vendor without any extra cost.

3.2.13 No extra rates are applicable for the additional joints to be made in Plates / Rolled sections.

3.2.14 Equipment details shall be hard stamped by encircling with paint and stencilled in a specific format with details of Project name, Customer No., Work Order No., PGMA No., Weight etc., for identification and dispatch as per the instructions of the outsourcing department. Fixing of Name plate, punching as per the details given in the drawings and rub-off.

3.2.15 Submission of economic cutting plans for the plate materials and approval shall be obtained from BHEL-HPVP before taking up the same. Wherever fabrication is done without proper approved cutting plans, any loss of materials arising due to the same will be recovered as per BHEL recovery rates.

3.2.16 Vendors shall have to return the excess / balance materials including off-cuts and total scrap available with the vendors exclusive of process allowance & invisible wastage to HPVP Stores after material reconciliation but before submission of their final bill. In case the same are not returned by the vendor, Recovery shall be made as per BHEL Rates / MSTC rates plus applicable taxes, prevailing at the time of processing of the final bills.

3.2.17 Though not mentioned specifically, any other activity which is required for completion of the work is deemed to be included in the scope of work of vendor.

4. <u>BHEL SCOPE</u>: BHEL – HPVP shall provide the following as free issue:

4.1 Drawings, GMS, QAP, WPS, Painting Schedule, applicable Procedures, Standards & Specifications etc.

4.2 Raw materials like full / off-cuts Plates other than shell plates, Pipes & Tubes, Round Bars, Structural items etc., and BOCs like Pipe Fittings, Nozzles, Flanges, Fasteners, Gaskets etc., as per GMS from HPVP stores. Transportation of these materials from BHEL-HPVP, Visakhapatnam to Lovagarden site is in vendor's scope.

4.3 All electrodes and Filler wires required for fabrication shall be supplied as free issue material by HPVP. However, Transportation from HPVP stores to Lovagarden site is in vendor's scope.

4.4 Marking, Cutting & Edge preparation of all the shell plates for formation of Shell segments including Clad removal as per drawings & approved QAP.

4.5 Forming of individual Skirt sections-II, III & IV. However, Transportation from HPVP shops to Lovagarden site is in vendor's scope.

4.6 Pressed segments of Skirt Section-I. However, Transportation from HPVP shops to Lovagarden site is in vendor's scope.

4.7 Bore Cladding of Nozzle Pipes up to 6" Dia.

4.8 Section bending wherever required.

4.9 Blind Flanges, Gaskets and Fasteners required for Hydro-test.

4.10 PWHT of the total column in 2 sections along with Production Test Coupons & Dished ends shall be carried out by a specialized agency engaged by HPVP separately at LG-1 site. **However, transportation of shell sections & Dished Ends from LG-2 site to LG-1 site and back to LG-2 site is in vendor's scop**e. Also, assistance is to be provided by the fabrication vendor for Stress Relieving of the column in handling of shell sections, Placement on Saddles / Supports, Fabrication, Assembly & Welding of Bulk Heads, Welding of Thermocouples etc.

4.11 75 MT crane along with operator will be provided by BHEL free of charge for fabrication. Maintenance of the crane including spares shall also be in the scope of BHEL. However, Riggers required for handling the job shall be provided by the vendor. Diesel required for the operation of BHEL crane will be Free Issue by BHEL. However, transportation of the same from BHEL-HPVP to Lovagarden site has to be arranged by Vendor.

4.12 All Paints as per requirement.

4.13 Area required for fabrication, site office and Stores at Lovagarden site will be provided free of charge.

4.14 Power & Water shall be provided free of charge at one point but further distribution to the desired location is in vendor's scope. Water available at Lovagarden site is to be tested in NABL approved laboratory for suitability to meet the Specifications by the vendor and if not suitable the same has to be arranged by the Vendor through tankers.

4.15 Vendor's scope shall include arranging & laying of cables, arranging Distribution Boards with suitable capacity Switch Fuse units as incomer, all outgoings with necessary safe trips like MCB, ELCB etc., as per the industrial safety norms and their installation, all outgoing cables from Distribution Board, termination at the distribution board, Working Area Lighting.

5. INSPECTION:

5.1 Inspection shall be carried out by M/s. BHEL–HPVP, Vizag / BHEL Authorized Inspection Agency (TPIA) / EIL / Customer as per approved QAP. Contractor shall have to offer for Stage wise and Final inspection as per approved QAP and obtain necessary stage wise & final clearances before proceeding for further operations.

5.2 Fabrication Vendor shall be solely responsible for preparation and submission of all Inspection Reports & documents duly certified by Inspection Authority along with the finished equipments.

5.3 All the documentation related to inspection clearance of M/s. BHEL / TPI / EIL / Customer, Generation of Inspection Reports, Preparation of Final Documents as per BHEL standard formats etc., are included in the scope of vendor and scanned copy as well as hard copy of the same is to be submitted to BHEL-QA.

6. DELIVERY:

6.1 Complete Column along with inspection documents and all other certificates are to be handed over to HPVP **within 3 months from the date of issue of First consignment of free issue materials or 6 weeks from the date of issue of Last consignment of materials, whichever is later.**

Note:

a) **Time schedule is very stringent and Vendor has to deliver the job as per Customer requirement and schedule which will be meticulously monitored by BHEL/ EIL/ Customer. All necessary steps to reduce the cycle time for the individual sub-activities and main activities will be mutually discussed and Vendor has to mobilize additional resources as per time to time requirement to achieve the same.**

b) For intermediate operations like SR, the time period from the date of handing over to the date of taking over will be excluded from the delivery period for the purpose of computation of LD.

c) In case the delivery period offered by the vendor is more than the tender delivery, Price quoted by the bidder shall be loaded for additional period @1/2 % per week or part thereof for the purpose of evaluation of Bidder Status.

7. SITE MOBILISATION:

7.1 Successful bidders shall have to complete site mobilization within 7 days from the date of receipt of order or from the date of intimation for the same by BHEL whichever is later.

8. PRICE:

8.1 The price shall be quoted strictly as per the Schedule of Rates enclosed at Annexure – I for the detailed scope of work and the quoted price shall be inclusive of all applicable taxes & duties except GST.

8.2 The prices shall be fixed & firm without any escalation during the entire period of contract and till completion of the work.

8.3 GST shall be reimbursable to the vendor as detailed in Clause - 10 and as per Annexure – GST.

8.4 Income tax will be deducted at applicable rates from RA & Final bills.

9. PAYMENT TERMS:

9.1 Out of 100 %, 90 % payment will be in RA Bills and Balance 10 % payment in Final Bill. Payment shall be made against RA Bills for **90% of the order value** for the following stages of supply and fabrication of the equipment:

9.1.1) After Completion of L-Seams of shell sections including NDE - 10%

9.1.2) After Completion of all C-seams of shell sections & Dished ends including NDE except Closing C-seam - 30%

9.1.3) After Mechanical Completion including Externals & Internals, SR Assistance, Hydro Testing, Pickling & passivation - 30%

9.1.4) After Completion of Fabrication of Structure, Blasting & Painting - 10%

9.1.5) After completion of Loading of finished equipment on trailers - 10%

9.2 Balance 10% payment shall be made after completion of the job in all respects including material reconciliation and handing over of the balance materials & returnable items, if any and submission of total documentation to BHEL (QC/QA).

9.3 The weight indicated in the tender is tentative and may be subject to increase or decrease after completion of detailed engineering. However, payment shall be made for the actual weights executed as per approved engineering drawings and documents with due certification by BHEL-HPVP site in-charge and QC.

This clause shall be read in conjunction with the clause 18.0 of Annexure – III i.e., General Terms & Conditions.

10. GOODS & SERVICES TAX (GST):

10.1 Bidders shall make a note of the following points of GST before submission of their offer:

a) Vendors shall have to mention their GSTIN no. (15 Digits) in their Technical Bid. If any specific exemption is available, a declaration with due supporting documents need to be furnished for considering the offer.

b) Semi-finished goods are to be delivered by the Vendors in BHEL, HPVP premises within a maximum period of one year from the date of issue of the material, failing which the whole transaction will be considered as Supply & Sale and GST is required to be paid along with interest (calculated @ SBI Base Rate + 6%) along with penalty, if any, from the date of Challan on the whole value of materials. Hence vendors shall have to ensure that materials issued to them are returned within 365 days.

c) After fabrication, the vendors shall have to deliver the Semi - finished Goods by fulfilling the following formalities:

i) GST invoice should be raised by the vendors by paying GST on job work charges at applicable rates and by incorporating the HPVP GSTIN no. in the invoice for availing the reimbursement of GST from HPVP.

ii) The vendor shall also have to enter in their GST Return -1 (GSTR-1) the details of invoice raised for payment of GST so as to enable HPVP to avail input credit.

11. REVERSE AUCTION:

11.1 BHEL shall be resorting to Reverse Auction (RA) for this tender. RA shall be conducted among the eligible techno-commercially qualified bidders. Business Rules for Reverse Auction are given at Annexure – V and Guidelines for Reverse Auction are available on our website, **www.bhel.com** → supplier registratıon → Guidelines for Reverse Auction 2021, before submission of their offer.

11.2 Sealed envelope / Electronic Price bids of all the techno-commercially qualified bidders shall be opened and the same shall be considered as initial bids of the bidders in RA. In case any bidder(s) do(es) not participate in online Reverse Auction, their sealed envelope price bid along with applicable loading, if any, shall be considered for ranking.

11.3 BHEL will inform bidders the details of service provider who will provide business rules, all necessary training and assistance before commencement of online bidding. The bidders participating in the Reverse Auction shall have to necessarily submit **'Process Compliance Form'** (PCF) to the designated Service Provider.

11.4 Bidders are advised to read the 'Business Rules' (Annexure – V) indicating details of RA event carefully, before reverse auction event.

12. Other Terms & Conditions, whichever applicable, shall be as per Annexure – III enclosed.

13. RISK PURCHASE:

In case the contractor fails to execute the work within the scheduled time or due to any other reasons, BHEL - HPVP reserves the right to get the same completed through some other party at the risk & cost of the contractor and any additional expenditure incurred due to the same shall be charged to the contractor**.**

14. VALIDITY OF OFFER:

The offer shall be valid for a period of **3 months** from the date of Reverse Auction.

15. GENERAL:

15.1 The bidders shall study the Tender documents, Drawings, Quality Documents and all other relevant documents in detail for understanding the scope of work and the processes involved before submission of offer. Bidders shall get clarifications, if any, from concerned officials on the scope of work or any other details of the tender document, over phone between 09:00 AM and 04:30 PM on any working day or through e-mail.

15.2 Drawings, QAP, WPS, other reference documents etc., shall be sent to vendor's e-mail address on e-mail request by the bidder.

15.3 **Conditional / Partial Price Bids and any other deviations to the tender terms & conditions are not acceptable and BHEL reserves the right to reject such offers without further correspondence**. Bidders shall confirm their acceptance to all the terms & conditions of the tender enquiry in the Techno-commercial Bids and any deviations mentioned in the Price Bids shall not be considered.

15.4 BHEL reserves the right to modify or cancel the tender enquiry at any stage without assigning any reasons thereof.

15.5 The General Terms & Conditions, if any, contradicting with the specific terms & conditions given in the tender, then specific terms & conditions shall only be considered.

16. The following documents shall form part of the tender enquiry:

i) Schedule of Rates : Annexure – I
ii) List of Reference Drawings & Documents : Annexure – II
iii) General Terms & Conditions : Annexure – III
iv) Acceptance to tender terms & conditions : Annexure – IV
v) Business Rules for Reverse Auction : Annexure – V
vi) GST Compliance for Indigenous Suppliers : Annexure – GST
vii) Applicable Drawings as per Annexure - II
viii) Drawings, Approved QAP, Painting Schedule, NDT procedures, Pickling & passivation procedures etc.

17. TENDER SUBMISSION (through E – Mail only):

17.1 Techno-commercial bids along with the tender document duly signed by the bidder on all pages and a covering letter on Company's Letter Head addressed to DGM (Outsourcing), BHEL –HPVP, Visakhapatnam shall be sent through an e-mail to **technicalbid-hpvp@bhel.in**

17.2 **Tentative List of Man Power, Machinery, Tools & Tackles to be engaged at site by the vendor shall also be attached to the Techno-Commercial Bid.**

17.3 Price bid (Annexure-I) shall be sent separately through e-mail to another e-mail ID **pricebid-hpvp@bhel.in**

17.4 Offers completed in all respects along with the supporting documents shall be sent through the above e-mails only **latest by 14.00 Hrs. on 22.02.2022** duly mentioning the Name of Work, Tender Ref. No. & Date and Technical Bid / Price Bid in the subject of the e-mail.

Note: Do not mark CC and BCC while submitting your offer as the system is designed to reject such mails having more than one recipient. Max. file size of the attachment shall be 20 MB only. In case the file size is more, bidder can submit their offer through multiple mails within the due date and time.

Bidders shall ensure correctness of the e-mail addresses while submitting their offer. There shall be no other e-mail address at the receiving end while submission of the above bids otherwise the system will reject such mails. Bidder shall be solely responsible for non-receiving of such mails at the above mentioned e-mail addresses and no communication in this regard will be entertained.

17.5 **TENDERS RECEIVED AFTER THE DUE DATE & TIME ARE NOT ACCEPTABLE.**

17.6 **OFFERS SENT IN ANY OTHER FORM WILL BE TREATED AS INVALID AND WILL BE SUMMARILY REJECTED.**

18. <u>TENDER OPENING</u>:

18.1 Techno-commercial Bids will be opened **at by 14.10 Hrs. on 22.02.2022.** The bidders may depute their representatives at the time of opening of Techno-commercial bids.

18.2 After evaluation of the Techno-commercial Bids, intimation regarding date & procedure of conducting reverse auction shall be given by the service provider to all the eligible techno-commercially qualified bidders through an e-mail in advance at an appropriate time.

For Bharat Heavy Electricals Limited,

12/02/2022

वाइ.वी.आर.राव/Y.V.R. RAO
उप महा प्रबन्धक (ओ एस)/Dy.GM (OS)
बीएचईएल, एचपीवीपी/BHEL-HPVP,
विशाखपट्टणम/VISAKHAPATNAM-530 012

ANNEXURE - I

SCHEDULE OF RATES

Ref: OS/21-22/2440/PV-LG/25/031 **Date: 12.02.2022**

Sub: Fabrication of Regenerator Column against S.O. 2440 at Lovagarden site of BHEL-HPVP, Visakhapatnam

Sl. No.	S.O. No.	Description of Work	Unit	Qty.	Unit Rate (Rs.)	Total Amount (Rs.)
		Fabrication of the Regenerator Column (Eqpt. Tag No. 06-CC-102; approx. weight - 109 MT) at Lovagarden site, Visakhapatnam which consists of Shell, Top & Bottom Dished ends, Skirt, Internals & External attachments, Platforms, Ladders, Handrails etc., including NDT, Local SR, Hydro-test, Pickling & Passivation, Surface Preparation, Blasting & Painting, Stage wise & Final Inspection etc., as per the approved drawings, QAP / ITP, WPS, Procedures, Specifications & Standards etc. and loading of the column sections onto the trailers. **(Detailed scope of work mentioned in the tender document)**				
1	**2440**	**Fab. of Regenerator Column - Vessel Tag No. 06-CC-102**	**MT**	**110**		
Total Amount in words:						

Notes :

1) Evaluation will be done on total cost basis.
2) The quoted price shall be inclusive of all applicable taxes & duties except GST. Income Tax shall be deducted at applicable rates from RA & Final Bills and GST shall be reimbursable to the vendor as per applicable guidelines.
3) The prices shall be fixed & firm without any escalation during the entire period of contract and till completion of work.
4) The quantity and weights indicated above are approximate and may vary on both sides subject to revision or addition or deletion of drawings. However, payment shall be made for the actual weights as per the applicable drawings / BOM.
5) The bidders are advised to go through all the drawings & documents before quoting the tender.
6) The evaluation currency for this tender shall be **INR**.
7) Tenderer should quote the amount in figures & words. It may be noted that corrections, overwriting etc. are not allowed. If there is a discrepancy between amount in figures & words, the amount in words shall prevail unless the amount expressed in words is related to an arithmetic error, in which case the amount in figures shall prevail. If there is an error in the total corresponding to the addition or subtraction of sub-totals, the sub-totals shall prevail and total shall be corrected accordingly.
   In case of mismatch between rate and amount in figures, rate in figures shall be taken into consideration for further evaluation and processing.

Signature of the Bidder with Stamp

ANNEXURE - II

Ref: OS/21-22/2440/PV-LG/25/031 **Date: 12.02.2022**

LIST OF REFERENCE DRAWINGS & DOCUMENTS

Sub: Fabrication of Regenerator Column against S.O. 2440 at Lovagarden site of BHEL-HPVP, Visakhapatnam

Sl. No.	S.O. No.	PGMA	Eqpt. Name	Description of Drawings / Documents	Drawing / Document No.	Rev. No.	No. of Sheets
01	2440	CL-010	Regenerator Column (CS with SS Clad) (Eqpt. Tag No. 06-CC-102)	General Assembly of Regenerator	1-CL-010-U0140	04	01
02				Internal Details for Regenerator	1-CL-010-U0142	02	01
03				Details of Pipe Support Clips	1-CL-010-U0145	01	01
04				Insulation & Fire proofing	1-CL-010-U0146	01	01
05				Shell Assembly of Regenerator	1-CL-010-U0154	05	01
06				Skirt Assembly of Regenerator	1-CL-010-U0155	05	01
07				Tray support Rings & Bolting Bars	1-CL-010-U0156	02	01
08				Detail of Pipe Davit	3-CL-010-U0195	00	01
09				Manhole Davit details	3-CL-010-U0198	00	01
10				Details of Internal Tray support Rings & Bolting Bars	3-CL-010-U0211	02	01
11				Details of Internal Tray support Rings & Bolting Bars	3-CL-010-U0212	02	01
12				Details of Platforms and Ladder Clips	1-CL-010-U0213	00	01
13				Rain Shield	3-CL-010-U0202	A	01
14				Dished Ends	3-CL-010-U0213	01	01
15				Assembly details for Hydrotest	3-CL-010-U0215	01	01
16				Details of Platform at El.106.700	1-ST-210-U0363	01	01
17				Details of Platform at El.112.100, 116.500, 119.850, 123.850 & 128.900	1-ST-210-U0364	01	01
18				Details of Platform at El.131.700	1-ST-210-U0365 (Sht. 1 & 2 of 2)	00	02
19				Details of Ladders at El. 106.700	1-ST-820-U0366	01	01
20				Details of Ladders at El. 106.700 to 116.500	1-ST-820-U0367	01	01
21				Details of Ladders at El. 116.500 to 131.700	1-ST-820-U0368	01	01
22				QAP	CQP 2501 Dtd. 09.12.2020	01	15
23				Procedure for Radiographic Examination	BHE-NDT-RT-07023	02	18
24				Procedure for Ultrasonic Examination	BHE-NDT-UT-07025	02	10
25				Procedure for Magnetic Particle Examination	BHE-NDT-MT-07024	02	13
26				Procedure for Liquid Penetrant Examination	BHE-NDT-PT-07026	02	09

Note : Drawings & Documents indicated above are purely tentative and may be subject to revisions due to incorporation of comments of the approving authority. Hence, the approved drawings and documents issued to the vendor after ordering shall only be followed for execution & inspection of the job.

Ref.: OS/21-22/2440/PV-LG/25/031 Date: 12.02.2022

GENERAL TERMS & CONDITIONS

1. TECHNICAL DELIVERY CONDITIONS:

The work should conform to the technical data given in our drawings, GMS, Shipping List Specifications, QAP, WPS etc.

2. PARTY'S SCOPE:

The scope of the party shall be as follows: -

a) All welding equipments, baking oven, tools, jigs and fixtures, measuring instruments duly calibrated, handling facilities, testing facilities etc.

b) All materials other than those mentioned under “Free Issue Materials", which are required for completion of the work.

c) All consumables such as electrodes, gases, grinding wheels etc.

Note: Electrodes of specification mentioned in the drawings / WPS and of BHEL approved brands only shall be used and MTCs of the same shall be submitted to BHEL for verification before use.

3. REVISION OF DRAWINGS:

There may be minor changes in the drawings during execution. In such a case, party should accommodate the same without any extra claim.

4. WELDING QUALIFICATION: Qualification of required number of Welders is party’s responsibility at their cost.

5. X–RAY:

All welding shall be of X-ray quality where specified on drawings. Inspection would specify the quantum of X-ray based on drawings / code requirement. Party should strictly follow the WPS and QAP issued by BHEL during welding. Getting the welds radiographed and getting them cleared by inspection is the responsibility of the party.

6. RECTIFICATIONS / REJECTIONS:

Any rectification due to defective work, if required, shall be done by the party free of charge with a suitable technology approved before hand by BHEL in writing. The cost of material, if any used for rectification work / rejection work, will be estimated by BHEL and the same shall be debited to party's account. In case any rectification / rework is to be carried out due to defective material supplied by BHEL, the replacement material and consumables will be supplied by BHEL free of Cost.

7. SECURITY DEPOSIT:

Vendors shall have to submit a Bank Guarantee for **10% of the order value in case of HPVP ADM site or 25% of the material cost in case of Vendor works** towards Security Deposit and safe custody of free issue materials within 15 days from the date of intimation by Outsourcing dept. The BG shall be valid for the entire contract period with a claim period of 12 months. This Bank Guarantee shall be released to the contractor after completion of work and on acceptance of the same by BHEL.

Bidder agrees to submit performance security required for execution of the contract within the time period mentioned above. In case of delay in submission of performance security, enhanced performance security which would include interest (SBI rate + 6%) for the delayed period, shall be submitted by the bidder. Further, if performance security is not submitted till such time the first bill becomes due, the amount of performance security due shall be recovered as per terms defined in NIT/contract, from the bills along with due interest.

8. PERFORMANCE BANK GUARANTEE:

Vendors shall have to submit Performance Bank Guarantee (with claim period of 12 months) for 10% of the order value covering for the defects liability period. If PBG is not submitted, 10% of the order value shall be deducted towards PBG from the final bill and shall be refundable after performance guarantee period, if no defects are found during this period.

9. RAW MATERIALS ISSUE:

Raw materials shall be issued with appropriate processing allowance and invisible wastage over the theoretical requirement of raw materials **(Plates, Sheets, Sections and Pipes).**

10. TRANSFER / RETURN OF LEFT OVER MATERIALS:

Party should maintain proper records for receipt & use of all free issue materials. The left over materials & scrap as per the material accounting statement shall be returned to HPVP stores along with finished job. Material Transfer Vouchers (MTV) from one order to another or from one vendor to another and Material Return Vouchers should be submitted immediately after transfer / return. The material reconciliation statement shall be submitted by the contractor after verification and certification by BHEL along with the final bill **within 30 days from the date of completion of work**. Otherwise, recovery for the balance materials shall be made from any of their pending bills without further intimation.

11. MATERIAL RECONCILIATION:

Orders issued to the vendors have to be completed in all respects including Material Accounting within a maximum of **180 days** from the **date of issue of the first material** from BHEL - HPVP stores.

Maximum of 0.5 % on the requirement of materials **(Plates, Sections and Pipes)** is admitted towards **process allowance and invisible wastage**.

Scrap quantity is permissible up to a **maximum of 1% on Structurals (Beams, Channels, Angles, Rods, Pipes etc.), 2% on Sheets, 3% for Plates** on the theoretical requirement of materials.

If wastage and scrap is beyond the above limits, it should be fully justified with cutting diagrams etc. which are to be approved in advance by BHEL. **Otherwise, the cost of raw materials beyond approved limits will be recovered from the contractor as per BHEL recovery rates including applicable taxes & duties**.

Material reconciliation including return of balance materials, off-cuts is to be completed within 20 days from the date of completion of the order. The material reconciliation statement shall be submitted by the contractor after verification and certification by BHEL-HPVP along with the final bill **within 30 days from the date of completion of work**. Otherwise, recovery for the balance materials shall be made from any of their pending bills without further intimation,

Repeated occurrence of inordinate delays in returning and settling the material accounting will entail BHEL the right to terminate the contract forthwith or impose a temporary suspension on further loading at the discretion of BHEL.

12. SCRAP & OFF-CUT NORMS:

Sl. No.	Description	Scrap Size (in mm)	Off-Cut (in MM)
1.	CS/AS Sheets & Plates	Below 500 × 250	500 × 250 & above
2.	Rolled sections Rod, angles etc. (other than -tubes, pipes)	Below 1000	1000 & above
3.	Tubes & Pipes	Below 500	500 & above
4.	Universal column	Below 1000	1000 & Above
5.	SS Sheets & Plates	Below 500 × 250	500 × 250 & above
6.	SS Structural, Rods, Tubes, Pipes	Below 250	250 & above
7.	Non – ferrous: sheets & plates, rods & tubes	Below 500 × 250 (S & PL), Below 250 (Rods & Tubes)	500 × 250 & above, 250 & above
8.	Big size Scrap	(2500 & above) × (150 to 249)	-

13. INSPECTION:

Party shall contact our Quality Control Dept. for stages of inspection before commencement of job and should strictly follow the stages of inspection as per QAP.

14. WORKMANSHIP GUARANTEE:

The vendors should give workmanship guarantee for fabricated items for a period of 18 months from the date of last delivery of the order. Any defects due to incomplete work, faulty workmanship found in the fabricated items after delivery during the defects liability period shall be rectified / replaced by the vendor free of cost. Otherwise, the expenditure incurred towards the same will be recovered from the pending bills of vendors.

15. WORK PROGRESS:

The fabricator shall furnish a weekly report on the progress of work along with the status of availability of free issue materials and requirement of further materials, if any.

Outsourcing dept. personnel will visit vendor's works from time to time to assess and review the work progress. Free access shall be provided to BHEL or its inspection agency at all reasonable times of the day / night.

In case the progress is not satisfactory or supplies are delayed abnormally beyond the contractual delivery date, BHEL-HPVP, Visakhapatnam reserves the right to cancel the order in part or full or get the balance job in as is where is condition completed elsewhere by another agency at the risk and cost of Fabricator. The value of the work carried out by the party will be assessed by BHEL and the same shall be final. No compensation will be given to the fabricator in case of cancellation of order or diversion of balance job even if the jobs have been processed partly.

16. DELIVERY:

Finished items should be handed over to BHEL-HPVP on party's delivery challans along with Job completion certificate / Final Inspection Report from inspection agency / HPVP-QC department.

17. PENALTY:

If delivery exceeds the stipulated delivery schedule, penalty 1/2 % of the total value of order per week or part there of subject to a maximum of 10% on the total value of the order will be levied. However, time taken for the following will not be considered as delay on the part of the Sub-Contractor.

1) Intermediate operations, if any, carried out by BHEL.
2) Waiting time for BHEL / Third party Inspection beyond a normal time of 3 days.

18. PAYMENT TERMS:

Payment shall be made against RA Bills within 45 days from the date of submission of Bill.

90% payment will be made after handing over of the finished equipments along with all inspection documents to HPVP shops / Logistics dept. / ADM site / Lova Garden site, duly inspected & cleared by Inspection authority. Balance 10% payment shall be made along with the Final Bill against completion of total order in all respects including documentation.

Vendors shall have to submit the bills in the formats specified by HPVP-Outsourcing and the bills submitted in the specified format along with necessary supporting documents are only admitted for processing. The following documents shall be submitted along with the Final Bill: -

1. No Claim Certificate from the contractor
2. No Dues Certificate from BHEL
3. Work Completion Certificate from BHEL
4. Material Reconciliation Statement submitted by the Contractor and certified by concerned authority of BHEL (if applicable)
5. Workmanship Guarantee certificate from the contractor

19. SECRECY:

All the documents of BHEL inclusive of Drawings, GMS and Standards made available to the fabricator should be kept in strict confidence and under no circumstance be made available to others or allow others to make use of them. Such documents shall be returned to BHEL on demand after completion of the job. This secrecy clause is binding on the employees of the fabricators also. Violation of the same may lead to suspension of business with the vendor and necessary legal action.

20. SUB-LETTING:

In general, sub-letting of jobs will not be permitted. But in special circumstances, this may be allowed. In such case, the party should obtain written approval from BHEL-HPVP, Visakhapatnam before sub-letting.

21. FACTORY RULES AND REGULATIONS:

Party shall abide by all the rules and statutory regulations in force from time to time as per factories act. It shall be party's responsibility to ensure the safety of their workmen and fulfilling the ESI, PF and other relevant statutory regulations.

22. **SAFETY:**

a) Contractor shall adhere to safe construction practices, guard against hazardous & unsafe working conditions and shall comply with the safety rules of BHEL and local authorities. He shall maintain First Aid facilities for all his employees and labour. Contractor's responsibility includes supply of welder kit, all safety items such as safety belts, white and colour glasses, goggles, safety helmets, safety shoes etc.

b) *Contractor and his employees shall follow all fire & safety, security regulations of BHEL.*

23. **HOUSE KEEPING:**

During execution of work, the contractor at all times keep the working place and storage area clean and free from accumulation of waste materials, rubbish etc.,

24. **ACCIDENT / DAMAGE / CONDUCT ETC.:**

Contractor will be held responsible for any disorderly conduct / misconduct, indiscipline, theft, smoking etc., on the part of his men. He will ensure summarily eviction of such men from his premises failing which BHEL would remove them from the factory on his responsibility. Any damage to and or loss of equipment, machinery, building etc., to BHEL or BHEL employees, visitors or other contractors resulting from his own or any of his men's negligence shall be liable to be made good by him. Contractor shall be solely responsible for any accident in which you or your men or your equipment may be involved during the execution of contract on account of any reason what so ever.

25. **TERMINATION OF CONTRACT:**

In the event of any failure on the part of the contractor, BHEL reserves the right to terminate the contract by giving a notice of 2 weeks for any of the following lapses and contractual violations: -

a) Failure to make labour payments in time as per the rules
b) Failure to progress the job according to the agreed schedule
c) Failure to mobilize adequate man power, tools & tackles and consumables in time
d) Failure to adhere to Quality Standards of BHEL
e) Refused to co-operate with other agencies working in the same area
f) Failure to resolve labour disputes like strikes etc., within 7 days of occurrence
g) Failure to comply with statutory regulations applicable at BHEL

BHEL shall also be free to intervene and take necessary remedial measures. All costs incurred with interest and overheads shall be recovered from contractor by such foreclosing or off-loading any part of the contract work.

26. DISPUTES:

Head of BHEL- HPVP Unit will be the final authority for any disputes arising out of this contract. The disputes / arbitration / settlement of contractual or legal issues shall be under the Jurisdiction of Visakhapatnam Court.

27. For this procurement, Public Procurement (Preference to Make in India), Order 2017 dated 15.06.2017 & 28.05.2018 and subsequent Orders issued by the respective Nodal Ministry shall be applicable even if issued after issue of this NIT but before finalization of Contract / PO / WO against this NIT.

In the event of any Nodal Ministry prescribing higher or lower percentage of purchase preference and / or local content in respect of this procurement, same shall be applicable**.**

28. The Bidder declares that they will not enter into any illegal or undisclosed agreement or understanding, whether formal or informal with other Bidder(s). This applies in particular to prices, specifications, certifications, subsidiary contracts, submission or non-submission of bids or any other actions to restrict competitiveness or to introduce cartelization in the bidding process.

In case, the Bidder is found having indulged in above activities, suitable action shall be taken by BHEL as per extant policies/ guidelines.

Signature of the Bidder with Stamp

ANNEXURE – IV

Ref.: OS/21-22/2440/PV-LG/25/031 Date: 12.02.2022

Acceptance to Tender Terms & Conditions

I / We hereby confirm that the Tender documents, Drawings, Quality documents etc. have been studied in detail and we have fully understood the scope of work.

I / We accept to all the Terms and Conditions of the Tender Enquiry and the prices quoted are in accordance with the same.

I / We give our acceptance to participate in reverse auction for this tender.

Tender documents duly signed on all the pages by the Owner / authorized representative of the bidder are attached herewith.

Signature of the Bidder with Stamp

ANNEXURE – V

Ref.: OS/21-22/2440/PV-LG/25/031 Date: 12.02.2022

BUSINESS RULES FOR REVERSE AUCTION (RA)

This has reference to tender no. **OS/21-22/2440/PV-LG/25/031 dated 12.02.2022**. BHEL shall finalize the Rates for **Fabrication of Regenerator Column against S.O. 2440 at Lovagarden site of BHEL-HPVP, Visakhapatnam** through Reverse Auction mode. BHEL has made arrangement with an authorized Service provider (details will be shared before reverse auction) for conducting RA. Bidders should go through the instructions given below and submit acceptance of the same.

The technical & commercial terms are as per (a) BHEL Tender Enquiry No. **OS/21-22/2440/PV-LG/25/031 dated 12.02.2022**, (b) Bidders' technical & commercial bid (in case of two-part bid) and (c) subsequent correspondences between BHEL and the bidders, if any.

1. **Procedure of Reverse Auctioning:**
   i) Price bids of all techno-commercially qualified bidders shall be opened.
   ii) **Reverse Auction**: The 'bid decrement' will be decided by BHEL.
   iii) The lowest bidder in sealed envelope price bid shall be shown as current L1 automatically by the system and no acceptance of that price is required. System shall have the provision to indicate this bid as current L1.
   iv) Bidders by offering a minimum bid decrement or the multiples thereof can displace a standing lowest bid and become "L1" and this continues as an iterative process. However, no bidder shall be allowed to lower its bid below the current L1 by more than 5 decrements at one go.
   v) After the completion of the reverse auction, the Closing Price shall be available for further processing.
   vi) Wherever the evaluation is done on total cost basis, after Reverse Auction, prices of individual line items shall be reduced on pro-rata basis.

2. **Schedule for reverse auction:** The Reverse Auction schedule will be intimated to the eligible techno-commercially qualified bidders at a later stage.

3. **Auction extension time:** If a bidder places a bid in the last {…} minutes of closing of the Reverse Auction and if that bid gets accepted, then the auction's duration shall get extended automatically for another {…} minutes, for the entire auction (i.e. for all the items in the auction), from the time that bid comes in. Please note that the auto-extension will take place only if a bid comes in those last {…} minutes and if that bid gets accepted as the lowest bid. If the bid does not get accepted as the lowest bid, the auto-extension will not take place even if that bid might have come in the last {…} minutes. In case, there is no bid in the last {…} minutes of closing of Reverse Auction, the auction shall get closed automatically without any extension. However, bidders are advised not to wait till the last minute or last few seconds to enter their bid during the auto-extension period to avoid complications related with internet connectivity, network problems, system crash down, power failure, etc.
   The above process will continue till completion of Reverse Auction.
   Complaints/ Grievances, if any, regarding denial of service or any related issue should be given in writing thru e-mail/ fax to M/s. {Service provider} with a copy to BHEL within 15 minutes prior to initial closing time of Reverse Auction.

4. **Bid price:** The Bidder has to quote the {……} Price inclusive of Packing & Forwarding charges, all the routine & type tests as per tender scope, taxes, duties, freight and insurance as specified in tender document including loading (if indicated by BHEL due to deviations in technical/ commercial terms) for the Items specified. Details are as shown in Excel Sheet for calculation of total cost to BHEL (To be specified by Unit as per NIT conditions).

5. **Bidding currency and unit of measurement:** Bidding will be conducted in *Indian Rupees* per *Unit* of the material as per the specifications mentioned in the tender.
   In case of foreign currency bids, exchange rate (TT selling rate of State Bank of India) as on scheduled date of tender opening (Part-I bid) shall be considered for conversion in Indian Rupees. If the relevant day happens to be a Bank holiday, then the forex rate as on the previous bank (SBI) working day shall be taken.

6. **Validity of bids:** Price shall be valid for 3 months from the date of reverse auction. These shall not be subjected to any change whatsoever.

7. **Lowest bid of a bidder**: In case the bidder submits more than one bid, the lowest bid at the end of Reverse Auction will be considered as the bidder's final offer to execute the work.

8. Unique user IDs shall be used by bidders during bidding process. All bids made from the Login ID given to the bidders will be deemed to have been made by the bidders/ bidders' company.

9. **Post auction procedure**: BHEL will proceed with the Lowest Bid in the Reverse Auction for further processing.

10. Any commercial/ technical loading shall be separately intimated to respective bidders prior to RA. The excel sheet provided in this regard shall cover all these aspects. Commercial/ technical loading if any, shall be added by the respective bidder in its price during Reverse Auction.
    Modalities of loading & de-loading shall be separately intimated to the bidders. The responsibility for correctness of total cost to BHEL shall lie with the bidders.

11. Reverse auction shall be conducted by BHEL (through M/s {*Service Provider}*), on pre-specified date, while the bidders shall be quoting from their own offices/ place of their choice. Internet connectivity shall have to be ensured by bidders themselves.

    During the RA process if a bidder is not able to bid and requests for extension of time by FAX/ email/ phone then time extension of additional 15 minutes will be given by the service provider provided such requests come before 5 minutes of auction closing time. However, only one such request per bidder can be entertained.

    In order to ward-off contingent situation of connectivity failure bidders are requested to make all the necessary arrangements/ alternatives whatever required so that they are able to circumvent such situation and still be able to participate in the reverse auction successfully. Failure of power or loss of connectivity at the premises of bidders during the Reverse auction cannot be the cause for not participating in the reverse auction. On account of this, the time for the auction cannot be extended and neither BHEL nor M/s. {*Service provider*} is responsible for such eventualities.

12. Proxy bids: Proxy bidding feature is a pro-bidder feature to safe guard the bidder's interest of any internet failure or to avoid last minute rush. The proxy feature allows bidders to place an automated bid in the system directly in an auction and bid without having to enter a new amount each time a competing bidder submits a new offer. The bid amount that a bidder enters is the minimum that the bidder is willing to offer. Here the software bids on behalf of the bidder. This obviates the need for the bidder participating in the bidding process until the proxy bid amount is decrementally reached by other bidders. When proxy bid amount is reached, the bidder (who has submitted the proxy bid) has an option to start participating in the bidding process.

    The proxy amount is the minimum amount that the bidder is willing to offer. During the course of bidding, the bidder cannot delete or change the amount of a proxy bid.

    Bids are submitted in decrements (decreasing bid amounts). The application automates proxy bidding by processing proxy bids automatically, according to the decrement that the auction originator originally established when creating the auction, submitting offers to the next bid decrement each time a competing bidder bids, regardless of the fact whether the competing bids are submitted as proxy or standard bids. However, it may please be noted that if a manual bid and proxy bid are submitted at the same instant manual bid will be recognized as the L1 at that instant.

    In case of more than one proxy bid, the system shall bid till it crosses the threshold value of 'each lowest proxy bid' and thereafter allow the competition to decide the final L1 price.

    Proxy bids are fed into the system directly by the respective bidders. As such this information is privy only to the respective bidder(s).

13. Bidders are advised to get fully trained and clear all their doubts such as refreshing of Screen, quantity being auctioned, tender value being auctioned etc. from M/s. {*Service provider*}.

14. M/s. {*Service provider}*, shall arrange to demonstrate/ train the bidder or bidder's nominated person(s), without any cost to bidders. M/s. {*Service provider}*, shall also explain the bidders, all the business rules related to the Reverse Auction. Bidders are required to submit their acceptance to the terms/ conditions/ modalities before participating in the Reverse Auction in the process compliance form as enclosed. Without this, the bidder will not be eligible to participate in the event.

15. Successful bidder shall be required to submit the final prices (L1) in prescribed format (Annexure – VI) for price breakup, quoted during the Reverse Auction, duly signed and stamped as token of acceptance without any new condition (other than those already agreed to before start of auction), after the completion of auction to M/s. {*Service provider*} besides BHEL within two working days of Auction without fail.

16. Any variation between the final bid value and that in the confirmatory signed price breakup document will be considered as tampering the tender process and will invite action by BHEL as per extant guidelines for suspension of business dealings (as available on www.bhel.com).

17. Bidders' bid will be taken as an offer to execute the work/ supplies the item as per enquiry no. **OS/21-22/2440/PV-LG/25/031 dated 12.02.2022.** Bids once made by the bidder, cannot be cancelled/ withdrawn and bidder shall be bound to execute the work as mentioned above at bidder's final bid price. Should bidder back out and not execute the contract as per the rates quoted, BHEL shall take action as per extant guidelines for suspension of business dealings (as available on www.bhel.com).

18. Bidders shall be able to view the following on their screen along with the necessary fields during Reverse Auction:
a. Leading (Running Lowest) Bid in the Auction (only total price of package)
b. Bid Placed by the bidder
c. Start Price
d. Decrement value
e. Rank of their own bid during bidding as well as at the close of auction.

19. BHEL's decision on award of contract shall be final and binding on all the Bidders.

20. BHEL reserves the right to extend, reschedule or cancel the Reverse Auction process at any time, before ordering, without assigning any reason, with intimation to bidders.

21. BHEL shall not have any liability to bidders for any interruption or delay in access to the site irrespective of the cause. In such cases, the decision of BHEL shall be binding on the bidders.

22. Other terms and conditions shall be as per bidder's techno-commercial offers and other correspondences, if any, till date.

23. If there is any clash between this business document and the FAQ available, if any, in the website of M/s. {*Service provider},* the terms & conditions given in this business document will supersede the information contained in the FAQs. Any changes made by BHEL/ service provider (due to unforeseen contingencies) after the first posting shall be deemed to have been accepted if the bidder continues to access the portal after that time.

24. Bidder shall not divulge either his Bids or any other exclusive details of BHEL to any other party. If the Bidder or any of his representatives are found to be involved in Price manipulation/ cartel formation of any kind, directly or indirectly by communicating with other bidders, action *as per extant BHEL guidelines for suspension of business dealings (as available on www.bhel.com)*, shall be initiated by BHEL.

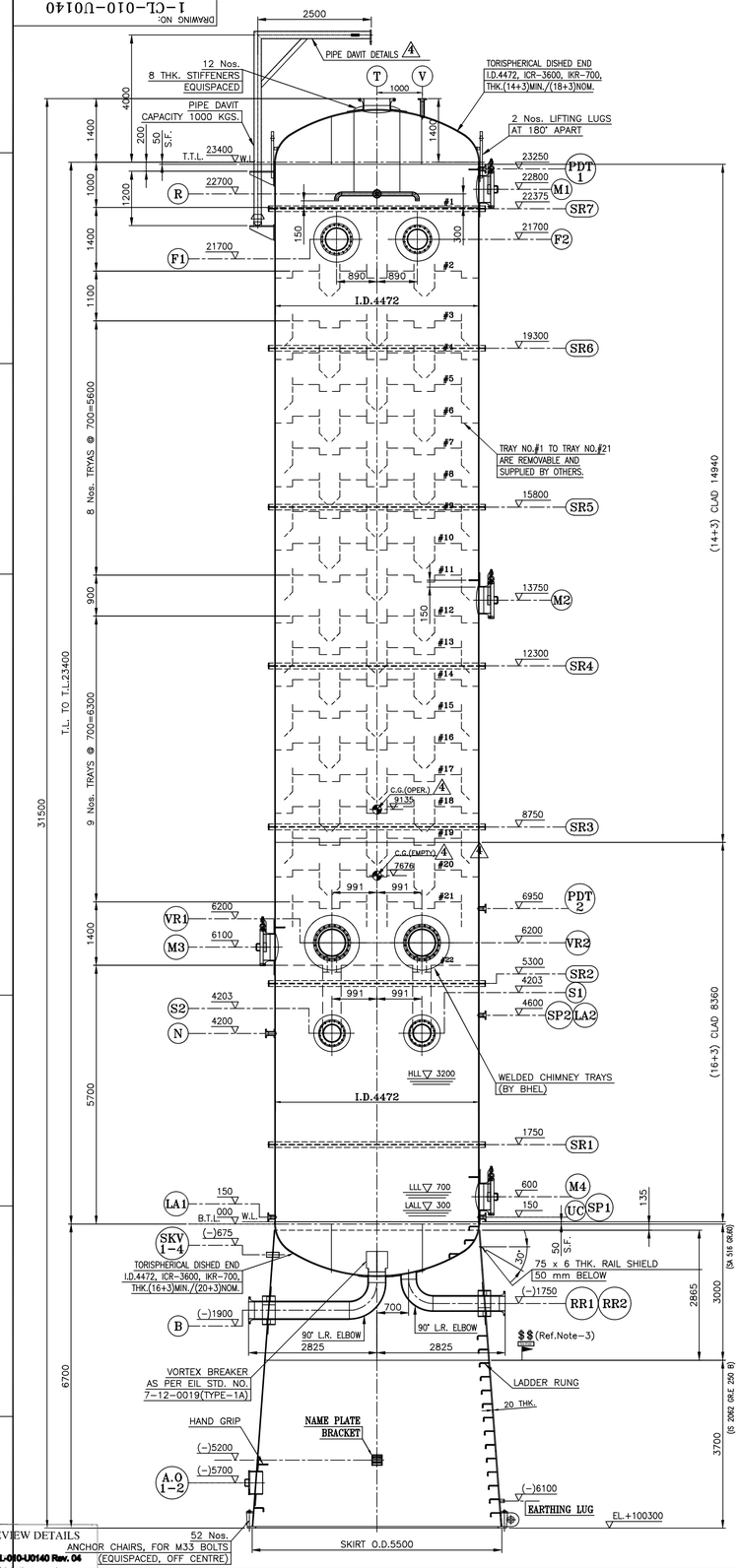
Signature of the Bidder with Stamp

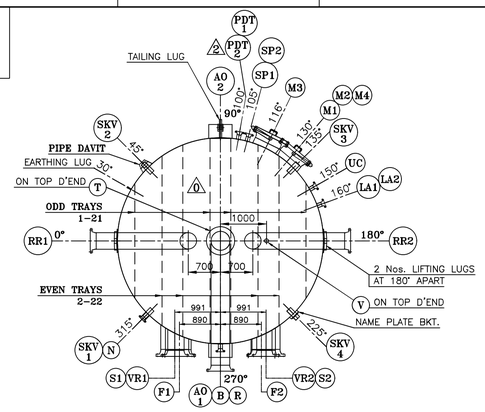
PROCEDURE FOR GST PAYMENT

1. In Response to Tenders for Indigenous supplier will be entertained only if the vendor has a valid GSTIN which should be clearly mentioned in the offer. If any specific exemption is available, a declaration with due supporting documents need to be furnished for considering the offer.
2. Supplier shall mention their GSTIN in all their invoices and invoices shall be in the format as specified/prescribed under GST laws. Invoices shall necessarily contain Invoice number (in case of multiple numbering system is being followed for billing like SAP invoice no, commercial invoice no etc., then the Invoice No which is linked/uploaded in GSTN network shall be clearly indicated), item description as per P0, Quantity, Rate, Value, applicable taxes with nomenclature (like IGST, SGST, CGST & UTGST) separately, HSN/ SAC Code, etc.
3. All invoices shall bear the HSN Code for each item separately (Harmonized System of Nomenclature)/ SAC code (Services Accounting Code).
4. A declaration to the effect that all invoice particulars are/were uploaded in the GSTN network/ portal & all tax liability as per GST rules and regulations have been and will be discharged, shall be mentioned in the invoice. If not mentioned in the invoice, a separate declaration shall be submitted as per the requirement of BHEL.
5. All documents like Test Certificate, LR copy, Guarantee/Warrantee certificate, work completion certificate, any other document mentioned in PO, shall be sent along with the vehicle/consignment where ever applicable. For all consignments received within the calendar month, input credit will be availed within that month in line with monthly returns filing cycle. In case of any discrepancy in the document or non-submission of documents mentioned in the PO, then BHEL will not be able to accept or account the material, in such case availing of tax credit will be deferred to next month or so.
6. In case of discrepancy in the data uploaded by supplier in the GSTN portal or in case of any shortages or rejection in the supply, then BHEL will not be able to avail the tax credit and will notify the supplier of the same. Supplier has to rectify the data discrepancy in the GSTN portal or issue credit note (details to be uploaded in GSTN portal) for the shortages or rejections in the suppliers, within the calendar month notified by BHEL.
7. For any such delay in availing of tax credit for reasons attributable to supplier (as mentioned above), interest (calculated @ SBI Base Rate + 6%) along with penalty if any will be deducted for the delayed period i.e. from the month of receipt till the month tax credit is availed, from the running bills.
8. Under GST regime, BHEL has to discharge GST liability on LD recovered from suppliers/contractors. Hence applicable GST shall also be recoverable from suppliers/contractors on LD amount. For this Debit note will be issued by BHEL indicating the respective supply invoice number.
9. This is to inform that GST portion of invoice, shall be released only upon Vendor declaring such invoice in his GSTR-1 and receipt of goods and Tax invoice by BHEL and Confirmation of payment of GST thereon by vendor on GSTN portal. Alternatively, BG of appropriate value may be obtained from vendor which shall be valid At least one month after the confirmation of date of payment of GST by vendor on GSTN portal and receipt of Tax invoice and receipt of goods, whichever is later. Above is subject to receipt of goods/service and tax invoice thereof along with vendor declaring invoice in his return and paying GST within timeline prescribed for availing ITC by BHEL.
10. That in case vendor delays Declaring such invoice in his return and GST credit availed by BHEL is denied or reversed subsequently as per GST law, GST amount paid by BHEL towards such ITC reversal as per GST law shall be recoverable from vendor/contractor along with interest levied/ leviable on BHEL.

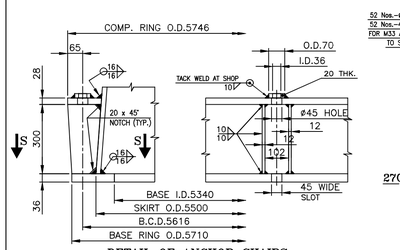
Note : The above will be followed strictly for processing vendor payments to ensure GST Compliance.

DRAWING NO: 1-CL-010-U0140

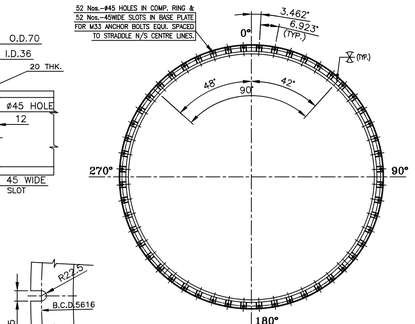




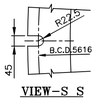
PLAN VIEW OF NOZZLE ORIENTATIONS



DETAIL OF ANCHOR CHAIRS (52 Nos.)



ORIENTATION OF SLOTS IN BASE RING, BOLT HOLES IN COMPRESSION RING (52 Nos.)



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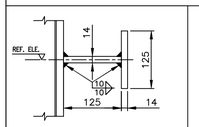

DETAIL OF STIFFENING RING SEGMENTS (MADE IN 4 SEGMENTS)

STANDARDS	
VESSEL TOLERANCES	7-12-0001
SKIRT BASE DETAILS	7-12-0004
SKIRT OPENING DETAIL	7-12-0005
MANHOLE WITH DAVIT	7-12-0010
LADDER RUNGS FOR MANHOLE/DEMISTER	7-12-0011
NOZZLE REINFORCEMENT AND PROJECTION	7-12-0013
STANDARD BOLT HOLE ORIENTATION	7-12-0015
ALLOY LINER DETAILS	7-12-0016
INTERNAL FLANGES	7-12-0018
VORTEX BREAKERS	7-12-0019
SUPPORT RING AND BOLTING BARS	7-12-0021
PIPE DAVIT	7-12-0023
LIFTING LUG TOP HEAD TYPE	7-12-0024
FIRE PROOFING AND INSULATION SUPPORTS	7-12-0025
EARTHING LUG	7-12-0026
NAME PLATE	7-12-0027
MANUFACTURER NAME PLATE	7-12-0028
BRACKET FOR NAME PLATE	7-12-0029
SUPPORTS FOR INTERNAL FEED PIPE	7-12-0032
ALLOWABLE NOZZLE LOADS	7-12-0038
SPECIFICATIONS	
GENERAL SPECIFICATION FOR PRESSURE VESSELS	6-12-0001
SUPPLEMENTARY SPECIFICATION FOR CS VESSELS	6-12-0002
SUPPLEMENTARY SPECIFICATION FOR CLAD VESSEL	6-12-0007
STD. SPECIFICATION FOR BQCS PLATES	6-12-0011
STD. SPECIFICATION FOR STRUCTURAL QUALITY PLATES	6-12-0014
SUPPLEMENTARY SPECIFICATION FOR CLAD PLATE	6-12-0015
STD. SPECIFICATION FOR SS PLATE	6-12-0020
JOB SPECIFICATION FOR SURFACE PREPARATION & PROTECTIVE COATING (NEWCONSTRUCTION)	B297-000-2-42-PCS-0001

APPLICABLE STANDARDS :
1. ASME BOILER & PRESSURE VESSEL CODE SEC VIII DIV 1 : ED-2019
2. ASME BOILER & PRESSURE VESSEL CODE SEC II PART A, C & D : ED-2019
3. ASME BOILER & PRESSURE VESSEL CODE SEC V : ED-2019
4. ASME BOILER & PRESSURE VESSEL CODE SEC IX ED-2019
5. ASME B16.5 ED-2013-STANDARD FOR PIPE FLANGES AND FLANGED FITTINGS.
6. ASME B16.11 ED-2016 FORGED STEEL FITTINGS, SOCKET WELDED & THREADED
7. ASME B36.10M ED-2018 WELDED AND SEAMLESS WROUGHT STEEL PIPE
8. ASME B1.20.1 ED2013 PIPE THREADS, GENERAL PURPOSE (INCH)

REFERENCE DRAWING LIST	
DRAWING / DOCUMENT TITLE	BHEL DOCUMENT NUMBER
GENERAL ASSEMBLY OF REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	1-CL-010-U0140
ASSEMBLY DETAILS OF REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	1-CL-010-U0141
SHELL ASSEMBLY OF REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	1-CL-010-U0154
SKIRT ASSEMBLY OF REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	1-CL-010-U0155
INTERNAL DETAILS FOR REGENERATOR (06-CC-102)	1-CL-010-U0142
TRAY SUPPORT RING & BOLTING BARS FOR REGENERATOR (06-CC-102)	1-CL-010-U0156,211,212
EXTERNAL ATTACHMENTS OF REGENERATOR (06-CC-102)	1-CL-010-U0145
INSULATION & FIRE PROOFING SUPPORT DETAILS FOR REGENERATOR (06-CC-102)	1-CL-010-U0146
SHELL DEVELOPMENT OF REGENERATOR (06-CC-102)	0-CL-010-U0006
MANWAY DAVIT DETAILS FOR REGENERATOR (COLUMN/TOWER-SS CLADED)(06-CC-102)	3-CL-010-U0198
PIPE DAVIT DETAILS FOR REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	3-CL-010-U0195
TEMPLATE FOR FOUNDATION OF REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	3-CL-010-U0204
NAME PLATE DETAILS FOR REGENERATOR (COLUMN/TOWER-SS CLADED) (06-CC-102)	3-CL-010-U0200
SCHEDULE OF MANDATORY SPARES & COMMISSIONING SPARES (06-CC-102)	4-CL-010-U0057
GENERAL NOTES FOR REGENERATOR (06-CC-102)	4-CL-010-U0058
TRANSPORTATION ARRANGEMENT FOR REGENERATOR (06-CC-102)	2-CL-010-U0047
MECHANICAL DESIGN OF REGENERATOR (06-CC-102)	PPPV-2440-CL-010-001
ASSEMBLY DETAILS FOR HYDROTEST OF REGENERATOR (06-CC-102)	3-CL-010-U0215

DESIGN DATA		
CODE		ASME SEC.VIII DIV.1 LATEST EDITION
WORKING PRESSURE	(Kg/cm^2g)	TOP : 0.9, BOTTOM : 1.2
DESIGN PRESSURE	(Kg/cm^2g)	INT. : 3.5, EXT. : FULL VACCUM
WORKING TEMPERATURE	(°C)	TOP : 97, BOTTOM : 125
DESIGN TEMPERATURE	(°C)	150
MDMT	(°C)	1.7
CORROSION ALLOWANCE	(MM)	NIL
TYPE OF HEAD		TORISPHERICAL
JOINT EFFICIENCY		SHELL : 1, HEAD : 1
RADIOGRAPHY		SHELL : FULL, HEAD : FULL
POST WELD HEAT TREATMENT		YES (COMPLTE EQUIPMENT)
HEAT TREATMENT		HEAD AS PER SPEC./CODE
OPERATING MEDIUM		AMINE
SP. GRAVITY		0.9775 TO 1.027
WIND SPECIFICATON		IS 875
SEISMIC		IS 1893+SITE SPECTRA
CAPACITY	(M^3)	391
VESSEL SL. NO.		**26683**
INSULATION THICKNESS	(mm)	125 HOT
FIRE PROOFING		YES (BY OTHERS)
HYDROSTATIC TEST PRESSURE	(Kg/cm^2g) (NEW & COLD)	HORIZONTAL (AT TOP) 5.25
CONSIGNMENT SIZE		ODC
INSPECTION BY		E.I.L.

MATERIAL OF CONSTRUCTION ($) (AS PER AMSE/IS)	
SHELL, HEADS, INSERT PLATES,	SA 516 GR.60 + SS 316L CLAD $
RAINFORCEMENT PADS	SA 516 GR.60
NOZZLE FLANGE UPTO 50 NB	SA 182 GR. F316L
NOZZLE FLANGE ABOVE 50 NB	SA 105+WELD OVERLAY OF SS 316L $
NOZZLE NECK UPTO 50 NB	SA 312 TP 316L
NOZZLE NECK ABOVE 50 NB UPTO 150 NB	SA 106 GR.B+WELD OVERLAY OF SS 316L $
NOZZLE NECK ABOVE 150 NB	SA 516 GR.60+SA 240 GR.316L CLAD $
PIPE FITTINGS	SA 234 GR.WPB+WELD OVERLAY OF SS 316L $
GASKET EXTERNAL	SPIRAL WOUND WITH SS 316L WINDING & GRAFOIL FILLER WITH CS OUTER RING & SS INNER RING AS PER ASME B16.20
GASKET INTERNAL	COMPRESSED FIBRE ASBESTOS FREE
EXTERNAL STUDS/BOLTS/NUTS	SA 193 GR.B7 / SA 194 GR.2H
INTERNAL STUDS/BOLTS/NUTS	SS 316L
SKIRT (PART)	SA 516 GR.60/IS 2062 GR E250 QUALITY-B
SKIRT / SUPPORT BASE	IS 2062 GR. E250 QUALITY-B
INTERNAL PARTS (WELDED)	SA 240 GR.316L
INTERNAL PARTS (BOLTED)	SA 240 GR.316L
CLIPS & ATTACHMENTS (EXTERNAL) DIRECTLY WELDED	SA 516 GR.60
CLIPS & ATTACHMENTS (EXTERNAL) WELDED OVER PAD	IS 2062 GR. E250 QUALITY-B
PAD FOR EXTERNAL ATTACHMENTS	SA 516 GR.60
LIFTING LUGS	SA 516 GR.60
PIPE DAVIT	SA 106 GR.B
$ ALL CLAD PLATES SHALL CONFIRM TO SA 264 3	

FOUNDATION LOADING DATA (OPERATING CONDITION)		
TYPE	MAX. MOMENT AT BASE (M) (Kgm.)	MAX. SHEAR FORCE AT BASE (H) (Kg.)
SEISMIC (DBE)	**1007000**	**47000**
SEISMIC (MCE)	**1496500**	**73600**
WIND	**566000**	**26000**

APPROXIMATE WEIGHT (kgs.) (PER ITEM)			
ERECTION	**91000**	OPERATING	**332500**
HYDROTEST (SHOP)	**482000**	HYDROTEST (FIELD)	**630000**

MARK NO.	QTY.	SERVICE	NB (N.P.S.)	O.D.	SCH. THK.	RATING CLASS	TYPE/ FACE	PROJECTION	R.F. PAD W x THK.	REMARKS
AO1,2	2	ACCESS OPENING	500 (20")	508.0	– 16 THK.	AS PER E.I.L. STD.			250 x 20	
SKV1-4	4	SKIRT VENT	100 (4")	114.3	SCH.40 –	AS PER E.I.L. STD.			–	
SP1,2	2	STAND PIPE	80 (3")	88.9	SCH.80 + #	150	WN/RF	2405	–	
N	1	NITROGEN CONNECTION	80 (3")	88.9	SCH.80 + #	150	WN/RF	2455	45 x 16	
PDT1,2	2	DIFFERENTIAL PRESSURE TRANSMITTER	80 (3")	88.9	SCH.80 + #	150	WN/RF	2405	–	
LA1,2	2	LEVEL SWITCH	80 (3")	88.9	SCH.80 + #	150	WN/RF	2405	–	
UC	1	UTILITY CONNECTION	80 (3")	88.9	SCH.80 + #	150	WN/RF	2405	–	
V	1	VENT	80 (3")	88.9	SCH.80 + #	150	WN/RF	REF. DRG.	–	
M1,2	2	MANHOLE+B.F.+DAVIT+ BOLTING+GASKET	600 (24")	609.6	– (14+3)	150	WN/RF	2505	300 x 14	
M3,4	2	MANHOLE+B.F.+DAVIT+ BOLTING+GASKET	600 (24")	609.6	– (16+3)	150	WN/RF	2505	300 x 16	
RR1,2	2	LIQUID RETURN (FROM REBOILER)	350 (14")	355.6	– (16+3)	150	WN/RF	REF. DRG.	175 x 16	
VR1,2	2	VAPOR RETURN (FROM REBOILER)	600 (24")	609.6	– (16+3)	150	WN/RF	2505	300 x 16	
S1,2	2	SIDE DRAWOFF (TO REBOILER)	400 (16")	406.4	– (16+3)	150	WN/RF	2505	200 x 14	
R	1	REFLUX	80 (3")	88.9	7.62+ 5mm W.O.L	150	WN/RF	2455	45 x 14	
T	1	TOP OUTLET	600 (24")	609.6	Clad:3mm 14+3 3	150	WN/RF	REF. DRG.	350 x 14	
B	1	BOTTOM OUTLET	400 (16")	406.4	Clad:3mm 16+3 3	150	WN/RF	REF. DRG.	200 x 16	
F1, F2	2	FEED	500/450 20"/(18"	508.0/ 457.0	Clad:3mm 14+3 3	150	WN/RF	2505	250 x 14	0

NOZZLES — FLANGES AS PER ASME B16.5-2013

TABLE OF NOZZLES AND FLANGES

NOTE:

1. MATERIAL OF CONSTRUCTION IS INDICATED IN THE TABLE WITH TITLE: " MATERIAL OF CONSTRUCTION"
2. PLEASE REFER ASSEMBLY DRAWING FOR BOM DETAILS
3. $$ REQUIRED NDT AS PER CODE SHALL BE DONE BY BHEL AT SITE

REV NO.	ZONE	BRIEF RECORD OF REVISIONS	PPD.	CHD.	APPD.	DATE
4		E.I.L. COMMENTS INCORPORATED.	GUR	LKM	SKB	13.11.21
3		E.I.L. COMMENTS INCORPORATED.	GUR	LKM	SKB	28.09.21
2		E.I.L. COMMENTS INCORPORATED.	SMG	IM	YPK	24.02.20
1		E.I.L. COMMENTS INCORPORATED.	SMG	IM	YPK	05.01.20
0		E.I.L. COMMENTS INCORPORATED.	NPR	IM	YPK	03.10.20

OWNER: GAIL (PATA).

LICENSOR : EIL

ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

E.I.L. JOB NO. B315, PR NO. B315-006-CC-PR-6010/0001

FORM NO. 0425/2

CAUTION: The information on this document is the property of BHARAT HEAVY ELECTRICALS LTD. It must not be used directly or indirectly in any way detrimental to the interest of the company.

Bharat Heavy Electricals Limited
UNIT: HEAVY PLATES & VESSELS PLANT
VISAKHAPATNAM-530012

	NAME	SIGNATURE	DATE
DRN	N PRAKASH	Sd/-	13.08.20
CHD	IM / YPK	Sd/-	13.08.20
APPD	SKB	Sd/-	13.08.20

DEPT: ALL DIMENSIONS ARE IN MM | PROJECTION | SCALE: 1 : 60 & N.T.S | WEIGHT (Kg.): XXX | CODE | REF TO ASSY / OLD DWG: –

TITLE: GENERAL ASSEMBLY OF REGENERATOR (ITEM NO.06-CC-102)

DRAWING NO : 1-CL-010-U0140 | REV 4

A1 SIZE

DOCUMENT REVIEW DETAILS

1 No Comments. Doc. 1-CL-010-U0140 Rev. 04
2 Proceed with manufacture / fabrication as per the commented document. Revised document required.
3 Document does not conform to basic requirements as marked. Resubmit for review.
R Retained for Records. V Void.

Signature with Date: 09-DEC-2021
Name of Reviewer: PANDEY SUNIL KUMAR (B632)
Page No. 1 of 3

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DOCUMENT REVIEW DETAILS

1 No Comments. **Doc. 1-CL-010-U0140 Rev. 04**

2 ✓ Proceed with manufacture / fabrication as per the commented document. Revised document required.

3 Document does not conform to basic requirements as marked. Resubmit for review.

R Retained for Records. V Void.

Signature with Date **09-DEC-2021**

Name of Reviewer **PANDEY SUNIL KUMAR (B632)**

Page No. **2 of 3**

1) Vendor to submit next revision of GAD, only after final approval/acceptance of all other fabrication drawing.
2) Please submit final fabrication drawing for Pipe davit, Piping clip and surface development highlighting fouling issues along with proposed resolution.
3) Please furnish break up of dressed up weight of column & justification of selected lifting lug, and submit revised tailing lug calculation in line with EIL comments.
4) Vendor to note that tentative detail of top head structural clip as per attached sketch. Vendor to develop the detail fabrication drawing taking guidance of the sketch and EIL Structural drawing and get EIL approval on the same before proceeding with fabrication.

DOCUMENT REVIEW DETAILS

1 No Comments. **Doc. 1-CL-010-U0140 Rev. 04**

2 ✓ Proceed with manufacture / fabrication as per the commented document. Revised document required.

3 Document does not conform to basic requirements as marked. Resubmit for review.

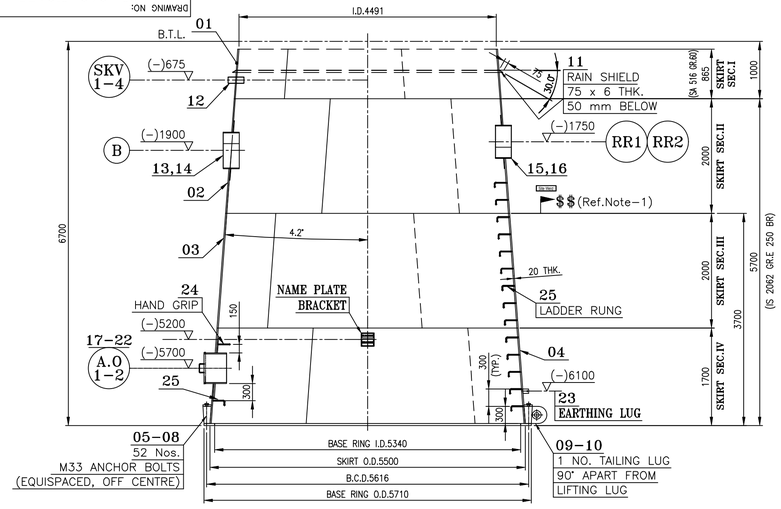
R Retained for Records. V Void.

Signature with Date **09-DEC-2021**

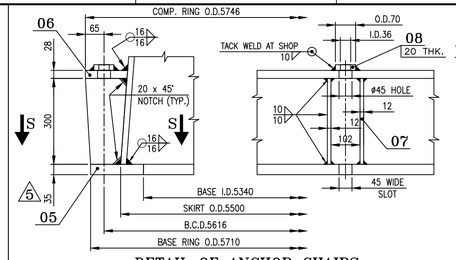
Name of Reviewer **PANDEY SUNIL KUMAR (B632)**

Page No. **3 of 3**

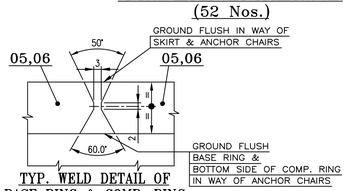
DRAWING NO: 1-CL-010-U0155



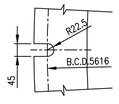
DETAIL OF SKIRT SECTIONS ASSEMBLY



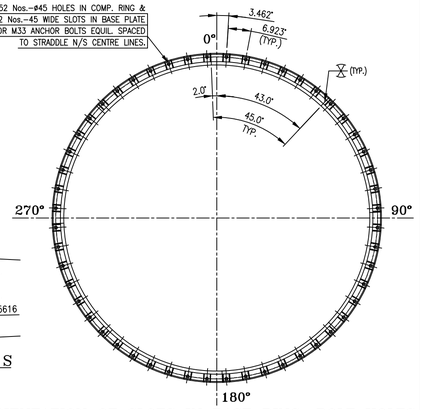
DETAIL OF ANCHOR CHAIRS (52 Nos.)



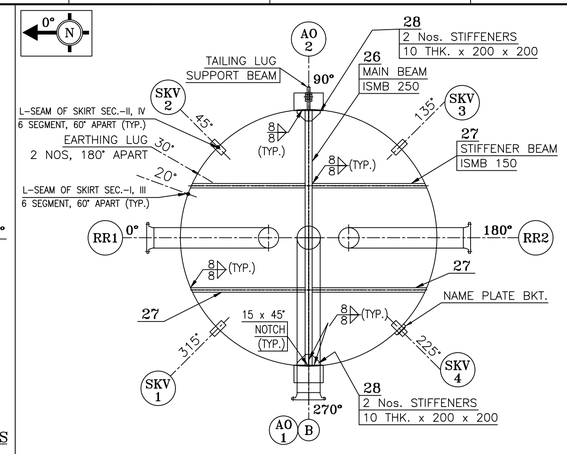
TYP. WELD DETAIL OF BASE RING & COMP. RING SEGMENTS



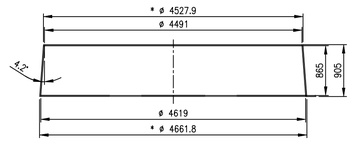
VIEW–S S



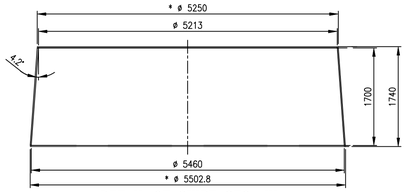
ORIENTATION OF SLOTS IN BASE RING, BOLT HOLES IN COMPRESSION RING (8–EQUAL SEGMENTS) (52 Nos.)



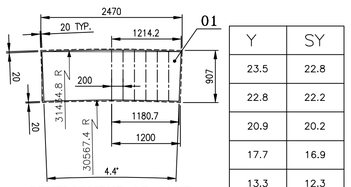
PLAN VIEW OF NOZZLE ORIENTATIONS



DETAIL OF SKIRT SEC.–I

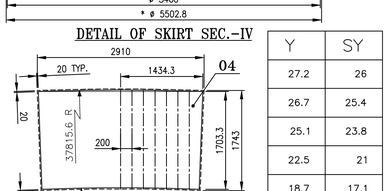


DETAIL OF SKIRT SEC.–IV



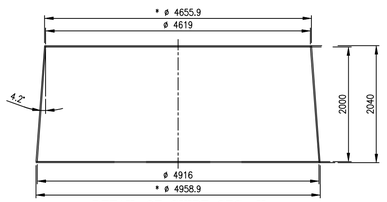
Y	SY
23.5	22.8
22.8	22.2
20.9	20.2
17.7	16.9
13.3	12.3
7.5	6.4
0.5	–0.8
–7.7	

DEVELOPMENT OF CONE (QTY. 6 Nos.)

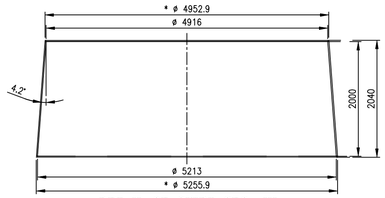


Y	SY
27.2	26
26.7	25.4
25.1	23.8
22.5	21
18.7	17.1
14	12.1
8.2	6
1.3	–1.2
–6.7	

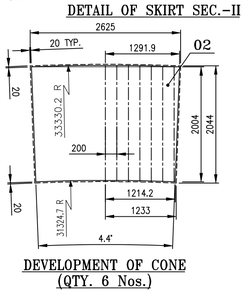
DEVELOPMENT OF CONE (QTY. 6 Nos.)



DETAIL OF SKIRT SEC.–II

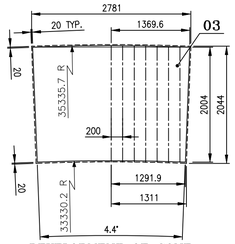


DETAIL OF SKIRT SEC.–III



Y	SY
25.0	23.5
24.4	22.9
22.6	21.0
19.6	17.8
15.4	13.3
10.0	7.6
3.4	0.5
–4.4	

DEVELOPMENT OF CONE (QTY. 6 Nos.)

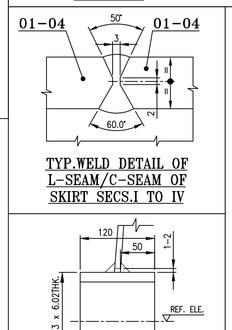


Y	SY
26.6	25.0
26.0	24.4
24.3	22.6
21.5	19.6
17.5	15.4
12.4	10
6.2	3.4
–1.2	

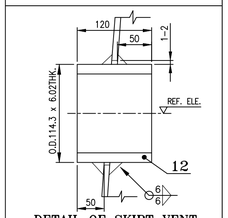
DEVELOPMENT OF CONE (QTY. 6 Nos.)

NOTE:–

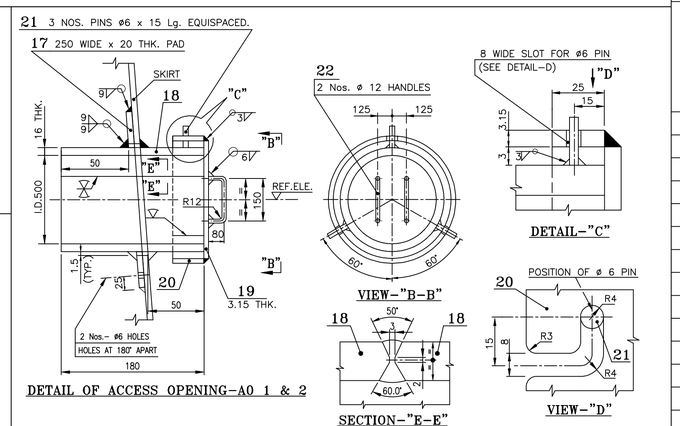
1.* THESE DIMENSIONS ARE FOR REFERENCE (TO BE USED FOR FABRICATION ONLY)



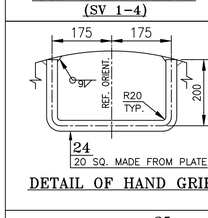
TYP.WELD DETAIL OF L–SEAM/C–SEAM OF SKIRT SECS.I TO IV



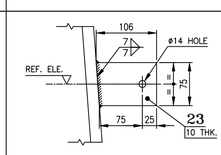
DETAIL OF SKIRT VENT (SV 1–4)



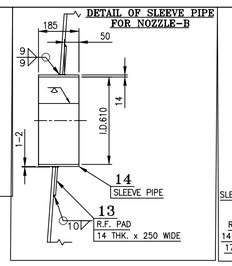
DETAIL OF ACCESS OPENING–A0 1 & 2

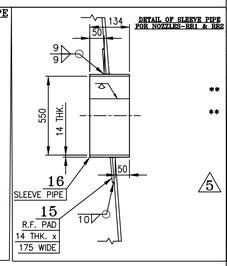


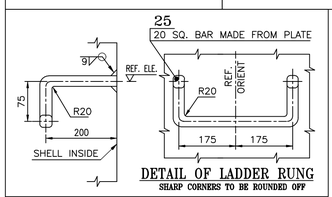
DETAIL OF HAND GRIP



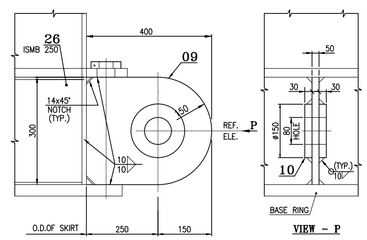
DETAIL OF EARTHING LUG (QTY. 2 Nos.)



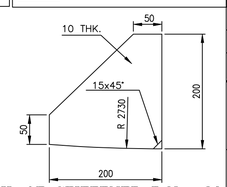




DETAIL OF LADDER RUNG
SHARP CORNERS TO BE ROUNDED OFF



5 DETAIL OF TAILING LUG (1 NO.)



DETAIL OF STIFFENER P.No. 28

REV NO.	DATE	BRIEF RECORD OF REVISIONS	PPD.	CHD.	APPD.
5	01.01.2022	E.I.L. COMMENTS INCORPORATED.	GUR	LKM	SKB
4	01.01.2022	E.I.L. COMMENTS INCORPORATED.	GUR	LKM	SKB
3	13.11.21	E.I.L. COMMENTS INCORPORATED.	GUR	LKM	SKB
2	09.10.21	E.I.L. COMMENTS INCORPORATED.	GUR	LKM	SKB
1	06.03.21	E.I.L. COMMENTS INCORPORATED.	SMG	IM	YPK
0	05.01.20	E.I.L. COMMENTS INCORPORATED.	SMG	IM	YPK

NOTE:

$$1.REQUIRED NDT AS PER CODE SHALL BE DONE BY BHEL AT SITE

**2.AS PER TAILING LUG CALCULATION

SPECIAL NOTE:

BHEL SHALL ENSURE COMPLIANCE OF ALL DIMENSIONS/SKETCHES IN THIS MANUFACTURING ASSEMBLY DRAWING W.R.T. GENERAL ASSEMBLY DRAWING.

ITEM NUMBER	DESCRIPTION	STD	DRAWING NUMBER		MATERIAL CODE	A/C/P	UNIT	UNIT WEIGHT
					MATERIAL SPECIFICATION			QUANTITY
28	STIFFENER PLATE 10 THK. x 200 x 200		–		XXX			3.140
					IS 2062 GR.E250 QUALITY–B			4
27	STIFFENER BEAM ISMB 150 – 2584 LG.		–		XXX			33.566
					IS 2062 GR.E250 QUALITY–B			4
26	MAIN SUPPORT BEAM ISMB 250 – 5456 LG.		–		XXX			203.509
					IS 2062 GR.E250 QUALITY–B			1
25	LADDER RUNG 20 x 20 x 900 LG.		–		XXX			2.826
					IS 2062 GR.E250 QUALITY–B			15
24	HAND GRIP 20 x 20 x 750 LG.		–		XXX			2.355
					IS 2062 GR.E250 QUALITY–B			1
23	EARTHING LUG 10 THK. x 75 x 100		–		XXX			0.589
					IS 2062 GR.E250 QUALITY–B			2
22	HANDLES FOR A.0.1 & A.0.2 ø12 x 330 LG.		–		XXX			0.293
					IS 2062 GR.E250 QUALITY–B			4
21	PIN – A01 & A02 ø6 x 15 LG.		–		XXX			0.003
					IS 2062 GR.E250 QUALITY–B			6
20	SIDE COVER – A01 & A02 O.D.544 x 3.15 THK. x 25 LG.		–		XXX			1.050
					IS 2062 GR.E250 QUALITY–B			2
19	COVER PLATE – A01 & A02 O.D.538 x 3.15 THK.		–		XXX			5.620
					IS 2062 GR.E250 QUALITY–B			2
18	ACCESS PIPE – A01 & A02 I.D.500 x 16 THK. x 180 LG.		–		XXX			44.510
					IS 2062 GR.E250 QUALITY–B			2
17	PAD – A01 & A02 O.D.1032 x I.D.536 x 20 THK.		–		XXX			96.430
					IS 2062 GR.E250 QUALITY–B			2
16	FAB. SLEEVE PIPE FOR NOZLS.–RR1 & RR2 O.D.578 x 14 THK. x 134 LG.		–		XXX			26.290
					IS 2062 GR.E250 QUALITY–B			2
15	R.F. PAD FOR NOZLS.–RR1 & RR2 O.D. 928 x I.D. 582 x 14 THK.		–		XXX			45.500
					IS 2062 GR.E250 QUALITY–B			2
14	FAB. SLEEVE PIPE FOR NOZL.–B O.D.638 x 14 THK. x 185 LG.		–		XXX			39.850
					IS 2062 GR.E250 QUALITY–B			1
13	R.F. PAD FOR NOZL.–B O.D. 1138 x I.D. 642 x 14 THK.		–		XXX			76.650
					IS 2062 GR.E250 QUALITY–B			1
12	SKIRT VENTS – SV–1–4 O.D. 114.3 x 6.02 THK.–120 LG.		–		XXX			1.930
					IS 2062 GR.E250 QUALITY–B			4
11	RAIN SHIELD 6 THK. x 75 x (A.P.D.)		3–CL–010–U0202		XXX			0.000
					SA 516 GR.60			1
10	TAILING LUG STIFFENERS O.D.150 x I.D.80 x 30 THK.		–		XXX			2.980
					IS 2062 GR.E250 QUALITY–B			2
09	TAILING LUG 50 THK. x 300 x 397		–		XXX			46.747
					IS 2062 GR.E250 QUALITY–B			1
08	WASHER O.D.70 x I.D.36 x 20 THK.		–		XXX			0.440
					IS 2062 GR.E250 QUALITY–B			52
07	ANCHOR GUSSETS 12 THK. x 147 x 300		–		XXX			4.154
					IS 2062 GR.E250 QUALITY–B			104
06	COMPRESSION RING O.D.5746 x I.D.5451 x 28 THK.		–		XXX			570.220
					SA 516 GR.70			1
05	BASE RING O.D.5710 x I.D.5340 x 35 THK.		–		XXX			882.25
					SA515 GR.70			1
04	SKIRT SECTION–IV 20 THK. x 1743 x 2910		–		XXX			796.324
					IS 2062 GR.E250 QUALITY–B			6
03	SKIRT SECTION–III 20 THK. x 2044 x 2781		–		XXX			892.445
					IS 2062 GR.E250 QUALITY–B			6
02	SKIRT SECTION–II 20 THK. x 2044 x 2625		–		XXX			842.384
					IS 2062 GR.E250 QUALITY–B			6
01	SKIRT SECTION–I 20 THK. x 907 x 2470 5		–		XXX			351.726
					SA 516 GR.70			6

OWNER

GAIL (PATA).

LICENSOR :

EIL

इंजीनियर्स इंडिया लिमिटेड (भारत सरकार का उपक्रम)

ENGINEERS INDIA LIMITED (A Govt. of India Undertaking)

E.I.L. JOB NO. B315, PR NO. B315–006–CC–PR–6010/0001

Bharat Heavy Electricals Limited
UNIT: HEAVY PLATES & VESSELS PLANT
VISAKHAPATNAM–530012

	NAME	SIGNATURE	DATE
DRN	N. PRAKASH		03.10.2020
CHD	UAZ M / YPK		03.10.2020
APPD	SKB		03.10.2020

DEPT / CODE: ALL DIMENSIONS ARE IN MM | PROJECTION | SCALE: 1 : 60 & N.T.S | WEIGHT (Kg.): 20214.270 | REF TO ASSY / OLD DWG: –

TITLE: SKIRT ASSEMBLY OF REGENERATOR (ITEM NO.06–CC–102)

DRAWING NO : 1–CL–010–U0155 | REV 5

FORM NO. 0425/2

A1 SIZE

	MANUFACTURER'S NAME & ADDRESS **BHEL-VISAKHAPATNAM OR APPROVED SUB-CONTRACTORS**	**QUALITY ASSURANCE PLAN FOR CLADDED COLUMN** Item: **Cladded Column** QAP No: CQP 2501 Rev **1** Date: 09.12.2020 Project: GAIL- Pata Page 1 of 15 EIL PR No. B315-006-CC-PR-6010/0001 Rev. 0	Customer: M/s GAIL, Pata. Licensor: EIL BHEL Sale Order No: 2440 GAIL FOA Ref: GAIL/PATA/C&P/2020/ REGENRATOR COLUMN/AD Dt:30.05.2020

Code of Construction: ASME Section VIII Div.1, Edition 2019

Sl. No.	Item Description	Customer / Unit	Tag Number
1.	Regenerator	M/s GAIL, Pata	06-CC-102

Approved with minor comment on 15-12-2020

P. Gopi Kishore/Mgr/QA/BHEL	A.K. Mandal/AGM/Q & BE /BHEL	ENGINEERS INDIA LTD. K BHAGYARAJ EIL 260 INSPECTION AUTHORITY
Prepared By	Reviewed By	Approved by Customer (as applicable)

	MANUFACTURER'S NAME & ADDRESS :**BHEL-VISAKHAPATNAM OR APPROVED SUB-CONTRACTORS**	**QUALITY ASSURANCE PLAN FOR CLADDED COLUMN**	Customer: M/s GAIL, Pata. Licensor: EIL BHEL Sale Order No: 2440 GAIL FOA Ref: GAIL/PATA/C&P/2020/ REGENRATOR COLUMN/AD Dt:30.05.2020
		Item**: Cladded Column** Project: GAIL- Pata EIL PR No. B315-006-CC-PR-6010/0001 Rev. 0	QAP No: CQP 2501 Rev **1** Date: 09.12.2020 Page 2 of 15

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
1.0	Design & Drawings approval	ASME Sec VIII Div.1 Ed 2019, MDS	Approved Drawings & Calculations	ASME Sec VIII Div.1 Ed 2019	Approved Drawings	-	H	H	
2.0	Inspection & Test Plan	ASME Sec VIII Div.1 Ed 2019 & Approved Drawings, PR	Documents & inspection stages	ASME Sec VIII Div.1 Ed 2019 & Approved Drg & PR	ITP	-	H	H	
3.0	**Review of Procedures**								
3.1	All Manufacturing, Test procedures (NDE, Surface Preparation & Painting, Forming & Heat Treatment)	ASME SEC.V, ASME Sec IX & Sec VIII Div.1 1 Ed 2019, PR, APPROVED DRAWING, PR Specifications.	Compliance to ASME CODES & PR	ASME SEC.V, ASME Sec IX & Sec VIII Div.1 1 Ed 2019, PR, APPROVED DRAWING	Procedures	-	H	R	To be submitted for information
3.2	Welding Process	WPS/PQR/WPQ (shall be within 5 years)	Compliance to ASME CODES & PR.	ASME SEC.V, ASME Sec IX & Sec VIII Div.1 1 Ed 2019, PR, APPROVED DRAWING	WPS/PQR/WPQ	-	H	R / W	R-for existing; W-for New.
4.0	**Raw materials**								
4.1	Plates, Pipes & Forgings at sourcing locations	Approved Drawings & Purchase Order, PR	As per PR and ASME Sec IIA Ed 2019	As per PR and ASME Sec IIA Ed 2019	Test Certificates	-	H	W*	*Refer Note -9

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
4.2	**Raw materials after receipt**								
4.2.1	Plates for shells, PTC and dished ends, All parts welded to Pr parts + All process wetted parts	Approved Drawings & Purchase Order, PR	As per PR and ASME Sec IIA Ed 2019	As per PR and ASME Sec IIA Ed 2019	Test Certificates	-	H	H	
4.2.2	Nozzles, forgings, pipes & flanges, and Fittings.	Approved Drawings & Purchase Order	As per TDC and ASME Sec IIA Ed 2019 & PR	As per TDC and ASME Sec IIA Ed 2019 & PR	Test Certificates	-	H	H	
4.2.3	Non-Pressure parts	Approved Drawings & Purchase Order	As per material specification	As per material specification	Test Certificates	-	H	R	
4.2.4	Welding consumables	Purchase Order	As per ASME Sec IIC Ed 2019 & PR	As per ASME Sec IIC Ed 2019 & PR	Test Certificates	-	H	R	
4.2.5	Fasteners and Gaskets	Approved Drawings & Purchase Order	As per TDC and ASME Sec IIA Ed 2019	As per TDC and ASME Sec IIA Ed 2019	Test Certificates	-	H	R	
4.2.6	Base Ring Template	Approved Drawings & Purchase Order	As per TDC and ASME Sec IIA Ed 2019	As per TDC and ASME Sec IIA Ed 2019	Test Certificates	P	H	R	~~IRN by EIL based on review of internal QC Records.~~

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
5.0	**Fabrication of Dished ends**								
5.1	Transfer of marking and heat number	As per Material test certificates	Heat no and material specification	Approved drawing	-	P	H	W	
5.2	Fit up & welding of long seam	Approved Drawings	Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	W	
5.3	100 % PT on root & final weld, chipped back LS weld, Cu SO4 solution test after clad removal (TYP)	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	
5.4	100 % RT of completed LS weld	Approved Drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	
5.5	Clad restoration on Long seam	Approved Drawings	Parameters as per WPS, Welder Qualification	WPS	-	P	H	-	
5.6	100 % PT on clad restoration after each pass	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	
5.7	Chemical analysis of clad (2 samples) per seam	ASME Sec IIC & Clad procedure	As per specification	As per specification	Analysis report (Note-3)	-	H	R	Per WPS/ Welder basis

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
5.8	Forming of dished end	Approved Drawings ASME Sec VIII Div. 1	Visual & Dimensional check, Template check	Approved Drawings	Dimension Report	P	H	-	
5.9	100 % PT of knuckle area (Note-2)	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	W	
5.10	100% UT on Crown , Knuckle, WEP and straight face	Approved procedures	Thickness measurement & Dis-bondment check	Approved Drawing, procedures & A 568 with S6 Level 2	UT report	P	H	W	
5.11	Visual & Final Dimensions including Dished end profile checking with Template	Approved Drawing ASME Sec VIII Div. 1	Dimensions	Approved Drawing	Dimension Report	P	H	W	
6.0	**Fabrication of Main shell along with PTC**								
6.1	Plate marking & cutting	Approved drawing & cutting plan	Dimensions	Approved Drawings	-	P	-	-	Refer Note-6
6.2	Shell rolling	Approved drawing & cutting plan	Dimensions	Approved Drawings	-	P	H	-	
6.3	Long seam fit up & welding along with test coupon	Approved Drawings	Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	W	
6.4	100 % PT on root & final weld ,chipped back LS weld	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
6.5	RT of completed LS weld & test coupon	Approved drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
6.6	Clad restoration on Long seam & test coupon	Approved Drawings	Parameters as per WPS	WPS	-	P	-	-	
6.7	100 % PT on clad restoration each layer	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	
6.8	Chemical analysis of clad (2 samples) per seam	ASME Sec IIC & Clad procedure	As per specification & PR	As per specification & PR	Analysis report (Note-3)	-	H	W	Per welder / WPS/ shell course basis
6.9	Ferrite check of clad overlay (2 spots per seam)	ASME Sec IIC Ed 2019	Ferrite content	As per drawing	Ferrite Report	-	H	RW	
6.10	UT on Rolled sections of clad and weld overlay	Approved procedures	Disbondment	Approved procedures,	UT report	P	H	W	
6.11	Testing of test coupon	ASME Sec VIII Div.1 Ed 2019	Tensile & Hardness	ASME Sec VIII Div.1 Ed 2019	Test reports	-	H	RW	
7.0	**Shell to Shell to Circular seam fabrication**								
7.1	CS fit up & welding	Approved Drawings	Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	W	
7.2	100 % PT on root & final weld, chipped back CS weld	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
7.3	RT of completed CS weld	Approved drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	
7.4	Clad restoration on C-seam	Approved Drawings	Parameters as per WPS	WPS	-	P	-	-	
7.5	100 % PT on clad restoration after each pass	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
7.6	Chemical analysis of clad (2 samples) per seam	ASME Sec IIC & Clad procedure	As per specification & PR	As per specification & PR	Analysis report (Note-3)	-	H	RW	
7.7	Ferrite check of clad overlay (2 spots per seam)	ASME Sec IIC Ed 2019	Ferrite content	As per drawing	Ferrite Report	-	H	RW	
8.0	**Shell to Dished end circular seam fabrication**								
8.1	CS fit up & welding	Approved Drawings	Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	W	
8.2	100 % PT on root & final weld, chipped back CS weld	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
8.3	RT of completed CS weld	Approved Drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	
8.4	Clad restoration on C-seam	Approved Drawings	Parameters as per WPS	WPS	-	P	H	-	
8.5	100 % PT on clad restoration after each pass	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	
8.6	Chemical analysis of clad (2 samples) per seam	ASME Sec IIC & Clad procedure	As per specification & PR	As per specification & PR	Analysis report (Note-3)	-	H	RW	
8.7	Ferrite check of clad overlay (2 spots per seam)	ASME Sec IIC Ed 2019	Ferrite content	As per drawing	Ferrite Report	-	H	RW	

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						Prod	Qua		
9.0	**Weld overlay of Nozzles, Pipes, Elbows and blind flanges**								
9.1	Weld overlay	Approved drawings	Welding parameters	Adherence to WPS	-	P	-	-	
9.2	Weld overlay thickness from inside the nozzles	Approved drawings	Thickness	Approved drawings	Inspection Report	-	H	W	
9.3	Chemical analysis of weld overlay (1 sample per size representing manual weld overlays of Nozzles, Pipes, Fittings) per seam	ASME Sec IIC & Clad procedure	As per specification	As per specification	Analysis report (Note-3)	-	H	RW	RW-by EIL is applicable during sample collection only.
9.4	Ferrite check of weld overlay(2 spots per weld overlay) (1 sample per size representing manual weld overlays of Nozzles, Pipes, Fittings)	ASME Sec IIC Ed 2019	Ferrite content	As per drawing	Ferrite Report	-	H	RW	
9.5	100 % PT of weld overlay after each pass	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
10.0	**Fabrication of Nozzle Assemblies**								
10.1	Fit up & welding of C-seams of pipes/ elbows/ flanges / nozzle neck, internal pipes	Approved Drawings	Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	R	Functional test for Davit.
10.2	RT of completed CS weld & L-seam of rolled nozzles	Approved Drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	

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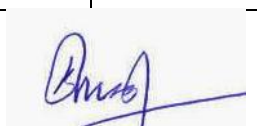
						Prod	Qua		
10.3	Clad restoration on C-seam	Approved Drawings	Parameters as per WPS	WPS	-	P	-	-	
10.4	100 % PT of weld overlay after each pass, nozzle to flange root welds	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	
10.5	Chemical analysis of weld overlay(2 samples) per seam	ASME Sec IIC & Clad procedure	As per specification	As per specification	Analysis report (Note-3)	-	H	RW	RW-by EIL is applicable during sample collection only.
10.6	Ferrite check of weld overlay (2 spots per seam (1 sample per size representing Nozzles, Pipes, Fittings)	ASME Sec IIC Ed 2019	Ferrite content	As per drawing	Ferrite Report	-	H	RW	
11.0	**Nozzle to shell/dished end fabrication**								
11.1	Marking and openings of nozzles on shells	Approved Drawings	Location and orientation	Approved Drawings	-	P	H	R	
11.2	PT on gas cut edges	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
11.3	Fit up & welding of nozzles on shells or dished ends	Approved Drawings	Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	RW	
11.3.1	Pneumatic test on RF Pads	Approved Drawing	Detection of leakage	Approved Drawing	Approved Drawing	P	H	RW	
11.4	100 % PT on chipped back CS weld	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
11.5	Clad restoration on welds	Approved Drawings	Parameters as per WPS	WPS	-	P	-	-	



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						Prod	Qua		
11.6	100 % PT of weld overlay after each pass	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	RW	
11.7	Chemical analysis of weld overlay(2 samples) per seam	ASME Sec IIC & Clad procedure	As per specification	As per specification	Analysis report (Note-3)	-	H	RW	RW-by EIL is applicable during sample collection only.
11.8	Ferrite check of weld overlay (2 spots per seam)	ASME Sec IIC Ed 2019	Ferrite content	As per drawing	Ferrite Report	-	H	RW	
11.9	100 % UT for nozzle to shells and nozzle to pipe	Approved Drawings	Detection of flaws	Approved UT Procedure	UT Report	P	H	W	
12.0	**Skirt fabrication, assembly and Final Inspection**								
12.1	Fit up & welding of Skirt, Skirt with Vessel	Approved Drawings	Dimensions & weld geometry	Approved drawing & WPS	Fit up report	P	H	W	
12.1 12.2	RT of C-seam & L-seam	Approved Drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	
12.3	100 % PT of welds (including root and final welds as applicable)	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	W	
12.4	Dimensional inspection of Skirt	Approved Drawings	Dimensions	Approved Drawings	Report	P	H	W	
12.5	Marking of Internal and external cleats, supports	Approved Drawings	Dimensions	Approved Drawings	Report	P	H	R	

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						Prod	Qua		
13.0	100% UT of attachments welded directly to cladding	Approved procedures	Detection of flaws	Approved procedures	UT report	P	H	R	Refer Note-12
14.0	Pneumatic test on RF Pads	Approved Drawing	Detection of leakage	Approved Drawing	Approved Drawing	P	H	RW	
15.0	Visual & Final dimensional inspection before PWHT including internals	Approved Drawings	Dimensions, orientations	Approved Drawings	Dimensional report	P	H	H	
15.1	Internals inside the column	Approved Drawings	Dimension, Orientation and 1) Ovality in Column ID 2) Support Ring Levelness 3) Bolting Bar offset distances 4) Bolting Bar Height including UDFC dimensions 5) Down-comer & Major Beam Stool Distance from top of Support Ring etc.	Approved Drawings, & EIL Standard Drawing No. 7-12-0001 & 7-14-0001	Dimensional report	P	H	H	
16.0	PWHT of equipment along with PTC	PWHT procedure	Calibration of thermocouples/ Recorders	PWHT procedure	HT Chart review	P	H	H for relea se	

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						Prod	Qua		
17.0	Testing of test coupons (PTC)	ASME Sec VIII Div. 1Ed 2019	Tensile & Hardness	ASME Sec VIII Div. 1Ed 2019	Test Reports	P	H	W	
18.0	NDE after PWHT 100% UT on pressure retaining weld	Approved Drawings	Detection of flaws	Approved UT Procedures	UT Report	P	H	W	
19.0	Spot PT on internal & external welds.	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	W	
20.0	Hardness check of all pressure part joints on weld / HAZ / PM	ASME Sec VIII Div. 1Ed 2019	Hardness	ASME Sec VIII Div. 1Ed 2019 & PR	Test report	P	H	RW	
21.0	Final dimensional inspection after PWHT	Approved Drawings	Dimensions, orientations	Approved Drawings	Dimensional report	P	H	H	
22.0	PMI Check (only for SS , Alloy Steels)	PR Specification	As per ASME Sec IIC Ed 2019	ASME Sec IIA Ed 2019.	PMI report	P	H	RW	
23.0	Shop Hydro test & Draining, drying, inside cleaning.	Approved Drawings	No pressure drop or leaks	Approved hydro test procedure; draining & drying procedure	Test report	P	H	H	Chloride content in hydro testing water to be less than 25ppm.
24.0	Pickling & passivation of weld overlay of nozzles, clad surface of shells, dished ends and further cleaning and drying	Approved Drawings	Visual examination	Approved Drawings & PR	Report	P	H	RW	

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						Prod	Qua		
25.0	Surface preparation & Primer painting,	Approved Drawings	Visual examination & DFT check	Approved Drawings	Report	P	H	RW	
26.0	Primer Paint application	Approved Drawings	Visual & DFT	Approved Drawings	Report	P	H	R	
27.0	Cutting of Complete Vessel into sections & Weld edge preparation for site weld	Approved drawing / cutting plan	Dimensions	Approved Drawings	-	P	H	W	Refer Note-6
28.0	Trial assembly of cut sections, match marking	Approved drawing / cutting plan	Dimensions	Approved Drawings	-	P	H	W	
29.0	Issue of IRN & clearance for dispatch	Approved drawings	All stages as per this approved ITP	-	Release Note	-	-	H	
30.0	**Site fabrication**								
30.1	Weld edge, CS fit up & welding	Approved Drawings	Visual, Offset & weld geometry	Approved drawing & WPS	Fit up report	P	H	W	
30.2	100 % PT on root & final weld, chipped back CS weld	Approved Drawings	Detection of flaws	Approved PT Procedure	PT Report	P	H	R	
30.3	RT of completed CS weld	approved drawings	Detection of flaws	Approved RT Procedure	RT Films	P	H	R	For site weld in Pressure part
30.4	Local Box Type Hydro test (as specified in drawing)	Approved Drawings	No pressure drop or leaks	Approved hydro test procedure; draining & drying procedure	Test report	P	H	H	
30.5	Local PWHT for the column	PWHT procedure	Calibration of thermocouples/ Recorders	PWHT procedure	HT Chart review	P	H	H for relea se	

SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		
30.6	Surface preparation & Primer painting	Approved Drawings	Visual examination & DFT check	Approved Drawings	Report	P	H	RW	Only where touch up is applicable
30.7	Issue of site IRN	Approved drawings	All stages as per this approved ITP	-	Release Note	-	-	H	
30.8	Manufacturer's Data Report & Final documentation	Approved drawings & this ITP	Completeness	Approved drawings & this ITP	Reports	-	H	H	QAP sign off by EIL

MANUFACTURER'S NAME & ADDRESS :**BHEL-VISAKHAPATNAM OR APPROVED SUB-CONTRACTORS**	**QUALITY ASSURANCE PLAN FOR CLADDED COLUMN** Item**: Cladded Column** Project: GAIL- Pata EIL PR No. B315-006-CC-PR-6010/0001 Rev. 0	QAP No: CQP 2501 Rev **1** Date: 09.12.2020 Page 15 of 15	Customer: M/s GAIL, Pata. Licensor: EIL BHEL Sale Order No: 2440 GAIL FOA Ref: GAIL/PATA/C&P/2020/ REGENRATOR COLUMN/AD Dt:30.05.2020

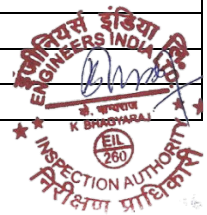
SL NO	ACTIVITY	REFERENCE DOCUMENT	CHARACTERISITIC TO BE VERIFIED	ACCEPTANCE NORMS	VERIFYING DOCUMENTS /RECORDS	BHEL		EIL	Remarks
						Prod	Qua		

Notes:

1) For qualification any new WPS, or new WPQ, witness of TPIA is envisaged.
2) In case, the bevel edges are made with gas cutting, the edges shall be 100 % PT tested.
3) Wherever chemical analysis of weld metal overlay shall be measured, it shall be at a depth of 2/3rd of the cladding thickness from top of the finished overlay surface.
4) Weld over lay thickness cannot be more than 3 mm over and above the required clad thickness.
5) All specifications as available in drawings shall be complied.
6) In case site weld is required to be done in line to drawing, suitable extra dimensions are to be provided such that complete equipment after shop hydro test is cut into pieces and transported to site followed by seam welding at site.
7) All requirements as per PR (Purchase Requisition) shall be met.
8) For weld overlay, electrode for barrier layer E309MoL shall be used in line with EIL Spec. No. 6-12-0007.
9) Witness by EIL for indigenous clad plates during explosion bonding activity of base plate with stainless steel plate followed by identification. Witness by TPIA for imported plate material.
10) Extent of RT will be in line to approved drawings.
11) EIL Spec 6-12-0005 Rev 5 Cl. No. 5.1.5: For welding of clad piping components such as pipe to pipe / pipe fitting from single side where approach from clad side is not accessible, shall be done with a welding consumable matching the clad material followed by an intermediate layer of pure iron (ARMCO/KARDO Iron) welding filler material and then by a welding consumable matching the base material.
12) EIL Spec 6-12-0005 Rev 5 Cl. No. 6.1.4: 100% UT shall be carried out of areas where attachments are to be welded directly to the cladding. The above areas shall include 50mm width of adjacent areas on both sides of attachment.
13. Clause no 30.5 for PWHT to be done before Hydro test of site joint for clause no 30.4

Legends:

P: Perform	**WPS: Welding procedure specification**	**DFT: Dry film thickness**	**LS: Longitudinal Seam welding**
R: Review	**WPQ; Welder performance Qualification**	**HT Chart: Heat Treatment chart**	**CS-Circular Seam welding**
H: Hold	**RT: Radiographic testing**	**PR-Purchase Requisition**	
W: Witness	**UT: Ultrasonic testing**	**Prod: Production**	
RW: Random Witness	**PT: Dye penetrant testing**	**Qua: Quality**	
	MPT: Magnetic particle testing	**IRN: Inspection release note issued by EIL**	



SPECIFICATION FOR SURFACE PREPARATION AND PROTECTIVE COATING SYSTEM - NEW CONSTRUCTION

PROJECT : 60 KTA PP UNIT AT GAIL, PATA

OWNER : GAIL (INDIA) LTD.

JOB NO. : B297

Rev. No.	Date	Purpose	Prepared by	Reviewed by	Approved by
0	11.10.2019	Issued For Tender	S S Pandey	P Chowdhary	A Roy

Contents

1.0 GENERAL

1.1 This technical specifications shall be applicable for the work covered by the contract, and without prejudice to the provisions of various international codes of practice, standard specifications etc. It is understood that contractor shall carry out the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-In-Charge.

1.2 Wherever it is stated in the specification that a specific material is to be supplied or a specific work is to be done, it shall be deemed that the same shall be supplied or carried out by the contractor. Any deviation from this standard without written deviation permit from appropriate authority will result in rejection of job.

1.3 This specification covers the requirement for protective coating for new construction.

2.0 SCOPE

2.1 Scope of work covered in the specification shall include, without being limited to the following.

2.1.1 This specification defines the requirements for surface preparation, selection and application of primers and paints on external surfaces of equipment, vessels, machinery, piping, ducts, steel structures, external & internal protection of storage tanks for all services and chimneys if any. The items listed in the heading of tables of Coating Systems, is indicative only. However, the contractor is fully responsible for carrying out all the necessary painting, coating and lining on external and internal surfaces as per the tender requirement.

2.2 Extent of Work

2.2.1 The following surfaces and materials shall require shop, pre-erection and field painting:

- All uninsulated Carbon Steel & Alloy Steel equipments like Vessels, Columns, Storage Tanks, Exchangers if any, parts of boilers etc.
- All uninsulated carbon steel and low alloy plant and related piping, fittings and valves (including painting of identification marks), furnace ducts and stacks.
- All insulated parts of vessels, boilers, chimneys, stacks, piping and steam piping and if any other insulated items present.
- All items contained in a package unit as necessary.
- All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.
- Flare lines, external surfaces of MS chimney with or without refractory lining and internal surfaces of MS chimney without refractory lining. (If present)
- Identification of colour bands on all piping as required including insulated aluminium clad, galvanized, SS and nonferrous piping.
- Identification lettering/ numbering on all painted surfaces of equipment/piping insulated aluminium clad, galvanized, SS and non-ferrous piping.

- Marking / identification signs on painted surfaces of equipment/piping including hazardous service.
- Supply of all primers, paints and all other materials required for painting (other than Owner supplied materials)
- Over insulation surface of equipments and pipes wherever required.
- Painting under insulation for carbon steel, alloy steel and stainless steel as specified.
- Painting of pre-erection/fabrication and Shop primer.
- Repair work of damaged pre-erection/ fabrication and shop primer and weld joints in the field/site before and after erection as required.
- All CS Piping, equipments, storage tanks and internal surfaces of RCC tanks in ETP plant.
- Quality control, testing and inspection during all stages of work (surface preparation, application of coating and testing of furnished coating).

2.2.2 The following surfaces and materials shall not require painting in general. However, if there is any specific requirement by the Owner, the same shall be painted as per the relevant specifications:

a. Uninsulated austenitic stainless steel.

b. Plastic and/or plastic coated materials

c. Non-ferrous materials like aluminum, Cu-Ni alloy.

2.3 Documents

2.3.1 The contractor shall perform the work in accordance with the following documents issued to him for execution of work.

a. Bill of quantities for piping, equipment, machinery and structures etc.

b. Piping Line List.

c. Painting specifications including special civil defence requirements.

2.4 Complete coating (i.e., primer, intermediate and top coats) of shop fabricated equipment and piping, may be carried out at shop. Any coating damage during transportation of equipment/piping to site shall be repaired by the fabricator/manufacturer in accordance with this specification.

2.5 In case of conflict between coating systems given in this document and any other system specified elsewhere in the applicable contractual documents like SOR, MR, and PR etc, Contractor shall approach the Client/Client's authorized representative for confirming the suitable coating systems.

2.6 Changes and deviations required for any specific job due to clients requirement or otherwise shall be referred to EIL for deviation permit.

3.0 REFERENCE CODES & STANDARDS

3.1 Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, latest editions of the following codes and standards are applicable for the work covered under this specification.

International Organization for Standardization (ISO):

ISO 12944: Corrosion Protection of steel Structures by Protective Paint System

ISO 14713-2: Zinc Coatings - Guidelines and Recommendations for the Protections against Corrosion of Iron and Steel in Structures, Part-2: Hot Dip Galvanizing

ISO 8502-3: Preparation of steel substrates before application of paints and related products -Tests for the assessment of surface cleanliness - Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)

ISO 8502-9: Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 9: Field method for the conductometric determination of water-soluble salts.

ISO 2808: Paints and varnishes - Determination of film thickness

National Association for Corrosion Engineer (NACE):

NACE SP 0198: Control of Corrosion under Thermal Insulation and Fireproofing Materials

NACE SP 0188: Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

Steel Structures Painting Council (SSPC)

SSPC VIS 1: Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

SSPC PA 2: Measurement of Dry Paint Thickness with Magnetic Gauges

American Society for Testing and Materials (ASTM):

ASTM D6677-18: Standard Test Method for Evaluating Adhesion by Knife

ASTM D1475-13: Standard Test Method for Density of Liquid Coatings, Inks, and Related Products

ASTM D5894–16: Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)

ASTM D823–18: Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panels

ASTM D2369-10 (2015): Standard Test Method for Volatile Content of Coatings

ASTM D1640/D1640M-14(2018): Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings

ASTM D522/D522M–17: Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

ASTM D3363 - 05(2011): Standard Test Method for Film Hardness by Pencil Test

ASTM D2197–16: Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion

ASTM D968–17: Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

ASTM D1044–13: Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion

ASTM D1849-95 (2019): Standard Test Method for Package Stability of Paint

ASTM D2247–15: Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity

ASTM D543–14: Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

ASTM D870–15: Standard Practice for Testing Water Resistance of Coatings Using Water Immersion

ASTM D5146-10(2019): Standard Guide to Testing Solvent-Borne Architectural Coatings

ASTM D2485–18: Standard Test Methods for Evaluating Coatings for High Temperature Service

Other Applicable Standards:

RAL DUTCH: International Standard for colour shade (Dutch Standard)

ANSI A 13.1: Scheme for identification of piping systems: American National Standards Institution

ISO 8501-1 **/** SIS-05 59 00: ISO standard for Preparation of steel substrates before application of paints and related products. This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-In-Charge.

3.2 The contractor shall arrange, at his own cost, to keep a set of latest edition of above standards and codes at site.

3.3 The paint manufacturer's instructions shall be followed as far as practicable at all times for best results. Particular attention shall be paid to the following:

a. Instructions for storage to avoid exposure as well as extremes of temperature.

b. Surface preparation prior to painting shall carried out as per this standard

c. Mixing and thinning.

d. Application of paints and recommended limit on time intervals in between coats.

4.0 EQUIPMENT

4.1 All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipments, scaffolding materials, shot & grit blasting equipments & air compressors etc. required to be used shall be suitable for the work and all in good order and shall be arranged by the contractor at site and in sufficient quantity. The manufacturer's test certificates **/** data sheets for all the above items shall be reviewed by Engineer-in-charge at site before start of work.

4.2 Mechanical mixer shall be used for paint mixing operations in case of two pack systems except that the Engineer-In-Charge may allow the hand mixing of small quantities at his discretion in case of specific requirement for touch up work only.

5.0 SURFACE PREPARATION, SHOP PRIMER COATING APPLICATION & REPAIR

5.1 General

5.1.1 In order to achieve the maximum durability, one or more of following methods of surface preparation shall be followed, depending on condition of surface to be painted and as instructed by Engineer-In-Charge. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system.

a. Abrasive blast cleaning

b. Mechanical or power tool cleaning

5.1.2 Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. Unless otherwise specified, surface preparation shall be done as per provisions of relevant tables given elsewhere in this specification. The minimum acceptable standard, in case of thermally sprayed metal coatings, in case of mechanical or power tool cleaning it shall be St. 3 or equivalent. In case of blast cleaning it shall be Sa 2-1/2 as per Swedish Standard SIS-055900 (latest edition) or SSPC-SP or ISO 8501-01.Blast cleaning shall be Sa 3 as per Swedish Standard in case thermally sprayed metal coatings.

Before surface preparation by blast cleaning, the surface shall be degreased by aromatic solvent to remove all grease, oil etc.

5.1.3 Irrespective of whether external or internal surface to be coated, blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceed 85%. In case of internal coating of storage tanks, dehumidifier shall be used, to control humidity level below 60%. Dehumidifier should depress the dew point of air in the enclosed space, sufficient enough so as to maintain it 3^0C below the metal substrate temperature during centre period of blasting and coating application. During the interval time between application of primer coat and subsequent intermediate and top coats or between blast cleaning completion and start of application of primer coat, dehumidifier unit should be in continuous operation to ensure that no condensation occurs on substrate.

Dehumidifier should be able to maintain grain drop (moisture removal) at the rate of 25 grains per pound of air per hour. Dehumidifier should have capacity of at least 2 air changes per hour of the enclosed space. All necessary psychometric data should be collected by contractor for the given site conditions before starting operation of dehumidifier to ensure that desired values of dew point, moisture content in enclosed scope is achieved.

Dehumidification to be maintained round the clock for surface preparation and painting till the total coating application is over.
Dehumidifier shall not be stopped under any condition till the entire blasted surface is primed to the satisfaction of the technical representative of the paint manufacturer interested with quality assurance for the work. In case the dehumidifier breaks down

in middle of the job, the same shall be replaced at the risk and the cost of the contractor and the entire unfinished work shall be repeated.

5.1.4 The Engineer in-charge shall have the right to disallow usage of dehumidifier if the performance is not meeting the specified requirements. Under such circumstances the contractor shall remove the equipment and replace the same with another equipment to provide satisfactory results without any additional cost to the owner.

5.1.5 Irrespective of the method of surface preparation, the first coat of primer must be applied by airless spray/ air assisted conventional spray if recommended by the paint manufacturer on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavorable weather conditions, the Engineer-In-Charge shall have the liberty to control the time period, at his sole discretion and/or to insist on re-cleaning, as may be required, before primer application is taken up. In general, during unfavorable weather conditions, blasting and painting shall be avoided as far as practicable.

5.1.6 The external surface of R.C.C. chimney to be painted shall be dry and clean. Any loose particle of sand, cement, aggregate etc. shall be removed by scrubbing with soft wire brush. Acid etching with 10-15% HCL solution for about 15 minutes shall be carried and surface must be thoroughly washed with water to remove acid & loose particles and then dried completely before application of paint.

5.2 Procedure for Surface Preparation

5.2.1 Air Blast Cleaning with abrasives

The surfaces shall be blast cleaned using one of the abrasives like angular chilled cast iron or steel grit, copper slag or Nickel slag, $A1_2O_3$ particles at pressure of 7kg/cm^2 at an appropriate distance and angle depending of nozzle size maintaining constant velocity and pressure. Chilled cast iron or steel shall be in the form of shot or grit of size in the range of G16 – G42 conforming to SSPC AB1 and S250 grade size of steel shots (maximum) to obtain a desired surface profile of 35-50 microns trough to peak. For all other abrasives, size shall be in the range of G16 – G24. The combination of steel grits and shots shall be normally in the ratio of 3:1. The quality of abrasives shall be free from contaminants and impurities and shall meet the requirements of SSPC AB1. Compressed air shall be free from moisture and oil. The blasting nozzles should be venturi style with tungsten carbide or boron carbide as the materials for liners. Nozzles orifice may vary from 3/16" to ¾". On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey white metallic luster. Primer/first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall not be done outdoors in bad weather without adequate protection or when there is dew on the metal, which is to be cleaned. Surface profile shall be uniform to provide good key to the paint adhesion (i.e. 35 to 50 microns). If possible vacuum collector shall be installed for collecting the abrasives and recycling.

5.2.2 Mechanical or Power Tool Cleaning

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire- brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust mill scale etc. shall be removed by clean rags and /or washed by water or steam and thoroughly dried with compressed air jet before application of paint.

5.3 Non-Compatible Shop Coat Primer

For equipments on which application of total protective coating (Primer + Intermediate + top coat) is carried out at shop, compatibility of finish coat with primer should be checked with paint manufacturer. If the shop coat is in satisfactory condition showing no major defect upon arrival at site, the shop coat shall not be removed.

5.4 Shop coated equipments (coated with Primer & finishing coat) should not be repainted unless paint is damaged. Repair shall be carried out as per this specification depending upon compatibility of paint.

5.5 Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer should be completely removed before application of selected paint system for particular environment.

5.6 For Package units/equipment, shop primer should be as per the paint system given in this specification. However, manufacturer's standard can be followed after review.

As mentioned in section 2.4, all coating application at field (field primer, intermediate and top coat) on equipments, structures, piping, etc., shall be carried out only after its erection and all welding, testing, steam purging (wherever carried out) have been completed.

5.7 Coating Procedure and Application

All paint coatings shall be applied by airless spray excepting at the following special cases where application can be carried out by brush subject to suitability of the application of the paint product by brush.

- Spot repair
- Stripe coating on edges
- Small bore parts not suitable for spray application.

Irregular surfaces such as sharp edges, welds, small brackets, and interstices may stripe coated to ensure specified DFT is achieved. Paint manufacturer recommendation should be followed before deciding for brush application.

5.7.1 Surface shall not be coated in rain, wind or in environment where injurious airborne elements exists, when the steel surface temperature is less than 5°F above dew point when the relative humidity is greater than 85% or when the temperature is below 40°F and when the ambient/substrate temp is below the paint manufacturer's recommended temperature of application and curing. De-humidifier equipment shall be used to control RH and Dew point. The paint application shall not be done when the wind speed exceeds 20 km per hour.

5.7.2 Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hrs. of the same day.

5.7.3 To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.

5.7.4 Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional

coat can be applied without the development of any detrimental film irregularities, such as lifting or loss of adhesion of the under coat. Manufacturer instruction shall be followed for inter-coat interval.

5.7.5 When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life and shall be recommended by the original paint manufacturer.

5.7.6 Airless spray application shall be in accordance with the following procedure: as per steel structure paint Manual Vol.1 & Vol.2 by SSPC, USA, Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is sued to operate a pump to produce pressures of 1000 to 6000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less over spray. Airless spray usually is faster, cleaner, more economical and easier to use than conventional air spray.

Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from any container, including drums. The unit shall have in built agitator that keep the paint uniformly mixed during the spraying. The unit shall consist of in built strainer. Usually very small quantity of thinning is required before spray. In case of high build epoxy coating (two pack). 30:1 pump ratio and 0.020-0.023" tip size will provide a good spray pattern. Ideally fluid hoses should not be less than 3/8" ID and not longer than 50 feet to obtain optimum results.

In case of gun choking, de-choking steps shall be followed immediately.

5.7.7 Brush application of paint shall be in accordance with the following:

a. Brushes shall be of a style and quality that will enable proper application of paint.

b. Round or oval brushes are most suitable for rivets, bolts, irregular surface, and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.

c. Paint shall be applied into all corners.

d. Any runs or sags shall be brushed out.

e. There shall be a minimum of brush marks left in the applied paint.

f. Surfaces not accessible to brushes shall be painted by spray, doubers, or sheepkin.

5.7.8 For each coat the painter should know the WFT corresponding to the specified DFT and standardize the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.

5.8 Drying of Coated Surfaces

5.8.1 No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exceed maximum specified for it as a first coat; if it exceeds the paint material has possibly deteriorated or maxing is faulty.

5.8.2 No paint shall be force dried under conditions which will cause chalking, wrinkling, blistering formation of pores, or detrimentally affect the conditions of the paint.

5.8.3 No drier shall be added to paint on the job unless specifically called for in the manufacturer's specification for the paint.

5.8.4 Paint shall be protected from rain, condensation, contamination, snow and freezing until dry to the fullest extent practicable.

5.9 Spot Repair of Damaged Primer

5.9.1 Where pre erection shop primer has been damaged at isolated localized spots during handling and transportation, or after erection / welding, the repair of damaged coating of pre-erection / pre-fabrication or shop primer shall be done as given below and as per the Table given at Clause no. 9.1 of this specification.

5.9.2 Repair of damaged inorganic zinc silicate pre-erection / pre-fabrication or shop primer (F9) after erection / welding in the design temperature of -90°C to 400°C and damaged silicone aluminium (F-12) pre-erection / pre-fabrication or shop primer after erection / welding for design temperature range of 401 – 550 °C.

Surface Preparation: Quickly remove the primer from damaged area by mechanical scraping and emery paper conforming to SSPC-SP-3 to expose the white metal. Blast clean the surface, if possible. Feather the primed surface over the intact adjacent surface surrounding the damaged area by emery paper.

Primer coating: One coat of F-9 shall be applied wherever damage was observed on pre-erection / pre fabrication or shop primer of inorganic zinc silicate coating (F-9). Similarly one coat of F-12 shall be applied wherever damage observed on pre-erection / pre-fabrication shop primer of silicone aluminium (F-12).

5.9.3 Wherever if damaged areas are found extensive and spread over large areas, then entire pre-erection / pre-fabrication or shop primer shall be removed by blasting to achieve SSPC-SP-10 then entire blasted surface shall be primed again with F-9 or F-12 as applicable for the intended design temp.

5.10 Paint Application

5.10.1 Shop priming/pre-erection priming with F9 or F12 shall be done only on blasted surface (SSPC-SP-10)

5.10.2 Shop priming / pre-erection priming with F9 or F12 shall be done only with airless spray.

5.10.3 Assessment of Painting Requirement:

The paint system to be applied for a specific job shall be arrived at sequentially as given below:

- Identify the environment from area classification details and chose the appropriate table.

- Identify the design temperature from the technical documents

- Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.

- Identify the shop priming requirement from clause 9.1 based on compatibility of the above paint system.

- Identify the need of repair of shop primer and execute as per clause 9.1.

6.0 DOCUMENTATION/ RECORDS

6.1 A written quality plan with procedure for qualification trials and for the actual work including test and inspection plan & procedure for approval before start of work.

6.2 Daily progress report with details of weather conditions, particular of applications, no of coats and type of materials applied, anomalies, progress of work versus program.

6.3 Results of measurement of temperatures relative humidity, surface profile, film thickness, holiday detection, adhesion tests with signature of appropriate authority.

6.4 Particulars of surface preparation and paint application during trials and during the work.

6.5 Details of non-compliance, rejects and repairs.

6.6 Type of testing equipments and calibration.

6.7 Code and batch numbers of paint materials used.

The coating applicator must maintain a job record consisting of all the information as per 6.2 - 6.7 above as well as the approved procedure of work (6.1 above). The job record consisting of information as required in accordance to 6.2 - 6.7 shall be entered on daily basis and should be daily signed by Engineer-in-charge.

7.0 SURFACE PREPARATION STANDARDS

Sr. No.	Description	Various International Standards (Equivalent)			Remarks
		ISO 8501-1/ SIS-05 59 00	SSPC-SP, USA	NACE, USA	
1	Manual or hand tool cleaning Removal of loose rust, loose mill scale and loose paint, chipping, scrapping, standing and wire brushing. Surface should have a faint metallic sheen	St 2	SSPC-SP-2	-	This method is applied when the surface is exposed to normal atmospheric conditions when other methods cannot be adopted and also for spot cleaning during maintenance painting.
2	Mechanical or power tool cleaning Removal of loose rust loose mill scale and loose paint to degree specified by power tool chipping, de-scaling, sanding, wire brushing and grinding, after removal of dust, surface should have a pronounced metallic sheen.	St 3	SSPC-SP-3	-	
3	Dry abrasive blast cleaning There are four common grades of blast cleaning				
3.1	White metal Blast cleaning to white metal cleanliness. Removal of all visible rust. Mill scale, paint & foreign matter 100% cleanliness with desired surface profile.	Sa 3	SSPC-SP-5	NACE No. 1	Where extremely clean surface can be expected for prolong life of paint system.
3.2	Near white metal Blast cleaning to near white metal cleanliness, until at least 95% of each element of surface area is free of all visible residues with desired surface profile.	Sa 2½	SSPC-SP-10	NACE No. 2	The minimum requirement for chemically resistant paint systems such as epoxy, vinyl, polyurethane based and inorganic zinc silicate paints, also for conventional paint systems used under fairly corrosive conditions to obtain desired life of paint system.
3.3	Commercial Blast Blast cleaning until at least two-third of each element of surface area is free of all visible residues with desired surface profile.	Sa 2	SSPC-SP-6	NACE No. 3	For steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint systems.

Sr. No.	Description	Various International Standards (Equivalent)			Remarks
		ISO 8501-1/ SIS-05 59 00	SSPC-SP, USA	NACE, USA	
3.4	Brush-off Blast Blast cleaning to white metal cleanliness, removal of all visible rust, mill scale, paint & foreign matter. Surface profile is not so important	Sa 1	SSPC-SP-7	NACE No. 4	

8.0 PAINT MATERIALS

Typical characteristics and codes of various paint materials used in this specification are as follows:

Table: Paint Materials Characteristics

Description	P-2	P-4	P-6	P-7
Technical name	Chlorinated rubber Zinc Phosphate primer.	Etch primer/wash primer	Epoxy zinc phosphate primer	Cold Galvanizing
Type and composition	Single pack, air drying chlorinated rubber based medium plasticized with unsaponifiable plasticizer, pigmented with zinc phosphate.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pigmented with zinc tetroxy chromate.	Two component polyamine cured epoxy resin medium, pigmented with zinc phosphate.	One pack Synthetic Resin based zinc galvanizing containing min 92% of electrolytic zinc dust of 99.95% purity.
Volume Solids %, Minimum	37	9	49	37
DFT per coat, µ	40-45	8-10	40-50	40-50
Theoritical covering capacity in m^2/coat/ litre	8-10	8-10	8-10	4m^2/kg
Weight per litre in Kg/litre	1.3±0.05	1.2±0.05	1.4±0.05	2.67 kg at 15°C
Touch dry at 30°C (max.)	30 min.	2 hrs.	30 min.	10 min.
Hard dry at 30 °C (max.)	8 hrs.	24 hrs.	8 hrs.	24 hrs.
Over-coating interval	Min.: 8 hrs	Min: 4-6 hrs.	Min.:8hrs.	Min.:4 hrs
Pot life at 30 °C for two component paints	NA	NA	6 - 8 hrs.	NA
Adhesion (ASTM D4541)	NA	NA	>7 MPa	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	60 (Method A)	NA	80 (Method A)	50 (Method A)

Table: Paint Materials Characteristics (Contd.)

Description	F-2	F-3	F-6A/B	F-6C	F-7
Technical name	Acrylic Polyurethane finish paint	Chlorinated rubber based finish paint	Epoxy-High Build coating	Solvent less epoxy coating	High build coal tar epoxy coating.
Type and composition	Two-pack aliphatic isocynate cured acrylic finish paint.	Single pack plasticized chlorinated rubber based medium with chemical and weather resistant pigments.	F-6A Two-pack Aromatic amine cured epoxy resin medium suitably pigmented. F-6B: polyamide cured epoxy resin medium suitably pigmented	Two pack, cured with Amine Adduct; catalyzed epoxy resin suitably pigmented	Two pack polyamide cured epoxy resin blended with coaltar medium, suitably pigmented
Volume Solids %, (Min.)	40	36	57	98	62
DFT per coat, µ	30-4	30-40	100-125	250-500	100-125
Theoritical covering capacity in M^2/coat/litre	10-15	11-15	5-6	2-3	5.2-6.5
Weight per liter in kgs/litre	1.15±0.03	1.15±0.03	1.42±0.03	1.40±0.03	1.40±0.03
Touch dry at 30 °C, (Max.)	30 min.	30 min.	3 hrs.	3 hrs.	4 hrs.
Hard dry at 30 °C, (Max.)	8 hrs.	8 hrs.	16 hrs.	16 hrs.	48 hrs.
Full cure at 30 °C (for immersion/ high temperature service)	NA	NA	5 days	5 days	5 days
Over-coating interval	Min.12 hrs.	Min. Overnight	Min. Overnight, Max. 5 days	Min. 8 hrs., Max. 48 hrs.	Min. 24 hrs., Max. 5 days
Pot life (approx.) at 30 °C for two component paints	5-8 hrs.	NA	3-6 hrs.	30 min.	4-6 hrs.
Adhesion (ASTM D4541)	>5 MPa	>4 MPa	>7 MPa	>8 MPa	>5 MPa
Abrasion Resistance (ASTM D4060) For 1000 g load	<300 mg /1000 cycles/CS17 or <100 mg /1000 cycles/CS10	NA	NA	NA	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	80 (Method A)	60 (Method A)	80 (Method A)	120 (Method A)	125 (Method A)

Table: Paint Materials Characteristics (Contd.)

Description	F-8	F-9	F-11	F-12
Technical name	Self-priming type surface tolerant high build epoxy coating (complete rust control coating)	Inorganic zinc silicate coating	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C dry temp.	Heat resistant silicone Aluminium paint suitable upto 540°C dry temp.
Type & composition	Two pack epoxy resin based suitable pigmented and capable of adhering to manually prepared surface and old coating.	A two pack air drying self-curing solvent based inorganic zinc silicate coating with minimum 80% zinc content on dry film. The final cure of the dry film shall pass the MEK rub test ASTM D4752.	Heat resistant synthetic medium based two pack Aluminium paint suitable upto 250°C.	Ambient Temperature Curing, Single pack silicone resin based medium with Aluminium flakes.
Volume Solids %, Min.	75	57	35	18
DFT per coat, µ	100-125	65-75	15-20	15-20 (Note-13)
Theoretical covering capacity in m^2/coat/litre	6.0-7.2	8-9	10-12	8-10
Weight per liter in kgs/litre	1.41±0.03	2.3±0.03	0.95±0.03	1.00±0.03
Touch dry at 30 °C (max.)	3 hrs.	30 min.	3 hrs.	30 min.
Hard dry at 30 °C (max.)	24 hrs.	12 hrs.	12 hrs.	24 hrs.
Full cure 30°C (for immersion /high temperature service)	5days	NA	NA	NA
Over-coating interval	Min. 10 hrs.	Min. 12 hrs. at 20 °C & 50% Relative Humidity	Min. 24 hrs.	Min. 24 hrs.
Pot life at 30 °C for two component paints	90 min.	4-6 hrs.	NA	NA
Adhesion (ASTM D4541)	>5 MPa	>5 MPa	NA	NA
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	80 (Method A)	400 (Method B)	250 (Method A)	540 (Method B)

Table: Paint Materials Characteristics (Contd.)

Description	F-14	F-15	F-16	F-17	F-20
Technical name	Polyamine cured coal tar epoxy	Two-component Epoxy phenolic coating cured with Polyamine adduct hardener	Ambient temperature curing Poly Siloxane coating/ High build cold applied inorganic copolymer based aluminium coating suitable for under insulation of CS and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Glass flake reinforced vinyl ester coating
Type & composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Two pack ambient temperature curing epoxy phenolic coating system suitable for application under insulation	Suitable for high temperature service and under insulation coating for CS, alloy steel and SS	Novolac epoxy phenolic coating cured with Polyamine adduct hardener	Two component glass flake filled vinyl ester lining for under immersion services upto 90 °C.
Volume Solids %, Min.	67	67	58	98	98
DFT per coat, µ	100-125	75-100	75-100	300-450	500-600
Theoritical covering capacity in m^2/coat/ litre	5-8	4-5	7- 9	6.5- 8	1.6 minimum
Weight per liter in kgs/litre (mix paint)	1.45±0.03	1.65±0.03	1.3	1.7	>1.2
Touch dry at 30 °C (max.)	4 hrs.	3 hrs.	1 hr.	2 hrs.	2 hrs.
Hard dry at 30 °C (max.)	24 hrs	24 hrs	16 hrs	24 hrs	4 hrs.
Full cure 30 °C (for immersion /high temp. service)	7 days	7 days	NA	7 days	4 days
Over-coating interval	Min. 6 hrs., Max.5 days	Min. 36 hrs., Max. 21 days	Min.16 hrs., Max. NA	Min. 16 hrs., Max. 21 days	Min. 4 hrs., Max.3 days
Pot life at 30 °C (for two component paints)	4 hrs.	4-6 hrs.	1 hr.	1 hr.	50 min-1 hr.
Adhesion (ASTM D4541)	>6 MPa	>7 MPa	>8 MPa for Polysiloxane	>8 MPa	>7, Tensile strength >20N/mm2 (ASTM D 638)
Temperature Resistance (min.), °C (ASTM D 2485) *Note 8	125 (Method A)	150 (Method A)	550 (Method B)	150 (Method A)	90 (Method A)

Notes applicable for "Table: Paint Materials Characteristics"

1. Covering capacity and DFT achieved per coat depends on method of application. Covering capacity specified above is theoretical. For estimation of actual quantity of paints required, include the losses during application. Minimum specified DFT should be maintained in any case.
2. All primers and finish coats should be ambient temperature curing and air drying unless otherwise specified.
3. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship should be ensured. Wherever a deviation is noticed from the specification in manufacturer data sheet, more stringent one between the data sheet and the specification shall prevail e.g. if this specification recommends Sa2½ and the manufacturer data sheet requires Sa3, the surface preparation shall be done as per Sa 3. However in another case if this specification requires the surface preparation of Sa 2½ and the manufacturer data sheet recommends only Sa 2 as minimum, the surface preparation shall be done as per Sa 2½.
4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.
5. Higher specific gravity of F-9 is also acceptable.
6. Internationally recognized & acceptable testing method shall be used for lab testing wherever testing standards are not mentioned.
7. Theoretical covering capacity, hard dry, pot life, full cure period, & over coating interval shall be as per manufacturer's data sheets and no testing is required. Slight variation in the values of these parameters along with weight per liter may be permissible with the discretion of engineer-in-charge only.
8. Temperature resistance tests (ASTM D2485) shall be carried out for minimum required temperature resistance indicated.
9. Wherever ASTM D 2485 method B is applicable, test results of the panels subjected to salt spray (ASTM B 117) after muffle furnace exposure shall be submitted for pre-qualification purpose.
10. F-6A shall be suitable for immersion services.
11. F-6C shall be suitable for immersion services of hydrocarbons and DM water.
12. F-7 shall be suitable for immersion service of hydrocarbons & underground service up to 80 °C minimum.
13. Where F12 is used as primer, anchor profile height shall be as per F12 paint manufacturer recommendation.
14. F-14 shall be suitable for under insulation service up to 125 deg C.
15. F-15 shall be suitable for high temperature immersion & under insulation services.
16. F-17 shall be suitable for high temperature immersion service and underground services

9.0 COATING SYSTEMS

Corrosivity category C5-I (very high – industrial) in accordance with ISO 12944-2 and other International Standards/Practices are considered for selecting the Coating Systems for bare steel surfaces exposed to atmosphere. Atmospheric zone coating systems are selected for a high durability (beyond 15 years) period.

For insulated surfaces, coating selection is based on NACE 0198 guidelines and other successful international practices.

9.1 Repair of pre-erection/pre-fabrication or shop primer after erection/welding for all un-insulated CS, LTCS & low alloy steel items

Sr. No.	Design Temp. in ºC	Surface Preparation	Coating System	Total DFT in Microns (min.)	Remarks
1	-90 to 400	SSPC-SP-3	1 coat of F-9	65-75	See Note below and Clause 5.9.1
2	401 to 550	SSPC-SP-3	1 coat of F-12	20	

Note: The application and repair of pre-erection/pre-fabrication or Shop Primer given in above tables shall be done for all the items to be painted. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with F-9 or F-12 as applicable.

9.2 Coating system for Gratings (Note 4), Rolling & Stationery Ladders, Spiral Stairways, Hand Rails

Sr. No.	Design Temp., °C	Coating System	Total DFT in Microns (min.)
1	Up to 60	Hot Dip Galvanizing to 80-85 microns as per ISO 14713-2/ ISO 1461 + 1 coat of P-6 @ 40µ DFT/coat + 1 coat of F-2 @ 40 microns DFT/coat	80 microns of Painting (excluding the thickness of galvanizing)

Notes:

1. No galvanized specimen shall have thickness less than 80 microns.

2. Repair of the damaged areas of galvanized coatings due to welding during erection shall be carried out as per recommended practice ASTM A 780, using cold galvanizing spray process. Organic paint systems are not acceptable for the repair.

3. After repair of damaged galvanized coating by cold galvanization (P-7), the repaired area shall be top coated with paint system as given in table above (i.e. 1 coat of P-6 @ 40µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).

5. Galvanized gratings don't require painting in general except for safety reason such as escape routes, walkways. Hence, Galvanized gratings shall be painted for indication of escape routes or walkways only as per table above (i.e. 1 coat of P-6 @ 40µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).

9.3 Coating System for uninsulated and above ground (atmospheric zone) CS, LTCS & low allow steel surfaces

(Structural steel, pipings, vessels, columns, reactors, pumps, compressors, exchangers, valves & other equipment etc.)

Sr. No.	Design Temp., °C	Surface Preparation & Pre-erection/ Shop Primer	Coating System		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
1	-90 to -15	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	None	None	65-75	**a)** No over-coating to be done on F-9 as it will lead to mud cracking.
2	-14 to 80	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	1 coat of P-6 @ 40 µ DFT/coat (Tie/ Mist Coat)	2 coats of F-6A/ F-6B @ 100 µ DFT/Coat + 1 coat of F-2 @ 40µ DFT/Coat	345-355	
3	81 to 400	SSPC-SP-10; 1 coat of F-9 @ 65-75µ DFT/Coat	None	2 coats of F-12 @ 20µ DFT/Coat	105-115	
4	401 to 540	SSPC-SP-10; 1 coat of F-12 @ 20µ DFT/Coat	None	2 coats of F-12 @ 20µ DFT/Coat	60	

Notes:

1. The list of items given in the heading of the above table is not exhaustive. There may be more items for a particular contract where these specifications are used. The Contractor is fully responsible for completing painting including prefabrication primer for all the items supplied and fabricated through his scope of work as per tender document.

2. If the Pre-erection/Pre-fabrication & Shop Primer has already been completed, the same shall not be repeated again in the field. In case the damages of primer are severe and spread over large areas, the engineer-in-charge may decide & advise re-blasting and priming again. Repair of pre-fabrication/pre-erection primer, if required, shall be done as per this specification.

3. Flare line within unit or offsite areas shall be coated as per Sr. No. 3 of above table

4. For external surface of MS chimney with or without refractory lining and for internal surface without refractory lining, paint system as per Sr. No. 3 of above table shall be followed.

5. For external surface of RCC Chimney, 2 coats of F-6B @ 100µ DFT/coat to obtain total DFT of 200 µ shall be applied after proper surface preparation as per clause no. 5.1.6.

6. In case of paint systems where finish (top) coat is F-12, the colour bands shall be applied over the Aluminum paint as per the Color coding requirement for specific service of piping.

9.4 Coating system for effluent treatment plant (ETP)

Sr. No.	Design Temp., °C	Surface Preparation	Coating System		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
1	For External Surfaces of C.S./M.S. items: Screens, Walk way bridges, Baffles, Dual media filters, Vertical pumps, piping in treated effluent sump, bio sludge pump, Screw pump and pump house, CS tanks, sumps and vessels.					
	-45 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat + 1 Coat of P-6 @ 40 µ	2 coats of F-6A/ F-6B @100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat; (2x100+40=240)	345-355	-
2	For Internal Surfaces of CS/MS Items: Bio-sludge sump, Filter feed sump, Process sump, Sanitary sump, Transfer sump, Sludge, Slop oil tank, scrapping mechanism in Clarifier					
	-45 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat + 1 coat of epoxy based mist coat	3 coats of F-6A @100µ DFT/coat (3x100=300)	365-375	Note:1
3	All R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc. in Process sump, TPI separator (Process and Oil), Aeration Tank and Transfer sump etc.					
	-45 to 80	Blast cleaning to SSPC-SP guide lines and Acid etching with 10-15% HCl acid followed by thorough water washing.	Epoxy Screed lining		3mm	Epoxy screed lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions
4	C.S/M.S Dual media filters (Internal), Chemical dosing tanks (internal) such as Di-Ammonium Phosphate (DAP) and Urea					
	Up to 60	SSPC-SP-10	Natural Rubber Lining (As per IS 4682, Part 1 or equivalent International standards)		4.5mm	Natural Rubber lining shall be applied as per specific manufacturer and Engineer-in-Charge instructions

Notes:

1. Coating manufacturers shall provide their Quality control test certificate of coating materials (F-6A) for immersion service of the exposed effluent.

9.5 External coating systems for uninsulated carbon steel and low alloy steel Storage Tanks

Sr. No.	Design Temp., °C	Surface Preparation (Field)	Coating system		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
a	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external and internal floating roof and associated external structural works.					
1	-45 to 80	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat + 1coat of P-6 @ 40µ DFT/ coat ;	2 coats of F-6A/ F-6B @ 100µ DFT /coat + 1 coat of F-2 @ 40µ DFT/ coat;	345-355	F-6 should be suitable for occasional water immersion
2	81 to 120	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat + 1 coat of F-15 intermediate coat @ 80µ DFT/coat ;	1 coat of F-15 finish coat @80µ DFT/ coat + 1 coat of F-2 @ 40µ DFT/ coat;	280	-
3	121 to 400	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat	2 coats of F-12 @20 µ DFT/ coat Or 1 coat of F-16 @ 125 µ DFT / coat	105-115 Or 190-200	For higher design temperatures, system as per Sr. No. c (1) of this table is applicable
b	External surfaces of bottom plate (soil side) for all storage tanks					
1	-45 to 80	SSPC-SP-10	1 coat of F-7 @ 125µ DFT/ coat	2 coats of F-7@ 125µ DFT/coat	375	F-7 should be suitable for immersion service of the products given
2	81 to 150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat + 1 coat of F-15 intermediate coat @ 80µ DFT/coat	1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-

3	151 to 400	SSPC-SP-10	1 coat of F-16 @ 125 µ DFT /coat	1 coat of F-16 @ 125 µ DFT /coat	250	-
c	For underside of the bottom plate (in case tank is not lifted during PWHT)					
1	-180 to 650	For CS, SSPC SP 10	1 coat of inert polymeric matrix coating @ 125 µ	1 coats of inert polymeric matrix coating @ 125 µ	250	Note 2(c)
		For SS, SSPC-SP-7 (15-25µ surface profile)				

Notes

1. All paint coating application including primer for tankage shall be carried out at field after erection and completion of all welding.

2. For underside of bottom plate :

   a) Painting shall be carried out before laying of bottom plate for tanks with Non-Post Weld Heat Treatment (PWHT).

   b) For tanks with PWHT, painting shall be carried out after PWHT.

   c) In case tank is not lifted during PWHT then painting shall be applied before laying of bottom plate.

Caution: PWHT temperature shall not exceed 650 °C.

9.6 Internal coating systems for carbon steel and low alloy Storage Tanks

Sr. No.	Design Temp., °C	Surface Preparation	Coating system		Total DFT, µ (min.)	Remarks
			Primer	Finish Coat		
a	**Crude Oil, ATF, Turpentine Oil, Lubricating Oil & Vegetable Oil** Underside of floating roof, internal surface of cone roof, inside of bottom plate, Internal surfaces of Shell - including wetted and free board height, oil side surfaces of deck plates, oil side surfaces of pontoons, roof structures, structural steel, ladders and other CS internals					
1	-45 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat;	240	-
b	**Petroleum Products & Intermediates like LDO, HSD , Gas Oil, Feeds of FCC-PC, FCC-LCO, VGO-HDT, ISOM, DHDT, Reformate, DCU, NHT & Gasoline, Naphtha, Isomerate & Kerosene** Underside of Floating roofs, internal surface of cone roof, inside of bottom plate, internal surfaces of Bare shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures and ladders etc.					
1	-45 to 45	SSPC-SP-10	1 coat of F-9 @ 75 µ DFT/coat	-	65-75	
2	46 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat;	240	-
c	**Potable Water, Raw Water & Fire Water** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 60	SSPC-SP-10	1 Coats of F-6A @ 100 µ DFT/coat;	2 Coats of F-6A @ 100µ DFT/ Coat	300	Note-1
d	**De-Mineralized (DM) Water** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 60	SSPC-SP-10	1 Coats of F-6B @ 100µ DFT/coat;	2 coats of F-6C @ 200µ DFT/ coat;	500	-
2	61 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat; (80+80=160)	240	-
e	**Hydrochloric Acid (HCl) 10 %** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					

1	-45 to 60	SSPC-SP-10	1 Coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat	2 Coats of F-20 @ 500µ DFT/ Coat	1100	-
f	**Aggressive Solvents like Hexane, Hexene, Benzene, Xylene & Toluene** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 65	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	---	65-75	-
g	**Ethylene Glycol (EG) Tanks** Internal shell-full height, bottom plate, underside of roof and all accessories					
1	All	SSPC-SP-10	None	3 coats of vinyl chloride co-polymer @ 75µ /Coat; (3x75=225)	225	-
h	**Inside Pontoon and Inside of Double Deck of all Floating Roofs**					
1	-45 to 80	SSPC-SP-3	1 coat of F-8 @ 100µ DFT/coat	1 coat of F-8 @ 100µ DFT/coat	200	-
i	**Wet Slops, Amine Solutions, Sour Water , Water Draw Off** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	-45 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat;	240	-
j	**Vacuum Residue, Fuel Oil , Dry Slop, Bitumen & Other High Temperature Hydrocarbon Liquids** Underside of floating roof, internal surface of cone roof, bottom plate, inside of bare shell – including wetted and non-wetted surfaces, oil side surfaces of deck plates, oil side surfaces of pontoons, roof structures, structural steel and ladders					
1	Up to 150°C	SSPC-SP-10	-	1 coat of F-17 @ 375µ DFT/ coat;	375-475	-
k	**Alkalis upto 50 % Concentration** All internal surfaces, accessories and roof structures of Cone and Dome roof tanks					
1	Up to 60°C	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	2 Coats of F-6 A @ 100µ DFT/coat;	280-300	-

Notes

1. For Potable water tank lining, F-6 A shall be suitable for drinking water service and should have certification from competent authority like NSF International Standard NSF/ANSI-61 2004 or Water Regulations Advisory Scheme (WRAS), UK or Central food research Institute Mysore, India.

9.7 Coating systems for external side of underground carbon steel plant piping and underground Vessels

Sr. No.	Design Temp., °C	Surface Preparation & Shop Primer	Coating system		Total Final DFT, µ (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
a	**Underground carbon steel plant piping**					
1	25 to 65		SSPC-SP-10; 1 coat of synthetic fast drying primer 25 @µ DFT/ coat	1 layer of coal tar tape coating @ 2mm +1 coat of synthetic fast drying primer 25 @µ DFT/ coat + 1 layer of coal tar tape coating @ 2mm /layer as per EIL Std. Spec. 6-79-0011	-	Note 1
2	65 to 150	---	SSPC-SP-10; 1 coat of F-17 primer @ 400µ DFT/ coat	1 coat of F-17 intermediate coat @ 400µ DFT/coat	800	-
3	151 to 450	---	SSPC-SP-10; 1 coat of F-16 primer @ 125µ DFT/ coat	1 coat of F-16 finish coat @125µ DFT/ coat	250	This system is suitable up to 550 °C
b	**External side of uninsulated underground storage vessels**					
1	-45 to 80	SSPC-SP-10; 1 coat of F-7 @ 125µ DFT/ coat	---	2 coats of F-7 @ 125µ DFT/coat	375	-
2	81 to 150	SSPC-SP-10; 1 coat of F-17 primer @ 400µ DFT/ coat	---	1 coat of F-17 @ 400µ DFT/coat	800	-
3	151 to 400	SSPC-SP-10; 1 coat of F-16 primer @ 125µ DFT/ coat	---	1 coat of F-16 finish coat @125µ DFT/ coat	250	This system is suitable up to 550 °C

Notes:

1. Alternatively, 3LPE shop coated pipes conforming to DIN 30670 Type S-n up to maximum design temperature of 75°C is also acceptable. Fittings for 3LPE coated pipes, shall be coated with liquid epoxy as per DIN EN 10289, Class C and type 3. Thickness of the coating shall be minimum 1500 microns.

9.8 Coating System for Insulated CS, LTCS, Low Alloy Steel & Stainless Steels Surfaces

(Insulated Structures, Piping, Equipments, Storage vessels, tanks, Columns etc.)

Sr. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT, µ (min.)	Remarks
			Primer/ Intermediate	Finish Coat		
a	**Carbon steel, LTCS and Low Alloy Steel Piping, Storage tanks, Vessels, Equipments etc. (Note-1)**					
1	-45 to 125	SSPC-SP-10; 1coat of F-15 @ 75µ DFT/coat	-	2 coats of F-15 @ 75µ DFT/coat;	225	-
2	126 to 540	SSPC-SP-10; 1coat of F-12 @ 20µ DFT/coat	-	2coat of F-12 @ 20µ DFT/coat;	60	Note-2
b	**Stainless Steel and Alloy-20 Piping, Vessels & Equipments (Note-1, 3)**					
1	-45 to 125	SSPC-SP-7 (15-25µ surface profile); 1 coat of F-15@ 75 µ DFT/coat	-	2 coat of F-15 @ 75 µ DFT/coat;	225	
2	126 to 550	SSPC-SP-7 (15-25µ surface profile); 1 coat of F-16 @ 125 µ DFT/coat	-	1 coat of F-16 @ 125 µ DFT/coat	250	
c	**Cyclic Service of Carbon Steel, LTCS, Alloy Steels & Stainless Steel (Note 4)**					
1	- 45 to 150	SSPC-SP-10 For CS, LTCS & Low Alloy Steel, SSPC-SP-7 for SS (15-25µ surface profile); 1 coat of F-15 @ 75 µ DFT/coat	-	2 coat of F-15 @ 75 µ DFT/coat;	225	Note-5

2	-180 to -45 and 150 to 650	SSPC-SP-10 For CS, LTCS & low Alloy Steel; SSPC-SP-7 for SS (15-25µ surface profile) ; 1 coats of inert polymeric matrix coating @ 125 µ	-	1 coats of inert polymeric matrix coating @ 125 µ	250	

Notes

1. Coating system for design temperature range not covered in Sr. No. a & Sr. No. b, shall be as per the Sr.No.c2.
2. Alternatively, for Tanks, Vessels & Equipments, thermally sprayed aluminium coating (TSAC) @ 300µ as per ANNEXURE-I is also acceptable.
3. The blast cleaning abrasives for SS and Alloy steel surfaces shall be Aluminium oxide grits/shots or garnet.
4. "Cyclic Service" is characterized by rapid temperature fluctuation.
5. Alternatively, for this temperature range, 1 coat of F-17 @ 300 µ is also acceptable.
6. No painting is required for insulated Monel, Incoloy and Nickel lines.

9.9 Internal Coating System for carbon steel components of coolers/ condensers for fresh water service

(Water boxes, channels, partition plates, end covers and tube sheets etc.)

Sr. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT, µ (min.)	Remarks
			Primer	Finish paint		
1	-45 to 80	SSPC-SP-10	1 coat of F-15 @ 80 microns	2 coats of F-15 @ 80µ DFT/coat;	240	-
2	80 to 140	SSPC-SP-10	---	1 coat of Glass Fibre Reinforced Novolac Epoxy	1500	-

Note: Above table is applicable in line with the data sheets of the respective exchangers.

9.10 Internal Coating System for galvanized or non-ferrous or stainless steel/ duplex stainless steel components of coolers/ condensers for fresh water service

Sl. No.	Design Temp., °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT (min.), µ	Remarks
			Primer	Finish paint		
1	-45 to 80	Sweep Blasting	1 coat of F-15 @ 80µ DFT/coat;	1 coat of F-15 @ 80µ DFT/coat;	160	-
2	80 to 140	Sweep Blasting	-	1 coat of Glass Fibre Reinforced Novolac Epoxy	1500	-

Note: Above table is applicable in line with the data sheets of the respective exchangers.

10.0 STORAGE

All paints and painting materials shall be stored only in rooms to be arranged by contractor and approved by Engineer-in-charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word "PAINT STORAGE – NO NAKED LIGHT – HIGHLY INFLAMABLE" shall be clearly displayed outside. Manufacturer's recommendation shall be followed for storage of paint materials.

11.0 COLOUR CODE

The colour coding of OWNER is applicable. It is in the applicators/contractors scope to obtain confirmation for applicable colour coding from the OWNER.

In absence of any existing color coding scheme of the OWNER, Color Code scheme given in ANNEXURE-II shall be followed.

12.0 IDENTIFICATION OF COLUMNS, TANKS, VESSELS & PIPINGS etc.

12.1 Equipment number shall be stencilled in black or white on each vessel, column, equipment & machinery (insulated or uninsulated) after painting. Line number in black or white shall be stencilled on all the pipe lines of more than one location as directed by Engineer-In-Charge; Size of letter printed shall be as below:

Column & Vessels	-	150mm (high)
Pump, compressor & other machinery	-	50mm (high)
Piping	-	40-150 mm

12.2 Identification of Storage Tanks

The storage tanks shall be marked as detailed in the drawing.

13.0 PAINTING FOR CIVIL DEFENCE REQUIREMENTS

13.1 Following items shall be painted for camouflaging if required by the Client:

a. All Columns
b. All Tanks in Offsites
c. Large Vessels
d. Spheres

13.2 Two coats of selected finishing paint as per defense requirement shall be applied in a particular pattern as per 13.3 and as per the instructions of Engineer-In-Charge.

13.3 Method of Camouflaging

13.3.1 Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matte finish).

Dark Green		Light Green		Dark Medium Brown
5	:	3	:	2

13.3.2 The patches should be asymmetrical and irregular.

13.3.3 The patches should be inclined at 30º to 60º to the horizontal.

13.3.4 The patches should be continuous where two surfaces meet at an angle.

13.3.5 The patches should not coincide with corners.

13.3.6 Slits and holes shall be painted in dark shades.

13.3.7 Width of patches should be 1 to 2 meters.

14.0 QUALITY CONTROL, INSPECTION AND TESTING

14.1 All painting materials including primers and thinners brought to site by contractor for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable (see section 16.0).

14.2 The contractor must produce Test Certificate from Pre-Qualified Paint Manufacturer for various tests as detailed out in section 17.0 of this document. The Engineer-in-Charge shall have the right to test wet samples of paint from each batch at random for verifying quality of paint supplied. Contractor shall arrange to have such tests, when called for by Engineer-in-Charge, performed at his cost at any one of the NABL accredited laboratories under witness of NACE CIP Level-2 (min.) / Owner/ Owner's representative.

Samples for the test will be drawn at random in presence Engineer-in-Charge or his representations. Following tests to be carried out if called for by Engineer-in-Charge:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)
- Drying time (touch dry & full curing)
- Adhesion
- Flexibility
- Hardness
- Storage stability (pot life)

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

14.3 The painting work shall be subject to inspection by Engineer-In-Charge at all times. In particular, following stage-wise inspection will be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

(a) Surface preparation
(b) Primer application
(c) Each coat of paint

14.4 **Surface preparation:** Following tests are to be carried out during surface preparation**.**

i) Test for presence of oil/ grease and contamination

The steel substrate after degreasing as per SSPC-SP 1 shall be tested as per following procedure to validate absence of oil and grease contamination:

- Visual inspection: Continue degreasing until all visible signs of contamination are removed.
- Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice

corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination.
- Continue degreasing and inspection till test is passed.

ii) Tests for surface finish of blasted surface shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component atleast once per 200 m^2 of blasted surface and minimum of 3 checks per shift.

iii) Test for presence of soluble salt as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg/m^2. Checks shall be done on each component atleast once per 200 m^2 of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of IS 12944-4 (water cleaning). After cleaning surface shall be retested for salt after drying.

iv) Blast Profile Measurement

The angular profile depth measurement shall be done by profile tape as per method NACE Standard RP 0287 or ASTM D 4417 method B (Profile depth gauge micrometer). Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported. If desired profile (35-50 µ or as recommended by paint manufacturer) is not achieved, blasting shall continue to get the required profile.

v) Test for Blasting Media (for every fresh batch of media and one random test during blasting):

- Blasting Media shall be visually inspected for absence of contamination and debris using 10X magnification.
- Inspection for the absence of oil contamination shall be conducted using following procedure:
  - Fill a small clean 200 ml bottle half full of abrasive.
  - Fill the bottle with potable water, cap and shake the bottle.
  - Inspect water for oil film/slick. If present, the blasting media is not to be used.
- Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.
- Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

vi) Test for Blasting Air (once daily before start of blasting and once at random during blasting):

The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate, zinc rich epoxy or zinc phosphate etc. Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer-In-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, contractor shall be responsible for making good any defects found during final inspection/guarantee period/ defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and

extra coat of paint should be applied to make-up the DFT specified without any extra cost to owner, the extra coat should have prior approval of Engineer-in-charge.

14.5 Primer Application

After surface preparation, the primer should be applied to cover the crevices, corners, sharp edges etc. in the presence of inspector nominated by Engineer-In-Charge. The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by Engineer-In-Charge before application of successive coats.

The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring dry film thickness of each coat, surface profile gauge for checking of surface profile, holiday detectors and pinhole detector and protector whenever required for checking in case of immersion conditions.

Prior to application of paints on surfaces of chimneys, the thickness of the individual coat shall be checked by application of each coat of same paint on MS test panel. The thickness of paint on test panels shall be determined by using gauge such as 'Elkometer'. The thickness of each coat shall be checked as per provision of this specification. This shall be approved by Engineer-In-Charge before application of paints on surface of chimney.

At the discretion of Engineer-In-Charge, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations. The contractor is responsible to arrange the same.

14.6 Inspection of finished coating: Inspection of applied coatings shall consist of measurement of the following:

i) Coating Dry Film Thickness Check: DFT measurement shall be as per ISO 2808. Type II electromagnetic gauges should be used for ferrous substrates. DFT gauge calibration, number of measurement shall be as per SSPC-DA 2. Measured DFT shall be within + 10% of the dry film thickness, specified in the specifications.

ii) Adhesion Testing: Adhesion of the primer to the steel substrate and inter-coat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife test in accordance with ASTM D 6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is destructive and tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform the adhesion test on a steel coupon coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m^2 of coated surface.

iii) Holiday Testing: Holiday testing shall be conducted in accordance with NACE SP 0188. For immersion services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP 0188. Any holiday is unacceptable and should be marked and repaired immediately.

14.7 The contractor shall arrange for spot checking of paint materials for Specific gravity, glow time (ford cup) and spreading rate.

14.8 Final Inspection of coating system

A final inspection shall be conducted prior to the acceptance of the work. The coating contractor and the facility owner shall both be present and they shall sign an agreed inspection report. Such reports shall include:

General

- Names of the coating contractor and the responsible personnel
- Dates when work was performed

Coating Materials

- Information on coating materials being applied
- Condition of coating materials received

Environmental Conditions

- Weather and ambient conditions
- Coating periods

Surface Preparation

- Condition of surface before preparation
- Tools and methods used to prepare surface
- Condition of surface after preparation

Coating Application

- Equipment used
- Mixing procedure prior to application
- Coating application techniques used

Testing

- Type and calibration of inspection instruments used
- Type of quality control tests performed, and results

15.0 GUARANTEE

The contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work.

16.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR/ SUB-CONTRACTOR

Painting contractor who is awarded any job for EIL, Projects under this standard must have necessary equipments, machinery, tools and tackles for surface preparation, paint application and inspection. The contractor mush have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The contractor supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

17.0 QUALIFICATION/ ACCEPTANCE CRITERIA FOR COATING SYSTEM

17.1 Pre-Qualification of Paint Coating Manufacturer and Products

Paint Coating manufacture meeting the following requirements shall be considered for supply of their products:

- Manufacturer should have been in continuous business of paint coating formulation and manufacturer for at least past 5 years.
- Manufacturer should posses past experience of supplying his products to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms in the past 5 years.
- Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon, petrochemical, fertilizer, chemical processing industry or offshore platforms.
- The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 requirements and preferably should posses ISO 14000 certificate.
- The Quality control set up should be manned by qualified paint technologists whose bio data should be sent along with quality control organization chart.

CONTRACTOR shall procure the paint materials from the qualified manufacturer meeting above requirements and after obtaining prequalification testing approval as per requirements mentioned in clause 17.2 below.

17.2 Pre-Qualification Testing Procedure:

The paint manufacturer engaged by the mechanical contractor shall carry out the tests in reputed Government Laboratories (like National Test House Mumbai, National Test House Kolkata, Institute of Chemical Technology Mumbai, HBTI Kanpur, IICT Hyderabad) as a part of qualification. Paint manufacturer shall provide the paint samples to laboratory for testing of the parameters for each category of paint as mentioned in Clause 8.0 (Paint Materials Characteristics) and testing of Coating System properties as per Table given below. The testing laboratory will confirm the compliance of the paint material with respect to the acceptance criteria mentioned in this specification. Contractor shall furnish these test certificates along with all necessary supporting documents/information to Site-in-charge for approval/ acceptance. The paint manufacturer will be qualified and approved by Site-in-charge for supply of paints after review/assessment of the submissions made by the contractor. Test certificates which are more than 3 years old will not be considered. Paint manufacturers are advised to carryout pre-qualification testing prior to paints supply at site.

TABLE: PRE-QUALIFICATION TESTING

System No.	Coating System	Reference Clause	Total DFT, µ (Min.)
1.	F-9+P6+F6A/B+F2	Clause 9.3, Sr. No. 2 of table	345
2.	F12+F12+F12	Clause 9.3, Sr. No. 3 of table	60
3.	F15+F15+F15	Clause 9.5,	240

		Sr. No. b (2) of table	
4.	F16+F16	Clause 9.5, Sr. No. b (3) of table	250
5.	F17	Clause 9.6, Sr. No. j (1) of table	375
6.	F8+F8	Clause 9.6, Sr. No. h (1) of table	200
7.	F7+F7+F7	Clause 9.5, Sr. No. b (1) of table	375
8.	F-20	Clause 9.6, Sr. No. e (1) of table	1100
9.	F6B+F6C+F6C	Clause 9.6, Sr. No. d (1) of table	500
10.	Inert Polymeric Matrix	Clause 9.5, Sr. No. c (1) of table	250
11.	F6A+F6A+F6A	Clause 9.6, Sr. No. c (1) of table	300

Sr. No.	Test	For System Number	Duration	Acceptance Criteria
1.	Cyclic Test Salt Spray: 72 hrs. Drying in air: 16 hrs. UV-A340 nm weather meter: 80 hrs. One cycle: 168 hrs. (25 cycles at 168 hrs. each cycle) (ASTM D5894)	1	4200 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling shall be observed.
2.	Chemical Resistance Test **(**ASTM D543)			
2a.	10% & 40% NaOH	3,5,8 & 11* *H_2SO_4 solution pH = 5.0 to 5.5 for system 11	1000 hrs.	Shall pass.
2b.	5% H_2SO_4		168 hrs.	No cracking, discoloration, blistering, peeling or softening of film shall be observed.
2c.	Xylene		4 weeks	
2d.	Acetone		4 weeks	
2e.	Ethanol		4 weeks	
2f.	Kerosene		4 weeks	

2g.	Sea water		2000 hrs.	
3.	Immersion in DM/DI water @ 90° (ASTM C868)	3,5 & 8	30 days	No softening, blistering or film damage.
4.	Resistance to DM water using water immersion. (ASTM D870)	9	2000 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling.
5.	100% Humidity Test (ASTM D2247)	1 to 11 (except system-2)	1440 hrs.	Shall pass
6.	Dry Heat Resistance Test (ASTM D2485 method B at 540^{o} C for system 2 and 550^{o} C for system 4)	2 & 4	-	Shall pass the test. No peeling, cracking, blistering, abnormal discoloration or loss of adhesion.
7.	Thermal Shock Resistance Test; 5 cycles @ 30 minutes in furnace at 120 ^{o} C and 15 minutes in water after quenching in water for each cycle. (ASTM D2485 method A)	2,3,4 & 10 (For system-2, testing to be done after heating the panels at 175°C for 2 hrs.)	-	Shall pass
8.	Cathodic Disbondment Test (ASTM G8 @ 60°C)	3 & 5	-	Shall pass

Each coating product to be qualified shall be identified by the following:

1) Specific gravity of Base and curing agent (Ref. ISO 2811)
2) Ash content (ASTM D1650), volatile and non-volatile matters (ISO 3251) of each component

These identification tests of coating materials shall be carried out on the batch, which is used for the Pre-qualification testing and in the same reputed government laboratory.

17.3 Information to be furnished during delivery of paint materials:

CONTRACTOR along with delivery of paint material has to furnish following information from paint manufacturer to EIL for acceptance/approval of products:

a) Batch test certificates

Along with paint products delivery to site from the pre-qualified coating manufacturer, CONTRACTOR has to produce test certificate (from paint manufacturer) for each category of product for the following test items. All test results must mention clearly the batch no. and category of product tested. Tests shall be witnessed by NACE CIP Leve-2 (minimum) inspector. Tests to be conducted for following properties:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)

b) Product information sheet/ technical data sheet for each category of product

The contractor shall be fully responsible for the quality of the paints products as per prequalification testing. After the paint materials are supplied to site, the supplier shall organize random sampling and testing in a laboratory as per discretion of the Engineer-in-charge (refer clause 14.2). Failing to meet the specified quality requirements may cause rejection of the paint products.

18.0 METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING

(Pre-Qualification tests (sec. 17.2), Batch testing (sec. 17.3) and Inspection testing (sec. 14.0))

18.1 Samples of coating materials should be submitted to the laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory.

18.2 All test panels should be prepared by testing laboratory. Surface preparation for a system shall be done in accordance with this specification. For individual products testing, minimum surface preparation shall be Sa 2.5. Colour photographs of test panels should be taken before and after the test and should be enclosed along with test report.

Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

18.3 Manufacturers should intimate EIL, details of sample submitted for testing, name of testing agency, date, and contact personnel of the testing agency.

ANNEXURE-I

SPECIFICATION FOR THERMALLY SPRAYED ALUMINIUM COATING (TSAC)

1.0 SCOPE

The following sections outlines the requirement of supply, application and testing of thermally sprayed aluminum coatings (TSAC) for corrosion protection of carbon steel piping and equipments with design temperature not exceeding 540 ^{0} C.

2.0 ITEMS TO BE THERMALLY SPRAYED

Steel Structures/equipments to be protected by TSAC shall be as specified in this specification. Structures, components thermally sprayed shall not have any uncoated area or shall not be in mechanically connected by flanges etc to any uncoated bare steel work. Such adjacent areas to TSA coated areas, if not coated by TSA shall have suitable paint coating system as per the standard specification.

3.0 TSAC REQUIREMENTS

3.1 Surface Preparation

All the parts to be sprayed shall be degreased according to SSPC-SP-1. The absence of oil and grease after degreasing shall be tested by method given elsewhere in the specification (Refer Sec. 6.7). Thereafter the surface to be abrasive blasted to white metal finish as per NACE 1/SSPC-SP-5 for marine and immersion service. Using SSPC VIS 1, it is to be visually assessed that the blast cleaned surface meets requirement of SSPC-SP-5. Thereafter clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on the blasted surface. Finally blasted surface shall be tested for presence of soluble salts as per method ISO 8502-9. Maximum allowable salt content shall be considered 50mg/m^2. (5 micrograms/cm^2) .In case salt content exceeds specified limit. The contaminated surface shall be cleaned by method as per Annex C of IS 12944-4 (Water Cleaning). After cleaning the surface shall be retested for salt content after drying. Testing shall be carried out at least on each component, once per 200 m^2 and a min of 3 times per shift during progress of work.

The blasting media shall be either chilled iron or angular steel grit as per SSPC-AB-3 of mesh size G-16 to G-40. Copper, Nickel slag, Garnet or Aluminum Oxide as abrasives will also be suitable having mesh size in the range of G16 to G24 (10-30 mesh), conforming to SSPC-AB-1. Mesh size shall be required as appropriate to the anchor tooth depth profile requirement and blasting equipment used. The blasted surface should be having angular profile depth not less than 65 microns with sharp angular shape but shall not exceed 85 microns. The profile depth shall be measured according to NACE standard RP 0287 (Replica Tape) or ASTM D 4417 method B (Profile depth gauge).

For manual blasting one profile depth measurement shall be taken every 10-20 m^2 of blasted surface. Surface preparation shall be completed in one abrasive blast cleaning operation wherever possible. If rust bloom (visual appearance of rust) appears on the blast cleaned surface before thermal spraying, the affected area shall be re-blasted to achieve specified degree of cleanliness after which only thermal spraying shall commence.

Air blasting pressure at nozzle shall be normally maintained at 100 psi. Air pressure and media size should be reduced and adjusted to preclude damage/distortion to thin gauge materials. Blasting time on work piece should be adjusted to only clean the surface and cut required anchor tooth with minimum loss of metal. Blast angle should be as close to perpendicular as possible but in no case greater than $\pm$ 30 ^{0} from perpendicular to work surface. Blasting media must be free of debris, excessive fines, and contaminants such as NaCl and sulfur salts (Ref. SEC 6.0 of this Spec). Blast cleaning shall not be performed when the surfaces to be blasted are wet or less than 5°C above dew point temperature or when the relative humidity in the vicinity of the work is greater than 90%.

3.1.1 Blasting Equipment

The TSAC applicator shall use mechanical (centrifugal wheel) or pressure pot blast cleaning equipment and procedures. Suction blasting equipment shall not be used. Sec 6.6.2 shall be used to validate clean and dry air.

3.1.2 Feed Stock

The feed stock shall be in the form of wire. The feed stock shall be 99.5% aluminum of commercial purity grade, its composition shall be in accordance with requirement of BS 1475 or ASTM B833 or ISO 209-1 type A1 (wrought aluminum and aluminum alloys, wire). Wire shall be supplied in protective wrapping indicating batch number and other details.

3.1.3 Thickness Requirement

The nominal thickness of finished TSAC shall be 300 microns having minimum value of 275 microns at low thickness areas (valleys) and not more than 325 microns at peak areas.

The finished thickness shall be measured using SSPC-PA 2 type 2 fixed probe gauge (Magnetic Gauge).

3.1.4 Coating Bond Strength Requirement

The TSAC coating shall have a minimum individual tensile-bond strength value of 1000 psi for flame sprayed and 1500 psi for arc sprayed coating with an average of 2000 psi for arc sprayed coatings. Minimum tensile bond strength should be achieved by proper anchor tooth profile of blasted surface, laying down the TSA thickness in multiple passes and carrying out TSA application under controlled environment

3.1.5 Porosity

All thermally sprayed metallic coatings will have porosity. For thermally sprayed aluminum coatings porosity shall not exceed 15% of total surface area for flame sprayed coating and 8% for arc spray coating.

4.0 THERMAL SPRAY APPLICATION PROCEDURE

Items in the atmospheric zone to be coated by TSA shall be applied by either Flame spray or Arc spray method only. For coating under insulation, application shall be by arc wire method.

4.1 Equipment Set Up

4.1.1 Thermal spray equipment shall be set up calibrated, operated (1) according to manufacturer instructions/technical manuals and also TSAC applicators refinement thereto and (2) as validated by Procedure Qualification (Sec 7.0 of this specification).

4.1.2 **Spray Parameters**

Spray parameters (see 4.1.3 below) and thickness of each crossing pass shall be set and shall be validated with bend test (See 6.5 of this Spec).

4.1.3 Spray Parameters

Spray Parameters	Method of Application	
	Arc wire Spray	Flame Wire Spray
Arc voltage	27 V	-
Air pressure	80 psi	80 psi
Steel surface cleanliness	NACE-1 white metal	NACE-1 white metal / or Near white metal
Steel surface profile	75 microns (minimum)	75 microns (min.)
Arc current	250-280A	-
Coating thickness	225 microns (nominal)	225 microns(Nominal)
Coating adhesion	> 1500 psi (Total coating),see 3.1.4	>1000 psi
Coating porosity	Less than 8%	Less than 15%.
Spray distance (spray Gun work piece)	6-8”	5-7”
Spray Pass width	40mm	20 mm

The above parameters to be validated with a bend test by the contractor before start of work (for details of bend test see Sec 6.5 of this Spec).

4.2 Post Blasting Substrate Condition and Thermal Spraying Period.

4.2.1 The steel surface temperature shall be at least 5°C above dew point of ambient air temperature.

Steel substrate surface temperature shall be recorded by with a contact pyrometer. Thermal spraying should commence within 15 minutes from the time of completion of blasting

4.2.2 **Holding Period**

Time between the completion of final anchor tooth blasting and completion of thermal spraying of blasted surface should be no more than four hours. If within this period rust bloom appears Sec 4.4.1 of this specification will apply.

4.3 Pre-Heating

For flame spraying, the initial starting area of 1-2 square feet to be preheated to approx.120^{0}C to prevent condensation of moisture in the flame on the substrate. For arc spraying the preheating is not required.

4.4 Thermal Spraying

Spraying should commence only after validation of equipment set up by procedure qualification test and spray parameter validation tests described in Sec 7.0 and 6.5 respectively. Thermal spraying must commence within 15 minutes from the time of completion of blast cleaning

The specified coating thickness shall be applied in several crossing passes. The coating bond strength is greater when the spray passes are kept thin. Laying down an excessively thick spray pass increases the internal stresses in TSAC and decreases the bond strength of total TSAC. The suitable thickness for crossing passes shall be determined by procedure qualification test described in Sec 7.0 of this specification.

For manual spraying, spraying to be done in perpendicular crossing passes to minimize thin spots in coating. Approx. 75-100 microns of TSAC shall be laid down in each pass.

The surface geometry of the item or area to be sprayed should be inspected before application. The spraying pass and sequence shall be planned according to following.

- Maintain Gun as close to perpendicular as possible and within $\pm$ 30° from perpendicular to the substrate.
- Maintain nominal standoff distance and spray pass width as given below:

Spray method	Standoff (Inches)	Spray pass width (Inches)
Arc Wire	6-8	1 ½(40mm)
Flame wire	5-7	¾(20mm)

4.4.1 **Rust Bloom** (Visual appearance of rust or Discoloration):

If Rust bloom appears on the blasted surface before thermal spraying, the affected area shall be re-blasted to achieve the specified level of cleanliness.

If Rust bloom in form of discoloration, or any blistering or a degraded coating appears at any time during application of TSAC, then spraying shall be stopped and acceptable sprayed area shall be marked off. The unsatisfactory areas shall be repaired to the required degree of surface cleanliness and profile.

Blast the edges of the TSAC to provide for 2-3" feathered area overlap of the new work into existing TSAC.

Then apply TSAC to the newly prepared surfaces and overlap the existing TSAC to the extent of feathered edge so that overlap is a consistent thickness.

4.4.2 **Masking**

Masking all those parts and surfaces which are not required to be thermally sprayed as instructed by purchaser should be inspected by applicator to ensure that they are properly marked and covered by purchaser.

Complex geometries (flanges, valve manifolds, intersections) shall be masked by applicator to minimize overspray i.e. TSAC applied outside spray parameters (primarily gun to substrate distance and spray angle).

4.4.3 **TSAC Finish**

The deposited TSAC shall be uniform without blisters, cracks, loose particles, or exposed steel as examined with 10 X magnification.

5.0 SEALER

Sealant shall be applied after satisfactory application of TSAC and completion of all testing and measurements of the finished TSAC as per Sec 6.0 of this specification.

For shop work Sealer shall be applied immediately after thermal spraying and for field work sealer shall be applied within 8 hours. The sealcoat shall be thin enough to penetrate into the body of TSAC.

The sealant shall be Silicone Alkyd Aluminium paint having DFT not more than 35-40 micron. Typically seal coat shall be applied at a spreading rate resulting in theoretical 38 microns DFT. The seal coat shall be applied in accordance with SSPC-PA 1 and the paint manufacturer instruction for sealing.

6.0 TESTING AND MEASUREMENT SCHEDULE

6.1 Surface Finish

That the blasted cleaned surface meets the required criteria (NACE 1/SSPC-SP 5) shall be visually inspected using SSPC-VIS 1. The clear cellophane-tape test as per ISO 8502-3 shall be used to confirm absence of dust or foreign debris on the cleaned surface. Checks shall be done on each component at least once per 200 m^2 of blasted surface and minimum of 3 checks per shift.

6.2 Blast Profile Measurement: (In-Process testing during actual production before application of TSA coating)

The angular profile depth measurement shall be done by profile tape as per method NACE Standard RP 0287 or ASTM D 4417 method B (Profile depth gauge micrometer). Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported.

If profile is <65 microns blasting shall continue till greater than 65 microns depth profile is achieved.

6.3 TSAC Thickness (In-Process Testing For finished coating during regular production)

6.3.1 TSAC finished thickness shall be measured using SSPC-PA 2 type 2 fixed probe gauge.

6.3.2 For flat surfaces, measurements shall be taken along a straight measurement line, one measurement line for every 15 m^2 of applied TSAC shall be selected along which 5 measurements to be taken at 25 mm internal and average to be reported.

6.3.3 For curved surface or complex geometry, 5 measurements shall be taken at a spot measuring 10 cm^2 in area. One spot to be taken for every 15 m^2 of applied TSAC area.

6.3.4 The TSAC thickness in surface changes or contour changes, welds and attachments shall be also measured and reported.

6.3.5 If TSAC is less than specified minimum thickness, apply additional TSAC until specified thickness range is achieved.

6.3.6 All locations and values of TSAC thickness measurements shall be recorded in Job Record (JR).

6.4 Tensile Bond Testing (In-Process testing for finished coating during regular production)

- Tensile Bond strength of the TSAC finish coat shall be determined according to ASTM D 4541 using a self-aligning adhesion tester.

- One measurement shall be made every 50 m^2. If tensile bond at any individual spot is less than 1000 psi for flame sprayed coating and 1500 psi for arc sprayed coating the degraded TSAC shall be completely removed and reapplied.

- The tensile bond portable test instrument to be calibrated according to ASTM C 633

6.5 Bend Tests

Bend test shall be carried out at beginning of each work shift. Bend tests shall also be conducted on sample coupons before start of thermal spraying work to qualify the following as mentioned earlier in this specification.

- To qualify spray parameters and thickness of each crossing pass.

6.5.1 **Test Procedure**

a) Five corrosion control steel coupons each of dimension 50 mm x 150 mm x 1.3 mm thick to be prepared.

b) Surface shall be prepared by dry abrasive blast cleaning as per this specification.

c) TSAC shall be applied as per specified thickness range. TSAC should be sprayed in crossing passes laying down approx. 75-100 microns in each pass.

d) TSAC applied coupons shall be bent 180° around a 13 mm diameter mandrel.

e) Bend test shall be considered passed if on bend radius there is

- No cracking or spalling or lifting by a knife blade from the substrate
- Only minor cracking that cannot be lifted from substrate with a knife blade.

f) Bend test fails if coating cracks with lifting from substrate.

6.6 Tests for blasting media, blasting air

6.6.1 Blasting Media (For every fresh batch of media and one random test during blasting)

Blasting Media shall be visually inspected for absence of contamination and debris using 10 X magnification.

a) Inspection for the absence of oil contamination shall be conducted using following procedure :

- Fill a small clean 200 ml bottle half full of abrasive.
- Fill the bottle with potable water, cap and shake the bottle.
- Inspect water for oil film/slick. If present, the blasting media is not to be used.

b) Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.

c) Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

6.6.2 Test for Blasting Air (Once Daily before start of blasting and once at random during blasting)

The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

6.7 Test for presence of oil/grease and contamination

The steel substrate after degreasing as per SSPC-SP 1 shall be tested as per following procedure to validate absence of oil and grease contamination.

a) Visual inspection - Continue degreasing until all visible signs of contamination are removed.

b) Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination.

Continue degreasing and inspection till test is passed.

7.0 TSAC APPLICATOR QUALIFICATION

Following tests to be carried out as part of procedure qualification test for the applicator.

- Thickness measurement
- Coating bond strength
- Porosity test
- Bend strength

TSAC applicator's surface finishing and application process and equipment set up, calibration and operation shall be qualified by application of TSA on a reference sample which shall be used as a comparator to evaluate the suitability of application process. Only that applicator will be permitted to carry out the work when test specimens coated by the applicator meets the desired requirements as cited below.

The sample shall be made of a steel plate measuring approx. 18"x 18" x ¼" thick. If the actual work is less than ¼" thick then the sample to be made from material of representative thickness.

The surface preparation, TSAC application shall be made with actual field equipments and process/spray parameters and procedures as per the specification. The depth profile of blasted surface, TSAC coating thickness for each cross pass and total thickness range shall be as per specification.

The surface preparation and thermal spraying shall be carried out in representative environmental conditions spraying with makeshift enclosure.

7.1 After application of coating, thickness and tensile bond measurements shall be made in following manner.

- Divide the sample piece into four quadrants.
- Measure thickness along the diagonal line of each quadrant.
- Four each quadrant five in-line thickness measurements at 1" interval shall be done using SSPC-PA 2 type 2 fixed probe gauge. Thus a total of four "five in line" thickness measurements to be done for the whole sample.
- One tensile bond measurement using ASTM D 4541 type III or IV portable self-aligning test instrument to be done at centre of each quadrant. Total of 4 measurements for the sample.
- One porosity evaluation test by Metallographic examination shall be conducted to demonstrate the achievement of porosity within the limits specified. Sample shall be prepared for Metallographic examination as per ASTM E-3.
- The procedure shall be considered qualified if thickness and tensile-bond strength and porosity values meet the specification requirement.

7.2 Bend test: Bend test shall be carried out as detailed at sec. 6.5 of this specification.

Applicators thermal spray equipment set-up, operation and procedure of application including in-process QC checkpoints adopted during procedure qualification as described above should be always subsequently followed during entire duration of work.

8.0 DOCUMENTATION

The following information shall be provided by TSAC applicator before award of work.

- TSAC application process consisting of equipment capabilities and their technical parameters, feed stock material and source of procurement.
- Detailed application procedure and in-process quality control check points for (a) surface preparation (b) thermal spraying (c) seal coats.
- Type and specification of instruments to be deployed for measurement of blast profile depth, TSAC thickness and tensile bond.
- Paint manufacturer data sheet for the selected sealing coat to be applied.

9.0 RECORDS

- The TSAC applicator shall maintain job record to record production and QC information. All the results of the tests and quality control checks shall be entered in the record for each component/part thermally sprayed. All the result of tests (thickness, tensile bond, bend tests) and other validation tests (e.g. procedure qualification test, test for surface cleanliness after abrasive blasting, test for cleanliness of abrasives and air) shall also be recorded and duly signed by the Owner/ Owner's Representative.

- All the information mentioned in Sec 8.0 above should also form part of the Job record.

- Any modification affected after procedure qualification in the procedure, QC, spray parameter, equipment spec to the original information (submitted before award of the work) must also form part of Job record.

10.0 WARRANTY

The TSAC applicator shall warrant the quality of material used by providing the purchaser with a certificate of materials used to include

- Spray feed stock: Alloy type/designation, Lot Number, wire diameter, chemical analysis, name of supplier, manufacturer.

- Sealant: Name of manufacturer, application data sheet.

11.0 SAFETY

The TSAC applicator shall follow all safety procedures required by the purchaser/owner. Owner shall also give compliance requirement to be followed by applicator. The applicator shall follow all appropriate regulatory requirements.

12.0 CODES AND STANDARDS

This specification shall apply in case of conflict between specification and following applicable standards:

AWS C. 2.17	Recommended Practice for Electric arc Spray.
ASTM C 633	Test Method for Adhesive/Cohesive Strength of Flame Sprayed Coatings.
ASTM D 4285	Method for indicating Oil or Water in Compressed Air.
ASTM D 4417	Test Method for Field Measurement of Surface Profile of Blasted Steel.
BS 2569	Specification for Sprayed Metal Coating.
NACE Standard RP 0287	Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape.
ASTM D 4541	Test method for Pull-Off Strength of Coating Using Portable Adhesion Testers.
ANSI/AWS C2.18	Guide for the Protection of Steel with Thermal Spray Coatings of Aluminum, Zinc and Their Alloys and Composites.
NACE No. 12/AWS C2.23M/SSPC-CS	Specification for the application of thermal spray coatings (Metallizing) of aluminum, zinc, and their alloys and composites for the corrosion protection of steel.

23.00	
SSPC Publication	The inspection of coatings and linings: A Handbook of Basic practice for Inspectors, Owners, and Specifiers.
SSPC-AB 1	Mineral and Slag Abrasives.
SSPC-AB 3	Ferrous Metallic Abrasives.
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel.
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages.
NACE No. 1/SSPC-SP 5	White Metal Blast Cleaning.
NACE No. 2/SSPC-SP 10	Near –White Metal Blast Cleaning.
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.

ANNEXURE-II

COLOR CODE

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on these specified length to identify the particular service. Colour code is applicable for both unit and offsite pipes.

SR. No.	SERVICE	RECOMMNDED COLOUR FOR PAINT SYSTEM	RAL COLOUR CODE	
			BASE COLOUR	BAND COLOUR
	HYDROCARBON LINES (UNINSULATED)			
1	CRUDE SOUR	Dark Admiralty grey with 1 orange band	7012	2011
2	CRUDE SWEET	Dark Admiralty grey with 1 red band	7012	3001
3	LUBE OILS	Dark Admiralty grey with 1 green band	7012	6010
4	FLARE LINES	Heat Resistant Aluminium	9006	
5	LPG	Orange with 1 oxide red band	2011	3009
6	PROPYLENE	Orange with 2 blue bands	2011	5013
7	NAPTHA	Orange with 1 green band	2011	6010
8	M.S.	Orange with 1 dark admiralty grey band	2011	7012
9	AV.GASOLINE (96 RON)	Orange with 1 band each of green, white and red bands	2011 6010	9010 3001
10	GASOLINE (regular, leaded)	Orange with 1 black band	2011	9005
11	GASOLINE (premium, leaded)	Orange with 1 blue band	2011	5013
12	GASOLINE (white)	Orange with 1 white band	2011	9010
13	GASOLINE (Aviation 100/130)	Orange with 1 red band	2011	3001
14	GASOLINE (Aviation 115/145)	Orange with 1 purple band	2011	4006
15	N-PENTANE	Orange with 2 blue bands	2011	5013
16	DIESEL OIL (White)	Oxide red with 1 white band	3009	9010
17	DIESEL OIL (Black)	Oxide red with 1 yellow band	3009	1023
18	KEROSENE	Oxide red with 1 green band	3009	6010
19	HY.KEROSENE	Oxide red with 2 green bands	3009	6010
20	DISUFIDE OIL (EX-MEROX)	Oxide red with 1 black band	3009	9005
21	M.T.O	Oxide red with 3 green bands	3009	6010
22	DHPPA	Oxide red with 2 white bands	3009	9010
23	FLUSHING OIL	Oxide red with 2 black bands	3009	9005
24	LAB FS	Oxide red with 2 dark admiralty grey bands	3009	7012
25	LAB RS	Oxide red with 3 dark admiralty grey bands	3009	7012
26	LAB (Off. Spec)	Oxide red with 1 light grey band	3009	7035
27	N-PARAFFIN	Oxide red with 1-blue band	3009	5013
28	HEAVY ALKYLATE	Oxide red with red band	3009	3001
29	BLOW DOWN, VAPOR LINE	Off white / Aluminum with 1-Brown band	9006	8004
30	BLOWDOWN	Off white / Aluminum with 2 brown bands	9006	8004
31	A.T.F.	Leaf brown with 1 white band	8003	9010
32	TOULENE	Leaf brown with 1 yellow band	8003	1023

33	BENZENE	Leaf brown with 1 green band	8003	6010
34	LAB PRODUCT	Leaf brown with 1 blue band	8003	5013
35	FUEL OIL	Black with 1 yellow band	9005	1023
36	FULE OIL (Aromatic rich)	Black with 2 yellow bands	9005	1023
37	ASPHALT	Black with 1 white band	9005	9010
38	SLOP AND WASTE OILS	Black with 1 orange band	9005	2011
39	SLOP AROMATICS	Black with 2 orange bands	9005	2011
	CHEMICAL LINES			
40	TRI-SODIUM PHOSPHATE	Canary yellow with 1 violet band	1012	5000
41	CAUSTIC SODA	Canary yellow with 1 black band	1012	9005
42	SODIUM CHLORIDE	Canary yellow with 1 white band	1012	9010
43	AMMONIA	Canary yellow with 1 blue band	1012	5013
44	CORROSION INHIBITOR	Canary yellow with 1 Aluminum band	1012	9006
45	HEXAMETA PHOSPHATE	Canary yellow with 2 black bands	1012	9005
46	ACID LINES	Golden Yellow with 1 red band	1004	3001
47	RICH AMINE	Canary yellow with 2 blue bands	1012	5013
48	LEAN AMINE	Canary yellow with 3 blue bands	1012	5013
49	SOLVENT	Canary yellow with 1 green band	1012	6010
50	LCS	Canary yellow with 1 smoke grey	1012	7031
	WATER LINES			
51	RAW WATER	Sky blue with 1 black band	5015	9005
52	INDUSTRIAL WATER	Sky blue with 2 signal red band	5015	3001
53	TREATED WATER	Sky blue with 1 oxide red band	5015	3009
54	DRINKING WATER	Sky blue with 1 green band	5015	6010
55	COOLING WATER	Sky blue with 1 light brown band	5015	1011
56	SERVICE WATER	Sky blue with 1 signal red brown	5015	3001
57	TEMPERED WATER	Sky blue with 2 green bands	5015	6010
58	DM WATER	Sky blue with 1 aluminum band	5015	9006
59	DM WATER ABOVE 150°F	Sky blue with 2 black bands	5015	9005
60	SOUR WATER	Sky blue with 2 yellow bands	5015	1013
61	STRIPPED WATER	Sky blue with 2 blue bands	5015	5013
62	ETP TREATED WATER	Sky blue with 2 oxide red bands	5015	3009
	FIRE PROTECTION SYSTEM (ABOVE GROUND)			
63	FIRE WATER FOAM & EXTINGUISHERS	Post office red	3002	
	AIR & OTHER GAS LINES (UNINSULATED)			
64	SERVICE AIR	Sea green with 1 signal red band	6018	3001
65	INSTRUMENT AIR	Sea green with 1 black band	6018	9005
66	NITROGEN	Sea green with 1 orange band	6018	2011
67	FREON	Sea green with 1 yellow band	6018	1023
68	CHLORINE	Canary yellow with 1 oxide band	1012	3009
69	SO_2	Canary yellow with 2 white bands	1012	9010
70	H_2S	Orange with 2 red oxide bands	2011	3009
71	GAS (Fuel)	Orange with 1 aluminum band	2011	9006
72	GAS (Sour)	Orange with 2 aluminum bands	2011	9006
73	GAS (Sweet)	Orange with 2 signal red band	2011	3001

74	HYDROGEN	Orange with 1 light green band	2011	6021
STEAM AND CONDENSATE LINES (UNINSULATED)				
75	HP STEAM	Off white / Aluminum with 1 yellow band	9006	1023
76	MP STEAM	Off white / Aluminum with 1 red band	9006	3001
77	MLP STEAM	Off white / Aluminum with 1 orange band	9006	2011
78	LP STEAM	Off white / Aluminum with 1 light green band	9006	6021
79	CONDENSATE	Sky blue with 1 white band	5015	9010
80	CONDENSATE ABOVE 150°F	Sky blue with 3 oxide red band	5015	3009
81	BFW	Sky blue with 2 red bands	5015	3001
Note: For all insulated steam lines, the colour coding shall be follow as given for un-insulated lines with the specified length of color bands.				
INSULATED HYDROCARBON PIPING				
82	IFO SUPPLY	1Black ground colour with 1 yellow band in centre	9005	1023
83	IFO RETURN	Black ground colour with 1 green band in centre	9005	6010
84	HPS	Black ground colour with 1 red band in centre	9005	3001
85	BITUMEN	Black ground colour with 2 red bands in centre	9005	3001
86	CLO	Black ground colour with 1 brown band in centre	9005	8004
87	VB TAR	Black ground colour with 2 brown bands in centre	9005	8004
88	VR AM (BITUMEN / VBU FEED)	1 Black ground colour with 1 blue band in centre	9005	5013
89	VR BH	1 Black ground colour with 2 blue bands in centre	9005	5013
90	VAC. SLOP	1 Black ground colour with 1 white band in centre	9005	9010
91	SLOP	1 Black ground colour with 1 orange band in centre	9005	2011
92	CRUDE SWEET	1 Dark admiralty grey ground colour with 1 red band in centre	7012	3001
93	CRUDE OUR	1 Dark admiralty grey ground colour with 1 orange band in centre	7012	2011
94	VGO / HCU	1 Oxide red ground colour with 2 steel grey bands in centre	3009	7011
95	OHCU BOTOM / FCCU FEED	1 Oxide red ground colour with 2 steel grey bands in centre	3009	7011
UNINSULATED EQUIPMENTS, TANKS AND STRUCTURES				
96	HEATER STRUCTURE	Steel grey	7011	
97	HEATER CASING	Heat resistant aluminium	9006	
98	VESSELS & COLUMNS	Aluminium	9006	
99	HYDROGEN BULLETS	Pink	3014	
100	LPG VESSELS	Oxide red	3009	
101	SO_2 VESSEL	Canary yellow	1012	
102	HEAT EXCHANGER	Heat resistant aluminium	9006	
103	FO TANK AND HOT TANKS	Black	9005	

104	ALL OTHER TANKS	Aluminum / Off white	9006
105	CAUSTIC / AMINE / ACID TANKS	Golden yellow	1004
106	SOUR WATER	Sky Blue	5015
107	OUTER SURFACE IN BOILER HOUSE	Heat resistant aluminum	9006
108	COMPRESSORS AND BLOWERS	Dark admiralty grey	7012
109	PUMPS	Navy blue	5014
110	MOTORS & SWITCH GEAR	As per Electrical Specification	-
111	HAND RAILING, MIDDLE RAIL, TOE PLATE, LADDER VERITAL POSTS, OVER HEAD MONORAIL, MONORAIL STOPPER PLATES, COKE CUTTING SYSTEM	Signal red	3001
112	STAIRCASE, LADDER, WALKWAYS, LADDER RUNGS, RAILING VERTICAL POSTS, CHEQUERED PLATE (BOTH FACES), GRATINGS	Black	9005
113	LOAD LIFTING EQUIPMENT	Leaf brown	8003
114	GANTRY GIRDER & MONORAIL	Dark Green	6009
115	EOT / HOT CRANES	Canary Yellow	1012
116	PIPE RACK STRUCTURALS, BUILDING STRUCTURALS, STEEL COLUMNS, BRACKETS, BEAMS, BRACINGS, ROOF TRUSSES, PURLINGS, SIDE GIRTS, LOUVERS, STRINGERS	Dark admiralty grey	7012
117	TRANSFORMERS & BATTERY ROOM STRUCTURALS	As per Electrical Specification	-
118	ELECTRICAL MOTORS	As per Electrical Specification	-
119	GENERAL STRUCTURE	Black	9005
	PIPES AND FITTINGS OF ALLOY STEEL AND SS MATERIAL IN STORE		
120	IBR	Signal red	3001
121	9Cr-1Mo	Verdigris green	6021
122	5Cr-0.5Mo	Satin blue	5012
123	$2_{1/4}$Cr-1 Mo	Aircraft yellow	1026
124	$1_{1/4}$Cr-½ Mo	Traffic Yellow	1023
125	SS-304	Dark blue grey	5008
126	SS-316	Dark violet	4005
127	SS-321	Navy blue	5014

SAFETY COLOUR SCHEMES				
128	DANGEROUS OBSTRUCTION	Black and alert orange band	9005	2008
129	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Alert orange	2008	

Notes:

- All LPG service PSVs shall be painted in Deep Blue (RAL 5014).
- All drains & Vents shall be painted in Main line colour.
- The colour code scheme is for identification of piping service group. It consists of a ground colour and 1 or more colour bands.

Ground Colour

On uninsulated pipes, the entire pipe has to be painted in ground colour, and on metal cladded insulated lines, minimum 2M long portion should be painted.

Colour Bands

Location of colour bands:

- At Battery Limits
- Intersection points & change of direction points in piping
- Midway of piping section, near valves, across culverts
- At 50 M interval on long stretch pipes
- At starting and termination points.

Minimum width:

NB	Width
3" and below	75 mm
Above 3" to 6"	NB X 25 MM
Above 6" to 12"	NB X 18 MM
Above 12"	NB X 15 MM

For insulated pipes, NB indicates OD of the insulation.

Sequence:

Colour bands shall be arranged in sequence showing Table above and the sequence follows the direction of flow. The width of the 1st Band to 2nd band is 4:1,

Wherever deemed required by Process Department or Safety, pipes handling hazardous substances will be given hazard marking of 30 mm wide diagonal stripes of Black and Golden Yellow as per IS : 2379 or any other equivalent international standard.

Special Camouflage Painting for Uninsulated Crude and Product Storage Tanks.

Coating System shall be as per this specification.

Camouflage painting scheme for Defense requirement in irregular patches will be applied with 3-colours:

Dark Green	:	Light green	:	Medium Brown
5	:	3	:	2

- The patches shall be irregular and asymmetrical and inclined at 30 to 60 Degrees.
- Patches should be continuous at surface meeting lines / points.
- Slits / holes shall be painted in dark green shade.
- Width of patches shall be 1 to 2 meters.

Identification Markings on Equipment / Piping

Equipment tag Numbers shall be Stenciled / neatly painted using normal 'Arial' Lettering Style on all equipment and piping (Both insulated & uninsulated) after completion of all paint works. Lettering colour shall be either BLACK or WHITE, depending upon the background, so as to obtain good contrast.

Operations Group shall specify location.

Sizes shall be:

Columns, Vessels, Heaters:	150 mm
Pumps and other M/c	50 mm
Piping	OD/2 with Maximum 100 mm
Storage Tanks	(As per Drawings)

Colour Coding for Control Valve

a) Carbon steel body - Light grey

Alloy steel body - Canary yellow

Stainless steel body - Natural

b) The actuator of the Control valve shall be painted as:

Direct action (open on air failure) valves - Green

Reverse acting (close on air failure) valves - Red

The painting Status shall be comprehensively updated every 6 months for compliance

ISSUE NO. : 2

PROCEDURE FOR RADIOGRAPHIC EXAMINATION

Issue No	Rev No	Date of Revision	Brief Records of Revision
1	0	02-02-2015	First Edition
1	1	11-04-2017	Cl. no. 3,7,10,12,13,15 revised as per ASME Sec V Edition 2015
2	1	25-04-2018	Cl. no. 3,14,15,18 revised as per ASME Sec V Edition 2017
2	2	15-05-2020	Cl. no. 3.1,3.2,9.2,11,12.1,12.4,16.5 revised; Cl. no.1,5,6,9,14,15,16.2 Modified.

EIL Comments:All NDT procedure viz RT/UT/MPI /LPI made are a generic and not to the specific order. .Additional requirement if any mentioned in PR shall be followed.
These procedure reviewed and noted .

Prepared by	Reviewed & Approved by
(K. JANAKI RAMULU) NDE LEVEL-II	VENKATA RAVI CHANDRA M. ASNT NDT LEVEL III-RT,UT,MT,PT CERTIFICATE No. 204694 (M.V. RAVI CHANDRA) NDE LEVEL-III

All NDT procedures shall meet the requirements of applicable codes and specifications, PR Scope and extent , acceptance criteria shall be as per applicable drawing and specifications

TABLE OF CONTENTS

1. SCOPE

This procedure specifies the requirement for radiographic examination of butt welded joints in steel(Carbon Steel, Alloy Steel, Stainless Steel etc.) and non-ferrous materials using x-rays or gamma rays as a source of radiation for detecting and evaluating flaws within the weld and HAZ (heat affected zone). It applies to the welded joints in pressure vessels, heat exchangers, columns and pipes etc. Radiographic technique used to demonstrate that required IQI sensitivity and density requirements are achieved.

2. POLICY

2.1. The radiographic examination be carried out either as or one of the procedures enumerated in the following pages which are verified and found to be in accordance with latest ASME SEC V or as per any other applicable referencing code sections and specifications.

2.2. Only personnel qualified in accordance with BHEL HPVP NDE Written Practice shall carry out any radiographic examination.

3. APPLICABLE STANDARDS

3.1. ASME SEC V Edition 2019.
3.2. Construction code sections ASME Sec I, ASME Sec VIII Div 1, ASME Sec VIII Div 2 Edition 2019, ASME B31.1 Edition 2016, NBIC NB 23 Edition 2019, SNT-TC-1A Edition 2016 & ASME SEC V Edition 2019 Art.1.

4. SYSTEM

All radiographic examination procedures be amended and approved as required by NDE level III taking into consideration of

4.1. Experience gained in various examination procedures.
4.2. Recommendations of audit teams.
4.3. Referencing code sections.

Each page of the document be independently controlled and revision status be indicated on the title page.

5. SURFACE PREPARATION:

The weld ripples or weld surface irregularities on both inside(where accessible) and outside shall be removed by any suitable process to such a degree that the images of surface irregularities cannot mask or be confused with the image of any discontinuity on the resulting radiograph.

The finished surface of all butt-welded joints may be flush with the base material or may have reasonably uniform crones, with reinforcement not to exceed that specified in the referencing code section.

Welds be visually examined to ensure free from surface irregularities which can mask or cause difficulty in detecting discontinuities. If required surface be ground and surface imperfections removed.

6. REINFORCEMENT

The thickness of reinforcement on each side of all butt welded longitudinal and circumferential joints not exceed the limits as given below:

As per ASME Sec-VIII Div 1:

Material thickness (Nominal) (mm)	Permitted Maximum Reinforcement	
	Cat B& C Butt welds (mm)	Other welds (mm)
< 2.4	2.4	0.8
2.4 to 4.8	3.0	1.5
>4.8 to 13	4.0	2.5
>13 to 25	5.0	2.5
>25 to 51	6.0	3.0
>51 to 76	6.0	4.0
>76 to 102	6.0	5.5
>102 to 127	6.0	6.0
>127	8.0	8.0

As per ASME Sec-VIII Div 2:

Material thickness (Nominal) (mm)	Permitted Maximum Reinforcement	
	Circumferential welds in Pipes & Tubes (mm)	Other welds (mm)
< 2.5	2.5	0.8
≥ 2.5 to < 5.0	2.5	1.5
≥ 5.0 to < 13.0	3.0	2.5
≥ 13.0 to < 25.0	4.0	2.5
≥ 25.0 to < 50.0	4.0	3.0
≥ 50.0 to < 76.0	4.0	4.0
≥ 76.0 to < 100.0	5.5	5.5
≥ 100.0 to < 125.0	6.0	6.0
≥ 125.0	8.0	8.0

As per ASME Sec-I:

Material thickness (Nominal) (mm)	Permitted Maximum Reinforcement	
	Circumferential welds in Pipes & Tubes (mm)	Other welds (mm)
< 3.0	2.5	2.5
3.0 to 5.0	3.0	2.5
>5.0 to 13.0	4.0	2.5
>13.0 to 25.0	5.0	2.5
>25.0 to 50.0	6.0	3.0
>50.0 to 75.0	The greater of 6 mm or 1/8 times the width of the Weld (in mm).	4.0
>75.0 to 100.0		5.5
>100.0 to 125.0		6.0
>125.0		8.0

7. SELECTION OF RADIOGRAPH

Either Agfa D4/D7 or Fuji IX 50/100 brand radiographs be used

8. INTENSIFYING SCREENS

For Iridium 192,X-ray(150 KV – 200 KV) 0.15 mm thick, Co-60 0.25 mm thick front and back Lead intensifying screens shall be used.

9. IMAGE QUALITY INDICATIORS (IQI)

9.1. SELECTION :

9.1.1. MATERIAL:

IQI shall be selected from either the same alloy material group or grade as identified in SE-747 for ASTM wire type or SE-1025 for hole type IQI or grade with less radiation absorption than the material being radiographed.

9.1.2. SIZE:

Nominal single wall Thickness of the base metal (thickness of the thinner incase dissimilar thickness base metals are joined) including the estimated allowed weld reinforcement both in ID and OD be considered for IQI selection. The values used for the estimated weld reinforcement thicknesses shall be representative of the weld conditions and shall not exceed the maximums permitted by the referencing code section. Physical measurement of the actual weld reinforcements not required. Backing rings or strips shall not be considered as part of the thickness in IQI selection. Refer Clause. 14 below for the selection of IQI designation.

9.2. PLACEMENT:

IQI(s) be placed on source side of the object unless hand placing of IQI is not feasible. In such case, the IQI be placed on radiograph side of weld with a letter ‘F’ placed adjacent to the IQI.

Wire type IQI’s be placed on the weld so that the lengths of the wires are transverse to the longitudinal axis of the weld and Hole type IQI’s be placed adjacent and parallel to the weld axis, one at each end of the radiography spot..

When weld reinforcement or backing strip is not removed, a shim of material radiographically similar to weld metal be kept under the hole type IQI.

9.3. NUMBER OF IQI's:

For unidirectional exposures, at least one IQI image appears on each radiograph where one or more radiograph holders are used for an exposure. If the density of the radiograph varies by more than –15% or +30% from the density through the body of hole type IQI, or adjacent to the required wire, an additional IQI be used for each exceptional area or areas and the radiograph is retaken.

For cylindrical components where the source is placed on the axis of the component for a single exposure at least three IQI's be placed approximately 120^0 apart.

10. RADIATION ENERGY SELECTION (SOURSE SELECTION):

The selection be such that required IQI sensitivity and density are achieved.

The recommended source for radiography of objects is as below.

Applicable ranges shall be as per provisions in Article 22 SE 94

a) Iridium 192 – with thickness from 6 to 65 mm.
b) Co-60 – for thickness above 35 mm.
c) X-ray equipments (100 KV – 200 KV) may be used for thickness 12 mm and below to achieve higher sensitivity, if required.

11. BACK-SCATTER RADIATION

A lead symbol 'B' shall be placed within the area of radiograph with minimum dimensions of 11 mm height and 1.5 mm thick be attached on the back side of each radiograph holder to determine if back-scatter radiation is exposing the radiograph.

12. SYSTEM OF IDENTIFICATION:

Each radiograph must be identified uniquely so that there is a permanent correlation between the part radiographed and the radiograph.

A system of permanent identification of the radiograph be provided with the following minimum details.

12.1. HPVP Manufacturer Symbol/Name and NDE Subcontractor's Symbol/Name.
12.2. Work Order Number.
12.3. SAP generated RT number if requisition raised through SAP.
12.4. Welder No. and Part Number for Non SAP Requisitions.
12.5. Equipment number, if any.
12.6. Weld seam number, if any.
12.7. Segment number (location marker).
12.8. Date of radiography.
12.9. Letter 'R1, R2' to indicate first repair, second repair etc. when required.
12.10. Letter 'RT' to indicate retaken radiograph when required.

13. RADIOGRAPH MAKING TECHNIQUES:

Normally a single wall single image (SWSI) radiography technique be used.

For test objects with external diameter less than 89 mm (DWDI) double wall double image Elliptical technique or (DWSI) double wall single image technique or Super imposition technique be used.

(Note: When DWDI technique is used, one exposure be taken unless otherwise specified. The source position be such that two weld images are clearly separated. The maximum separation between two weld images / distance between two weld images be one weld width. IQI be placed on the source side.

In case of DWSI or Super imposition techniques sufficient number of radiography shots ensuring full coverage of the weld seam be used. The IQI be placed close to the radiograph with a lead letter "F")

14. IQI SELECTION: As per Table T-276 of ASME Sec V Edition 2019

Weld thickness (base metal thickness + Estimated allowed reinforcement) (mm)	Source side			Radiograph side		
	Hole Type Designation	Essential hole	Wire-type Essential wire	Hole Type Designation	Essential hole	Wire type Essential wire
Upto 6.4	12	2T	5	10	2T	4
Over 6.4 to9.5	15	2T	6	12	2T	5
Over 9.5 to12.7	17	2T	7	15	2T	6
Over12.7 to19.0	20	2T	8	17	2T	7
Over 19.0 to25.4	25	2T	9	20	2T	8
Over 25.4 to38.1	30	2T	10	25	2T	9
Over 38.1 to50.8	35	2T	11	30	2T	10
Over 50.8to 63.5	40	2T	12	35	2T	11
Over 63.5to 101.6	50	2T	13	40	2T	12
Over 101.6 to 152.4	60	2T	14	50	2T	13

15. GEOMETRIC UNSHARPNESS:

Recommended maximum values of Ug are tabulated below

Material Thickness (mm)	Ug Maximum (mm)
Under 50	0.51
50-75	0.76
75-100	1.01
>100	1.78

$$\text{Exposure Time (Ci minutes)} = \frac{\text{Film factor} * (\text{SFD in Meters})^2 * 2^{(\text{thickness of job/HVT of material})}}{(\text{RHM of Source})} \times 60$$

General requirements:

- Persons working in radiation areas be provided with Personnel monitoring device (TLDs) and Radiation area monitoring devices (Survey meters).

- Personnel Qualification: The minimum qualification of radiography operator be BARC qualified and certified radiographer.

- The minimum Qualification of Radiography Evaluation personnel be ASNT / ISNT Level II.

- Extent of Examination: As per Applicable Drawing / QA plan / NDE plan.

- Marking and identification of the radiograph: Work order no., Joint No., Spot No(s). be permanently marked on the job by stamping. Where stamping is not permitted by code / specification (< 6mm for ferrous plates) sketches be prepared to identify weld joints and radiography spots.

- Location of weld in the radiograph: Set of Markers (arrows or V's) be placed on both sides of the weld at least 5 mm from the edge of the weld. At least two such sets be placed at each end of the radiography spot.

- Alignment of radiation beam: be directed to the centre of the area being radiographed and shall be perpendicular to the object surface at that point.

- Over lap of radiographs: When multiple radiographs are used to cover entire length of weld seams adjacent radiographs overlap at least 25 mm.

- Radiation Exposure times: Exposure charts indicating thickness vs exposure time (Gamma ray-Ir-192) or thickness vs milli Ampere minutes(mA-mts) (X-ray) prepared exclusively for a particular brand / type industrial x-ray radiograph shall be used.

16. EVALUATION:

16.1. FACILITIES FOR RADIOGRAPH VIEWING:

Radiographs shall be viewed in a room with subdued light after dark adaptation of eyes (minimum 5 minutes) using an illuminator of sufficient illumination. The illuminator shall have facility to adjust the illumination level required for the particular radiograph.

16.2. QUALITY OF RADIOGRAPHS:

All radiographs be free from mechanical, chemical or other blemishes to the extent that they cannot mask or be confused with the image of any discontinuity in the area of interest including:

i. Fogging
ii. Processing marks such as streaks, chemical stains, water marks, air bubble marks
iii. Handling marks such as scratches, finger marks, nail marks, static marks, marks due to dirt on lead intensifying screens.
iv. False indications due to defective screens.

16.3. RADIOGRAPHIC DENSITY:

Density estimation / measurement: The Density be estimated either with a calibrated densitometer or with a step wedge comparison radiograph.

Density of a radiograph at adjacent to essential hole/ wire and area of interest shall be from 1.8 minimum for single film viewing with X-Ray and 2.0(minimum) for Gamma Rays. For composite viewing of multiple film exposures, each film of the composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for single or composite viewing.

The density anywhere through the area of interest be within – 15% and +30% of that density obtained through the body of the hole type IQI adjacent to the essential hole or adjacent to the essential wire of wire-type IQI.

A tolerance of 0.05 in density is allowed for variation between densitometer readings.

When shims are used with hole type IQI(s) the +30% restriction may be exceeded, and the minimum density requirements mentioned above do not apply provided required IQI sensitivity is met.

16.4. EXCESSIVE BACKSCATTER

If a white image of a letter 'B' appears against a darker background, protection from back scatter radiation is needed and the radiograph be retaken by keeping a lead sheet of 1/16" thick at the back of the radiograph cassette.

16.5. IQI SENSITIVITY:

Essential Hole or Essential wire as referred above in "Clause 14" IQI selection be visible. For wire type IQI's the essential wire shall be visible within the area of interest representing the thickness used for determining the essential wire, inclusive of the allowable density variations described in Clause 16.3.

17. DISPOSITION OF WELDS:

Radiography review form shown in Exhibit 1 be used for recording, reporting evaluation and disposition details.

The indications shown on the radiographs which are unacceptable after interpretation and evaluation be repaired by grinding, welding or gouging. Repair welding be performed using qualified procedure and in a manner acceptable to the inspector. The weld repaired areas be re radiographed in accordance with written procedure.

18. PRESERVATION OF RADIOGRAPHS & EVALUATION REPORTS

The complete set of radiographs and radiography evaluation reports be preserved as per the following.

ASME Sec I & B 31.1	…. 5 Years
ASME Sec VIII Div 1	Radiographs-- Till Data Reports are signed by AI RT Reports – 3 Years
ASME Sec VIII Div 2	…. 3 Years
NBIC Part 3	…. 5 Years

RADIOGRAPHY ACCEPTANCE LEVELS

Ref : ASME SEC I , ASME SEC VIII Div 1, ASME SEC VIII Div 2 Edition 2019.

Full Radiography

Imperfection	Maximum permitted size / length
Any indication characterized as a crack or zone of incomplete fusion or penetration	Unacceptable
Elongated indications (also see notes 1. & 2. Below)	(a) 6 mm for t up to19 mm (b) 1⁄3t for t from 19 mm to 57 mm (c) 19 mm for t over 57 mm Where t is the thickness of the weld excluding any allowable reinforcement
Rounded indications	As specified by the acceptance standards given in pages 13 to 16.

Note:

1. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet be included in t.
2. Any group of aligned indications that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.

Spot Radiography

Imperfection	Maximum permitted size / length
any indication characterized as a crack or zone of incomplete fusion or penetration	Unacceptable
slag inclusions or cavities	2⁄3t where t is the thickness of the weld excluding any allowable reinforcement.
Rounded indications	Not a factor in the acceptability of welds not required to be fully radiographed.

Note:

- If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet be included in t.
- If several indications within the above limitations exist in line, the welds be judged acceptable if the sum of the longest dimensions of all such indications is not more than t in a length of 6t (or proportionately for radiographs shorter than 6t) and if the longest indications considered are separated by at least 3L of acceptable weld metal where L is the length of the longest indication. The maximum length of acceptable indications be 3⁄4 in.(19 mm). Any such indications shorter than 1⁄4 in. (6 mm) be acceptable for any plate thickness.

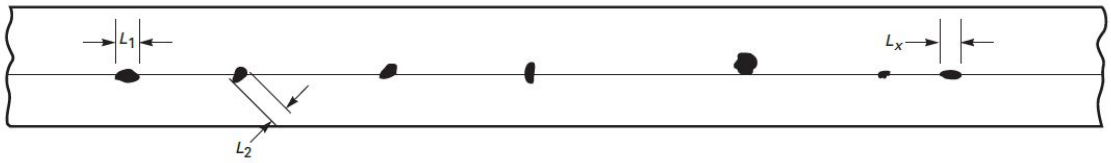
Acceptance Criteria for Rounded Indications

(Ref: Mandatory Appendix 4 ASME SEC I, SEC VIII DIV I Edition 2019)

SI Units

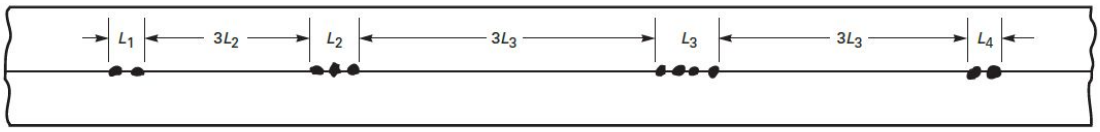
Thickness, t, mm	Maximum Size of Acceptable Rounded Indication, mm		Maximum Size of Nonrelevant Indication, mm
	Random	Isolated	
Less than 3	$\frac{1}{4}\,t$	$\frac{1}{3}\,t$	$\frac{1}{10}\,t$
3	0.79	1.07	0.38
5	1.19	1.60	0.38
6	1.60	2.11	0.38
8	1.98	2.64	0.79
10	2.31	3.18	0.79
11	2.77	3.71	0.79
13	3.18	4.27	0.79
14	3.61	4.78	0.79
16	3.96	5.33	0.79
17	3.96	5.84	0.79
19.0 to 50, incl.	3.96	6.35	0.79
Over 50	3.96	9.53	1.60

Figure 4-1
Aligned Rounded Indications



GENERAL NOTE: Sum of L_1 to L_x shall be less than t in a length of $12t$.

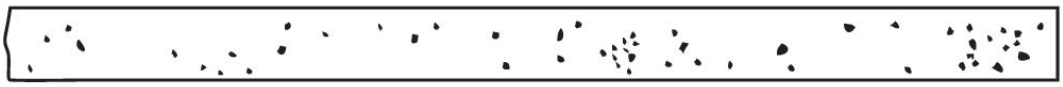
Figure 4-2
Groups of Aligned Rounded Indications



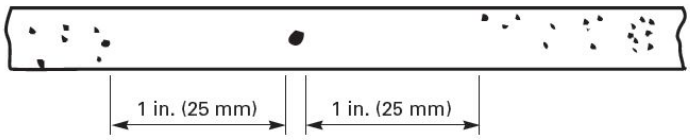
Maximum Group Length	Minimum Group Spacing
L = $1/4$ in. (6 mm) for t less than $3/4$ in. (19 mm) L = $1/3t$ for t $3/4$ in. (19 mm) to $2\,1/4$ in. (57 mm) L = $3/4$ in. (19 mm) for t greater than $2\,1/4$ in. (57 mm)	$3L$ where L is the length of the longest adjacent group being evaluated

GENERAL NOTE: Sum of the group lengths shall be less than t in a length of $12t$.

Figure 4-3
Charts for t Equal to $1/8$ in. to $1/4$ in. (3 mm to 6 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



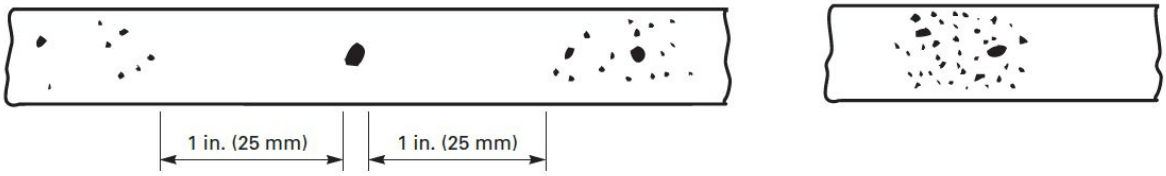
(b) Isolated Indication [See Note (2)]

(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-4
Charts for *t* Over 1/4 in. to 3/8 in. (6 mm to 10 mm), Inclusive

(a) Random Rounded Indications [See Note (1)]



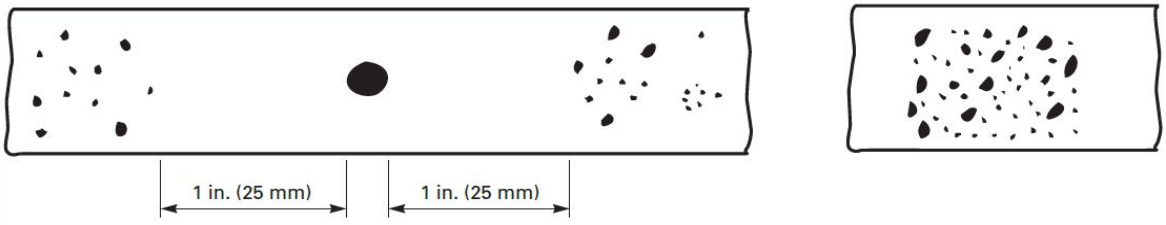
(b) Isolated Indication [See Note (2)]

(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-5
Charts for *t* Over 3/8 in. to 3/4 in. (10 mm to 19 mm), Inclusive

(a) Random Rounded Indications [See Note (1)]

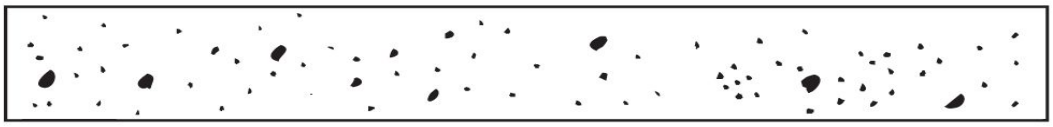


(b) Isolated Indication [See Note (2)]

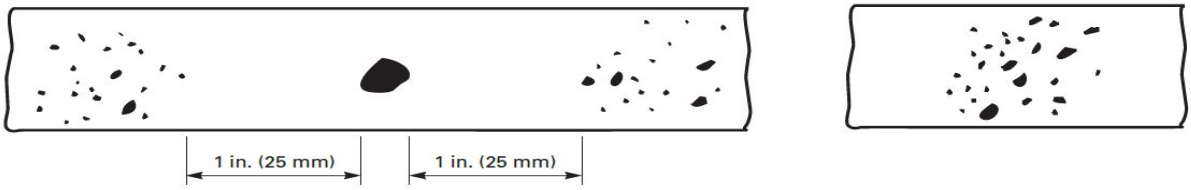
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-6
Charts for *t* Over ¾ in. to 2 in. (19 mm to 50 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]

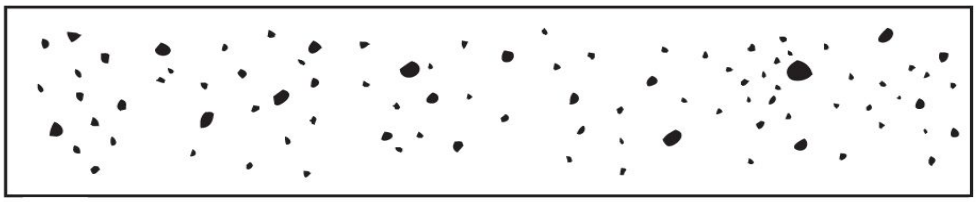


(b) Isolated Indication [See Note (2)]

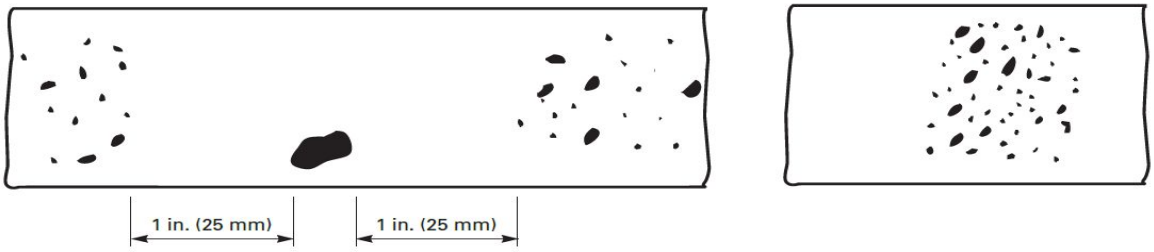
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-7
Charts for *t* Over 2 in. to 4 in. (50 mm to 100 mm), Inclusive



(a) Random Rounded Indications [See Note (1)]



(b) Isolated Indication [See Note (2)]

(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

(For other Codes such as ASME B31.1, NBIC NB23 refer respective current Edition)

ISSUE NO.2

PROCEDURE FOR ULTRASONIC EXAMINATION

Issue No	Rev No	Date of Revision	Brief Records of Revision
1	0	02-02-2015	First Edition
1	1	11-04-2017	Cl no. 2,3,12,13 revised as per ASME Sec V Edition 2015
2	1	25-04-2018	Cl no. 2,3,12,13 revised as per ASME Sec V Edition 2017
2	2	15-05-2020	Cl no. 1,5,7,12 Modified and Cl no. 2.2,2.3,3,12 Revised as per ASME Sec V Edition 2019

Refer comments in 1st page of RT

Prepared by	Reviewed & Approved by
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TABLE OF CONTENTS

1. SCOPE:

This procedure covers Ultrasonic Examination for Ferritic welds (Carbon or Alloy steels) and Claddings by Manual, A-Scan, pulse-echo direct contact method of testing for detection of inclusions(slag) and planar discontinuities (cracks, non-fusion, etc.) and thickness measurement as

a) Full penetration butt welds (double V, single V type), Full penetration corner welded nozzle joints for boiler and pressure vessels of equal to or greater than 10mm thickness.
b) Butt joints in pipes with thickness equal to or greater than 10mm thickness.
c) Claddings.
d) Direct thickness read out by manual Ultrasonic Pulse echo contact method.

2. SYSTEM:

2.1 EXAMINATION PROCEDURE AND APPLICABLE STANDARDS:

All Ultrasonic Examination procedures shall be prepared in accordance with ASME SEC V Edition 2019 by at least NDE Level II and reviewed and approved by NDE Level III.

2.2 REFERENCING CODE SECTION FOR ACCEPTANCE CRITERIA:

ASME SEC I, ASME SEC VIII Div 1, ASME SEC VIII Div 2 Edition 2019, ASME B31.1 Edition 2018 & NBIC NB 23 Edition 2019, SNT-TC-1A Edition 2016 & ASME SEC V Edition 2019 Art.1.

.

2.3 EXAMINATION PERSONNEL AND APPLICABLE STANDARDS:

All NDE Level – I, NDE Level – II and NDE Level III personnel are qualified in accordance with NDE written practice (Based on SNT-TC-1A 2016& ASME Sec V Edition 2019 Art.1) and appearing in Latest List of Qualified NDE Personnel shall carry out any Ultrasonic Examination.

At the appropriate stage, the Ultrasonic Examination shall be carried out as per the requisitions from production shops endorsed by concerned Quality Controls.

3. WRITTEN PROCEDURE REQUIREMENTS:

This procedure based on T-421 of ASME SEC V Edition 2019 shall contain the requirements listed in the Table below of this procedure.

Table T-421
Requirements of an Ultrasonic Examination Procedure

Requirement	Essential Variable	Nonessential Variable
Weld configurations to be examined, including thickness dimensions and base material product form (pipe, plate, etc.)	X	...
The surfaces from which the examination shall be performed	X	...
Technique(s) (straight beam, angle beam, contact, and/or immersion)	X	...
Angle(s) and mode(s) of wave propagation in the material	X	...
Search unit type(s), frequency(ies), and element size(s)/shape(s)	X	...
Special search units, wedges, shoes, or saddles, when used	X	...
Ultrasonic instrument(s)	X	...
Calibration [calibration block(s) and technique(s)]	X	...
Directions and extent of scanning	X	...
Scanning (manual vs. automatic)	X	...
Method for discriminating geometric from flaw indications	X	...
Method for sizing indications	X	...
Computer enhanced data acquisition, when used	X	...
Scan overlap (decrease only)	X	...
Personnel performance requirements, when required	X	...
Personnel qualification requirements	...	X
Surface condition (examination surface, calibration block)	...	X
Couplant: brand name or type	...	X
Post-examination cleaning technique	...	X
Automatic alarm and/or recording equipment, when applicable	...	X
Records, including minimum calibration data to be recorded (e.g., instrument settings)	...	X

It shall establish a single value, or range of values for each requirement. When required performance shall be demonstrated to the inspector. Any change in specified value or range of values of the essential variables mentioned above shall require requalification of the written procedure.

4. SURFACE CONDITION :

4.1 BASE MATERIAL, WELD, CALIBRATION BLOCK:

The base material and weld surface shall be prepared by grinding and sandering. The scanning surfaces of the basic calibration block shall be done by sandering.

4.2 TEMPERATURE DIFFERENCE:(examination surface vs calibration block)

The temperature difference between examination surfaces and the calibration block shall be within +/- 14 deg C (25 deg F) .

5. EQUIPMENT:

5.1 INSTRUMENT:

A Pulse-echo-type of ultrasonic instrument appearing in current list of NDE equipments under calibration and capable of operation at frequencies over the range of 2-4 MHz equipped with 2dB stepped gain control shall be used.

5.2 SEARCH UNITS:

Longitudinal wave Straight beam probe of size 10 mm to 24 mm Ø, 2 - 4 MHz ; Transverse wave angled beam probes 45º, 60º , 70º of nominal size (miniature size) 8 x 9 mm² ; make Modsonic / Olympus / GE with suitable 2mtr long probe cables shall be used.

5.3 COUPLANT:

SAE 30 Hylube machine oil or grease oil mixture shall be used. Calibration shall be carried out using the same couplant to be used in examination of welds.

6. TECHNIQUE (S):

Manual, A-Scan, pulse-echo direct contact using either single or dual element straight beam and angle beam search units.

7. CALIBRATION:

7.1 EQUIPMENT CALIBRATION:

The screen height linearity and amplitude control linearity shall be performed in accordance with Procedure No. 07013 (latest revision) at the beginning of each period of extended use or every 3 months.

7.2 TECHNIQUES FOR STRAIGHT BEAM AND ANGLE BEAM CALIBRATION:

7.2.1. SWEEP RANGE CALIBRATION:

The sweep range shall be adjusted to minimum 2T for straight beam, 3T for 45º angle beam and 4T for 60º using an IIW - V1 or V2 reference block.

7.2.2. SENSITIVITY CALIBRATION:

DAC curve plotted on the CRT screen Using Flat basic calibration block 1.5 inch ASME Block for Both Straight beam and Angle beam.

7.2.3. CALIBRATION VERIFICATION FREQUENCY:

Sweep range and DAC curve shall be calibrated at the beginning of each test and shall be verified at the end of each test,

- Whenever any component of test system is changed,
- Whenever operator is changed,
- At intervals of 4 hours during continuous testing.

7.2.4. CONFIRMATION ACCEPTANCE VALUES:

- If the deviation in distance range points exceeds 10% of the distance reading or 5% of full sweep which ever is greater, correct the distance range calibration, reexamine areas since last calibration and record.
- If the sensitivity decreases by 20% or 2dB of its amplitude correct the sensitivity and reexamine areas since last calibration and record. If the sensitivity increases by 20%

or 2dB of its amplitude correct the sensitivity correct the data sheets since last valid calibration. If the sensitivity varies beyond 20% or 2dB of its amplitude recalibrate and reexamine areas since last valid calibration and record.

7.3 WELD METAL OVERLAY CLADDING CALIBRATION BLOCKS

7.3.1. CALIBRATION BLOCKS FOR TECHNIQUE ONE:

The basic calibration block configuration and reflectors shall be as shown in figure T-434.4.1 of ASME Sec V Article 4. Either a side –drilled hole or flat bottom hole may be used. The thickness of the weld metal overlay cladding shall be at least as thick as that to be examined. The thickness of the base material shall be at least twice the thickness of the weld metal overlay cladding.

7.3.2. ALTERNATE CALIBRATION BLOCKS FOR TECHNIQUE ONE:

Alternately, calibration blocks as shown in figure T-434.4.2.1. or figure T-434.4.2.2. of ASME Sec V Article 4 may be used. The thickness of the weld metal overlay cladding shall be at least as thick as that to be examined. The thickness of the base material shall be at least twice the thickness of the weld metal overlay cladding.

7.3.3. CALIBRATION BLOCK FOR TECHNIQUE TWO:

The basic calibration block configuration and reflectors shall be as shown in the figure T-434.4.3 of ASME Sec V Article 4. A flat bottom hole drilled to the weld /base metal interface shall be used. This hole may be drilled from the base material or weld metal overlay cladding side. The thickness of the weld metal overlay cladding shall be at least as thick as that to be examined. The thickness of the base metal shall be within 1 in. (25mm) of the calibration block thickness when the examination is performed from the base material surface. The thickness of the base material on the calibration block shall be at least twice the thickness of the weld metal overlay cladding when the examination is performed from the weld metal overlay cladding surface.

7.4 CALIBRATION FOR WELD METAL OVERLAY CLADDING

Dished end of clad plates shall be Ultrasonically examined after final heat treatment for lack of bond. 100% UT examination shall be carried out on areas where attachments are to be welded directly to the cladding. Above areas shall include 50mm of adjacent areas on both sides of attachment.

7.4.1. CALIBRATION FOR TECHNIQUE ONE:

Calibrations shall be performed utilizing the calibration block shown in figure T-432.4.1 of ASME Sec V Article 4. The search unit shall be positioned for the maximum response from the calibration reflector. When a side –drilled hole is used for calibration, the plane separating the elements search unit shall be positioned parallel to the axis of the hole. The gain control shall be set so that this response is 80% ± 5% of full screen height. This shall be the primary reference level.

7.4.2. CALIBRATION FOR TECHNIQUE TWO:

Calibrations shall be performed utilizing the calibration block shown in figure T-434.4.3 of ASME Sec V Article 4. The search unit shall be positioned for the maximum response of the first resolvable indication from the bottom of the calibration reflector. The gain shall be set so that this response is 80%± 5% of full screen height. This shall be the primary reference level.

7.4.3. ALTERNATE CALIBRATION FOR TECHNIQUE ONE:

Calibration shall be performed utilizing the calibration blocks shown in figure T-434.4.2.1. or figure T-434.4.2.2 of ASME Sec V Article 4. The calibration shall be performed as follows;

(a) The search unit shall be positioned for the maximum response from the reflector, which gives the highest amplitude.
(b)When the block shown in the figure T-434.4.2.2 is used, the plane separating the elements of the dual elements search unit shall be positioned parallel to the axis of the hole.
(c) The gain shall be set so that this response is 80% ± 5% of full screen height. This shall be the primary reference level. Mark the peak of the indication on the screen.
(d)Without changing the instrument settings, position the search unit for maximum response from each of the other reflectors and mark their peaks on the screen.
(e) Connect the screen marks for each reflector to provide a DAC curve.

Note: When examination for lack of bond and weld metal overlay cladding flaw indications is required, Technique One shall be used. When examination for lack of bond only is required, Technique Two may be used.

8. SCANNING:

8.1 GENERAL:

8.1.1. EXAMINATION SURFACE:
Examination shall be carried out from identity-punched surface.

8.1.2. COVERAGE:
Shall be on both sides of the weld from 0 to 1½ skip.

8.1.3. SCAN OVERLAP:
Each pass of the search unit shall overlap a minimum of 10% of the active transducer (piezoelectric element) dimension perpendicular to the direction of the scan.

8.1.4. SPEED AND SENSITIVITY:
The weld shall be scanned at a speed not exceeding 6” per second at a scanning sensitivity 6 dB above the DAC or primary Reference Level (PRL).

8.2 BASE MATERIAL:

Prior to angle beam examination of weld, adjacent parent material up to a width of 4T on both sides of the weld shall be scanned with a straight beam search unit to find discontinuities that could interfere with interpretation of indications obtained during subsequent angle beam scanning.
Any discontinuity found by straight beam search unit shall be investigated and not be a cause of rejection of element.

8.3 WELD:

Weld shall be scanned with two different angles beam search units for detection of Longitudinal and transverse discontinuities

8.3.1. DIRECTION AND EXTENT OF SCANNING:

8.3.1.1. REFLECTORS PARALLEL TO THE WELD SEAM:

The angle beam shall be directed at approximate right angles to the weld axis from both side of the weld (i.e., is from 2 directions) on the same surface when possible and probe manipulated so as to pass ultrasonic energy thro' the required volume of the weld and adjacent base material.

8.3.1.2. REFLECTORS TRANSVERSE TO THE WELD:

The angle beam shall be directed essentially parallel to the weld axis. The search unit shall be manipulated so that the ultrasonic energy passes thro' the required volume of weld and adjacent base material. Search unit shall be rotated 180 ° and the examination repeated.

9. SIZING:

9.1 METHOD OF SIZING INDICATIONS:

Length dimension of indications shall be measured by half maximum amplitude method.

9.2 CALIBRATION CORRECTION:

The surface finish difference between calibration block &scanning surface shall be compensated by using Transfer Correction.

Calibration correction due to Mode conversion and redirection for planar reflectors perpendicular to the examination surface at or near the opposite surface is carried out as per the following.

Position the search unit for maximum amplitude from the notch on the opposite surface of the basic calibration block and mark the position of peak of the indication on the screen
The opposite surface notch may give an indication 2 to 1 above DAC for a 45º angle beam search unit and ½ DAC for a 60º search unit. Therefore, the indications from the notch must be considered when evaluating reflectors at the opposite surface

10. EVALUATION :

It shall be carried out by at least NDE Level II personnel as per the following.

- All indications exceeding 20% of DAC shall be scanned for their nature and location and recorded. The gain shall be increased an additional amount so that no calibration reflector indication is less than 40% FSH during evaluation.

- The identity, maximum amplitude, location and extent of reflector causing a geometric indication(s) (segregates in the heat-affected zone, surface conditions such as weld root geometry) shall be recorded.

- Following shall be considered for Classifying an indication as geometric or not.
  - Plot and verify the reflector coordinates. Prepare a cross-sectional sketch showing the reflector position and surface discontinuities such as root and counter bore.
  - Review fabrication or weld preparation drawing. Other ultrasonic techniques or nondestructive examination methods may be helpful in determining a reflector's true position, size, and orientation.

11. RECORDING AND REPORTING:

11.1 METHOD OF RECORDING:

- Test data shall be recorded manually in the Proforma appended in exhibit-1 Annexed and reported and Direct thickness read out by manual Ultrasonic pulse echo contact method is recorded in exhibit-2.
- As a minimum all rejectable indications, type of indications (Crack, non-fusion, slag etc.), location and extent (length), depth below surface shall be recorded.
- Non-rejectable indications exceeding 50% of DAC shall be recorded

Report shall contain the following in addition to those mentioned in the table appended next page.

- Procedure identification and revision.
- Instrument reference level gain and, if used, damping and reject settings(s).
- Calibration data (including reference reflector(s) indication amplitude(s), and distance reading(s).
- Identification and location of weld or volume scanned.
- Map or record of rejectable indications detected or areas cleared.
- Areas of restricted access or inaccessible welds;
- Examination personnel identity and, when required by referencing code section qualification level.
- Date of examination.

12. ACCEPTANCE STANDARDS:

As per ASME SEC I, ASME SEC VIII Div 1, ASME SEC VIII Div 2 Edition 2019, ASME B31.1, NBIC NB 23 Latest Edition.

UT on clad plate (Dished ends) shall be performed as per ASME A 578.

ACCEPTANCE-REJECTION STANDARDS:

(Ref: ASME SEC I, ASME SEC VIII Div 1,ASME SEC VIII DIV 2 Edition 2019)

Imperfections recorded as per para 10 above shall be evaluated as below.

1. Indications characterized as cracks, lack of fusion or incomplete penetration are unacceptable regardless of length.

2. Other imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths which exceed 1/3 T - (weld thickness(T) excluding any allowable reinforcement) or 6 mm whichever is greater.

Notes: Butt welds joining two different thicknesses at the weld, T is the thinner of these two thicknesses.

(For other Codes such as ASME B31.1, NBIC NB23 refer respective current Edition)

13. PRESERVATION OF DATA REPORTS:

All the reports of ultrasonic test shall be preserved till MDR signed.

ISSUE NO.2

PROCEDURE FOR MAGNETIC PARTICLE EXAMINATION

Issue No	Rev No	Date of Revision	Brief Records of Revision
1	0	02-02-2015	First Edition
1	1	11-04-2017	Cl no. 3,5,8.6,9,14 revised as per ASME Sec V Edition 2015
2	1	25-04-2018	Cl no. 3,5,8.2,19,14 revised as per ASME Sec V Edition 2017
2	2	15-05-2020	Cl. no. 1,6,7.1,7.2 Modified; 13,14,15,16,17,18 renumbered; Cl. no. 3,4,9.2,18 revised; Cl.no.8,10,11,12 added.

Refer coments in 1st page of RT

Prepared by	Reviewed & Approved by
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TABLE OF CONTENTS

1. SCOPE :

This Procedure shall be applied for detecting of surface and near surface discontinuities in Butt welds, fillet welds, partial penetration welds, Back Gouging welds, Full penetration butt and corner welds, Nozzles of Boiler components, pressure vessels, heat exchangers, power piping and Non pressure parts welds, plates, forgings, etc. of Ferro Magnetic Materials to detect surface and subsurface discontinuities using visible Dry & wet particle Continuous Prod or Yoke technique and Fluorescent Wet Prod or Yoke Techniques.

2. POLICY:

2.1 The Magnetic Particle Examination shall be carried out either as per one of the procedures enumerated in the following pages which are verified and found to be in accordance with ASME SEC V or as per any other applicable referencing code sections and specifications.

2.2 Only personnel qualified to MT NDE Level II / MT NDE Level III in accordance with NDE written practice shall carry out any Magnetic Particle Examination.

3. APPLICABLE STANDARDS:

3.1 ASME SEC V Edition 2019

3.2 Construction code sections ASME Sec I, ASME Sec VIII Div 1, ASME Sec VIII Div 2 Edition 2019, ASME B31.1 Edition 2018, NBIC NB 23 Edition 2019, SNT-TC-1A Edition 2016 & ASME SEC V Edition 2019 Art.1.

4. SYSTEM:

All Magnetic particle examination procedures shall be amended and approved as required by NDE level III taking into consideration of

4.1 Experience gained in various examination procedures

4.2 Recommendation of Audit Teams

4.3 Referencing Code sections.

5. WRITTEN PROCEDURE REQUIREMENTS:

This procedure based on Table T-721 of ASME SEC V Edition 2019 shall contain the requirements listed in the Table below.

It shall establish a single value, or range of values for each requirement. When required performance shall be demonstrated to the inspector. Any change in specified value or range of values of the essential variables mentioned in Table shall require requalification of the written procedure.

Table T-721
Requirements of a Magnetic Particle Examination Procedure

Requirement	Essential Variable	Nonessential Variable
Magnetizing technique	X	...
Magnetizing current type or amperage outside range specified by this Article or as previously qualified	X	...
Surface preparation	X	...
Magnetic particles (fluorescent/ visible, color, particle size, wet/ dry)	X	...
Method of particle application	X	...
Method of excess particle removal	X	...
Minimum light intensity	X	...
Existing coatings, greater than the thickness demonstrated	X	...
Nonmagnetic surface contrast enhancement, when utilized	X	...
Performance demonstration, when required	X	...
Examination part surface temperature outside of the temperature range recommended by the manufacturer of the particles or as previously qualified	X	...
Shape or size of the examination object	...	X
Equipment of the same type	...	X
Temperature (within those specified by manufacturer or as previously qualified)	...	X
Demagnetizing technique	...	X
Post-examination cleaning technique	...	X
Personnel qualification requirements	...	X

6. SURFACE CONDITIONING :

6.1 SURFACE PREPARATION:

6.1.1. Prior to Magnetic Particle Examination, the surface to be examined and all adjacent areas within at least 1” shall be dry and free of all dirt, grease, lint, scale, welding flux & spatter, oil and other extraneous matter that could interfere with examination.

6.1.2. As welded, ground, Machined and Back Gouged conditions are preferable. However, Surface preparation by grinding or machining may be necessary where surface irregularities could mask indications due to discontinuities. This

procedure does not address the testing of parts covered with coatings and / or non magnetic surface contrast enhancement.

6.1.3. The surfaces which are to be examined by Magnetic particle testing shall be free from any external Nonmagnetic coatings. If any nonmagnetic coatings are present, it shall be demonstrated that indications can be detected through the existing maximum coating thickness applied.

6.1.4. Nonmagnetic Surface Contrast Enhancement:

Nonmagnetic surface contrasts may be applied by the examiner to uncoated surfaces, only in amounts sufficient to enhance particle contrast. When nonmagnetic surface contrasts are used, it shall be demonstrated that indications can be detected through the enhancement. Thickness measurement of surface contract enhancement is not required.

6.2 TEMPERATURE OF PART SURFACE:

The surface temperature of the part examined with dry particles shall be within the range of 17 ºC to 315 ºC (within maximum temperature specified by the manufacturer of the particles) and wet particles shall be maximum 57 ºC or temperature specified by the manufacturer of the particles.

7. EQUIPMENT:

7.1 TYPE OF EQUIPMENT:

7.1.1. Portable magnetic particle testing equipments appearing in the current list of NDE Equipments under calibration (230V, single phase, open circuit voltage <25V) provided with stepped / continuous current control, remote control switch for momentarily switching on / off, prods for application of current and capable of generating max 1000A HWDC shall be used for magnetization.

7.1.2. Direct/Alternating current electromagnetic yokes shall be used to detect discontinuities that are open to the surface of the part by longitudinal magnetization method and to examine the surfaces where arcing is not permitted or prod method is not practicable.

7.2 CALIBRATION OF EQUIPMENT:

7.2.1. Each magnetizing equipment with an ammeter shall be calibrated at least once a year, or whenever the equipment has been subjected to major electric repair, periodic overhaul, or damage.

7.2.2. The magnetizing power of yokes shall be verified prior to use on every day the yoke is used. The magnetizing power of yokes shall be verified whenever the yoke has been damaged or repaired.

7.2.3. Each alternating current electromagnetic yoke shall have a lifting power of at least 4.5 kg at the maximum pole spacing that will be used with contact similar to what will be used during the examination.

7.2.4. Each direct current or permanent magnetic yoke shall have a lifting power of at least 18 kg at the maximum pole spacing that will be used with contact similar to what will be used during the examination.

7.2.5. Each weight shall be weighed with a scale from a reputable manufacturer and stencilled with the applicable nominal weight prior to first use. Weight need only be verified again if damaged in a manner that could have caused potential loss of material.

8. EXAMINATION MEDIUM:

8.1 DRY PARTICLES:

Finely divided ferromagnetic dry particles (non-fluorescent free flowing dry particles of colors either red or grey.) supplied by M/s Arora / M/s Pradeep with brand name Automag RD-7 Red or M/s Ferrochem with Brand names Ferrochem grey and Ferrochem Red shall be used.

8.2 WET PARTICLES:

8.2.1. WET PARTICLE CONCENTRATION:

Non fluorescent or fluorescent wet particles will be black or reddish brown in color that provide adequate contrast with the surface being examined.

Wet particles shall be suspended in kerosene or water for application to the test surface by flowing or spraying. Suitable conditioning agents shall be added to the water to provide proper wetting and corrosion protection for the parts being examined.

The bath concentration shall be determined by measuring the settling volume through the use of pear-shaped centrifuge tube with a 1-mL stem (0.05-mL divisions) for fluorescent particle suspensions or a 1.5-mL stem (0.1-mL divisions) for non-fluorescent suspensions. The suspension shall be mixed thoroughly or shall be run through the re-circulating system for at least 30 minutes to ensure thorough mixing of all particles. Take a 100-mL portion of the suspension from the hose or nozzle, demagnetize and allow it to settle for 30 minutes' minimum with water based suspension or 60 minutes' minimum with petroleum distillate suspension before taking the reading.
For fluorescent particles, the required settling volume is from 0.1 mL to 0.4 mL in a 100-mL bath sample and from 1.2 mL to 2.4 mL per 100 mL of vehicle for non-fluorescent particles or as recommended by the manufacturer. Concentration checks shall be made at least every eight hours.

8.2.2. WET PARTICLE CONTAMINATION:

Both fluorescent and non-fluorescent suspensions shall be checked periodically for contaminants such as dirt, scale, oil, lint, loose fluorescent pigment, water (in the case of oil suspensions), and particle agglomerates which can adversely affect the performance of the magnetic particle examination process. The test for contamination shall be performed at least once per week.

8.2.2.1. Carrier Contamination:

For fluorescent baths, the liquid directly above the precipitate should be examined with fluorescent excitation light. The liquid will have a little fluorescence. Its color can be compared with a freshly made-up sample using the same materials or with an unused sample from the original bath that was retained for this purpose. If the "used" sample is noticeably more fluorescent than the comparison standard, the bath shall be replaced.

8.2.2.2. Particle Contamination.

The graduated portion of the tube shall be examined under fluorescent excitation light if the bath is fluorescent and under visible light (for both fluorescent and non-fluorescent particles) for striations or bands, differences in color or appearance. Bands or striations may indicate contamination. If the total volume of the contaminates, including bands or striations exceeds 30% of the volume magnetic particles, or if the liquid is noticeably fluorescent, the bath shall be replaced.

Note: In any case, color of particles used shall have adequate contrast with the surface being examined.

9. EXAMINATION:

9.1 EXAMINATION COVERAGE:

All examinations shall be conducted with sufficient field overlap to ensure 100% coverage at the required sensitivity.

9.2 MINIMUM LIGHT INTENSITY:

9.2.1. Visible Light Intensity

9.2.1.1. The examination area and the accumulation of magnetic particles shall be observed under adequate lighting. An intensity of 1076 lux is adequate. The minimum light intensity shall be 100 fc (1076 lux). The light intensity, natural or supplemental white light source, shall be measured with a white light meter prior to the evaluation of indications or a verified light source shall be used. Verification of light sources is required to be demonstrated only one time, documented, and maintained on file.

All following activity shall be done under the illumination of 100 watt 230V incandescent bulb at a minimum distance of 25 cms from test part for ensuring 1076 Lux light intensity at test part surface.

9.2.2. Black Light (UV-A Light)

9.2.2.1. Black light intensity at the examination surface shall be not less than 1000 micro watt/ cm^2 at a distance of 15 inch.

9.2.2.2. The black light intensity shall be measured at least once in every 8 hrs. and whenever the work station is changed. The UV-A and White Light Meter should be calibrated once in One year.

9.2.2.3. With fluorescent particles, the examination is performed in a darkened area. The Intensity of Ambient visible light in the darkened area shall not exceed 2 fc or 21.5 lux.

9.2.2.4. The examiner shall be in the darkened area for at least 5 minutes prior to performing the examination for eye adaptation. The examiner shall not wear glasses with permanent Tint or Photo Chromic (light sensitive) lenses which change colour in Sunlight.

9.2.2.5. The black light shall be warmed up for a minimum period of 5 minutes prior to use or measurement of the intensity.

Lux meter/Light meter shall be calibrated at least once a year or whenever a meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

For selection of other light sources vs maximum distances permitted refer Exhibit 1.

9.3 DIRECTION OF MAGNETIZATION:

Two separate examinations shall be performed on each area. During second examination, the lines of magnetic flux shall be approximately perpendicular to those used in the first examination.

10. METHOD OF EXAMINATION:

Examination shall be made by continuous method.

10.1 Dry continuous magnetization method:

The magnetizing current remains on while the examination medium (Brick red Dry particle) is being applied and while the excess of the examination medium is being removed.

10.2 Wet continuous magnetization method:

The magnetizing current shall be turned on after the particles have been applied. Flow of particles shall stop with the application of current. Wet particles applied from aerosol spray cans/pump sprayers may be applied before and/or during magnetizing current application.

11. TECHNIQUES:

11.1 PROD TECHNIQUE:

11.1.1. Magnetizing Procedure:

The prod electrodes are pressed firmly against the surface in the area to be examined. In order to avoid arcing, a remote control switch shall be built into the prod handles, to permit the current to be turned on after the prods have been properly positioned and to be turned off before they are removed. The prods tips shall be kept dressed and cleaned to make satisfactory electrical contact.

11.1.2. Magnetizing Current and Prod Spacing:

Single-phase (half-wave rectified) current HWDC shall be used. The current shall be 100 to 125amps per inch of prod spacing for sections 0.75 inch thick or greater. For sections less than 0.75 inch thick the current shall be 90 to 110 amps per inch of prod spacing. Prod spacing shall not exceed 8 inches and shall not be less than 3 inches.

11.2 YOKE TECHNIQUE:

11.2.1. This technique is primarily intended to cover the region between the poles. The pole spacing shall be between 100 mm to 150 mm. In order to ensure that the region of interest gets 100 % coverage, every region (or segment of the test area, divided according to the pole spacing), shall be tested twice such that the pole space displacements are mutually perpendicular in the former and later cases. For example, in the case of the weld, the pole space orientation can be 45 Deg. and 135 Deg. Respectively with respect to the weld center line orientation, in the first and second attempts.

11.2.2. Pie-Shaped Magnetic Particle Field Indicator shall be used to ensure field adequacy as well as direction of field. It shall be positioned on the surface to be examined with copper-plated side away from the inspected surface.

Suitable field strength is indicated by formation of clearly defined lines of magnetic particles across the copper face of the indicator when the magnetic particles are applied simultaneously with the magnetizing force. When a clearly defined line of particles are not formed in the desired direction, the magnetizing technique shall be changed as needed.

11.3 For inspection of components of Gr 91 material including Gr C12A, prod technique shall not be used. This shall be inspected by Yoke technique using Dry or Wet method.

12. METHOD OF PARTICLE APPLICATION AND EXCESS PARTICLE REMOVAL:

12.1 DRY PARTICLES:

12.1.1. The dry particles shall be applied in such a manner that a light uniform dust-like coating settles on the surface of the area being examined. The application technique shall be such that the particles are suspended in air and reaches the examination surface in a uniform cloud with a minimum force, using hand powder applicators (squeeze bulb) or specially designed mechanical blower or by a spray nozzle.

12.1.2. Dry particles shall not be applied to a wet surface nor when there is excessive wind. The particles shall not be applied by pouring, throwing, or spreading with fingers.

12.1.3. Any excess powder shall be removed while the magnetization current is on and shall be with a gentle air stream by a blower or squeeze bulb without removing or disturbing particles attracted by a leakage field that may prove to be a relevant indication.

12.2 WET PARTICLES:

12.2.1. The application of wet particles involves the bathing of the area to be examined, by spraying or flowing during the application of magnetizing current.

12.2.2. Two or more shots shall be applied, but the last shot shall be applied while the bath still remains on the area to be examined and after the particle flow has been stopped. Care shall be taken to cut off the bath application before

removing the magnetic field, to prevent high-velocity particle flow that may wash away or remove fine or weakly held indications.

13. INTERPRETATION AND EVALUATION :

(a) All indications shall be evaluated in terms of the acceptance standards of the referencing Code Section.
(b) Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface irregularities due to machining marks or other surface conditions may produce false indications.
(c) Broad areas of particle accumulation, which might mask indications from discontinuities, are prohibited, and such areas shall be cleaned and reexamined.

All indications shall be evaluated by a NDE Level II or NDE Level III in terms of the acceptance standard of ASME SEC VIII DIV 1, ASME SEC VIII DIV 2, ASME SEC I, ASME B31.1, NBIC NB 23 current Edition.

14. REPORTING :

Interpretation and evaluation shall be reported in the Proforma appended in Exhibit-2.

15. POST-EXAMINATION CLEANING :

The examination surface shall be wiped clean using cloth / cotton waste.

16. DEMAGNETIZATION :

No demagnetization is required unless specifically required by customer. When required one of the following methods (ref. SE-709-95 for detail techniques) shall be used**.**

- Withdrawing from AC coil.
- Decreasing alternating current.
- Demagnetizing with yokes.

17. RECORDS :

All the reports of Magnetic particle test shall be preserved till MDR signed**.**

18. ACCEPTANCE STANDARDS:

(Ref: ASME SEC I, ASME SEC VIII Div 1 & Div 2 Edition 2019)

All surfaces to be examined shall be free of

- Relevant Linear indications
- Relevant rounded indications greater than 5 mm.
- Four or more relevant rounded indications in a line separated by 1.5 mm or less edge to edge.

Notes: Any indication believed to be non relevant shall be confirmed by re-examination using same method or other non destructive examination method and/or by surface conditioning.

1. **Relevant indications**: Indications having any dimension greater than 1.5 mm.
2. **Linear indications:** Relevant Indications having length greater than three times the width.
3. **Rounded indications:** Relevant indications having circular or elliptical shape with a length equal to or less than three times its width**.**

(For other Codes such as ASME B31.1, NBIC NB23 refer respective current Edition)

ISSUE NO.: 2

PROCEDURE FOR LIQUID PENETRANT EXAMINATION

Issue No	Rev No	Date of Revision	Brief Records of Revision
1	0	02-02-2015	First Edition
1	1	11-04-2017	Cl no. 3,5,13 revised as per ASME Sec V Edition 2015
2	1	25-04-2018	Cl no. 3,5,6.2,6.4,6.6,7.2.4,7.3,10,15 revised as per ASME Sec V Edition 2017
2	2	15-05-2020	Cl no. 3.1,3.2,6.2,14 revised and Cl no.1,6.1,6.4,8 modified as per ASME Sec V Edition 2019.

Refer coments in 1st page of RT

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1. SCOPE:

This Procedure shall be used for the detection of open surface discontinuities in welds, plates, and forgings etc., used in Pressure Vessels., Heat Exchangers, Boilers and parts thereof by visible Liquid Penetrant Examination using solvent removable process for ferrous and non-ferrous materials.

2. POLICY:

2.1. The Liquid Penetrant Examination shall be carried out either as per one of the procedures enumerated in the following pages which are verified and found to be in accordance with ASME SEC V or as per any other applicable referencing code sections and specifications.

2.2. Only personnel qualified in accordance with BHEL HPVP NDE Written Practice shall carry out any Liquid Penetrant examination.

3. APPLICABLE STANDARDS:

3.1 ASME SEC V Edition 2019.

3.2 Construction code sections ASME Sec I, ASME Sec VIII Div 1, ASME Sec VIII Div 2 Edition 2019, ASME B31.1 Edition 2018, NBIC NB 23 Edition 2019, SNT-TC-1A Edition 2016 & ASME SEC V Edition 2019 Art.1.

4. SYSTEM:

All Liquid Penetrant Examination procedures shall be amended and approved as required by NDE Level III taking into consideration of

4.1. Experience gained in various examination procedures.

4.2. Recommendation of Audit Teams.

4.3. Referencing Code sections.

5. WRITTEN PROCEDURE REQUIREMENTS: (As per ASME Sec V Article 6 T-621)

Liquid Penetrant examination shall be performed in accordance with a written procedure, which shall as a minimum contain the essential and non-essential variable as mentioned in the table below. The written procedure shall establish a single value, or range of values, for requirement.

Table T-621.1
Requirements of a Liquid Penetrant Examination Procedure

Requirement	Essential Variable	Nonessential Variable
Identification of and any change in type or family group of penetrant materials including developers, emulsifiers, etc.	X	...
Surface preparation (finishing and cleaning, including type of cleaning solvent)	X	...
Method of applying penetrant	X	...
Method of removing excess surface penetrant	X	...
Hydrophilic or lipophilic emulsifier concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers	X	...
Hydrophilic emulsifier concentration in spray applications	X	...
Method of applying developer	X	...
Minimum and maximum time periods between steps and drying aids	X	...
Decrease in penetrant dwell time	X	...
Increase in developer dwell time (Interpretation Time)	X	...
Minimum light intensity	X	...
Surface temperature outside 40°F to 125°F (5°C to 52°C) or as previously qualified	X	...
Performance demonstration, when required	X	...
Personnel qualification requirements	...	X
Materials, shapes, or sizes to be examined and the extent of examination	...	X
Post-examination cleaning technique	...	X

Any change of requirement specified as an essential variable mentioned above shall require requalification of the written procedure.

6. METHOD OF EXAMINATION:

6.1. IDENTIFICATION OF PENETRANT EXAMINATION MATERIALS:

6.1.1. PRADEEP/PMC/MAGNAFLUX brands of PT chemicals be used. Other brands may also be used with the approval of NDE Level-III.

6.1.2. Refer certification of contaminant content for all liquid penetrant materials used.

6.1.3. Ensure manufacturers batch numbers, on the penetrant material containers and Certificate mentioned above are same.

6.2. **MINIMUM LIGHT INTENSITY:**

All following activity shall be done under the illumination of 100 watt 230V incandescent bulb at a maximum distance of 25 cms from test part for ensuring 1076 Lux light intensity at test part surface.

6.3. **SURFACE PREPARATION (FINISHING AND CLEANING, INCLUDING TYPE OF CLEANING SOLVENT) (As per ASME Sec V Edition 2019Article 6 T-642)**

This procedure applies to below mentioned surface preparations.

6.3.1. As welded
6.3.2. As ground
6.3.3. As machined /As Forged/As Plates

6.3.4. SURFACE CLEANING:

6.3.4.1. Ensure Surface examined and all adjacent areas within 1" shall be free of scale, welding flux, weld spatter.
6.3.4.2. Use Organic solvent - Cleaner mentioned above to remove oil, and other extraneous matter.
6.3.4.3. Wait for a minimum of 3 minutes for evaporation of cleaning solvent used above.

6.4. **SURFACE TEMPERATURE (As per ASME Sec V Edition 2019 Article 6 T-652)**

Ensure that the temperature of the penetrant and the surface of the part to be subjected to penetrant testing is between 5 to 52 deg centigrade. For examination between 5- 10 deg Centigrade, the minimum Penetrant dwell time shall be two times than that established for testing between 10 to 52 deg Centigrade.

6.5. **METHOD OF APPLYING PENETRANT**

Use brush or spray for application of penetrant to the surface of the part.

6.6. **PENETRATION (DWELL) TIME**

6.6.1. Allow penetrant on the weld surface for minimum 5 minutes and maximum 10 for welds & Casts.

6.6.2. Allow penetrant on the surface for minimum 10 minutes and maximum 15 minutes and for plates & forgings.

Note: Ensure that penetrant is not dried during dwell time.

6.7. **METHOD OF REMOVING EXCESS SURFACE PENETRANT**

6.7.1. After completion of penetration (dwell) time remove any penetrant remaining on the surface using clean, dry, and lint free cloth.

6.7.2. Remove the remaining traces of penetrant on the weld surface by wiping the surface with clean, lint- free material lightly moistened with the solvent remover. Complete this step within 10 minutes after start of excess penetrant removal.

6.7.3. Do not flush the weld surface with cleaning solvent for removal of excess penetrant.

6.8. **DRYING AFTER EXCESS PENETRANT REMOVAL (AS PER ASME SEC V ARTICLE 6 T-674)**

Wait for a maximum of 2 minutes for evaporation of cleaning solvent used above for Excess Penetrant Removal.

6.9. **METHOD OF APPLYING DEVELOPER**

Apply Developer using aerosol can spray after above step. (i.e. Drying After Excess Penetrant Removal). Maximum time for Developer application is 5 min.

6.10. **DEVELOPER DWELL TIME (INTERPRETATION TIME)**

6.10.1. Developing time for final interpretation begins immediately after developer coating is dry.

6.10.2. Wait for a minimum of 2 minutes after developer spray for developer coating to dry.

6.10.3. Observe closely during application of developer to aid in characterization of indications developed.

6.10.4. Final interpretation shall be made within 10 to 20 min after developer coating is dry.

6.11. **MINIMUM AND MAXIMUM TIME PERIODS BETWEEN STEPS AND DRYING AIDS**

6.11.1. Minimum time between surface cleaning and application of penetrant 3 minutes. Maximum No limit.

6.11.2. Minimum/Maximum time between application of penetrant and start of excess Penetrant removal 5/10 minutes for welds and 10/15 minutes for plates and forgings.

6.11.3. Maximum time between excess penetrant removal and application of Developer 10 minutes.

6.11.4. Final interpretation time minimum 10 and maximum 20 minutes after developer coating is dry.

7. PERSONNEL QUALIFICATION REQUIREMENTS

Personnel qualified and certified to NDE Level III in PT shall demonstrate this procedure to the satisfaction of AI. Application of this procedure on jobs shall be by personnel qualified and certified to NDE Level II / NDE Level III in PT as per the Written Practice.

8. MATERIALS, SHAPES, OR SIZES TO BE EXAMINED AND THE EXTENT OF EXAMINATION

This procedure is applicable to welds, plates, forgings of all shapes and sizes for ferrous and non ferrous materials. The extent of examination shall be as per referred specification or test plan.

9. POST EXAMINATION CLEANING TECHNIQUE:

Using cloth or cotton waste Post-examination cleaning shall be done as soon as practical after Evaluation and Documentation.

10. GENERAL REQUIREMENTS:

10.1. If the surface to be examined is large enough to complete examination within the above established times the examination shall be performed in increments.

10.2. Ensure bleed-out from large indications does not alter the examination results during interpretation time.

10.3. Any change of requirement specified as an essential variable in para 5 shall require requalification of this written procedure.

11. EVALUATION:

All indications shall be evaluated in terms of the acceptance standards Referred below.

12. DOCUMENTATION (AS PER ASME SEC V EDITION 2019ARTICLE 6 T-690):

Recording of Indications shall be done in Liquid Penetrant Examination Requisition cum report format referred in Exhibit 2.

12.1. Non rejectable Indications: Non rejectable indications shall be recorded as specified by the referencing Code Section.

12.2. Rejectable Indications: Rejectable indications shall be recorded.
As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

13. RECORDS:

All the reports of Liquid Penetrant Examination shall be preserved till MDR signed.

14. ACCEPTANCE STANDARDS FOR LIQUID PENETRANT EXAMINATION:

REF: ASME SEC I, ASME SEC VIII Div 1 & Div 2 Edition 2019.

All surfaces to be examined shall be free of

1. Relevant linear indications.
2. Relevant rounded indications greater than 3/16 inch (5mm).

3. Four or more relevant rounded indications in a line separated 1/16 inch (1.5mm) or less (edge to edge).

Notes:

- Only indications with major dimensions greater than 1/16 inch (1.5 mm) shall be considered relevant.
- A linear indication is one having a length greater than three times the width.
- A rounded indication is one of circular or elliptical shape with the lengthy equal to or less than three times the width.
- Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

(For other Codes such as ASME B31.1, NBIC NB23 refer respective current Edition)