

QUALITY CONTROL PROCEDURE FOR PIPING FIELD FABRICATION AND ERECTION
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QUALITY CONTROL PROCEDURE FOR PIPING FIELD FABRICATION AND ERECTION

1. SCOPE

This procedure addresses the various stages of piping erection and inspection of metallic piping in Fadhili Sulfur Recovery Unit.

2. PURPOSE

This quality procedure describes the minimum quality requirements to ensure that piping erection activities are performed in accordance with applicable Saudi Aramco specifications and international codes.

3. DEFINITIONS

PROJECT	: Fadhili Gas Plant Sulphur Recovery Unit- Package-3
COMPANY	: Saudi Aramco (SA)
CONTRACTOR	: Petrofac Saudi Arabia International Limited (PSAL)
SUB-CONTRACTOR	: Nasser S Al Hajri Corporation (NSH)
SAES	: Saudi Aramco Engineering Standard
SAEP	: Saudi Aramco Engineering Procedure
SAMSS	: Saudi Aramco Material System Specification
ITP	: Inspection and Test Plan
WPS	: Welding Procedure Specification
NDT	: Non Destructive Testing
PWHT	: Post Weld Heat Treatment
PMI	: Positive Material Identification

4. REFERENCES

SAES-L-100	: Applicable Codes and Standards for Pressure Piping Systems
SAES-L-105	: <u>Piping Material Specification</u> <i>PIPING Line classes</i>
SAES-L-108	: Selection of Valves
SAES-L-109	: Selection of Flanges, Stud Bolts and Gaskets
SAES-L-110	: Limitations of Piping Joints and Components
SAES-L-132	: Material Selection for Piping Systems
SAES-L-136	: Pipe, Flange and Fitting Material Requirements
SAES-L-150	: Pressure Testing of Plant Piping and Pipelines
SAES-L-310	: Design of Plant Piping
SAES-L-350	: Construction of Plant Piping
SAES-H-200	: Storage, Handling, Installation and of externally coated pipe
SAES-A-206	: Positive Material Identification

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SAES-A-004 : General Requirements for Pressure Testing



SAES-A-007 : Hydrostatic Testing Fluids and Lay-up Procedures

SAES-W-011 : Welding Requirements for On-Plot Piping

SAES-W-016 : Welding of Special-Resistance Materials

01-SAMSS-010 : Fabricated Steel Piping

01-SAMSS-035 : API Line Pipe

01-SAMSS-043 : Carbon Steel Pipes for On-Plot Piping

01-SAMSS-046 : Stainless Steel Pipe

02-SAMSS-005 : Butt Welding Pipe Fittings

SAEP-310 : Piping and Pipeline Repair



SAEP-351 : Bolted flange joints assembly

SAEP-1160 : Tracking and Reporting of Welding, NDT and Pressure Testing for Capital Projects

SATIP-W-011-01 : Welding of On-Plot Piping

SATIP-L-350-01 : On-Plot Metallic Piping Installation



SATIP-L-350-08 : Shop Fabrication - Piping & Miscellaneous Steel Structures



SATIP-L-108-01 : Valve Inspection, Testing & Installation

SATIP-A-004-01 : Pneumatic Pressure Testing



SATIP-A-004-02 : Hydrostatic Testing of On-Plot Piping

D44-A-RE-589196 : Pipe marking & color coding

D44-A-RE-585265 : Piping Material specification/

Applicable ITP : Inspection and Test plan

Schedule "Q" : Quality Requirements

ASME SEC.II Part A : Ferrous material specification

ASME SEC.II Part B : Nonferrous material specification

ASME SEC.II Part C : Specifications for welding rods, electrodes, and filler metals

ASME SEC.V : Nondestructive Examination

ASME SEC.IX : Welding and Brazing Qualifications

ASME B31.3 : Process Piping

PFI-ES-43 : Standard for protection of Austenitic Stainless Steel & Nickel Alloy Materials

NSH-PSAL-FSRU-PQP-QC-0001 : Project Quality Plan

NSH-PSAL-FSRU-PRO-GE-0013 : Material Control Procedure

NSH-PSAL-FSRU-PRO-GE-0014 : Material Handling, Storage & Preservation Procedure

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NSH-PSAL-FSRU-PRO-PI-0003	: Welder and WPS qualification and control & Procedure
NSH-PSAL-FSRU-PRO-PI-0006	: Welding Consumables Handling and Storage Procedure
NSH-PSAL-FSRU-PRO-PI-0016	: Procedure for Weld Joint Repair and NDT Identification
NSH-PSAL-FSRU-PRO-PI-0017	: Back Purge Procedure
NSH-PSAL-FSRU-PRO-PI-0015	: Gasket and Bolt Tightening Procedure
NSH-PSAL-FSRU-PRO-PI-0024	: Socket/ Threaded Weld Gap Control & Seal Welding Procedure- Shop & Field
NSH-PSAL-FSRU-PRO-PI-0025	: NDT Control Procedure
NSH-PSAL-FSRU-PRO-PI-0027	: Pressure Testing of AG Piping
NSH-PSAL-FSRU-PRO-PI-0028	: Piping Internal Cleanliness Procedure
NSH-PSAL-FSRU-PRO-PA-001	: Procedure for blasting, coating and painting
Capps	: Construction Applications Software (NSH Database)



5. RESPONSIBILITIES

- 5.1 **Project Manager** shall be the responsible for the overall implementation of the company safety & quality plan and ensure efficient execution of work in accordance with project specification and this procedure.
- 5.2 **QA/QC Manager** shall be responsible for ensuring all activities are carried out as per the project quality plan, project specifications, and this procedure. He shall ensure inspections, testing, and examinations are carried out as per the approved ITP.
- 5.3 **Construction Manager** shall be the responsible for all mechanical and piping erection activities pertaining to this project.
- 5.4 **Piping Manager** shall be responsible for ensuring all piping erection activities are carried out as per this procedure. He shall have close coordinating with project quality control department. He shall co-ordinate with personnel at field, plan work schedule allocate job to piping superintendents.
- 5.5 **Piping Superintendent** shall plan the daily work schedule; the job to concerned Supervisors and controlling piping works in the field.
- 5.6 **Piping Supervisor** shall be the responsible to ensure the safe and efficient working environment to monitor plant and equipment requirements and to ensure that productivity and quality are maintained by their subordinates. They are also responsible for ensuring that the proper material is being used in addition to the correct welding consumable and the correct welding procedure.
- 5.7 **Planning Engineer** shall receive all the drawing from document controller and same will be kept updating as per the latest revisions. Preparation of weekly, monthly and overall schedule will be compiled and the same will be monitored on daily basis. He shall be the responsible for

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work orders, approval of field material request, and progress updating. The Planner will issue the S.T.Q (Site Technical Query) to PSAL if any engineering constraints are reported.

5.8 Material Manager shall be overall responsible for the construction materials. He shall release all required material to field after receiving of field material request requested by piping supervisor and approved by planning engineer. He shall be responsible for receiving inspection notification to quality department and preservation of materials.

5.9 Material Controller is responsible for all material receiving & issuing of the material to field as per the field material request approved by material manager. Records shall be made for shifting and an updated status of materials stock and transfer to field will details to be maintained daily basis.

 **5.10 QC Supervisor** shall arrange and supervise all QC activities ensuring that all inspections are performed in timely manner and documented. Before starting new activity tool box shall be conducted.

5.11 Piping Inspector shall be responsible for inspection and testing of all piping activities such as material receiving, piping internal cleaning, fit up, alignment, dimensional check etc...

5.12 Welding Foreman shall be responsible for arranging and checking all welding related tools and equipment for welder and welding activity. He shall give the practical training to welders whenever required. He shall be responsible for welder passport (NSH will issue welder passport to all qualified welders for updating progress, weekly repair percentage, observations etc...) updating.

5.13 Welding Inspector shall be responsible for inspection and testing of all piping welding activities. He shall be responsible for welding consumable receiving inspection, fit up, weld visual, welding consumable issuance, and NDT witness. The welding report shall be prepared by welding inspector and submitted to PSAL and Saudi Aramco Inspector. Before starting activity tool box shall be conducted. He shall monitor welder rejection rate, welder passport and progressive examination weekly.

 **5.14 NDT Coordinator** shall co-ordinate with welding inspectors and NDT service providers for executing the NDT. He shall correctly identify and verify the NDT selected weld joints before offering to NDT service provider. He shall identify joints with warning tapes as per the Attachment-2. RT offer for reshot joints shall be done by same NDT service provider. He shall prepare weekly welding rejection rate, welder rejection rate etc. as per the SAEP-1160. NDT Coordinator shall ensure that, spot/percentage radiography joints are selected by PSAL Inspector.

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- 5.15 **PWHT Inspector** shall be responsible for coordinating with welding inspectors, PWHT technician and NDT Coordinator for executing PWHT. He shall identify the joints and tag shall be put as per the Attachment-2. He shall monitor before, during, and after PWHT joints. He shall be responsible for all calibration of PWHT machines.
- 5.16 **PMI Inspector** shall be responsible for coordinating with welding inspectors, PMI technician and NDT Coordinator for executing PMI.
- 1 5.17 **RTFI** shall be responsible for the interpretation of radiographic films and to evaluate the quality of weld as well as the film quality. He shall responsible for the preparation of assessment report based on the radiographic films after proper interpretation with reference to applicable codes.

6. MATERIAL HANDLING

- 6.1 Responsible personnel for the transportation and handling of all kind of piping materials (pipe, fitting, valve, flange, support material, instruments and pipe spools) are assigned to ensure its safety and quality are assured during receiving, storage, issuing, and transportation to field and fabrication shop.
- 6.2 All materials shall be handled with care during fabrication and installation to prevent damage.
- 6.3 Stainless steel & high alloy steel, fittings and valves shall be handled and segregated separately in accordance with SAES-L-108.
- 6.4 Slings for lifting pipe shall be nylon or similar material to prevent damage to the pipe surface.
- 6.5 Materials shall be inspected upon delivery with requirements of the Purchase Order to ensure the shipping documentation, certification records, material test certificate and delivery notes are correct. Notification shall be given to Quality department for receiving inspection.
- 6.6 Piping identification, color code, labels and marking shall be carried out as per the Piping marking and color coding specification (D44-A-RE-589196)

7. MATERIAL RECEIVING INSPECTION

- 7.1 All materials shall be inspected on receipt in accordance with procedure no. NSH-PSAL-FSRU-PRO-GE-0013.
- 7.2 QC Inspector shall check material with relevant approved ITP and quality records.
- 7.3 The responsible QC Inspector shall check and verify the identification tags on materials.
- 7.4 If the materials are not conforming to the relevant drawing or specification, it shall be separated from undamaged materials and tagged with REJECTED mark so those material can easily identified.
- 7.5 Damaged material shall be documented, photographed and report shall indicate the reason for the condition of the materials.

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- 7.6 The receiving inspector shall record condition of material on the material receiving so that the materials personal can take necessary corrective measures.
- 1 7.7 Pipes, fittings, valves, instruments and fabricated spools shall be received by piping supervisor at field.
- 1 7.8 Each spool shall be stamped or stenciled with spool identification number and the responsible personals in spool releasing from shop and receiving at field shall be verified for the correctness of spools with the latest approved IFC drawings and related documents including NDT.
- 1 7.9 The spool shall be clean and dry, all loose foreign material and weld spatter is removed from the inside and outside of the spool.
- 1 7.10 Flange faces are protected by suitable flange protectors.
- 1 7.11 All spools shall be received at site shall be with proper end covers for protecting the entrapment of foreign materials.

8. MATERIAL STORAGE AND PRESERVATION

- 8.1. All piping material shall be stored and preserved as per the approved 'Material Handling, Storage and Preservation Procedure' (NSH-PSAL-FSRU-PRO-GE-0014).
- 8.2. Pipe shall not be stored directly on the ground. Pipe shall be placed on mounds or sleepers. Separate area shall be allocated with proper area identification for different materials.
- 8.3. Stacking of pipes shall be made in a manner to avoid damage to pipes or coatings.
- 8.4. Fittings and valves shall be stored in shipping crates or on racks. Stainless steel pipes and fittings must be separate from carbon steel to avoid contamination.
- 8.5. All materials shall be handled with care during fabrication and installation to prevent damage.
- 8.6. End protectors on pipes, flanges, weld bevels, threads, and socket ends shall be firmly attached.
- 8.7. Pipe shall not be rolled or dropped off trucks.
- 8.8. End bevel protectors shall remain on pipes and fittings while in storage, protectors shall not damage internal or external coating.
- 8.9. Flange face and threads shall be protected from rust by applying suitable rust preventives.
- 8.10. Lined and coated pipes and fittings shall be lifted with wide fabric or rubber-covered slings and padding shall be used to prevent damage to lining or coating. Wire rope slings shall not be used.
- 8.11. Stainless steel materials shall be covered and protected from water splash and other contamination during shipment and storage.

1 9. MATERIAL IDENTIFICATION AND TRACEABILITY

- 9.1. All pipe and fittings shall have the material specification and grade stamped, stenciled, or otherwise clearly marked with permanent marking method.
- 9.2. Spools are stamped, stenciled, or clearly marked with a permanent marking method.

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- 9.3. Paint marking shall be done with water-insoluble material that contains no substances that harmfully affect the metal at ambient or elevated temperatures. In particular, the marking material shall be free of lead, sulfur, zinc, cadmium, mercury, chlorine, or other halogens.
- 9.4. The identification markings shall be transferred to retain material identification when a plate or pipe is cut.
- 9.5.1 The color coding system for material identification is intended to help prevent fabricators from using incorrect alloy material. The principal purpose of color coding is for visual identification during storage and after the components has been cut for fabrication.
- 9.5.2 Color coding may be done by the material manufacturer or material supplier. Color coding need not be retained after painting.
- 9.7. ASTM A193, Grade B7 stud bolts do not require color coding if the grade of the material is stamped on one end of each bolt.
- 9.8. Spiral-wound gaskets shall be color coded in accordance with ASME B16.20. Sheet type gaskets do not require color coding.
- 9.9. Pipe and Fittings: Each length of pipe and fitting shall have a 5 mm or larger stripe running full length. One inch NPS and smaller may have a 3 mm stripe running full length.
- 9.10. Valves: When required, stripe across the body from flange to flange or end to end.
- 9.11. Flanges: When required, stripe across edge up to hub.
- 9.12. Bolting: When required, stripe around the midpoint of each bolt or stud.
- 9.13. Plate, Sheet, and Strip: Stripe on surface near two perpendicular edges for entire length.
- 9.14. Tubes and Bars: Stripe entire length.
- 9.15. The materials received without proper marking shall be segregated, marked and stored in rejected items to prevent unauthorized usage.

10. FIELD FABRICATION AND ERECTION PROCEDURE

10.1 General

- 10.1.1 Construction of plant piping shall be in accordance with SAES-L-350.
- 10.1.2 Inspection for shop fabrication of Pipe Spools and miscellaneous Steel Structures shall be performed as per SATIP-L-350-08.
- 10.1.3 Metallic Piping field Installation inspection shall be performed as per SATIP-L-350-01.
- 10.1.4 Pipe spools shall be checked against piping specifications and drawings prior to installation.
- 10.1.5 Each spools, pipes and fittings shall be visually inspected for physical damage prior to installation or erection.
- 10.1.6 Prefabricated pipe spools shall be taken to field only after completion and acceptance of all NDT.

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- 1 10.1.7 PWHT piping spools with flanged joints shall be performed before flange assembly.
- 1 10.1.8 When PWHT of pipe spools is required, non-pressure containing welded attachments such as shoe support for insulated lines, dummy extensions and legs, and wear pads are to be welded to pipe spools before stress relieving.
- 10.1.9 Prior to erection all pipe spools shall be checked and cleaned from any kind of debris or foreign material inside the pipe.
- 1 10.1.10 Pipe spools end shall be covered after inspection to prevent unauthorized removal of end covers before making succeeding joints.
- 10.1.11 Handle pre-painted piping only using canvas, belt with softener, leather or rubber padded slings. Bare cables, chains, hooks, pipe clamps or other similar are not permitted.
- 10.1.12 Pulling and dragging of pipe spool is not allowed to avoid the damage at painting. Rigging of pipe materials shall be carried out with proper tools and methods to avoid the damage in the surface of material.
- 10.1.13 Do not support piping from handrails.
- 10.1.14 Verify weights of heavy piping assemblies or components prior to erecting to assure safe handling and lifting.
- 1 10.1.15 On erection / placing of spools in position, shall be aligned to meet the drawing requirements including the orientation, levels, slopes, support location, expansion joints etc. All piping shall be installed without dead legs.
- 1 10.1.16 The sensitive items like rotating machinery, orifices, control valves, flow-elements, soft-seated valves, globe valves, strainers, rupture discs, insulation, thermo wells, pressure gauges, in line instruments, check valves, and relief valves will not be installed and are to be removed if installed prior to commencing cleaning/flushing/pressure testing process.
- 10.1.17 Modification to pipe routing may be necessary to avoid interference. Details of all modifications shall be reflected on line history sheet and as-built drawings.
- 10.1.18 Special care shall be taken to handle safety relief valves and control valves.
- 10.1.19 All flanges shall be installed and tightened in accordance with procedure 'Gasket and Bolt Tightening Procedure' (NSH-PSAL-FSRU-PRO-PI-0015).
- 1 10.1.20 Damaged or rejected spools and items are identified, segregated, controlled and tracked. Such items are clearly marked REJECTED to prevent inadvertent use. A quarantined area has been established.
- 1 10.1.21 Branch connections for new construction of metallic piping shall be made in accordance with SAES-L-110.
- 1 10.1.22 ERW pipe shall not be used below 0°C design temperature in low temperature service.

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- 10.1.23 Where Charpy impact is specified on the WPS (low Temp Service), Heat input (HI) of each production weld is calculated (using formula below) to confirm not to exceed the heat input limits listed in the WPS's.

$$HI (kj/cm) = \text{Volt} \times \text{Amp} \times 60 / \text{Travel Speed (cm/min)}$$

10.2 Internal Cleaning

- 10.2.1. All pipes and spools shall be internally cleaned as per the approved 'Piping Internal Cleanliness Procedure' (NSH-PSAL-FSRU-PRO-PI-0028).
- 10.2.2. All pipes and spools shall be internally cleaned by air blowing. In addition, for large diameter pipes rag cleaning should be conducted if found practical.
- 10.2.3. All prefabricated pipe spools shall be visually inspected for cleanliness, and shall have foreign material removed from the inside.
- 10.2.4. Spool cleanliness checks prior to installation (best with mirror and natural sunlight) are identifiable as "clean".



10.3 Pipe Laying, Spool Erection & Assembly on Pipe racks and Sleeper ways

- 10.3.1. Piping fabrication and field installation shall be performed within the tolerance specified in SAES-L-110 (Limitations on pipe joints and components)
- 10.3.2. Pipe rack and sleeper way supports have been completely erected or installed.
- 10.3.3. Centerlines of piping runs are laid out and Piping line numbers are marked on the beam (centerlines)
- 10.3.4. Minimum line spacing between piping supported on sleepers or pipe racks is verified and confirmed with Saudi Aramco Standard Drawing for pipe spacing AB-036207.
- 10.3.5. Insulated lines & insulation thickness is identified per Notes and details of Std Drawings AA-036911 & AA-036913 and considerations allow proper clearance between piping (critical).
- 10.3.6. Flange spacing considerations (staggering of flanges may be required) have been incorporated and spacing is adequate.
- 10.3.7. In all cases, a minimum clearance of 50 mm is provided for inspection & freedom of pipe movement between above ground piping crossing with any structure (incl. pipe support structure). This clearance is also required for above ground piping crossing with another pipe.
- 10.3.8. 300mm piping clearance above finished grade elevation is shown on approved drawings for horizontal piping runs and Pipe elevation of vertical drains (lowest point) allows adequate clearance for serviceability (hoses can be attached to drain lines).
- 10.3.9. Flare lines and other flammable and toxic services are located on pipe racks and sleeper ways. These type lines are not routed below ground at any location except through an acceptable pipe chase that offers full inspection and maintenance access.

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10.3.10. Low friction (sliding type) supports shall not allow sand or other debris to accumulate on sliding surface.

10.3.11. Prior to installation the Pipes or pipe spools shall be internally cleaned by air blowing and large diameters pipes are rag cleaned when possible.

10.3.12. Piping ends are covered after inspection to prevent unauthorized removal of end covers before making succeeding joints.

10.3.13. All temporary facilities including temporary supports for proper alignment shall be arranged on pipe racks before line installation.

10.3.14. All precautions shall be taken care during lifting and installation of line on pipe rack (Method of lifting, Slings used, metal hooks to be padded, etc.).

10.4 Fit-up

10.4.1. All fit up and welding shall be carried out only in accordance with approved IFC isometric drawing and WPS.



10.4.2. Pre-Welding & Weld Joint Fit-Up Inspection shall be performed as per SATIP-W-011-01, SAIC-W-2005 and the report shall be prepared based on SATR-W-2006.

10.4.3. Cutting shall be carried out as follows;

- Carbon steel pipes : Gas Cutting and Grinding
- Alloy Steel Pipes : Flammable Cutting and grinding
- Stainless Steel : Grinding and Plasma Cutting
- Nonferrous materials : Grinding and Plasma Cutting

10.4.4. All material removal and cleaning tools for stainless steel and nickel alloys shall be stainless steel that are not previously used on other materials.

10.4.5. Material traceability shall be transferred before cutting pipes.

10.4.6. Thermal cut or gouged surfaces for all materials, including carbon steel, shall be power brushed or ground prior to welding.

10.4.7. Thermal cut surface of stainless steel and non-ferrous materials shall be ground to bright (un-oxidized) material prior to welding.

10.4.8. A minimum of 1.5mm depth shall be removed by grinding or machining from thermally cut or gouged surfaces of air hardenable materials.



10.4.9. Bevel preparation and fit-up shall be done as per approved WPS. Field bevel shall be checked for lamination.

10.4.10. For nozzles with reinforcing pads, the nozzle attachment weld shall be completed and inspected prior to installing the reinforcing pad.

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10.4.11. Fittings that are re-cut or re-beveled shall have the cut surface examined for laminations before welding. The NDT method to be used shall be determined by Saudi Aramco Inspector.

10.4.12. Internal misalignment of butt joints shall not exceed 1.5mm. Internal tapering in accordance with ASME B31.3 by machining, back welding, or a combination may be used to correct the misalignment.

10.4.13. Oil, moisture, rust, scale, sand, paint (except weldable primers for approved applications) metallic coatings (e.g. zinc) or other foreign matter shall be removed from the weld surface and at least 25mm of adjacent base metal prior to welding, including any such coating on temporary attachments or supports.

10.4.14. All weld joints shall be marked for identification minimum as follows

ISO. No.		Joint No.	
Piping Class		WPS No.	
Fitter No.		Fit-up Date & QC Clearance	
Welder No.		Weld Date & Weld Visual	

10.4.15. Use suitable permanent weather proof markers, and materials for Joint matrix identification. Certified low chloride (50 ppm) markers shall be used for stainless steel and nickel alloy steels.

10.4.16. All material removal & cleaning tools shall be stainless steel (it shall not previously used on CS materials) for SS and Ni Alloys and are marked to identify that they are to be used on austenitic & nickel alloy materials only. Marking is visible while a tool is in use. (Yellow color code)

10.4.17. All WPSs, PQRs, and Weld and line description table shall be available at the work site for verification at any time for the authorized Saudi Aramco Inspector.

10.4.18. All tack welds shall be made by qualified welders. All tacks or temporary welds shall be performed with the same care, materials, electrodes, minimum preheat, and procedure that are used for permanent welds.

10.4.19. Tack welds shall be sufficient size to maintain joint alignment. The recommended tack thickness is 3.2 - 4.8 mm and length is 12.5 - 25.4 mm.

The minimum numbers of tack welds are:

Pipe diameter of 101.6mm or less : Three equally spaced tacks.

Pipe diameter above 101.6mm : minimum of four equally spaced tacks. The designated inspector should determine if more tacks are needed.

10.4.20. SAES-W-016 Corrosion resistance alloys shall be tacked with minimum equally spaced four tacks.

10.4.21. Bridge tacks (located above the root area) are acceptable but such tacks must be completely removed prior to completion of the weld.

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10.5 Welding

10.5.1. The wind velocity in the area for GTAW, GMAW, or gas shield FCAW shall not exceed 8kph (2.2m/s). Necessary shielding and wind protection shall be installed if wind velocity exceeds 8kph.

10.5.2. Welding shall not be done when surfaces are wet or damp or exposed to rain or snow or when the welders are exposed to inclement conditions.

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10.5.3. All WPSs, PQRs shall be available at the work site for all time. WPSs shall be displayed at site.

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10.5.4. Welding inspection (Before welding, during welding and after welding) shall be performed as per SATIP-W-011-01.

1

10.5.5. Contamination from the environment, such as wind, sand storm and moisture shall be prevented by use of adequate shielding or protection.

10.5.6. Welding shall not commence before clearance from NSH & PSAL Quality Inspector. Welders shall have qualification stipulated in ASME SEC IX to cover the type of materials concerned in the piping works, and the welder qualification test in accordance with 'Welder and WPS Qualification and Control Procedure' (NSH-PSAL-FSRU-PRO-PI-0003).

10.5.7. All welding shall be carried out only by qualified welders with valid Job Clearance Card (JCC) and as per approved Welding Procedure Specification (WPS).

10.5.8. All pressure containing welds shall be made with multiple passes

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10.5.9. Adjacent beads of a weld shall be staggered and not started in the same location.

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10.5.10. All nozzles, branch, and tee connections shall be made with full penetration groove welds only and as per approved PMS.

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10.5.11. Preheating shall be carried out as per the approved WPS and the acceptable methods are:

- a. Oxy-fuel gas torch with heating tip.
- b. Air-fuel gas torch.
- c. Flexible ceramic mats (For low alloy steel)

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10.5.12. Post weld heat treatment shall be carried out as per the approved WPS and the acceptable methods are:

- a. Electrical resistance heater.
- b. Induction heater.

10.5.13. Preheat temperature shall be established over a minimum distance of 75mm on each side of the weld. If wall thickness exceeds 25 mm and preheating to be done from the same side as welding, then the heat source shall be removed for 1 minute to allow for temperature equalization prior to measuring the temperature.

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- 10.5.14. Temperature indicating crayons shall not be used on deposited weld metal or on the joint surfaces to be covered by weld metal.
- 10.5.15. All socket and seal welding shall be carried out in accordance with procedure 'Socket/Threaded Weld Gap Control & Seal Welding Procedure-Shop & Field' (NSH-PSAL-FSRU-PRO-PI-0024).
- 10.5.16. For P.No.5 and high materials, back purging shall be maintained until at least a minimum 10mm of the weld deposit thickness has been completed. Back purging shall be done as per 'Back Purge procedure' (NSH-PSAL-FSRU-PRO-P1-0017).
- 10.5.17. All Welding Consumable storage and handling shall be in accordance with the "Welding consumable handling and storage procedure (NSH-PSAL-FSRU-PRO-P1-0006).
- 10.5.18. Arc strikes, gouges, and other indications of careless workmanship (such as surface porosity, uneven weld profiles, and undercut) shall be removed by grinding and tested by MT/PT.
- 10.5.19. Any temporary welded attachments or temporary tacks shall be ground off. Attachments may be cut off no closer than 3mm to the base metal surface, prior to the required grinding.
- 10.5.20. Buttering of Weld Joint
- I. Buttering or weld build-up on the prepared surfaces shall not exceed the lesser of 1/3 of the base metal thickness or 10 mm without the approval of CSD. If the buttering or build-up exceeds this, then the following requirements shall apply:
- Specific approval is required from PSAL QC. If not approved, the spool pipe shall be replaced to a length agreed by PSAL QC.
 - The buttering operation shall be witnessed by Saudi Aramco Inspection
 - The buttering shall be inspected by RT, PT or MT after completion of the build-up but before final welding of the joint
- II. Buttering of joints between dissimilar metal joints requires prior approval by CSD.
- 10.5.21. For all materials, inspection by MT/PT methods of area shall be performed where temporary welds have been removed or weld repair to ground areas of the base material have been made or arc strikes after repair by grinding.
- 10.5.22. Except for ASME P.No.1 through P.No.5A/5B/5C base materials, all manual GTAW shall use a high frequency start and post-purge gas flow for the torch.
- 10.5.23. Each weld pass shall be thoroughly cleaned and slag or other foreign matter removed before the next pass is deposited.
- 10.5.24. All slag, flux and spatter shall be removed from the completed weld and surrounding areas.

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10.5.25. The heat input (HI) of each production weld must be calculated, if notch toughness test are specified, and then confirmed not to exceed the heat input limits listed in the welding procedure specifications. Heat input shall be calculated with format 'Heat input calculation sheet' (NSH-PSAL-FSRU-FM-PI-030).

10.5.26. The minimum distance between parallel butt welds shall be 20mm or three times the wall thickness of the joint, whichever is greater.

10.5.27. Pressure containing welds (e.g., nozzles and other attachments) shall be separated from other pressure containing welds by no less than 20mm or three times the joint thickness, whichever is greater. Contractor approval is required if the minimum separation is not met. Radiography of the butt welds is required for situations in which the minimum separation is not achieved. For joints other than butt welds, other appropriate inspection methods shall be used, depending on the geometry and material. The following are exemptions:

- I. Structural components and reinforcing pads
- II. Hot tap split tee end welds which cross the pipe longitudinal seam.

10.5.28. Identification tag shall be followed as per 'Warning tape Color code for spools & joints' (find Attachment-2)

10.5.29. When a circumferential weld with an intersecting longitudinal weld(s) is examined, at least the adjacent 38 mm (1 1/2 in.) of each intersecting weld shall be examined.

10.5.30. If any grinding reduces the base metal thickness to less than the design minimum, the ground area shall be rewelded and ground flush with the original base metal surface followed by PT/MPT or the component shall be replaced. Rewelding shall be done only with the prior approval of PSAL/Saudi Aramco.

10.6 Nondestructive Testing

10.6.1. All welds shall be visually inspected and accepted prior to performing NDT.

10.6.2. NDT shall be witness by approved welding inspector.

10.6.3. All NDT shall be controlled in accordance with NDT control procedure (NSH-PSAL-FSRU-PRO-P1-0025).

10.6.4. NDT shall be performed as required by SAES-W-011, ASME B31.3 & Approved isometric drawing. After NDT clearance, spools shall be released for blasting & painting as required.

10.6.5. Joint repair will be done immediately and additional penalty shots as stipulated within SAES-W-011 shall be radiographed.

10.6.6. Rejected welds shall be repaired in accordance with approved repair procedure (NSH-PSAL-FSRU-PRO-P1-0016) and WPS by qualified welders and inspected as a minimum using the original test method of the joint.

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△ 1 10.6.7. Prior to start of post weld heat treatment work, NSH shall prepare a table listing each joint/spool requiring heat treatment and shall be submitted to contractor & company for review. The table shall include joint no. / location, spool no., drawing no., diameter, wall thickness, material heating rate, cooling rate, soaking temperature, soaking time etc.

△ 1 10.6.8. Hardness testing shall be where applicable, shall be performed by trained and approved personnel as per approved third party hardness testing procedure

△ 1 10.6.9. Positive Material Identification (PMI), where applicable, shall be performed by trained and approved personnel as per approved Third party PMI procedure.

△ 1 10.6.10. Ferrite test where applicable, shall be performed by trained and approved personnel and as per approved Third party Ferrite test procedure.

△ 1 10.7 Austenitic/Duplex Stainless Steels

10.7.1. Abrasive tooling and or grinding disc shall not be used on either carbon steel or other grade of stainless steel material. The selection of grinding and cleaning tools shall be appropriate for the base material. E.g. carbon steel brushes shall not be used on stainless steel material.

10.7.2. All filler materials should be individually and clearly stamped, flagged or stenciled to ensure traceability and correct usage on site.

10.7.3. The GTAW process shall be used for all passes for wall thickness less than 9.5mm for duplex stainless or for wall thickness less than 6.5 mm for other corrosion resistant alloys (CRA)

10.7.4. All manual GTAW shall use a high frequency start and post-purge gas flow for the torch.

10.7.5. The maximum interpass temperature for duplex stainless steel shall not exceed 100°C.

10.7.6. Unless specified otherwise, the maximum interpass temperature shall be 177°C for P-No. 8 materials.

0.05% 10.7.7. The purge shall achieve actual oxygen levels inside or exiting the joint (via the vent) no greater than 1% prior to and during welding.

10.7.8. Ferrite measurements shall be performed in accordance with AWS A4.2

10.7.9. For production welds, the ferrite content shall be checked in the as-welded condition. The ferrite number shall be between 3 and 10FN.

10.7.10. Purge dam installation and removal shall be controlled by accordance with procedure for back purging of pipe welding (NSH-PSAL-FSRU-PRO-PI-0017)

10.7.11. Special requirements for duplex stainless steels.

a) GTAW process must be used for the root and hot passes if the wall thickness is equal to or greater than 9.5mm.

b) Repair of defective welds requires separate repair welding procedure qualifications if duplex stainless steel was used for corrosion resistance.

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- c) The ferrite content of completed welds shall be checked in accordance with AWS A.2. It shall be within range of 30 to 60 % ferrite using the appropriate ferrite number based on the correlation established by the PQR measurements.
- d) The welding parameters shall be monitored in order to conform compliance to the minimum and maximum heat input restrictions.
- e) Hardness testing shall be conducted on a 20% random sampling of all production welds. Both the weld metal and HAZ shall be tested.



10.8 Orifice Plate & Restriction Orifice Installation

10.8.1. Orifice plates shall have a fine finish (honed, lapped, polished or buffed). Orifice plates shall be free of surface defects and bore edges are smooth.

10.8.2. Orifice plates bores shall be in center of the plate and the plate are in flat.

10.8.3. Orifice Plates shall be free from mechanical damage and welding distortion.

10.8.4. Welded handles shall be parallel to the plates with welds ground flush.

10.8.5. Plates are free from mechanical damage and welding distortion.

10.8.6. Orifice flanges are to be weld-neck with an internal bore to match the internal diameter of the pipe. Any distortion resulting from the butt weld shall be removed and ground flush with the inside diameter of the pipe.

10.8.7. Prior to installation Orifice Plate Orientation shall be confirmed with the SASD AD-036004.

10.8.8. The inspection of Venturi, Flow Orifice Plate & Restriction orifice installation shall be performed as per SAIC-L-2016.

10.9 Installation of Pipe Supports

10.9.1. All supports, anchors, guides and other support attachments shall be fabricated in accordance with details indicated in the pipe support drawing, approved isometric drawings and contract specification requirements etc.



10.9.2. Inspection of pipe supports and anchor installation shall be performed as per SAIC-L-2018.



10.9.3. Reinforcing pad material shall be of the same pipe material as per support standard unless otherwise approved in writing by the SAPMT.

10.9.4. Fit-up and welding shall be done as per the approved WPS and approved drawing.



10.9.5. All welds of pipe supports to the pipe wall shall be continuous with smooth finish.

10.9.6. Installing additional dummy supports other than those in the design drawings shall not be installed without prior review and approval from the chairman of piping standards committee or his representative.

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10.9.7. A 6mm weep hole shall be drilled for all dummy supports. The weep hole shall be located near the base plate for all vertical dummy supports, and near the run pipe at 6 o'clock position for all horizontal dummy supports.

10.9.8. Separate storage facility shall be made to store fabricated supports in area wise and material wise.

10.9.9. Fabricated CS, LTCS, SS & Nonferrous supports shall be placed separately with proper identification like type of support, sequence number, etc. with legible marking.

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10.9.10. All welds to the pipe shall be continuous with smooth finish, spot welding is not acceptable.

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10.9.11. Minimum fillet weld size shall be 3/16 inch (5mm) for structural welds.

10.9.12. Pipe supports shall be full contact with supports that carry the load.

10.9.13. Low friction supports sliding surfaces shall be protected during all construction activities including painting and sandblasting.

10.9.14. Spring support

- I. The spring settings shall be verified that they are matching the design requirements.
- II. The spring support shall be full engagement with pipe.
- III. All spring shall be in compression, so that failure will not result in the complete release of load.

10.9.15. Hanger rods

- I. Rod hangers shall not be used for lines 12" NPS and larger in liquid service or multi-phase flow.
- II. All hangers shall be provided with means for vertical adjustment.
- III. Suitable locking devices shall be used at all threaded connections of hanger assembly (double nuts).
- IV. Rod hangers shall be subjected to tensile load only.

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10.10 Threaded Connection Requirements

10.10.1. All thread joints shall be taper pipe thread (NPT) conforming to ASME B1.20.1.

10.10.2. All threaded connections shall be performed as per NSH-PSAL-FSRU-PRO-PI-0024 (Socket/Threaded Weld Gap Control & Seal Welding Procedure)

10.10.3. Site threading operations are monitored in process for code quality per ASME B1.20.1 as follows:

- a) Pipe ends are reamed clean after threading.
- b) Oil and residual shavings are removed from inside piping
- c) OD threads are chased and cleaned of debris and deburred.

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- d) Starting threads and run out threads are chamfered and rounded.
- e) Threads are free of burrs, flat spots, chatter, tears, cuts, etc.)
- f) Dies are in good condition and produce smooth quality threads.

10.10.4. The engaged pipe threads shall be verified to have a minimum thread engagement as follows

<u>Nominal pipe size</u>	<u>Number of threads engaged</u>
½" & ¾"	6
1" through 1-1/2"	7
2" through 3"	8

10.10.5. In hazardous services, maximum size of threaded connections shall be 1½-inch for standard fittings & valves. In non-hazardous services, maximum size is 3".

10.10.6. PTFE (Teflon) tape shall not be used for service temperature greater than 204°C on threaded connections.

10.11 Installation of Valves



10.11.1. Ensure that all valves are hydro tested and test reports are available at site.



10.11.2. Valve Inspection, Testing & Installation shall be performed as per SATIP-L-108-01.



10.11.3. Valves are completely drained of test fluid & thoroughly dried after the completion of testing. Machined surfaces are coated with a light film of high viscosity rust inhibiting oil that will not become fluid & run off at temps below 80°C.



10.11.4. Valves shall be purchased from manufacturers approved in accordance with SAES-L-102.



10.11.5. Prior to installation ensure that valve is easily opening and closing full stroke.

10.11.6. Valve direction shall be checked and confirmed for directional valve like check valves, globe valves etc. and valve handle orientation shall be as per approved isometric drawing.

10.11.7. Valve identification shall be checked as per the approved isometric drawing.

10.11.8. Valve shall be checked for any damage and flange facing shall be checked before installation.



10.11.9. Chain wheel operation shall not be provided for emergency isolation valves or valves having a threaded body connection



10.11.10. Atmospheric drain and vent valves shall be provided with a plug or blind on the discharge side.



10.11.11. Check valves in sizes NPS 3 inch and above shall not installed in vertical lines, unless approved by company.



10.11.12. Control valves shall not be used as emergency shutdown valves.



10.11.13. Valve hand wheel shall be fully accessible for operation.



10.11.14. All valves in services below -45°C shall be full austenitic SS.

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- 1 10.11.15. All bolting in low temperature service valves shall be ASTM A320, Grade L7. The corresponding nuts shall be ASTM A194, Grade 4.
- 1 10.11.16. For check valves sizes NPS 4 inch & above, a turbulence-free minimum distance of 5 pipe diameters upstream & 2 pipe diameters downstream of every check valve shall be maintained. No pipe fittings or devices that restrict flow (elbows, reducers, tees, orifices, and control valves) shall be installed in these zones. Note: Exempted are check valves in intermittent service & valves in skid-mounted systems
- 1 10.11.17. Swing Checks (unidirectional) are installed with flow arrow pointing downstream. Verify Flow direction and correct installation.
- 1 10.11.18. Control valves are installed in the direction of flow casted or steel-stamped on the valve body and shall be installed in horizontal lines.
- 1 10.11.19. Control valves and their actuating systems are mounted such that all adjustments are accessible (and all indicators/gauges are readable) from grade, permanent platform, walkway or fixed ladder.
- 1 10.11.20. Relief valve inlet & outlet piping mating flange alignment is within tolerance:
- a) Rotation of flanges, measured as the offset between elevations of bolt holes on opposite sides of a flange centerline, shall not exceed ± 2.4 mm.
 - b) The tilt of a flange measured at the periphery across any diameter shall not exceed 1.6 mm from the square position.
- 10.11.21. Flanged valves shall be tightened in accordance with procedure 'Gasket and Bolt Tightening Procedure' (NSH-PSAL-FSRU-PRO-PI-0015)
- 1 10.12. **Flange Joint Assembly and Bolt Tightening**
- 10.12.1. All flanged items shall be installed and tightened in accordance with SAEP-351 and procedure 'Gasket and Bolt Tightening Procedure' (NSH-PSAL-FSRU-PRO-PI-0015).
- 10.12.2. Inspection of bolted flange assembly shall be performed as per SAIC-L-2014.
- 10.12.3. Flange bolt holes shall be oriented as follows, unless otherwise indicated on the construction drawings:
- The tilt of a flange measured at the periphery across any diameter shall not exceed 1.6 mm from the square position and the flange face parallelism shall not exceed 0.8 mm.
 - The flange face center line tolerance shall not exceed 1.5 mm.
 - The gap between mating flanges shall be minimum "t" (Gasket thickness) and maximum two times the gasket thickness.
 - The bolt hole rotational offset shall not exceed 3 mm.

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- 10.12.4. Gaskets shall be suitable for the intended service and compatible with the flange facing, rating and bolting.
- 10.12.5. Gasket shall not be damaged or distorted and free of all foreign particles, the defective gaskets shall be replaced.
- 10.12.6. The bolting materials shall be selected in accordance with SAES-L-109, Sec-13.
- 10.12.7. Bolts, nuts and washers shall be visually checked for proper size, grade and dimension and for any physical damage such as corrosion, rust and burrs. Also, the suitability of the stud bolts and nuts material for the service temperature and the compatibility with the flange material shall be checked.
- 10.12.8. Bolts and nuts shall be replaced when reassembling existing flanges.
- 10.12.9. The nuts shall have full thread engagement after the flange assembly.
- 10.12.10. When reassembling flange joint, all indications of the previous gasket installation shall be removed.
- 10.12.11. Lubricant shall not be used in the gasket and the gasket seating area.
- 10.12.12. Hammering / flogging is not permitted during bolts losing or tightening.
- 10.12.13. Manual torque wrenches shall not be used for 1" bolt size and larger.
- 10.12.14. Tightening tools shall be checked for adequacy, performance and calibration. The tools accuracy should not exceed $\pm 5\%$.
- 10.12.15. Tightening shall have a minimum of four passes (33%-66%-100%-100%) to achieve the required torque load.
- 10.12.16. After completion of flange assembly inspection flange joint tightening inspection Report (SATR-L-2001) shall be prepared and documented.

11.0 Installation Requirements for Piping Connected to Equipment *as per API 686, Chapter 106 Annex A*

- 11.1. All piping shall be routed and supported to allow access to machinery for operation, inspection and maintenance. Inlet and outlet isolation block valves around machinery shall be accessible from grade near machinery.
- 11.2. Isolation block valves are required in the inlet and outlet process piping to and from all machinery. A check valve shall be installed in the discharge line of all pumps. The check valve shall be located between the machine discharge flange and the discharge block valve.
- 11.3. Pump suction piping shall be arranged such that the flow is as smooth and uniform as practicable at the pump suction nozzle.
- 11.4. Reducers used on horizontal suction line shall be eccentric with the flat side on top. Eccentric reducer with the flat side on top shall be utilized for overhead piping into a top suction pump. Concentric reducer shall be used on the vertical suction line as required.

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- 11.5. Suction and discharge piping for vertical in-line pumps shall have adjustable supports.
- 11.6. Suction piping to wet gas compressors shall be heat traced and insulated.
- 11.7. The load induced on to the equipment nozzle due to a misalignment of the pipe and equipment nozzle. It can consist of the following:
 - Horizontal centerline offset
 - Flange face vertical offset
 - Angular misalignment between two flange faces
 - Inadequate supports
 - Wrong pipe supports selected (fixed vs. adjustable) and/or not enough supports used.
- 11.8. Piping shall not be attached until rotating equipment has been grouted and final alignment has been completed and accepted.
- 11.9. All piping for the equipment connection shall be designed and installed as per the requirements of manufacturer recommendations, *AS PER API 686, CHAPTER 6 & 7*
- 11.10. Piping shall not be hydro tested while connected to equipment. *as per API 686, chapter #06*
- 11.11. All spring supports shall be securely chocked in position and any temporary supports required for hydro testing shall be installed prior to the test. *clause 4.3.*
- 11.12. Prior to grouting a pre-alignment check shall be conducted to ensure precision alignment can be achieved *as per API 686, chapter 07 clause 5.1.5*
- 11.13. After grouting, grouting thickness shall be verified and confirmed as per manufacturer data sheet. *& as per API 686 IFC drawing / vendor drawing*
- 11.14. Field installed auxiliary piping connections and other attachments shall be mounted separately from equipment, these items do not interfere with the removal or installation of equipment or access for normal operation and maintenance.
- 11.15. Check and ensure the completeness and proper installation of the auxiliary piping and instruments are as per approved drawings and procedures
- 11.16. Inter connecting piping shall only be attached to the equipment after anchor bolts are tightened, final shaft alignment is completed, final welding and flange alignment have been completed.
- 11.17. All process piping shall not be connected to the equipment until necessary testing and supporting activities are completed and accepted.

1 12.0 PAINTING/COATING

- 12.1. Surface preparation shall be done prior to apply the paint on the pipe.
- 12.2. Painting and coating area should be properly covered
- 12.3. Prior to coating, flange faces valve stems, sight glasses, name plates machinery surfaces shall be protected by masking.
- 12.4. Areas of coating operation shall be clearly marked at a safe distance from the other works.

11-18, Should it be necessary to attach piping to machinery for purpose of field welding or electric field stress relief (Pipe strain, machinery shall be isolated from pipe flange using a full circle 3mm thick composition gasket, as per

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- 12.5. All painting/coating shall be performed in accordance with procedure for blasting, coating and painting (NSH-PSAL-FSRU-PRO-PA-001)
- 12.6. Repair Procedure for Atmospheric Coatings - Follow the surface preparation and application requirements in the applicable APCS and the manufacturer's technical data sheet.

13.0. INSPECTION AND TEST PLAN

13.1. General

- 13.1.1. No fabricated spools shall be released from fabrication shops to laydown yard, painting, or to site before fully inspected and released by Quality Control department of both NSH & PSAL.
- 13.1.2. Saudi Aramco representative shall have free access to the work at all times.
- 13.1.3. Prior to start, NSH shall ensure that all required Welding Procedure Specification (WPS) are approved and have evidence of approval in each pages of WPS.
- 13.1.4. Ensure the all welders have valid JCC qualified for the welding process, thickness range, diameter range and welder is having a valid JCC for particular welding.
- 13.1.5. Inspection & Test for the Piping installation shall be carried as per the approved ITP.
- 13.1.6. NSH Construction representative shall raise request for inspection (RFI) as per the approved ITP to NSH Quality Inspector.
- 13.1.7. NSH Quality Inspector shall forward inspect and accepted items RFI to PSAL/Saudi Aramco.
- 13.1.8. All quality reports/records shall be written as per the approved ITP and attached with RFI.
- 13.1.9. RFI shall record and control on database 'CApps'
- 13.1.10. NSH shall record and control all piping related activities on database 'CApps'.
- 13.1.11. NSH shall timely record all quality control reports on database 'CApps' like fit up, welding, NDT reports etc.
- 13.1.12. CApps is a software package designed and developed for NSH to meet its complete requirements for project execution. CApps is developed as per the SAEP-1160 'Tracking and reporting of welding, NDT and pressure testing for capital projects'.



13.2. Positive Material Identification (PMI)

- 13.2.1. PMI testing shall be carried out as per SAES-A-206 for verify the stainless steel and alloy materials.
- 13.2.2. PMI Testing of welding consumables shall be performed in accordance with SAES-A-206 section 7.7.
- 13.2.3. PMI Testing shall be performed by third party NDT service provider with approved procedure.
- 13.2.4. Inspection for PMI of Alloy Piping & Alloy Components (All Applications) shall be as per SAIC-L-2010.

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13.2.5. Manufacturer's standard calibration samples and certified samples with the traceability of "known" materials are available for random (spot) checks.

13.2.6. Calibration records for the PMI instrument are available and current as required by manufacturer's documentation for calibrations.

13.2.7. PMI testing of welds shall be done after removal of slag and/or oxide from the weld surface.



13.3. Post Weld Heat Treatment (PWHT)

13.3.1. Post weld heat treatments (PWHT) shall be in accordance with ASME B31.3.

13.3.2. PWHT shall be performed as per procedure NSH-PSAL-FSRU-PRO-PI-0030.

13.3.3. Prior to start of work the sub-contractor shall prepare a table listing for each joint. The table shall include the following information for each joint: location, drawing number, diameter, wall thickness, material, heating rate, soak temperature, and soak time.

13.3.4. PWHT for carbon and low alloy steels shall be performed as per requirement of SAES-W-011 clause 13.3.

13.3.5. The PWHT heating and cooling rates above 316°C shall not exceed 222°C/hr.

13.3.6. The minimum PWHT soak time shall be 1 hour.



13.4. Hardness Testing

13.4.1. Production hardness testing of welds shall be performed as required by ASME B31.3.

13.4.2. Hardness testing shall be performed as per procedure NSH-PSAL-FSRU-PRO-PI-0030.

13.4.3. Production hardness testing for welds in P-No 1 material in sour or PWHTed service shall also be performed. 10% of the welds shall be sampled. The maximum allowed hardness is 200 BHN.

13.4.4. If any reading exceeds the specified limit by no more than 10 BHN, then a minimum of three (3) additional indentations shall be made near the original high reading. If all three (3) retests are below the specified limits, then the joint is acceptable. If any of the retest readings are found to exceed the specified limits, then the weld shall be considered unacceptable.

14.0. PRE-TEST PUNCH LISTING

14.1. Pre-test punch listing shall be performed as per SAIC-A-2010 and SATR-A-2007.

14.2. All permanent flange joints shall be inspected; gasket material shall be verified & properly torqued.

14.3. All supports shall be verified as per approved drawing.

14.4. Vents and drain valves, both temporary and permanent shall be conformed to the piping class or rating.

14.5. Expansion joints and spring hangers or spring supports shall be provided with temporary restraints where needed to prevent excessive travel or deformation under the test loads.

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- 14.6. Arc strikes and other indications of careless workmanship (such as porosity, uneven weld profiles and undercut) shall be removed by grinding and inspected by magnetic particle or liquid penetrant method.
- 14.7. Temporary welded attachments to the pipe shall be ground off and inspected by magnetic particle or liquid penetrant method.
- 14.8. Process instruments and equipment that may be damaged by the strength pressure test shall be disconnected.
- 14.9. During pre-test punch listing the punch items to be cleared or rectified before pressure testing and after pressure testing shall be clearly identified.

15.0. FINAL INSPECTION AND RELEASE FOR TESTING

-  15.1. Erection and welding completed piping packages shall be verified by NSH construction department and notify (through RFI) QC department completed piping test packages.
- 15.2. NSH Construction accepted piping test packages pre-test punch listing shall be carried out by NSH Quality Inspector.
- 15.3. NDT Coordinator/Piping Inspector/Welding Inspector shall verify joint history sheet for the piping test packages.
-  15.4. All completed test packages shall be submitted to PSAL/Saudi Aramco for approval of piping test package and release for testing.
-  15.5. Pre-test punch listing shall be conducted by NSH QC and PSAL QC. Punch list shall be prepared.
- 15.6. All category punches shall be completed before releasing for pressure testing.
-  15.7. Approved piping test packages shall be released for testing and testing shall be conducted in accordance with procedure 'Pressure Testing Procedure for AG Piping' (NSH-PSAL-FSRU-PRO-PI-0027).

16.0. PRESSURE TESTING

- 16.1. Approved test procedure shall be available at the site prior to commencing any pressure testing activities.
- 16.2. All pipes and fittings shall be visually inspected for damages that may have occurred during erection/installation.
- 16.3. If any damaged pipes, fittings or unacceptable joints observed, these unacceptable items should be repaired/replaced as per the approved procedure before commencement of pressure test.
- 16.4. Before commencing the testing make sure that all "A" punches shall be cleared, pressure test package is approved and released for testing. Temporary supports shall be provided at required locations and all the joints should be left exposed for leak detection.

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- 16.5. A minimum of two pressure gauges (Calibrated) are required for the test system. One pressure gage shall be on the test manifold and the other(s) on the test system. Their accuracy shall be within 5% of one another. When large systems are tested, Inspection personnel will determine the need for additional gauges.
- 16.6. All gauges shall have a range such that the test pressure is within 30 to 80% of the full range.
- 16.7. All in line valves that shall not be used as test isolation valves shall be partially open position.
- 16.8. The test medium used for pressure testing shall be approved as per the project requirements.
- 16.9. Perform system walk through and visually inspect the whole line and joints in the test system to make sure the joint/line integrity.
- 16.10. The test pressure shall be maintained for a sufficient time, but shall not be less than 30 minutes.
- 16.11. If any leakage observed, the system shall be depressurized and repaired followed by retest.
- 16.12. Proper barriers and sign boards shall be provided to prevent unauthorized entry at testing area.
- 16.13. After successful completion of pressure test, the test reports shall be prepared and documented.

17.0. REINSTATEMENT

- 17.1. Pressure testing completed piping test packages shall be flushed/dried/blow in accordance with procedure 'Pressure Testing Procedure for AG Piping' (NSH-PSAL-FSRU-PRO-PI-0027).
- 17.2. Reinstatement shall be done after completion of flushing/blowing/drying.
-  17.3. All removed items for pressure testing shall be re-installed after completion of flushing / blowing or drying.
- 17.4. All flanged items shall be installed and tightened in accordance with procedure 'Gasket and Bolt Tightening Procedure' (NSH-PSAL-FSRU-PRO-PI-0015)
-  17.5. All in-line equipment & Instruments are to be installed in their respective locations as shown in the P&ID. (i.e: Strainer, meter tube, straightening vanes, flow meter, orifice fitting, Pressure Indicators, Temperature, temperature indicators, sample probes, etc.)
- 17.6. Color coded piping are stenciled with the following:
 - a. Flow directional arrows and fluid service
 - b. Line designation number, size, class and specification
- 17.7. Identification are stenciled on major components of the PIPING such as but not limited to :
(Note: Identification shall follow Equipment identification number designated on the P&ID)
 - a. Identification number for metering skid
 - b. Strainer
 - c. Flow element/flow meter
 - d. Control Valves
 - e. MOV's

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f. Relief Valves

17.8. Installed relief valves shall be calibrated and reports signed as per SAEP-319 'Pressure Relief Devices-Testing and Inspection Requirements'



17.9. Pressure gauges & temperature gauges installed are of the same range as shown in the P&ID.

17.10. Flow direction of Control valves, check valves and globe valves follow the process flow direction.

17.11. Pipes are in full contact with the supports. (Fully Restrained)

17.12. Weld attachments to the pipe are seal welded.

17.13. Jack screw bolts installed in flanges with spectacle plates.

17.14. A 6 mm weep hole shall be drilled for all dummy supports and shall be located near the base plate for all vertical dummy supports, and near the run pipe at 6 o'clock position for all horizontal dummy supports.

17.15. All vents and drains are provided with bar stock plugs or blinds.

17.16. All nuts and bolts of flange connections are fully engaged.

17.17. A minimum clearance of 50 mm shall be provided for inspection and freedom of pipe movement between above ground piping crossing with any structure (including pipe support structure). This clearance is also required for above ground piping crossing with another pipe.

17.18. Pipe guides are installed at locations as shown in the approved isometric drawings.

17.19. Details of the installed pipe supports conform to the Pipe Support Detail per project specification.

17.20. Travel stops of spring supports are removed after pressure test.

17.21. The pipe shall not be used to support other pipes and structures.

17.22. All outstanding B-Category punch items shall be completed before reinstatement.

18.0. PIPING TOLERANCES



18.1. All fabrication and erection shall be performed within the tolerance specified in the approved WPS and the project requirements.

18.2. Where internal misalignment exceeds 1.5mm, internal trimming/sloping shall be in accordance with ANSI/ASME B31.3 Fig: 328.4.3 after agreeing with PSAL QC.

18.3. The maximum tolerance for axial dimensions, face-to-face, center-to-face and location of attachments shall be ± 3 mm maximum.

18.4. Lateral transition of branches and connections from centerline of run shall not exceed ± 1.5 mm.

18.5. Flange bolt holes shall be oriented as follows, unless otherwise indicated on the construction drawings:

- a) Flange face vertical : bolt holes to straddle vertical centerlines.
- b) Flange face horizontal : bolt holes to straddle horizontal centerlines.

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- c) Rotation of flanges, measured as the offset between elevations of bolt holes on opposite sides of a flange centerline shall not exceed ± 2.4 mm
 - d) The tilt of a flange measured at the periphery across any diameter shall not exceed 1.6mm from the square position.
- 18.6. For Socket welds, to avoid cracking of the fillet weld, the pipe shall keep at least 1.5 mm from the bottom of the socket before welding.
- 18.7. For piping over 3" NPS and connected to machinery/equipment, flange alignment shall be within the following limits.
- a) Vertical bolt hole offset : ± 2.4 mm
 - b) Horizontal bolt hole offset : ± 2.4 mm
 - c) Rotational Offset : ± 2.4 mm
 - d) Flange face separation, gasket thickness : ± 1.6 mm
 - e) Combination of vertical, horizontal and rotational offset : ± 3.2 mm
- 18.8. Flange face tilt across diameter: 0.025 mm per 25 mm of flange outside diameter up to a maximum of 0.672 mm, and 0.254 mm for all flanges with an outside diameter less than 10".
- 18.9. In case where as spectacle plate is installed between two flanges, these tolerances can be increased by 30% except for tolerance for flange face tilt across diameter and flange separation.
- 18.10. If the slope is specified in the latest IFC drawing, the slope shall be verified with reference to slope survey report.

19.0. INSULATION

- 19.1. Industrial insulation for piping and equipment shall be as per SAES-N-001
- 19.2. Insulation shall not be installed in pumps, air-cooled equipment, compressors, steam traps, nameplates, expansion joints, rotating joints and other applications where the intended use would be compromised.
- 19.3. Carbon steel in contact with insulation shall be coated according to SAES-H-001, SAES-H-002 and SAES-H-101.
- 19.4. Fireproofing shall be in accordance with SAES-B-006 or SAES-B-009, as appropriate.
- 19.5. All equipment, vessels, and piping shall have been tested, Painted and inspected as required by the relevant specification prior to the installation of insulation.
- 19.6. Manufacturers' instructions and recommendations of insulation and vapor barrier manufacturers shall be followed.
- 19.7. Inspection for Cold Service Insulation shall be as per SATIP-N-001-01
- 19.8. Inspection for Hot Service Insulation shall be as per SATIP-N-001-02

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20.0. DOCUMENTATION

20.1. Fabrication and erection of piping record book shall contain the following minimum records for each piping test packages.

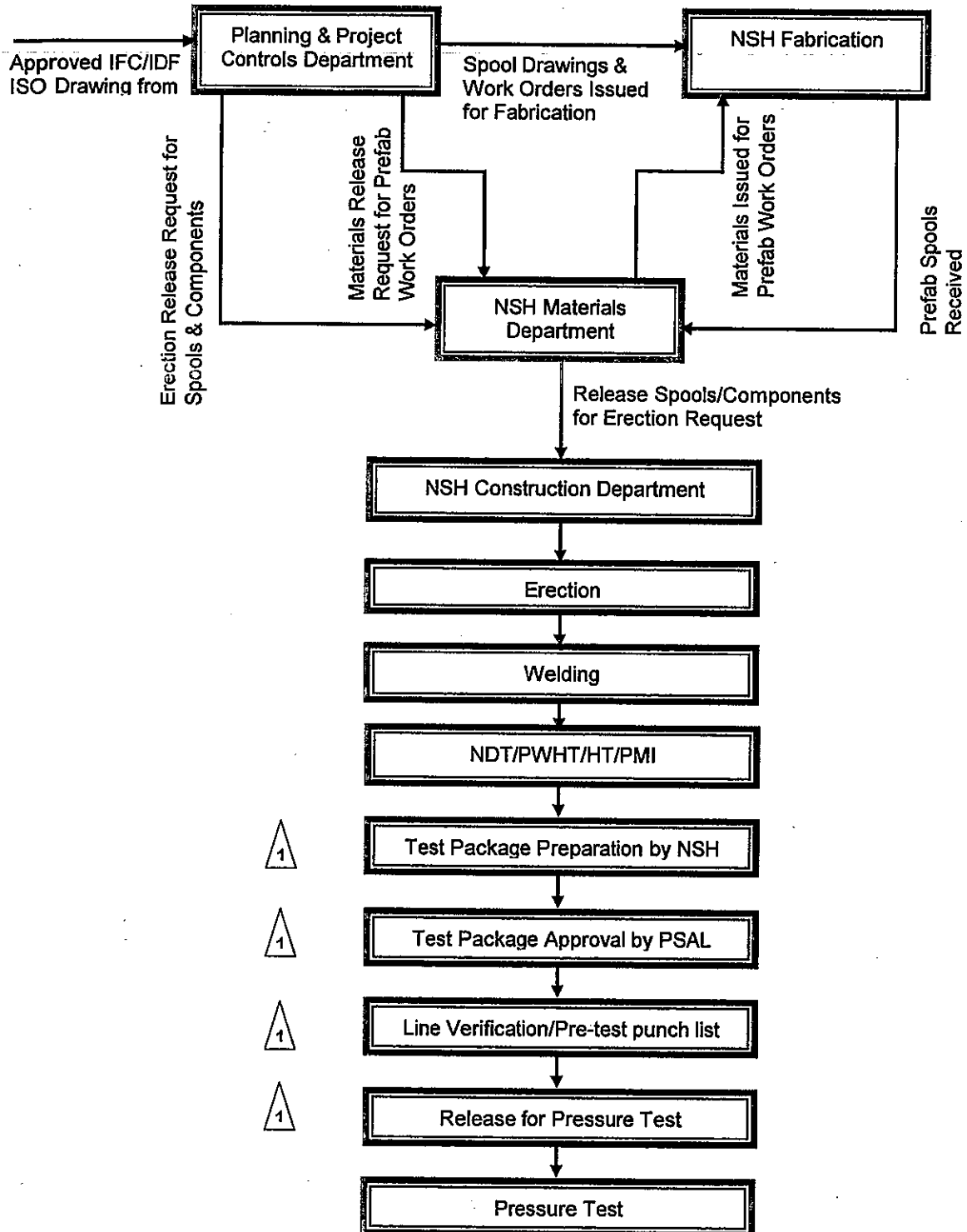
- a) Material Receiving Inspection Report
- b) Fit-up Inspection Report
- c) Daily Welding Inspection Report
- d) Internal Cleaning Report
- e) NDT Reports
- f) PMI reports
- g) Hardness reports
- h) PWHT/FN test reports
- i) Joint History Sheet
- j) Flange Bolt Tightening Report
- k) Orifice Installation Report
- l) Pad Test Report
- m) Pressure Test Report
- n) Flushing / Blowing / Drying Reports
- o) Reinstatement Report
- p) Painting Inspection Report
- q) Dimensional inspection report.
- r) Valve testing report



21.0. ATTACHMENTS

- Attachment #1 : Piping Erection Flow Chart
- Attachment#2 : Warning tape Color code for spools & joints
- Attachment#3 : Heat input calculation sheet

Spools/Components Erection Flow Chart



Warning tape Color code for spools& joints

Description	Warning tape Color code	Remarks
RT joint	Yellow &Black tag	
RT repair joint	Red tag	
PWHT Joint	Blue tag	
Spool released for Painting	Red &white tag	
Rejected Material	Yellow tag	

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Heat Input Calculation Sheet

[illegible]