

QA/QC ENGINEER / INSPECTOR

QUALITY MANAGEMENT SYSTEMS

1. Describe the difference between QA & QC?

Answer: **Quality Control** is the operational techniques (Inspection, Examination & Testing) that are used to fulfill requirements for quality. **Quality Assurance** is the system of action and planning needed to provide confidence that a Product or Service will satisfy quality requirements

2. What do quality system audits evaluate?

Answer: The degree of quality system conformance to established requirements.

3. Saudi Aramco has adopted the basic framework and definitions of the International Quality Management System Standards **ISO-9000 Series**. This has been done to provide universal understanding and improve communication between the COMPANY and prospective CONTRACTORS whose Quality Management System is congruent with the ISO **-9000 Series**. Describe the basic elements of an ISO 9000 Series Quality Program?

Answer:

Quality Management & Quality Assurance Standards per **ISO-9000**

Quality Management Systems per **ISO-9001, 9002, 9003**

Quality Plan Guidelines per **ISO 10005**

SCHEDULE "Q" – Is describe a minimum requirement for Contractor Quality System
ISO 9001 – Quality Management System requirements
ISO 9000 – Quality Management System Fundamental and Vocabulary

QUALITY PROCEDURE - Is used to establish instruction for inspection and control of all construction Activities. This will apply to the incoming materials, intermediary and final works.

QA – system of action and planning needed to provide confidence that a product or services will satisfy the quality requirements.

QC – is the operational techniques (Inspection, Examination & Testing) that are used to fulfill quality requirements.

QUALITY CONTROL PROCEDURE - Is a document that details the specific steps needed to fulfill the Quality activity in the ITP.

QUALITY CONTROL FORM - Is a writing documentation detailing a specific activity in the ITP and QC procedure.

A CODE – is a body of laws as of a nation, state or industry group, arranged systematically for ease of use and reference.

A STANDARD – is a rule or a basis of comparison in measuring quality, quantity, content, relative value and etc.

A SPECIFICATION – is a detailed description of parts or statement of particulars as to actual or required quality, size and etc.

P&ID – Is a Piping & Instrument diagram show piping layout and detailed notes relating to piping Instrumentation. This drawing is commonly referred to as the P&ID its object is to indicate all process service lines, instrument and controls, equipment & data necessary for the design

group. The process flow diagram is the primary source of information for developing the P&ID.

ARAMCO CODE & STANDARD REFERENCES:

- ISO 9001 : 2000 Quality Management System
- SATIP - Saudi Aramco Typical Inspection Plan
- SAIP - Saudi Aramco Inspection Procedure
- SAEP - Saudi Aramco Engineering Procedure
- SAES - Saudi Aramco Engineering Standard
- SAIR - Saudi Aramco Inspection Requirements
- SAIC - Saudi Aramco Inspection Check list
- Saudi Aramco Standard Contractor Schedule "Q" (**Project Quality Requirements**)

INSPECTION & TEST PLAN (I T P)

Is all about document based on detailed manufacturing, fabrication and construction program that identifies each process description, sets out related sequence of activities to be inspected, examined and tested with relevant approved procedures for particular materials, components and assembly.

It includes identification of required documents, acceptance criteria, which is responsible, the inspection surveillance and the type and level of inspection including hold, witness and review points of the contractor, sub-contractor and Saudi Aramco.

INSPECTION & TEST PLAN should include the following information:

- Process descriptions
- Quality Control Requirements
- Notification Requirements for Supplier Inspection (min. 10 day calendar days)
- Responsibilities for Inspection / Test
- Acceptance Criteria
- Verifying Document
- Inspection Points (Hold, Witness, Review and Surveillance)

INSPECTION ACTION POINT

Hold Point (H)

An inspection point, defined in an appropriate document, beyond which an Activity must not proceed without the approval of the designated organization or authority.

Witness (W)

An inspection point, defined in an appropriate document, beyond which an Activity can proceed after notifying the designated organization or authority. Contractor's QC Inspector has the full responsibility for performing detailed Inspection during the work activity.

Review Point (R)

Defined in an appropriate document is the point in which a work activity cannot Proceed without first ensuring the review and approval of applicable documents Or personnel qualification by a designated organization or authority

Surveillance (S)

QA/QC organization to monitor work in progress without notice from construction organization

DEFINITION OF INSPECTION LEVEL as per (SAER – 1972)

- Level 0 - Documentation Requirements only No vendor Inspection required

- Level 1 - Only Final Inspection is required prior to shipping
- Level 2 - Includes as minimum, pre-inspection meeting, one or more Un-specified "in progress" surveillance visits, all witness, hold points, final inspection and release for shipment
- Level 3 - Same as level 2 except that "in progress" surveillance shall be on a regular basis (daily, weekly or bi-weekly)
- Level 4 - Resident inspector continually monitoring the work

NON-CONFORMANCE - An Activity does not conform with an International Code /Standard.

NCR (Non Conformity Report) - A record reporting the variation from the specified requirements.

CAR (Corrective Action Report) – It is a record reporting the action take to eliminate the effect & causes of an existing Non Conformity defect or other undesirable situation in order to prevent recurrence.

DR (Deviation Report) – A report of the concession granted by client or owner to certain deviation from project specification

QUALITY CONTROL INSPECTOR / ENGINEER (QCI)

Responsibility:

- Insuring quality control site surveillance
- Witness inspection and test in accordance with SATIP & SAIC
- Verifying the inspection reports and validating the results
- Shall continually inspect the work at site and all QA/QC documents shall be managed by inspectorate and technical clerk assigned by the quality department
- Monitor the timely production of the Inspection Certificate by construction contractor or sub-contractor.
- Ensure the proper disposition of the non-conformities with the assistance of specialist as required.

MECH'L PIPING INSPECTION ENGINEER / INSPECTOR

- Shall be Conduct an Inspection in accordance with International Code & Standard
- Monitoring daily Piping activities
- Verify compliance according to project specification
- Preparing Quality Record
- Final acceptance documentation

MATERIAL INSPECTION ENGINEER / INSPECTOR

Shall perform the receiving inspection according to SATIP & SAIC as follows:

1. Verifying that all required documents and records have been supplied by the vendors
2. Review Certified Material Test Report (CTMR) and other records received from vendor
3. Perform visual check that the items have not been damaged during transportation
4. Verify that all items meet all requirement on material requisition
5. Verify that the identification markings of the items are identical with CMTR and other relevant document received from vendor.

UPON THE COMPLETION OF RECEIVING INSPECTION

Material Inspector shall prepare material receiving inspection report and shall include the following:

1. Name of item received
2. Serial ID Number
3. Vendor Name
4. Material Requisition Number
5. Material Inspector Signature and Inspection Date

AFTER COMPLETION OF RECEIVING INSPECTION,

Material Inspector shall document the receiving inspection result on the report and provide the copies to Material Control Supervisor and related construction discipline department.

NON-CONFORMING ITEMS

Items found to be nonconforming at receiving inspection shall be clearly identified and Controlled using Non Conformance Report (NCR) Procedure: KGF-PM-6008-001, Segregate and place on the hold area and attached "HOLD Tag".

CAR – Corrective Action Request issued by the QA/QC manager to the department responsible for nonconforming products.

MATERIAL RECEIVING

- Before inspection takes place, construction department should submit Request for Inspection (RFI) to the QA/QC department.
- RFI includes SAIC.
 - Purchase Order
 - Delivery Note
 - Packing List
 - Certificate of Compliance
 - Equipment Test Report
 - Approved Data Sheet
 - Approved Drawings
 - Inspection Release Certificate
 - Inspection Disposition Reports
- Verify and validate the above documents
- Installation Manual
- Perform the equipment, material pre-inspection
- See to it that the materials and or equipments are free from defects or damaged during transportation
- Material or Equipment shall be in accordance with company Material Requisition, approved Standard and Specification.
- Fill in the necessary information on the checklist liked, name of the item received, serial number, vendor name, material requisition, material inspector signature, inspection date...
- Once the inspection was carried out all the pertaining documents should be submitted to Saudi Aramco for signature and acceptance.

FINAL DISPOSITION REPORT includes the following:

- Narrative details of Quality activities performed during manufacturing and fabrication of the equipment or material.
- Copies of Saudi Aramco approved waivers
- All SA-175 Contractor witness inspections.
- Copies of supplier Quality Records as specified in SA-175.
- Copies of all NCR's with final dispositions and resolutions.
- Outstanding punch list items from pre-shipment inspections.
- **Verify that all the requirements specified on the Saudi Aramco Inspection Requirement Form 175-311500 have been met.**

MATERIALS:

All pipe and fittings SHALL have the material specification and grade stamped, stenciled, or Otherwise clearly marked with permanent marking method.

STORAGE:

The following requirements SHALL apply to storage areas relevant to the particular project

which includes, but no limit to, layout yards, receiving areas, warehouse etc.

1. Pipe SHALL not be stored directly on the ground. Pipe SHALL be placed on mounds or sleepers.
2. Stacking of pipe SHALL be made in a manner to avoid damage to pipes or coating. Refer to **SAES-H-200**
3. Fittings and valves SHALL be stored in shipping crates or on racks.
4. End protector on pipes, flanges, weld bevels, threads, and socket ends SHALL be firmly attached.

HANDLING:

1. Lined and coated pipes and fittings SHALL be lifted with wide fabric or rubber covered slings and padding's SHALL be used to prevent damage to lining or coating in accordance with **SAES-H-200**

ERECTION AND INSTALLATION (SAES-L-350)

1. All sensitive equipment to damage during cleaning and flushing of the piping system SHALL not be installed and SHALL be removed if installed prior to commencing the cleaning process. The list of these equipment SHALL be established during early stages of the execution of the project. Examples of sensitive equipment are: Rotating machinery, orifices, Control valves, Flow element, soft valves, glove valves etc.
2. All erected piping system and component SHALL be internally clean and free from foreign objects.

CLEANING

1. During project proposal and details design, details procedure for cleaning and flushing of the piping spools and system SHALL be established identifying acceptable method that will be applicable for every individual system category. These procedure SHALL be agreed on by PMT proponent & Inspection Agency.

PRIOR TO INSTALLATION As a minimum & prior to installation/erection of pipe spools on the Pipe Racks and pipe support the following SHALL be conducted:

1. All pipe SHALL be internally cleaned by air blowing. In addition, for large diameters pipes rag cleaning should be conducted if found practically
2. All prefabricated pipe spools SHALL be visually inspected for cleanliness, and SHALL have foreign material removed from inside.
3. The pipe ends SHALL be covered after inspection to prevent unauthorized removal of the end cover prior to making the joint to the succeeding section of piping.

DURING ASSEMBLY & ERECTION

1. During assembly and erection, the construction agency SHALL ensure that no foreign materials (such as welding consumables, ladders, gloves, etc.) are left inside the piping system.
2. After assembly and installation, the piping SHALL be cleaned inside to remove all loose material. The cleanliness SHALL be verified visually and/ or by video inspection techniques.

PIPE FIT-UP AND TOLERANCES (SAES-L-350)

1. Maximum tolerance for axial dimensions, face to face, center to face and location of attachment shall be $\pm 3\text{mm}$.
2. Flattening of bends measure as the difference between the largest & the smallest outside diameter of any cross section, shall not exceed 5% of the nominal diameter of the pipe. Flattening of bends at weld ends shall not exceed 3% of the nominal pipe diameter.
3. Lateral transition of branches and connection from the centerline of the run shall not exceed $\pm 1.5\text{mm}$.

4. Rotation of flanges, measured as the offset between elevation of bolt holes on opposite sides of flange centerline shall not exceed $\pm 2.4\text{mm}$.
5. The tilt of flange measured at the periphery across any diameter shall not exceed 1.6mm from the square position.
6. Piping over 3-inch NPS and connected to machinery/equipment, flange alignment shall be within the following limits unless piping analysis per SAES-L-120 shows that loads and moment are within the manufacturers limit for the machinery/equipment nozzles:
 - a. Vertical bolt hole offset $\pm 2.4\text{mm}$.
 - b. Horizontal bolt hole offset $\pm 2.4\text{mm}$.
 - c. Rotational offset $\pm 2.4\text{mm}$.
 - d. Flange face separation, gasket thickness $\pm 1.6\text{mm}$.
 - e. Combination of vertical, horizontal and rotational offset $\pm 3.2\text{mm}$.
7. A 6mm weep hole shall be drilled for all dummy support at 6 o'clock position for all horizontal dummy supports.

FLANGE JOINT TIGHTENING METHODS

1. Torque Wrench Method per SAEP-351

- Torque wrench should be calibrated
- Apply lubricant to stud thread and face of nut contacting the flange
- All stud and nuts installed should be hand tight
- All stud should be number
- Studs are tighten as number with impact wrench or equivalent following bolt tightening sequence
 - 1st stage tightening @30% of required torque (maximum)
- Required torque value and actual attained value are recorded in
- Bolt Tightening Report
- Final Tightening to $\pm 5\%$ of torque required (actual torque)
- After tightening all bolts have full thread engagement with the nut
 - Note: complete engagement (less 1 full thread) is acceptable (ASME B31.3 par. 335.2.3)

2. Bolt Tensioning Method (HYDRATIGHT) – 50% Tensioning Method

- Pressure gauge in the Tensioning Machine are calibrated
- Mark bolts in 2 sets, set A and set B
- Tensioners are fitted to every other bolt of set A
- Pressurized the tensioner to pre-determined "pressure A" per approved procedure (this is repeated 2 more times).
- Transfer tensioner to set B bolts and pressurized to pre-determined pressure B and tighten nuts (this should be repeated 2 times).
 - Note: pressure B is lower in value than pressure A
- After tensioning, Break Loose Pressure is verified to be greater than or equal to pressure B by the following steps
 - Fit the tensioner to one of the tension bolt in set A
 - Pressurized slowly until the nut is loosen using Tommy Bar and socket
 - Once the nut moves, stop pressurizing and record the achieved pressure.
 - This is the "Break Loose Pressure"(Note: If BLP < pressure B, tensioning is fail)

SAES-A-004 General Requirements for Pressure Testing

HYDROSTATIC TEST

- A pressure test conducted using water or other approved liquid as the test medium.

PRE START-UP TEST

- A pressure test to ensure tightness of flanged and threaded joints at the test Pressure. It is normally conducted before initial start-up, during commissioning or after T&Is.

PNEUMATIC TEST

- A pressure test conducted using air or other approved gas as the test medium or in conjunction with liquid.

PRESSURE TEST

- A test conducted to piping or equipment by subjecting it to an internal pressure using liquid or gas to ensure strength or tightness of the system at the test pressure.

REVALIDATION TEST

- A pressure test performed to prove the integrity of existing piping or equipment. This test is administered by the proponent organization.

SERVICE TEST

- A pressure test conducted at operating pressure using the service fluid.

STRENGTH TEST

- A pressure test at an internal pressure determined in accordance with this standard and the applicable Code to verify the integrity of the piping systems or equipment for service at the design pressure.

SYSTEM TEST

- An in-situ pressure test applied to a group of piping and equipment tested as a system.

PRESSURE TEST PROCEDURE

- Information assembled to ensure all requirements listed in GI-0002.102, All referenced Saudi Aramco standards and Industrial standards are met.

TIGHTNESS TEST

- A pressure test to ensure tightness of the piping system (i.e., no leaks in the system) at the test pressure.

ALL SYSTEM (PIPING & EQUIPMENT) WHILE PRESSURE TESTED SHALL BE PROTECTED FROM BEING OVERPRESSURED BY THE FOLLOWING

- **RELIEF VALVE** (s) of adequate capacity set to relieve at **5%** above the test pressure shall be installed unless the test pressure is less than **85%** SMYS at which time it can be set at **10%** above the test pressure. Sizing of these relief valves used for testing shall follow the requirements of API RP 520, Part 1. The relief valve(s) shall be tested, dated, and tagged within **One Week prior to the pressure test** for new construction projects, and within **One Month for maintenance operations**.
- In addition to the pressure relieving device, a bleed valve shall be provided to protect the piping and equipment from overpressure. The bleed valve shall be readily accessible in case immediate depressurization is required.
- An isolation valve shall be provided between the pressure testing manifold and the system being tested. The isolation valve shall be rated for the manifold test pressure when in the closed position.
- **PRESSURE GAUGES** and pressure recorders shall be calibrated before the Test. The calibration interval shall not exceed one **(1) month**. Calibration certificates shall be made available to Inspection personnel prior to commencement of the pressure test. Stickers shall be applied indicating the latest calibration date.
- All gauges shall have a range such that the test pressure is within **30 to 80%** of the full range.
- A minimum of **two pressure gauges** 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.
- Recording gauges shall be used where it is necessary to keep a permanent record, e.g., when the test duration exceeds four hours, or otherwise as required by this standard.

- **PRESSURE TESTING MANIFOLD** in the actual system pressure test, it **shall be separately pressure tested to at least 1.2 times the system test pressure** but not less than the discharge pressure of the pump used for the pressure testing.

HYDRO-TEST PACKAGE CONTENT Test procedure SHALL be available at site all times.

1. Flow chart
2. Hydro test index
3. SIS / Test press diagram / legend
4. Piping plan drawing
5. P&ID drawing
6. Isometric drawing
7. Welding summary report including NDT report & RTFI assessment.
8. Support type & drawing
9. Valve test certificate
10. Flange joint inspection report
11. Internal cleaning & flushing report
12. Pre-test punch list - punch "A" should be close prior for proceeding test package review & testing.
13. Reinforcing pad pneumatic test report
14. Calibration report
15. Filling & pressurization report
16. Pressure test report
17. Lay-up report
18. Reinstatement
19. Final inspection report
20. Coating report.

FOUNDATION GENERAL INFORMATION

- Top of Concrete Foundation shall have a minimum of **150mm** above finish grade. (not applicable to instrument stand pipe, or pedestal inside the building not subjected to wash-down water).
- Curing period of concrete foundation should be **not less than 7 days** after placement or until the compressive strength has reach **70%** of the specified strength.
- All column base plate has a minimum of **4 anchor bolts**.
- Installed padding plate with **25mm minimum** elevation from top of the foundation and level the foundation plate using magnetic leveling or precision leveling.
- Leveling shims are installed with a maximum top elevation of **25mm** from the top of concrete elevation.
- Top of the concrete has been roughened or chipped with hammer to remove laitance, oil-soaked or damaged concrete to the level of sound concrete or to a minimum of **1inch (25mm)** from the top of the concrete.
- Top of the bearing surface and the bottom plate should be clean thoroughly.
- Variation in dimension between the centers of any two anchor bolts within an anchor bolt group shall be **equal to or less than 1/8" (3mm)** AISC Code of standard Practice for Steel Building and Bridges.
- Variation in elevation of the tops of anchor rods shall be equal to or less than **±13mm** AISC Code of Standard Practice for Steel Building and Bridges.
- Installed the sole plate with **±1mm tolerance**.
- Check the dimension of the anchor bolts and the bolt hole of the equipment, anchor bolts subject to vibration should be provided with **additional nut to serve as locknut**.

CENTRIFUGAL / POSITIVE DISPLACEMENT PUMP REFERENCE STANDARD

- SATIP-G-005-01 Centrifugal Pump
- SATIP-G-006-01 Positive Displacement Pump
- SATIP-G-115-01 Lubrication, Shaft Sealing & Oil System

- SAIC-G-2002 Receiving inspection of Centrifugal Pump
- SAIC-G-2003 Handling, Storage & Inspection of Centrifugal Pump
- SAIC-G-2004 Inspection of Auxiliary Piping Installation
- SAIC-G-2005 Inspection of Pump Suction & Discharge Piping Con.
- SAIC-G-2021 Mounting Plate Installation & Leveling for Pumps
- SAIC-L-2014 Inspection of Bolted Flanges Joint Assembly
- SAIC-G-2022 Final Pump / Driver Alignment
- SAIC-G-2007 Final Inspection / Walkthrough (By Contractor)
- SAES-G-005 Centrifugal Pumps
- SAES-B-054 Access, Egress & Material Handling of Plant Facility
- SAES-B-053 Machine Safety Guarding, Elevators, Escalators...
- 31-SAMSS-004 Centrifugal Pumps
- 31-SAMSS-009 Positive Displacement Pump Controlled Volume
- 01-SAMSS-017 Auxiliary Piping for Mechanical Equipment
- Schedule "Q" Saudi Aramco Quality Requirements
- API 610 Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Services
- API 675 Positive Displacement Pump Controlled Volume

COATING REFERENCE STANDARD

- SAES-H-001 Selection Requirements for Industrial Coating
- SAES-H-100 Painting Requirements for Industrial Facilities
- SAES-H-101 Approved Protective Coating Systems

PRESSURE VESSEL REFERENCE STANDARD

- SATID-D-001-01 Pressure Vessel Installation
- SATIP-D-100-01 Field Erected Storage Tank (API 650)
- SATIP-D-109-01 Shop Fab. Storage Tank (API 12F/12P/UL 142)
- ASME Sec. VIII Div. 1-3 Rules for Construction for Pressure Vessels
- API 650 Welded Steel tanks for Oil Storage
- API 651
- 32-SAMSS-004 Manufacture of Pressure Vessels
- 32-SAMSS-005 Manufacture of Atmospheric Tanks
- 32-SAMSS-006 Manufacture of Low Pressure Storage Tank
- SAES-D-001 Design Criteria For Pressure Vessels
- 32-SAMSS-020 Manufacture of Trays and Packing
- SAES-W-010 Welding Requirements for Pressure Vessel
- SAES-W-014 Weld Overlay and Welding of Clad Materials
- VEFV1100/1102 Process Industry Practices (Fabrication/Installation)
- SAES-L-350 Construction of Plant Piping
- SAES-B-054 Access, Egress & Material Handling for Plant Facility
- SAES-B-006 Fireproofing for Plants
- SAES-N-001 Basic Criteria, Industrial Insulation

GENERAL INFORMATION ON PRESSURE VESSEL

- Hydrostatic Testing of a completed pressure vessel shall not exceed 90% of the minimum yield strength
- Hydrostatic Pressure shall be $1.3 \times \text{MAWP}$ as per ASME VIII Div. 1
- Holding time shall be 1hr/25mm of the vessel shell thickness or in no case less than 1 hour
- Medium shall be potable water with 50ppm chloride and pH = 10 to 11 and temperature of 17°C
- Alignment shall be within 1/1000 but not more than 25mm
- Orientation tolerance shall be within $\pm 3\text{mm}$

PWHT (POST WELD HEAT TREATMENT) – applied to some welded steels in order to ensure that the properties of weldment will be suitable for intended applications often called **Stress Relief**

- Intermediate Stress Relief = 600°C for 1 hour
- Dehydrogenation Heat Treatment = 350°C for 4 hours
- Specified PWHT area extending at least 6 times the thickness of the material being welded but not less than 25mm from the edge of the weld, which is greater
- If PWHT not perform in Furnace, insulation shall be applied 300mm on either side of the weld, insulation shall be remove before the temperature has cooled to 150°C
- Minimum soaking time shall be 1 hour per 25mm of thickness

PWHT BENEFITS

- To improve the resistance of the joint to brittle fracture
- To improve the resistance of the joint to stress corrosion cracking
- To enable welded joints to be machined to accurate dimensional tolerance

PWHT HEAT SOURCES

- Permanent or Semi-permanent furnace using gas or oil or electric heater
- Electrical Resistance Heater
- Induction Heater

THERMOCOUPLE LOCATION IN FURNACE

- Thinnest major component
- Thickest member
- Top of the vessel
- Bottom of the vessel
- Temperature recorder shall be calibrated every 3 months or can be extended to 12 months with aramco approval
- Machine surfaces, flange faces, threaded bolt holes, threads, etc. shall be protected from oxidation it shall be coated with deoxiluminite or other suitable materials
- After completion of PWHT attachment areas shall be ground smooth, if specified by inspector areas shall be examined by MT or PT after grinding

PARTS OF PRESSURE VESSEL

1. Head
2. Shell
3. Nozzle
4. Support

TYPES OF VESSEL SUPPORTS

1. Lug Support
2. Leg Support
3. Saddle Support
4. Skirt Support

TYPES OF VESSEL INTERNAL

1. Tray
2. Inlet Distributor
3. Anti-Vortex Baffle
4. Catalyst Bed Grid & Support Beam
5. Outlet Collector
6. Flow Distribution Grid
7. Cyclone and Plenum Chamber System
8. Demister

COMPRESSOR

- | | |
|----------------|--|
| - SATIP-K-402 | Centrifugal Gas Compressor |
| - SATIP-K-403 | Reciprocating Compressor for Process Air & Gas |
| - 31-SAMSS-001 | Centrifugal Compressor |
| - 01-SAMSS-017 | Auxiliary Piping for Mechanical Equipment |
| - API 617 | Centrifugal Compressor for Petroleum, Chemical.. |
| - Schedule Q | Contractor Quality Requirements |
| - API 618 | Reciprocating Compressor for Petroleum, Chemical.. |

HEAT EXCHANGER

- | | |
|----------------|--|
| - SATIP-E-004 | Heat Exchanger Installation-Shell & Tube |
| - SAES-E-004 | Design of Shell & Tube Heat Exchangers |
| - 32-SAMSS-007 | Manufacture of Shell & Tube Heat Exchanger |
| - SAES-H-100 | Coating Materials & Application Requirements.. |

AIR COOLED HEAT EXCHANGER (FIN FAN COOLER) REFERENCE STANDARD

- | | |
|------------------|---|
| - SATIP-E-007-01 | Air Cooled Heat Exchanger (Fin Fan Cooler) |
| - SAES-E-007 | Design Criteria of Air Cooled Heat Exchanger |
| - 32-SAMSS-011 | Manufacture of Air Cooled Heat Exchanger |
| - API 614 | Lubrication, Shaft Sealing & Control Oil System |
| - Schedule Q | Contractor Quality Requirements |
| - SAES-H-100 | Painting Requirements for Industrial Facilities |

ON-PLOT METALLIC PIPING INSTALLATION

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|------------------|---|
| - SATIP-L-351-01 | On-Plot Metallic Plant Installation (Excluding Brazed Piping) |
| - SAES-L-100 | Applicable Code & Standard for Pressure Piping System |
| - SAES-L-102 | Piping Material Specification |
| - SAES-L-108 | Selection of Valve |
| - SAES-L-109 | Selection of Flanges, Stud Bolts and Gasket Piping... |
| - SAES-L-110 | Limitation of Pipe joint & Component |
| - SAES-L-150 | Pressure Testing of Plant Piping & Pipeline |
| - SAES-L-125 | Safety Instruction Sheet for Piping & Pipeline |
| - SAES-L-310 | Design of Plant Piping |
| - SAES-L-350 | Construction of Plant Piping |
| - SAEP - 351 | Bolted Flange Joint Assembly |

PRESSURE TESTING REFERENCE STANDARD

- | | |
|------------------|--|
| - SATIP-A-004-02 | Hydrostatic Testing of On-Plot Piping |
| - SAES-A-004 | General Requirements for Pressure Testing |
| - SAES-A-007 | Hydrostatic Testing Fluid & Lay-up Procedure |
| - SAES-L-125 | Safety Instruction Sheet for Piping & Pipeline |
| - SAES-L-150 | Pressure Testing of Plant Piping & Pipelines |
| - G.I 0002.102 | General Instruction Pressure Testing Safety |

GROUTING REFERENCE STANDARD

- | | |
|------------------|--|
| - SATIP-Q-011-01 | Epoxy Grout for Machinery Support |
| - SATIP-Q-010-01 | Cement Based Non-Shrink Grouting |
| - 09-SAMSS-088 | Aggregates for Concrete |
| - SAES-Q-005 | Concrete Foundations |
| - SAES-Q-010 | Cement Based, Non-Shrink Grout for Structural... |
| - SAES-Q-011 | Epoxy Grout for Machinery Support |

DEFINITION OF TERMS

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|-------|------------------------|
| - RFI | Request for Inspection |
|-------|------------------------|

- SAER	Saudi Aramco Engineering Requirements
- SAES	Saudi Aramco Engineering Standards
- SAMSS	Saudi Aramco Material System Specifications
- ASTM	American Society for Testing & Materials
- MEEDCO	Middle East Eng'g and Dev't Company Ltd.
- HDEC	Hyundai Engineering & Construction Company Ltd.
- ITP	Inspection & Test Plan
- ITR	Inspection & Test Report
- IRC	Inspection Release Certificate
- TPI	Third Party Inspector
- TPIR	Third Party Inspection Report
- PRB	Project Record Book
- P & ID	Piping & Instrument Diagram
- ASME	American Society of Mechanical Engineer
- ASCE	American Society of Civil Engineer
- SAEP	Saudi Aramco Engineering Procedure
- SAIC	Saudi Aramco Inspection Checklist
- SATIP	Saudi Aramco Typical Inspection Plan
- SATR	Saudi Aramco Test Report
- SASD	Saudi Aramco Standard Drawing
- PIP	Process Industry Practices
- API	American Petroleum Institute
- AARH	Average Arithmetic Roughness Height
- MDMT	Minimum Design Metal Temperature
- DFT	Dry Film Thickness
- APCS	Approved Protective Coating Systems
- ANSI	American National Standard Institute
- AWS	American Welding Society
- ASD	Allowable Stress Design
- LRFD	Load & Resistance Factor Design
- OID	Operation Inspection Design
- NFPA	National Fire Protection Association
- NPS	Nominal Pipe Size
- NPT	Nominal Pipe Thread
- ERW	Electric Resistance Welded
- MEU	Material Engineering Unit
- SALD	Saudi Aramco Library Drawing
- CDMS	Corporate Drawing Management System
- HIC	Hydrogen Induced Cracking
- NACE	National Association of Corrosion Engineer
- FRPT	Fiberglass Reinforced Plastic Tank
- PMI	Positive Material Identification
- PWHT	Post Weld Heat Treatment
- SAEF	Saudi Aramco Engineering Form
- EDSD	Engineering Drawing Services Division
- NMR	Non Material Requirements (Certified Drawings, Literature, Photographs, Maintenance Manual, Installation Instruction, Shop Detailed Drawings)
- IAP	Inspection Assignment Package
- NCR	Non Conformance Report
- IRC	Inspection Release Certificate
- IDR	Inspection Disposition Certificate
- WIN	Witness Inspection Notice
- VIRB	Vendors Inspection Record Book
- BLP	Break Loose Pressure

- CSD	Consulting Services Department
- PFI	Pipe Fabrication Institute
- AISC	American Institute of Steel Construction
- ASNT	American Society of Nondestructive Testing
- WRC	Welding Research Council
- MAWP	Maximum Allowable Working Pressure
- NDE	Non Destructive Examination
- SAID	Saudi Aramco Inspection Department
- WPS	Welding Procedure Specification
- PQR	Procedure Quality Record
- EIS	Equipment Inspection Schedule
- IRB	Inspection Record Book
- NAAMM	National Association of Architectural Metal Manufacturer
- MSS	Manufacturers Standardization Society
- PQP	Project Quality Plan
- QMIS	Quality Management Information Systems
- EDMS	Electronic Document Management System
- PQL	Project Quality Plan
- HSE	Health and Safety Environment
- GTAW	Gas Tungsten Arc Welding
- GMAW	Gas Metal Arc Welding
- FCAW	Flux Cored Arc Welding
- SMAW	Shielded Metal Arc Welding
- SAW	Submerged Arc Welding
- UT	Ultrasonic Examination
- RT	Radiographic Examination
- MT	Magnetic Particle Examination
- PT	Liquid Penetrant Examination
- RTRP	Reinforced Thermosetting Resin Pipe
- BMG	Bottled Gas Manual
- DMW	Dissimilar Metal Weld
- BI Number	Budget Item Number
- TOFD	Time of Flight Diffraction (detection of flaws)

PRE-GROUT MEETING

- A pre-grout meeting should be held at least one day prior to the grout pour to understand and agree on procedures to ensure all necessary materials are on hand and to clarify grouting responsibilities. The party present in this meeting should include as a minimum, the grout manufacturing technical representative, the foreman in charge of the grouting activities, the grouting materials coordinator and the safety representative. A representative from grout manufacturer is recommended if the installation personnel are not familiar with the grouting materials, forming, installation, and so forth or if a special purpose equipment train is being installed.

GROUTING OF FOUNDATION GENERAL INFORMATION

- Before grouting see to it that the foundation is clean, dry and oil free
- Soak/Moisten the surface with water at least **24 hours (NSCG)**
- Start grouting from one side going to the other side to prevent air entrapment.
- Do not vibrate the grout as a means of helping it flow as this tends to separate the aggregate from the resin binder.
- Violent ramming of the grout is not permitted.
- Limited use of push tools maybe employed to help distributed the grout using long stroke rather than short stroke jabs.
- Air bubbles rising to the surface maybe remove by lightly spraying the bubbles surface with the grout manufacturing solvent cleaner.

- Remove any grout head boxes after the grout has set sufficiently.
- Foundation should be protected by burlap and polyethylene sheet to prevent from contamination
- Grout formworks shall be constructed with adequate strength.
- Concrete foundation should be cured for a minimum of **7 days or 70%** of the concrete compressive strength.
- Grout minimum thickness is **25mm**
- Temperature of grout when placed shall **23°C ±3**
- Compressive strength should be **35 MPa (5000 psi) minimum at 28 days**
- Compressive strength should be **24.5 MPa (3500 psi) minimum at 7 days**
- When grout water/cement ratio is **0.4 or less** the grout shall be given a continuous water cure (cover with wet burlap and 0.15mm polyethylene) for minimum of **7 days**
- Grout shall be tooled/chamfer to a **45° angle** down from the bottom of the base plate after placement but before it sets up hard
- Total dissolved solids in water shall not exceed **500ppm**
- pH shall be between **6-8**
- Epoxy grout temperature **30°C to 32°C and no need of soaking**

SAUDI ARAMCO, API, ASME AND ASTM STANDARD

- | | |
|----------------|---|
| - SCHEDULE "Q" | Contractors Quality Requirements |
| - SAER 1972 | Inspection Requirement (SA Material Inspection & Testing) |
| - G.I 0002.102 | General Instruction Pressure Testing Safety |
| - SAES-A-004 | General Requirements for Pressure Testing |
| - SAES-A-005 | Safety Instruction Sheet |
| - SAES-A-007 | Hydrostatic Testing Fluid & Lay-up Procedure |
| - SAES-L-105 | Piping Material Specification |
| - SAES-L-108 | Selection of Valves |
| - SAES-L-109 | Selection of Flanges, Stud Bolts and Gasket Piping... |
| - SAES-L-110 | Limitation of Pipe joint & Component |
| - SAES-L-150 | Pressure Testing of Plant Piping & Pipeline |
| - SAES-L-125 | Safety Instruction Sheet for Piping & Pipeline |
| - SAES-L-310 | Design of Plant Piping |
| - SAEP-351 | Bolted Flange Joint Assembly |
| - SAES-L-350 | Construction of Plant Piping |
| - SAES-L-410 | Design of Pipelines |
| - SAES-L-450 | Construction of On-land & Near-shore Pipelines |
| - SAES-W-010 | Welding Requirement for Pressure Vessel |
| - SAES-W-011 | Welding requirement for On Plot Piping |
| - SAES-W-012 | Welding requirement for Pipelines |
| - SAES-W-014 | Weld Overlays and Welding of Clad Materials |
| - SAES-H-001 | Selection Requirements for Industrial Coating |
| - SAES-H-100 | Painting Requirements for Industrial Facilities |
| - SAES-H-101 | Approved Protective Coating Systems |
| - SAES-G-005 | Centrifugal Pumps |
| - SAES-G-006 | Positive Displacement Pumps-Controlled Volume |
| - SAES-D-001 | Design Criteria for Pressure Vessel |
| - SAES-M-001 | Structural Design Criteria |
| - SAES-B-006 | Fireproofing for Plants |
| - ASTM A780 | Repair of Damaged and Uncoated Areas on Hot Dip Galvanized |
| - ASTM A123 | Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel |
| - 12-SAMSS-007 | Fabrication of Structural and Miscellaneous Steel |
| - 12-SAMSS-008 | Erection of Structural and Miscellaneous Steel |

- 31-SAMSS-004	Centrifugal Pumps
- 31-SAMSS-009	Positive Displacement Pumps-Controlled Volume
- 01-SAMSS-017	Auxiliary Piping for Mechanical Equipment
- 32-SAMSS-011	Manufacture of Air-Cooled Heat Exchangers
- 04-SAMSS-048	Valve Inspection and Testing Requirements
- 32-SAMSS-020	Manufacture of Trays and Packing
- 32-SAMSS-022	Manufacture of Components for Flare Systems
- 31-SAMSS-004	Centrifugal Pumps
- 32-SAMSS-004	Manufacture of Pressure Vessel
- SAES-A-206	Positive Material Identification
- SAES-B-054	Access, Egress & Material Handling for Plant Facilities
- SAES-B-053	Mach. Safety Guarding, Elevators, Escalators & Conveyors
- SAES-M-001	Structural Design Criteria for Non-Building Structures
- SAES-C-001	Process Design of Trays & Packing
- SAES-J-200	Pressure...
- SAES-J-300	Level...
- SAES-J-400	Temperature...
- SAES-F-007	System Design Criteria for Flares
- SAES-J-600	Pressure Relief Devices
- SAES-B-067	Safety Identification & Safety Colors
- SAES-N-101	Basic Criteria, Industrial Insulations
- SAEP-20	Equipment Inspection Schedule
- SAES-M-001	Structural Design Criteria
- SAIC-M-2007	Structural Alignment Inspection Checklist
- SATR-M-2002	Structural Alignment Test Report
- SAIC-M-2009	Structural Bolt Tightening
- SATR-W-2008	Weld Summary Report
- API-610	Centrifugal Pumps for Petroleum, Heavy Duty Chemicals and Gas Industry Services
- API-614	Lubrication, Shaft Sealing & Control Oil Systems
- API-661	Air-Cooled Heat Exchangers & Components
- API-675	Positive Displacement Pumps-Controlled Volume
- API-686	Recommended Practices for Machinery Installation and Installation Design
- API-1104	Welding of Pipelines and related facilities
- API-598	Valve Inspection and testing
- API-570	Piping Inspection Code
- API-577	Welding Inspection and Metallurgy
- API RP-1110	Pressure Testing of Liquid Petroleum Pipeline
- ASME-B31.1	Power Piping
- ASME-B31.2	
- ASME-B31.3	Process Piping
- ASME-B31.4	
- ASME-B31.5	
- ASME-B31.8	
- ASME-B31.9	
- ASME-Section VIII	Rules for Construction for Pressure Vessels
-	

PRESSURE VESSEL - (SATIP-D-001-01)

Document Review

- Safety Instruction Sheet (SIS)
- Procedure – Vessels Internal Component Installation

Material Receiving

- NMR's Vessels and Trays
- Visual Inspection
 - o External Inspection
 - o Internal Inspection
- Ladders, platforms and other Structural Steel Attachment
- Storage, Handling and Preservation
- Verification and Visual Inspection of vendor supplied electrical and instrumentation materials

Installation

- Pre-installation Inspection
- Equipment Installation
 - o Alignment and elevation survey (vertical & horizontal vessels)
- Inspection of Vessel Trim
- Inspection of Tray & Component installation
- Tray Testing
- Flange Joint, Gasket Verification and Bolt Tightening
- Final Inspection / Punch Listing for Re-instatement (by Contractor)

CENTRIFUGAL PUMPS - (SATIP-G-005-01)

Document Review

- Material & Equipment Storage, Handling & Preservation Procedure

Material Receiving

- Equipment Verification & Visual Inspection of Centrifugal Pumps
- Equipment Handling and Preservation Procedures

Installation

- Equipment Support Structure or Foundation (Pre-Installation Inspection)
- Mounting Plate (Base Plate & Sole Plate)
- Inspection of Auxiliary Piping Installation
- Pump Suction & Discharge Piping Connection
- Flange Joint, Gasket Verification and Bolt Tightening
- Final Pump / Driver Alignment
- Final Inspection / Walk-Through (by Contractor)

Pre-commissioning

- Final Pump/Driver Alignment
- Final Inspection/walkthrough (by contractor)

STRUCTURAL STEEL - (SATIP-M-001-01)

Document Review

- Procedure for Tightening of High Strength Bolted Connections
- Procedure for localized heating for warpage repair
- Procedure for Steel pile driving
- Procedure for structural welding

Material Receiving

- Structural Steel Shapes and Plates
- Bolts, Nuts and Washers
- Fabricated Steel Structures
- Storage, Handling & Preservation

Installation

- Inspection of Support Foundation prior to Structural or Equipment Installation
- Structural Alignment prior to Grouting
- Final Bolt Tightening Inspection and Testing
- Inspect Access Structure Installation

Pre-commissioning

- Structural Re-instatement / Final Punch Listing

Type of Bolt Joint

- Snug Tight
- Pre-tensioned
- Slip Critical

Methods of Bolt Tightening

- Turn-Off-Nut
- Twist-Off-Bolt
- Direct Tension Indicator (DTI)
- Calibrated Wrench

STEEL STRUCTURE BOLT TIGHTENING / PRE-TENSIONING PROCEDURE

1. In erection of steel structure, fastening materials such as bolts, nuts and washers shall be in accordance with ASTM A325, ASTM A 563, ASTM F436 and other applicable Code and Standard for primary connections.
2. Fastening materials for secondary connections shall be ASTM A307.
3. Fastening materials shall not be reused without prior approval.
4. Mill Certificates shall be verified as per ASTM Specifications.
5. Identify the conditions of connected plies, faying surfaces, bolt holes, burrs, and washer as per 12-SAMSS-008.
6. Check the fastening materials as per approved contract drawings and specifications.
7. All joint surfaces, including those adjacent to the bolt heads, nuts and washers shall be free of burrs, dirt and other foreign materials that would prevent solid seating of parts. (PIP STS05130 & 12-SAMSS-008).
8. Fasteners shall be inserted and aligned in the bolt hole and care to prevent undue damage of the thread joints.
9. Bolt assembly shall be brought to snug tight condition to ensure that it has a firm contact with the faying surfaces.
10. Bolt shall be tightened in sequence and systematic starting from the most rigid part of the joint to the free edges to minimized relaxation of the previously pre-tensioned bolts.
11. If impact wrenches to be used, it shall be of adequate capacity, sufficient supply of air to perform the required tightening.
12. All nuts shall be wax-dipped so as to reduce the friction during the installations.
13. Fasteners that are pre-tensioned and ready for inspection shall be color coded, die punch or otherwise mark the ends of the torque bolts.
14. Bolts shall have full thread engagement or penetration with the nut. The bolt length used shall be such that the end of the bolt extends beyond or at least flush with outer face of the nut.
15. If Calibrated wrench to be used, it shall be calibrated in a daily basis.

SKIDMORE WILHELM TENSION CALIBRATOR

1. Use to perform the rotational capacity test
2. Suitability of the fastener assembly to satisfy the requirements
3. Calibration of the wrenches if applicable
4. Understanding and proper use by the bolting crew of the method of tensioning

5. For bolts that are too long to fit in the Skidmore Wilhelm calibrator, the bolt, nut and washer assembly shall be assembled in the unit.
6. For bolt that are too short to test in the Skidmore Wilhelm Calibrator may tested in a steel joint. The maximum torque requirements, $Torque \leq 0.25 PD$
 $Torque = \text{measured torque (foot-pounds)}$
 $P = \text{measured bolt tension, 1.15 times the fastener tension in the table (pounds)}$
 $D = \text{bolt diameter (feet)}$

HOW SKIDMORE WILHELM TENSION CALIBRATOR WORKS

Is a hydraulic device that is designed for calibrating impact wrenches (and other types of installation tools) and testing shorter grip-length, high-strength fasteners. Each calibrator is a hydraulic load cell with a hole in the center for inserting a sample bolt, nut, and washer. As the bolt and nut are tightened, they compress the load cell, creating internal hydraulic pressure. A gauge measures the pressure and provide a dial readout calibrated in kilograms/pounds equivalent to the torque created in the fastener.

BASIC CALIBRATION SET-UP

1. Clamp the calibrator on a convenient beam or column using the two wing screws. Do not over tighten. Excessive force can damage the body.
2. Select a sample bolt for the wrench calibration test. Attached plate (item 5) appropriately sized for the bolt to the front of the calibrator using four cap screws (item 16). Anytime you change to a different size bolt for the test, you will need to change the plate as well.
3. Insert the bolt bushing (item 6), either round or hexagonal head, into the back of calibrator. The bushing fits over the back of two dowel pins and is held in place with the bushing retainer (item 15).
4. Insert the bolt from the back of the calibrator so that it fits into the bushing. From the front side of the calibrator, first place a hardened washer over the bolt, then tighten the nut so it is snug against the plate. The hardened washer prevent the nut from galling the plate.
5. The bolt can be tightened with an impact wrench, hand torque wrench, or other installation tool.

CALIBRATED WRENCH PRETENSIONING METHOD

Calibrated wrench maybe used to achieve minimum bolt tension provided the wrenches are checked in daily basis in a tension measuring device for consistent tightening performance. Furthermore, a hardened washer must be used under the part of the fastener that turns during tightening.

Procedure:

1. Insert the bolt, hardened washer & nut as described in the basic calibration set-up.
2. Tighten the nut with the wrench to be calibrated.
3. Adjust the torque control mechanism or the air pressure or down so that the reading on the calibrator dial is at least 5% greater than the minimum tension required for the sized of the fastener. Minimum fastener tension requirements for A325 and A490 fasteners as specified by the Research Council on Structural Connections are printed on the gauge dial.

ALTERNATIVE DESIGN BOLT (TENSION-CONTROL BOLTS)

Tension control bolts are fasteners that undergo a physical change at installation such as the shearing off of a splined end. Although this bolts may require special installation tools, they can be tested in the calibrator in the same manner as standard. Some tension control bolts have a round head instead of a hexagonal head. Special adapters are available from the factory for these bolts. Testing sample bolts will ensure that the installation tools and fasteners are performing to their manufacturers specs.

Procedure:

1. Install the special bushing available from the skidmore-Wilhelm for use with tension-control bolts. Use the same plate you would use for regular hexagonal bolts. Also install any special hardened flat washer used in the actual joint.
2. Tighten the tension control bolt, according to the manufacturers installation procedures, until twist-off. The reading on the calibrator dial should be at least 5% greater than the minimum tensioned required.

DIRECT TENSION INDICATORS (DTI's)

Load indicating washer or DTI's can be used in the calibrator and check to see that they are performing properly. Special bushing that allow a socket to be placed on the nut are available for those bolts where the washer is placed under the bolt head. These bushings replace the normal bushings used to prevent bolt head rotation.

Procedure:

1. Install the bolt with the load indicating washer under the bolt head and any special hardened flat washer used in the actual joint, through the front plate. Installing the bolt from the front allows a feeler gauge to be used to check the washer.
2. From the back of the calibrator, install the nut onto the bolt along with any special hardened flat washers used in the actual joints.
3. Tighten the fastener assembly, according to the device manufacturer installation procedures, until the washer indicates the proper tension. Tightening the assembly will require two (2) wrenches, one wrench to tighten the nut from the back and the second wrench to prevent the bolt head from rotating.
4. Compare the tension reading on the calibrator gauge to the minimum tension required. The reading should be at least 5% greater.

TROUBLE SHOOTING SUGGESTIONS

1. If you are not satisfied with any test results (for example, if readings are widely scattered), check the following:
 - a. Make sure you are using hardened washer.
 - b. Make sure each bolt is properly marked A325 or A490.
 - c. Make sure that the bolts are not completely dry. On most bolts the rust preventive is sufficient lubrication. However, if bolt are completely dry there is a tendency for the tread to seize before the bolt gets up to tension. A small amount of oil on all bolts, both test and installation bolts, will correct this situation.
2. Use a new bolt, nut and washer for each test since used nuts and bolts give erratic calibration results. Also, the values marked on the gauge dial are minimum bolt tension as approved by the Research Council on Structural Connections and endorse by the AISC. It is recommended that the wrench be set to induce bolt tension **5% to 10%** in excess of these values.
3. Daily rechecks or wrench calibration should be made. This should be done at the job site using the same length of hose and connections that will be used on the job. In this way, calibrating conditions will be identical with the job conditions.

ADDITIONAL INSTRUCTIONS FOR TENSION CONTROL BOLTS

Typically, the bolts, nuts, and washer are packaged as a calibrated assembly, So testing must be in strict accordance with the manufacturer's specifications. Lubrication of the components is a key element of the specifications. Verify that correct lubrication has been used before testing. If bolts do not twist off according to specification, check the following:

1. Verify that the correct lubrication has been used.

2. Friction between the bolt head and the calibrator bushing should be great enough to prevent rotation of the bolt during tightening. If bolt turns, remove excessive oil or grease from the mating surface of the bushing.
3. If bolts are being tested above the AISC tension requirements, thicker plates may be needed. They are available from the factory. Refer to Bulletin 308-1 for more information.

Before starting pre-tensioning or torquing, inspector should check if the Torque Wrench has been calibrated as per SATR-M-2004. The calibration frequency, shall be in a daily basis. Torque Values are found in the Table Specification of Structural Joint Using ASTM A325 & ASTM F490 bolts.

Theoretical torque value (T_v) = $D_b \times T_t \times \text{Coef. of friction}$

Where:

T_v = calculated torque value

D_b = bolt diameter in ft.

T_t = tension value in the table in kips

Coefficient of friction = 0.20

1 kip = 1000 lbs

AIR COOLED HEAT EXCHANGER (Fin Fan Cooler) SATIP-E-007-01

Document Review

- Safety Instruction Sheet

Material Receiving

- Receiving Inspection & NMR
- Verification of Fin Fan Coolers
- Storage, Handling and Preservation
- Instrumentation & Motor – receiving inspection activities

Installation

- Pre-Installation / Foundation Support Confirmation
- Equipment Alignment Elevation Check
- Flange Joint, Gasket Verification & Bolt Tightening
- Inspection Component Assembly
- In-Situ Strength Testing of Fin Fan Coolers

Pre-Commissioning

- Equipment Closure Inspection / Internal Cleanliness Inspection
- Unit Reinstatement / Final Inspection

12-SAMSS-008 - Enlargement of bolt holes shall be done by **reaming or drilling** only. Flame cutting or burning are not allowed (PIP STS05130, para. 6.7.3)

SAIC-W-2068

Welding Inspection on Vessel Fabrication

Document required at welding station:

- All weld joint shall be marked for identification by a weld number & welder symbol and made with suitable weather proof marking material.
- The markings shall be placed in location such that they will be easily observed and remain visible for a time suitable for SAPID.

ROTATING EQUIPMENT ALIGNMENT:

Vertical Angular Mis-Alignment

- (+) Reading, add shim to FF
- (-) Reading, remove shim to BF

Horizontal Angular Mis-Alignment

- (-) Reading, move BF to the right
- (+) Reading, move BF to the left

Vertical Parallel Mis-Alignment

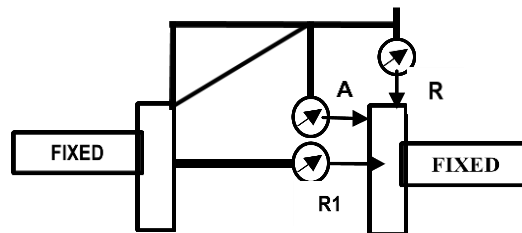
- (+) Reading, remove shim to all feet
- (-) Reading, add shim to all feet

Horizontal Parallel Mis-Alignment

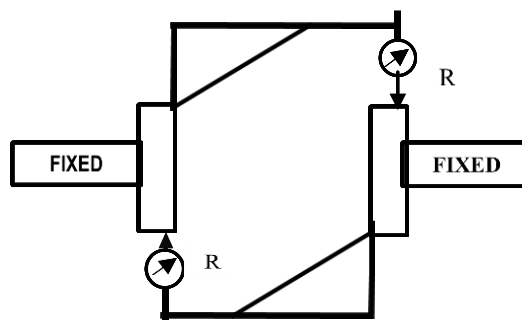
- (-) Reading, move all feet to the right
- (+) Reading, move all feet to the left

ALIGNMENT TYPES

1. Rim (Radial) and Face (Axial) Method
R= radial A= Axial



2. Reverse Rim (Dial) Indicator Method
R= radial



ALIGNMENT FIXTURES

1. Brackets – should be rigid to minimize sag
2. Dial Indicators – shall be calibrated
3. Wrenches

GENERAL REQUIREMENTS

1. Alignment bracket shall not be used to rotate the equipment.
2. Reading shall be at 90 degree increments in the horizontal and vertical plane.
3. Readings to be considered valid, the readings and zero shall repeat within 0.02mm (1mil). The algebraic sum of the horizontal readings shall be equal to the algebraic sum of the vertical reading within 0.05mm (2mils).
4. Reverse dial (rim) alignment shall be performed while turning both shaft at the same time in the direction of rotation.
5. Rim and face alignment is recommended when the coupling hub is greater than the spacing between indicators or one end of the train elements cannot be turn.
6. When the shaft cannot be rotated, micrometer measurement with an accuracy of 0.01mm (0.5mil) are to be used.

FINAL ALIGNMENT TOLERANCES

1. All piping is disconnected.
2. Fixed and movable shafts free to move.
3. Maximum five shims under any support.
4. Shim 300 series stainless steel or better material not laminated and flat to 1/1000. At least 3mm (0.125in) but not more than 12mm (0.5in) under movable machine foot. No more than one $\geq 3\text{mm}$ ($\geq 0.125\text{in}$) thick under any foot.
5. Shim are full bearing.
6. Bolts are not undercut.
7. Washer are not lock washer and do not yet yield when hold-down bolt are tightened.
8. Hold-down bolts are not bolt bound and reasonably centered in bolt holes.
9. Soft-foot is not more than 0.05mm (0.002in)
10. Pipe Strain checks made in accordance with procedure in Chapter 6-Piping; section 4 par. 1.8.1 through 1.8.5. API 686/REIE 686

ALIGNMENT PROCEDURE

1. Indicate and Record Rim (Radial) Reading @ 6:00 O'clock
2. Indicate and Record Face (Angular) Reading @ 6:00 O'clock
3. Use Formula to compute the shim
 - + sign means shaft is low so add shim
 - sign means shaft is high so remove shim

Formula: $S1 = \pm R/2 + \pm F \times B / A \quad \rightarrow \quad S1 = B/A \times F + R/2$

$S2 = \pm R/2 + \pm F \times C / A \quad \rightarrow \quad S2 = C/A \times F + R/2$

Where:

S1 = shim needed under Front foot

S2 = shim needed under Rear foot

R = rim reading at the bottom

F = face reading at the bottom

4. Install or Remove Shim as required
5. Repeat 1 & 2 as needed. If reading is within tolerance the alignment is satisfactory

CLEANING (SEAS-L-350)

1. During project proposal and detailed design, detailed procedures for cleaning and flushing of the piping spool and systems shall be established identifying acceptable methods.
 - a. All pipes shall be internally cleaned by air blowing prior to installation.

- b. Chemical or Vapor or Foam Cleaning after hydrostatic pressure testing to remove oil, grease, preservatives, rust and mill scale per approved procedures. (refer to 01-SAMSS-017, SAES-G-116 and SAEP-1024).
2. Pressure Testing of the piping systems shall be in accordance with SAES-A-004 and SAES-L-150.
3. Lay Up Requirements after cleaning and pressure testing has been completed shall be in accordance with SAES-A-007.
4. All piping systems shall be flushed using high pressure (60.8mPa/8.8ksi) jet such as rotating hose or rotating nozzle.
5. Below 4" use High Velocity Water Flushing (HVWF) with a minimum of 3m/s velocity. Flushing medium shall be plant/process water or raw water.
6. When flushing stainless steel lines, the chloride ion content shall be less than 50mg/l. After flushing it should be completely drain, dried to a dew point below 1°C and protect against corrosion.
7. Pneumatic Flushing with dry air (dew point - 1°C or less) or steam with a minimum exit velocity of 15m/s.
8. Pressurized Air Shock Blowing (PASB) for initial cleaning for instrument air, plant air and as an alternative method cleaning method for initial cleaning of small bore pipe (less than 2 inch), working pressure shall never be more than 810 kPa (115 psi).
9. Alignment of flange joints with spectacle plate is within the following tolerances:
 - a. Vertical bolt hole offset $\pm (2.4\text{mm} + 30\%) = \pm 3.12\text{mm}$.
 - b. Horizontal bolt hole offset $\pm (2.4\text{mm} + 30\%) = \pm 3.12\text{mm}$.
 - c. Rotational offset $\pm (2.4\text{mm} + 30\%) = \pm 3.12\text{mm}$.
 - d. Combination of vertical, horizontal and rotational offset $\pm 3.12\text{mm}$.

WELDING – ASME SEC.IX

- **A weld** – is a union of materials produced by heat and or pressure
- **A joint** – is a configuration of members

Types of Common Welds

1. Butt weld
2. Fillet weld
3. Spot weld
4. Seam weld
5. Edge weld

Types of Common Joints

1. Butt joints
2. Tee joints
3. Lap joints
4. Open corner joints
5. Close corner joints

Weld Preparation

1. Single bevel butt weld
2. Single vee butt weld
3. Single J butt weld
4. Single U butt weld
5. Double bevel butt weld
6. Double vee butt weld

Normally made on thinner materials when access from both sides are restricted

Normally made on thicker materials when access from both sides are unrestricted

7. Double J butt weld
8. Double U butt weld

5 Acceptable Heat Treatment of Process Piping

1. Enclosed furnace
2. Local flame heating
3. Electric resistance
4. Electric induction
5. Exothermic chemical reaction

DUTIES AND RESPONSIBILITIES OF A WELDING INSPECTOR

The duties and responsibilities of a welding inspectors are to ensure that all operations concerning or related to welding are carried out in strict compliance with written, agreed practices or specifications.

This includes monitoring and checking a number of welding operations and its associated actions as per the following stages:

A. BEFORE WELDING

The welding inspector has to ensure that all operations are carried out in complete compliance with local, company, or National safety legislations (i.e. permits to work are in place).

A.1 Before Fit-up

A.1.1 The welding inspector has to check, review and verify;

1. Applicable code, standard or specification to be implemented on the job is up-to-date with the latest revision or amendment.
2. Correct fabrication or construction drawings to be issued and its revisions have been approved and the issuance number is marked.
3. Procedures like Welding Procedure Specifications, Procedure Qualification Records, Weld Repair Procedure, Non Destructive Test (NDT) Procedure, etc. have been approved and are employed during the fabrication, construction or production process.
4. Documents pertaining to the raw materials and consumables like Material Test Certificates (MTC), Material Traceability Record, etc. are available and in conformance with the applicable code and standards.
5. List of equipments and other devices to be used were calibrated and calibration certificate has been provided so with calibration stickers or labels attached to it.
6. List of qualified welders according to the process they are qualified are available. Approved welders/welding operators are provided with their identification card or I.D.
7. The welding inspector has to check and verify the welding materials and consumables shall have proper storage or housekeeping according to their types and classifications.

A.2 After Fit-up

A.2.1 The welding inspector has to check and verify;

1. Joints to be welded shall meet the requirement of the approved Welding Procedure Specifications (WPS) e.g. shapes and dimensions of the weld preparation as specified, fusion faces and adjacent surfaces are cleaned. Parts to be joined are fixed in relation to each other.
2. Pre-heating if required is in accordance with the specified and approved preheating procedure.

B. DURING WELDING

The welding inspector has to check, monitor and record the voltage, amperage and travel speed for each run of weld in order to control the heat inputs on the weld joint. Once the root bead is finished, he has to inspect the root penetration for possible imperfections or defects that may occur. He has to check that the surface of each run of weld is cleaned and particular attention to be paid off to the junctions between the weld metal and the fusion face. If imperfections are observed, it shall be reported so that remedial actions shall be taken before the deposition of further weld metal. He has to check that the transition between the runs and between the weld and the parent metal has such a shape that satisfactory melting can be accomplished when welding the next run.

C. AFTER WELDING

The welding inspector has to check the cleaning of the finished weld e.g. all slag has been removed by manual or mechanical means to avoid imperfections being obscured. He has to check the profile of the weld face and the height of any excess weld or dimensions shall meet the requirement of the acceptance standards, the blending of the toe with the parent metal and the proper merging of the inter-runs. If a defect is detected, it shall be reported to the concerned personnel to go with the repairs in accordance with the approved Weld Repair Procedure. Area of defect shall be marked-out positively and clearly and full removal should be monitored with visual inspection and the applicable Non Destructive Test (NDT) process. Once the re-welding is finished, the welding inspector has to re-examine the weld with the applicable Non Destructive Test (NDT) process for further verification. If Post Weld Heat Treatment (PWHT) is required, it should be monitored and recorded.

MAIN RESPONSIBILITIES OF A WELDING INSPECTOR

The main responsibilities of a welding inspector are;

1. **TO OBSERVE** all relevant actions related to weld quality throughout the production. This will include a final visual inspection of the weld area.
2. **TO RECORD**, or log all production inspection points relevant to quality, including a final map and report sheet showing all identified welding imperfections.
3. **TO COMPARE** all reported information with the acceptance levels/criteria and clauses within the applied application standard.

Generally, the welding inspector has to make a final inspection report which is signed off along with the updated as-built drawing or weld maps and to be submitted to the concerned Quality Assurance/Quality Control (QA/QC) personnel or higher authority for record analysis and for any remedial actions.

VISUAL INSPECTION

At any time point in the course of welding, i.e. tacking, root pass, filler pass or capping, but particular for the root and cap, a detailed inspection may be required. British Standard 5289: 1976 gives guidance to tools and responsibilities together with sketches of typical defects.

The inspector at this point must –

1. Observe, identify and perhaps record (measure) the features of the weld.
2. Decide whether the weld is acceptable in terms of the particular levels that are permitted; defects levels may be in-house or national codes of practice. When the defect size is in excess of the permitted level then either a concession must be applied for (from a competent person) or the weld rejected.

AIDS OF VISUAL INSPECTION

4. Illumination: Good lighting is essential
5. Inspection Lenses: The magnification should not exceed 2-2.5 diameters. If higher magnification is required use a binocular microscope. Optical viewing can progressively develop from eyesight, to use a hand torch and mirror, to the addition of a magnifier and light source.

In order to achieve accessibility, remote probe units are available which must have the following properties:

1. Large field of vision
2. Freedom from distortion of image
3. Accurate preservation of colour values
4. Adequacy of illumination

CODE OF PRACTICE

A code of practice for an inspection department should take from outlined below. It is appreciated that full implementation of the code would be extremely costly and therefore it may be necessary to reduce the amount of inspection to less than is theoretically required.

The inspector should be familiar with the following:

1. All applicable documents
2. Workmanship standards
3. All phase of good workshop practice
4. Tools and measuring devices

INSPECTION BEFORE WELDING

Before Assembly:

Check:

1. All applicable documents
2. Quality plan is authorized and endorsed with signature, date and company stamp
3. The drawing are clear, the issue number is marked and the latest revision or amendment
4. Welder qualification with identification and the range of approval are verified and that only approved welders as required are employed in production.
5. Calibration Certificates, Material Certificates (mill sheets) and consumer certificates are available and valid

6. Parent material identification is verified against documentation and markings
7. Material composition, type and composition
8. Identification of welding consumables such as electrodes, filler wire, fluxes, shielding and backing gases and any special requirements (e.i. drying) are met.
9. Plant and equipment are in safe condition and adequate for the job
10. Safety permits e.g. hot works permit, gas free permit, enclosed space certificate are available and valid

After Assembly

Check:

1. Dimensions, tolerances, preparation, fit-up and alignment are in accordance with the approved drawings and standards
2. Tack welds, bridging pieces, clamping and type of backing – if any used are correct
3. Cleanliness of work area is maintained
4. Preheat in accordance with procedure

Note: Good inspection prior to welding can eliminate conditions that lead to the formation of defects.

INSPECTION DURING WELDING

Check:

1. The welding process must be monitored
2. Preheat and interpass temperatures must be monitored
3. Interpass cleaning – chipping, grinding, gouging must be monitored
4. Root and subsequent run sequence
5. Essential variables such as current, voltage, travel speed to be monitored
6. Filler metals, fluxes and shielding gases are correct
7. Welding is in compliance with the weld procedure sheet and application standard

INSPECTION AFTER WELDING

Check:

1. Visual inspection to be carried out to ascertain acceptability of appearance of welds
2. Dimensional accuracy to be ascertained
3. Conformity with drawing and standards requirements
4. Post weld heat treatment, if any, monitored and recorded
5. NDT carried out and reports assessed
6. Assess defects as to either repairing or application for concession
7. Carry out any necessary repairs
8. Control of distortion

REPAIRS

1. Repair procedure and welding code should be authorized
2. Defect area should be marked positively and clearly
3. Check when partially removed and fully removed (Visual and NDT)
4. Re-welding should be monitored
5. Re-inspect complete repair

QUALITY SYSTEMS

1. Describe the difference between QA & QC?

Answer: **Quality Control** is the operational techniques (Inspection, Examination & Testing) that are used to fulfill requirements for quality. **Quality Assurance** is the system of action and planning needed to provide confidence that a Product or Service will satisfy quality requirements

2. What do quality system audits evaluate?

Answer: The degree of quality system conformance to established requirements.

6. Saudi Aramco has adopted the basic framework and definitions of the International Quality System Standards **ISO-9000 Series**. This has been done to provide universal understanding and improve communication between the COMPANY and prospective CONTRACTORS whose Quality System is congruent with the ISO-**9000 Series**. Describe the basic elements of an ISO 9000 Series Quality Program?

Answer:

Quality Management & Quality Assurance Standards per **ISO-9000**

Quality Systems per **ISO-9001, 9002, 9003**

Quality Plan Guidelines per **ISO 10005**

4. What is an essential variable as related to a Welding Procedure Specification (WPS)?

Answer: A change in a welding condition that will affect the weld's mechanical properties.

5. What is the relationship between a Procedure Qualification Record (PQR) and a WPS?

Answer: The PQR documents what occurred during the welding and testing of the test coupon.

6. Heat input (SMAW per ASME IX) is a combination of what two electrical characteristics & travel speed?

Answer: Voltage and Amperage

7. Excessive heat input is mainly attributed to what poor welding techniques during SMAW process?

Answer: Excessively wide weaving and slow travel speed.

8. What are 3 potential sources of Hydrogen encountered during SMAW process?

Answer: Moisture in the metal and electrode coating, oil, elemental Hydrogen in the base metal

9. What are several likely causes of porosity in carbon steel welds using the SMAW process?

Answer: Poor welding technique and equipment, excessive wind, moisture & weld contaminants.

10. What dimension is measured to determine the size of a concave fillet weld?

Answer: Throat

12. What dimension is measured to determine the size of a convex fillet weld?

Answer: Leg

13. Where would cracking most likely occur from excessive current input in a single pass weld?

Answer: Centerline of the weld

14. Using GTAW process, describe what happens to a weld without proper purging/back gassing on SS material?

Answer: Oxidation at the ID (Sugaring)

15. Name 3 of the 5 mechanical tests in ASME IX employed for procedure & performance qualifications?

Answer: Tension, Guided Bend, Fillet-weld, Notch-toughness & Stud-weld tests
Mechanical/NDT (assume SMAW process used for all questions)

16. How is Magnetic Particle inspection of a weld using the wet continuous test method performed?
Answer: The particles (usually fluorescent) are sprayed, poured on or applied by immersion and the magnetizing current is applied while the particles are still flowing.
17. Indications with Liquid Penetrant Testing are easily seen if the surface has been prepared by grinding prior to testing? True/false? Why?
Answer: False, because grinding can smear metal and mask/cover discontinuities.
18. Name an NDT method and technique that employs a reflected sound beam that can be used for the volumetric examination of welds?
Answer: Ultrasonic Testing using Shear Wave Technique provides good volumetric exam coverage.
19. List 3 disadvantages of RT over other NDT Methods.
Answer: Radiation Safety Precautions, Planar defects not readily detectable, Heavy equipment
20. If a product is to be stress relieved, why is it important to use exactly the same RT procedure before and after stress relieving?
Answer: So that a baseline evaluation is performed to ensure that borderline indications are not misinterpreted after stress relief.
21. A dark narrow area 2-3mm wide appears on a radiograph all along the edge of the area representing the weld. The joint has a 60° double-vee groove. What is the indication most likely to be?
Answer: External Undercut
22. A localized darker density Radiographic image with fuzzy edges in the center of the width of the weld image that may or may not be wider than the width of the root pass image is most likely what?
Answer: Burn-through
23. Name 5 common film artifacts that may be cause for rejection of Radiographic Film?
Answer: Film Scratches, light leaks, chemical stains, fogged film, static marks, water marks, streaks, crimp marks, finger marks, lint, dirt
24. When the radiation source is located inside piping with the film located outside, single-wall exposure and single-wall view, name this type of exposure?
Answer: Panoramic
25. How do gamma rays compare with X-rays when applied to RT of welds?
Answer: Gamma rays have greater penetration ability, but give poorer contrast.
26. Per ASME B31.3 (assume latest edition), name three of the four Categories of Fluid Service?
Answer: Categories D, M, High Pressure & Normal
27. Per ASME B31.3, who is responsible for classification of service to a given category?
Answer: The Owner
28. Per ASME B31.3 (assume latest edition), what are the RT requirements for Socket welds in severe cycle service?
Answer: None
29. Relating to the above question, Give good reasons why random RT of socket welds is recommended?
Answer: Both gross welding defects & poor quality welders can be identified, with repairs and corrective action taken, & Gap can be verified.
30. Briefly describe good QC practice relating to the installation & bolting of flanges?
Answer: Verify Materials (type, size and rating) are acceptable, gasket verification & good bolting practices (torque value requirements met) in accordance with approved procedures.
31. What is an often-overlooked Inspection/NDT requirement on the installation of an orifice flange?
Answer: Visual weld inspection of the seal weld & NDT has been missed prior to bolting of flanges
32. Per ASME Section VIII, Div. 1, can a nozzle to be attached to the exterior surface of a pressure vessel without any portion of the nozzle projecting into the shell?
Answer: Yes, with many restrictions
33. Explain the difference between a 2:1 Ellipsoidal head and a hemispherical head?
Answer: A hemispherical head has no flange and knuckle region and holds greater volume.
34. Which of the above two heads given equal thickness can withstand greater internal pressure?
Answer: The 2:1 elliptical head can withstand much more internal pressure given equal thickness.
35. In ASME Section VIII, Division 1, Parts UW and UCS cover what scope of work?
Answer: UW designates requirements for pressure vessels and vessel parts fabricated by welding, and UCS designates requirements for pressure vessels and vessel parts constructed of carbon and low alloy steels.

36. Name several Inspection items on internal component/tray installation for new columns?
Answer: Drawings, Calcs & Data review
 Verification of Material Construction of Internal components (tray assemblies & systems, hardware, packing medium)
 Location, levelness and orientation of internal components per Mfg. Drawings/tolerances.
 Seams, holes, gaps, missing items, looseness of hardware in trays
 Leakage Tests as needed for trays, troughs, weirs, etc.
 Final Cleanliness of Tray Assemblies
37. What API documents apply to the replacement of an existing floor for an Aboveground Oil Storage tank?
Answer: API 653 & API 650
38. What are two key items to be resolved prior to addition of new nozzles to older tanks per API 653?
Answer: Tank Material identification, Material Design Considerations & selection (need for shell insert).
39. Briefly describe an area impressed Cathodic Protection System?
Answer: Electrical current & use of selectively placed sacrificial anodes is employed to stop/slow the electrochemical reaction that occurs during the corrosion process.
40. Relating to Contractor Weld Shop evaluation prior to the beginning of pipe welding for a major project, what are several key items you would look for as the Inspector assigned to approve the shop for Company?
Answer: 5M + E formula = Manpower, Methods, Materials, Machines, Measurement & Environment
1. **Manpower** = Ensure adequate Personnel that are trained, qualified, certified & approved
 2. **Methods** = Ensure that standards are followed and that welding procedures, special processes (PMI, PWHT, etc) are acceptable and that there is a good quality system (paper trail) in place.
 3. **Materials** = Ensure Materials are approved, certified, documented (traceable), stored correctly with area for deficient items (quarantined), and segregation of dissimilar metals.
 4. **Machines** = Ensure Equipment is adequate for the intended work and in good working condition.
 5. **Measurement** = Ensure Contractor QC Program & testing/calibration program is in place for equipment and work.
 6. **Environment** = Ensure that the working environment (building) is safe, sheltered from the elements and adequate to ensure quality work.
41. Briefly describe good QC practice relating to the installation & bolting of flanges?
Answer: Verify Materials (type, size and rating) are acceptable, gasket verification & good bolting practices (torque value requirements met) in accordance with approved procedures.
42. Name several Inspection items on internal component/tray installation for new columns?
Answer: Drawings, Calcs & Data review
 Verification of Material Construction of Internal components (tray assemblies & systems, hardware, packing medium)
 Location, levelness and orientation of internal components per Mfg. Drawings/tolerances.
 Seams, holes, gaps, missing items, looseness of hardware in trays
 Leakage Tests as needed for trays, troughs, weirs, etc.
 Final Cleanliness of Tray Assemblies

GENERAL INFORMATION

1. What is an Inspection & Test Plan (SATIP)?

Answer: It is a mandatory item in the Quality Plan to guide and assure quality in a specific type of work in and a sequence of QC activity. A SATIP is a Saudi Aramco Test & Inspection Plan indexed of inspection activity using SAIC.

2. What is meant by QA/QC?

QA – system of action and planning needed to provide confidence that a product or services will satisfy quality requirements.

QC – is the operational techniques (Inspection, Examination & Testing) that are used to fulfill quality requirements.

3. What are the three types of Bolt Joints?

Answer: 1. Snug Tight 2. Pre-Tensioned 3. Slip Critical

4. State the procedure in bolt pre-tensioning?

1. In erection of steel structure, fastening materials such as bolts, nuts and washers shall be in accordance with ASTM A325, ASTM F436 and other applicable Code and Standard for primary connections.

2. Fastening materials for secondary connections shall be ASTM A307.
3. Fastening materials shall not be reused without prior approval.
4. Mill Certificates shall be verified as per ASTM Specifications.
5. Identify the conditions of connected plies, faying surfaces, bolt holes, burrs, and washer as per 12-SAMSS-008.
6. Check the fastening materials as per approved contract drawings and specifications.
7. All joint surfaces, including those adjacent to the bolt heads, nuts and washers shall be free of burrs, dirt and other foreign materials that would prevent solid seating of parts. (PIP STS05130 & 12-SAMSS-008).
8. Fasteners shall be inserted and aligned in the bolt hole and care to prevent undue damage of the thread joints.
9. Bolt assembly shall be brought to snug tight condition to ensure that it has a firm contact with the faying surfaces.
10. Bolt shall be tightened in sequence and systematic starting from the most rigid part of the joint to the free edges to minimized relaxation of the previously pre-tensioned bolts.
11. If impact wrenches to be used, it shall be of adequate capacity, sufficient supply of air to perform the required tightening.
12. All nuts shall be wax-dipped so as to reduce the friction during the installations and torquing.
13. Fasteners that are pre-tensioned and ready for inspection shall be color coded.
14. Bolts shall have full thread engagement or penetration with the nut. The bolt length used shall be such that the end of the bolt extends beyond or at least flush with outer face of the nut.
15. If Calibrated wrench to be used, it shall be calibrated in a daily basis.

5. What is PIP?

Answer: PIP means Process Industry Practice that deals with a common Industry Practices regarding manufacturing, installations, constructions, erections, and etc.

6. What is the maximum segment of the piperack to allow for structural steel thermal expansion?

Answer: 42.5 meters (140 ft.)

7. What is the Saudi Aramco Engineering Standard used in grouting of Steel Structure and Equipment?

Answer: SAES-Q-010

8. What is the Saudi Aramco Engineering Standard used in the Structural Design Criteria for Non-Building Structures?

Answer: SAES-M-001

9. Discuss how Tension Calibrator Works?

Answer: Is a hydraulic device that indicates the pretension that is develop in a bolt that is installed in it. By tightening the fastener, the calibrator induces a pressure that is transmitted to the hydraulic fluid which is also connected to the pressure gauge. The gauge gives a reading equivalent to the fastener tension in kilograms or in pounds. Also it will check if your torque wrench has been calibrated properly.

10. What is Snug Tight?

Answer: Is a condition where a faying surface has a firm contact with the application of few impacts of the impact wrench or with the full effort of an iron worker using an ordinary spud wrench.

What Saudi Aramco "Letter codes" are applicable for different types of equipment installations & where are the code references found?

- Vessels (C&D) ASME VIII
- Exchangers (E-004) API 660
- Air Coolers (E-007) API 661 (Coolers)
- Pumps (Centrifugal-G-005) API (610, 682)
- Pumps (Positive Displacement-Injection-G-006) (Antifoam Injection Pump)
- Compressors (Centrifugal-K-402) API (617)

- Compressors ([Reciprocating-K-403](#)) API (618, 680)
- Boilers - [ASME I & ASME B31.1](#) for piping portions
- Turbines ([K501, 502](#)) – None on our project
- Mixers ([G-005, K503](#)) Antifoam Tank Mixer
- Fired Heaters ([F-001](#)) Furnaces and Burners, Comb Chambers, Thermal Oxidizer API 560
- Air Blowers-Procedures needed for installation
- Flares & Stacks ([F-007](#)) Procedures needed from vendor for installation - API 521, API 526, AWS D1.1, ASME IX
- Cooling Towers

ITP→QCP/FIP→Referenced Std/Specs→ Code references, Candidate must know how to follow the path to the correct code for each item.

What documents will control the erection sequence and control work activities in accordance with Schedule Q and the approved Quality Procedure?

MATERIAL INSPECTION

Internals and Hardware

Match physical condition in field to service condition shown on Drawings/Hardware lists

- How do you verify (name several items to check) that correct material is used? Specification and marking/color-coding and Positive Material Identification.
- How do you identify grade of material and hardware by markings? ASTM spec listed on dwg/bolting list will give clear requirements.
- How do you identify fittings and flanges? Correct ratings, sizes, class, schedules as marked on fittings & mill certs
- How do you check piping for the correct schedule? Use a Vernier Caliper and ensure piping is within tolerances.
- What are the tolerances for physical straightness and defects?
- What is the standard mill tolerance for piping? [87-1/2% \(all\) to 115% \(greater than 2"\)](#), [120% \(2" & less\) of nominal pipe thickness](#).

OVALITY OF SECTIONS CONSTRUCTED

1. What is the tolerance for ovality of piping? [1%](#).

Example: 24" piping is 610mm. One joint can be 610 x 610 (oval), another can be 604 x 616 ([1% out & within tolerance](#)).

When matched for fitting, how will internal alignment of piping meet [1.5mm tolerance in SAES-W-011](#)? Crescent technique for repairing ovality is required (method statement). Crescent is (2) 12mm crescent shaped plates separated by steel bar center that distributes load and bearing force and increases efficiency, doubles production by and reduces potential damage to piping. [Jacking limits \(30 ton maximum for CS, 20 ton for SS\) to 25mm max](#). Cold bending and forming repairs including rolling thick repads require a method statement and must conform to [ASME B31.3](#). Hammering on steel is not allowed and evidence of hammer marks is cause for rejection and removal of affected item.

Flanged Joints (SAES-L-050, PIPs PNSC series, Checklists, PFI-ES-3)

1. What are the different types of mating flanges? [There are 4 most common RF, RFSO, RTJ, and FF](#).
2. Describe good inspection practice during gasket installation? List common problems associated with poor practice.

GASKET INSTALLATION CHECKLIST (APPROVED) DETAILED DISCUSSION TO FOLLOW.

1. What is the requirement for bolting and torqueing flanges at SA? [SAES-L-050](#), Tables and applicable procedure
2. What is a friction factor?
3. What is the difference between torqueing CS and SS bolting? Yield strength is greater in Carbon and torque values are greater
4. Does the use of galvanized bolts require any special torqueing consideration, or can the CS bolt torqueing values be used?
5. What is a spectacle plate? Mandatory SA Std dwg with plate used for service and shutdown (isolation) for maintenance purposes.
6. What are jackscrews and when are they required? They are located at flanged connections To facilitate maintenance and removal of spectacle and orifice plates to facilitate maintenance
7. What is often overlooked during orifice flange fabrication? Grinding butt welds flush and seal welding orifice.
8. What NDT methods are required during orifice flange installations? Visual and PT/MT
9. Flange tolerances during construction are found where? [SAES-L-050 & PFI-ES-3](#).

1. Describe how flanges can be misaligned in different directions? Rotational offset & hole misalignment misaligned vertically & horizontally.
2. What is cold spring? Application of mechanical stress (bending twisting pulling) upon a piping segment to achieve bolting and connection to another segment. Is cold spring acceptable? No
3. How can an inspector determine if cold spring exists visually on a flanged section of piping? Visual determination is easy. Close inspection of flanged connection and any visible deformation, especially in small diameter sections.
4. When a flange connects to a pump or other equipment, is there any special tolerance involved? Yes, Mfg tolerance.

THREADED JOINTS (SAES-L-010, PIPs, Checklists)

1. What care must be exercised to avoid deep cuts in threaded piping installation?
[Use strap wrenches or coverings](#) during tightening.
2. What is the maximum diameter piping allowed in hazardous service? [1-1/2"](#)
3. What is the minimum sized piping that can be installed on pipe racks? [1" \(AB-036207-Pipe spacing\)](#)
4. What is the required thread engagement for piping at SA and where can it be found?
5. What is the requirement for seal welding at SA? [SAES-L-010 and specifications](#).
6. Can Teflon tape be used prior to seal welding? [No](#)
7. How many threads can be visible after seal welding threaded joints? [Zero, seal welding must cover all threads.](#)

SOCKET JOINTS (SAES-L-010, PIPs, Checklists)

1. What is the gap requirement for socket welds for new construction? [1.5mm to 3mm gap prior to welding.](#)
2. What is the best way to assure consistent gap is maintained? [Use of gap-o-let rings](#)
3. What is the minimum fillet weld size for a socket welded connection? [1-1/4t but not less than 3.2mm.](#)
4. What are common failures in the quality system during fit up that leads to hydrotest failures?
[Failure to properly clean, deburr and degrease fittings and piping prior to welding. Oil residue from cutting causes weld porosity and leakage during hydro tests.](#)

SPECIALTY ITEMS

- Seal Welding
- Leak tests
- Vacuum Box tests
- Functionality Tests

- Preservation Monitoring (Construction)
- Preservation Planning (Construction)
- B-standard Compliance (Construction)
- Pre-Commissioning (-----a complete list of QC coverage on activities is to be established by TPSA-----Visual Inspections, Chem cleaning, flushing, Functionality Tests of Equipment, Engineering Forms, Documentation, Lay-up & Preservation, Noise Control, B-standard Compliance)

GENERAL MECHANICAL EXAMINATION

1. What is NACE MR0175?

Ans. National Association of Corrosion Engineers

NACE MR0175: Standard Material Requirement-Sulfide stress cracking resistant metallic material for oilfield equipment.

2. What is the meaning of CSD?

Ans. Consulting Services Department

3. What is RTR?

Ans. Reinforce Thermosetting Resin

4. What is AWWA?

Ans. American Water Works Association

5. AWS D1.1 structural, don't need to qualify for WPS? (True or false)

Ans. False

6. What is the vision of an inspector?

Ans. Jaeger 1

7. What electrode used for overhead position?

Ans. 6010,

8. Does the 6010 can apply over the 7018 vertical position?

Ans. No

9. Stud welding is based on AWS D1.1? (True or false)

Ans. True

10. Lack of fusion can detect by?

Ans. Ultrasonic Test (UT)

11. Which one will be a shielding?

Ans. Flux

12. What is the purpose of shielding?

Ans. To prevent atmospheric contamination during welding

13. What is the Carbon Equivalent? Why it is important?

Ans. To determine the material capabilities

14. How to measure raised faced finish?

Ans. Surface comparator gauge

15. What is thermal expansion?

Ans. The increase of material due to increase of temperature

16. PWHT is required to apply on 1" thickness? (True or false)

Ans. True

17. In overhead position, what kind of electrode is acceptable?

Ans. 6010

18. What other American code required for testing pipeline and welder qualification?

Ans. ASME IX (Welding & Brazing Qualification)

19. Is hardness test, can be use to determine tensile strength?

Ans. No

20. Preheat is needed in tack welding in thick materials?

Ans. Yes

21. What are the types of joint?

Ans. Butt, lap, tee, corner, edge

22. Which is harder, steel containing 0.1% or 0.5% carbon?

Ans. 0.5% carbon

23. What grooves use for SAW process? When to use this preparation(groove)?

Ans. U, V & Square grooves

24. What is GMAW mode of transfer?

Ans. Globular, spray, pulse , short circuiting

25. Type of RTR joints?

Ans. Bell & spigot, socket, flange joint

26. Basic instrument use to measure preheat temperature?

Ans. Temperature indicating crayon (Tempil stick), contact pyrometer

27. Circumferential seam, weld first than longitudinal seam? (True or false)

Ans. False

28. Is 6010 electrode design to apply to 7018 electrode on vertical position? (True or false)

Ans. False

29. How to repair too close root gap?

Ans. By means of grinding

30. What you will do if you found welder doing wrong?

Ans. ask the welding foreman

31. What American standard for structural welding?

Ans. AWS D1.1

32. Why 316L has low carbon content in stainless steel?

Ans. L- is represent low carbon content

33. What is a good attitude of an inspector?

Ans. Quality minded. knowledgeable, experience, impartial, informed etc.

34. Type of joint category?
[Ans.](#) Category A, B, C, D base on UW 3, table UW 13
35. Hardness test is one requirement of NACE MR0175, what the other requirements?
[Ans.](#) Nickel content shall be less than 1%
36. Ferromagnetic materials can be detected by?
[Ans.](#) (MT) Magnetic Particle Test
37. Code of quality inspection standard?
[Ans.](#) ISO
38. Difference between DCRP(Direct Current Reverse Polarity) & DCEP (Direct Current Electro Positive)?
[Ans.](#) No difference
39. What is ASME sec. V?
[Ans.](#) Non-Destructive Examination (NDE)
40. Where to apply preheat?
[Ans.](#) On weld joint plus 50mm both side of the joint
41. Where to measure preheat?
[Ans.](#) at both side of the joint (parent metal)
42. For non-magnetic materials, what kind of NDT to be used?
[Ans.](#) Penetrant Test (PT)
43. Give two kinds of material that direct current (DC) welding machine can be used?
[Ans.](#) P1, P5 materials
44. Describe 3G position?
[Ans.](#) Vertical position
45. Radiographic test is the most effective to detect lack of sidewall fusion? (True or false)
[Ans.](#) False, UT is the most
46. Why preheat is needed for alloy materials?
[Ans.](#) To avoid cracking
47. What 5G position in ASME sec IX is qualified?
[Ans.](#) Flat, overhead, vertical position
48. What filler metal to be used on 304 to SA 516 GR70 material first layer?
[Ans.](#) ER309L
49. What P number for SA 516 GR70?
[Ans.](#) P1
50. As an inspector, do you reject if the NDE results have a discontinuity?
[Ans.](#) No
51. In 10'0"circumferential, how much @ 45 degree?
[Ans.](#) 1 ¼ feet

52. Lamination defect can detect by?

Ans. Ultrasonic Test (UT)

53. How many minutes in 1 degree?

Ans. 60 minutes

54. What 6G position?

Ans. All position

55. What is the minimum tensile strength of 7018 electrode?

Ans. 70,000 psi

56. What is MILS?

Ans. Thousand of an inch

57. Give at least 3 essential variables of WPS?

Ans. Electrode, preheat, volt/amp, position, base metal

58. What is WPS?

Ans. Welding Procedure Specification- a prepared welding procedure which serve as guidance of the welders

59. What is WPQ?

Ans. Welders Performance Qualification- is the performance testing of the welder capability to do the weld in accordance with approved WPS

60. What is PQR?

Ans. Procedure Qualification Record- a record of welding data used to weld a test coupon

61. What is PMI?

Ans. Positive Material Identification- a process use to determine the constituents of a materials

62. What is HAZ?

Ans. Heat affected zone- a portion of base metal that was not melted during welding process but whose microstructure & properties were altered by heat

63. What is PWHT, its purpose?

Ans. Post weld heat treatment- to relieve internal stress that has trapped inside the weld during welding process

64. What is purpose of preheat?

Ans. To slow down the cooling rate, to reduce hardness of the weld to avoid cracking & brittleness

65. What is interpass temperature?

Ans. The highest temperature in the weld allowed prior to interpass weld in the case of multiple pass weld

66. What essential variables in WPS?

Ans. A change in welding condition which will affect the mechanical properties of the weldment

67. Why maintenance temperature is very important for austhenetic materials?

Ans. To reduce intergranular corrosion near the weld

68. What is hardness in accordance with NACE MR0175?

Ans. 22 HRC maximum @ 620 degree (Rockwell C hardness)

69. Type of toughness test?

Ans. Charpy V-notch, IZOD, CTOD (Crack Tip Opening Displacement)

70. Type of hardness test?

Ans. Rockwell, Vickers, Brinell

71. What mechanical test is an additional requirement for materials in low service temperature?

Ans. Impact test

72. What toe cracks is?

Ans. Generally cold cracks a results of thermal shrinkage stress acting on the weld HAZ

73. Differentiate between discontinuity & defects?

Ans. Defects- a discontinuity which exceed the permissible limit in relevant code

Discontinuity- irregularity in the normal pattern of the weld metal not necessary a defects

74. Prevention before using low hydrogen electrode?

Ans. Electrode shall be dried at 260 degree ~ 430 degree for 2 hrs. and shall stored continuously in the oven at 120 degree

75. What is GMAW?

Ans. Gas Metal Arc Welding- often called MIG (Metal Inert Gas) welding. Widely use as semi-automatic joining process w/c coalescence of metal is produce by heat from an electric arc that is maintained between the tip of a consumable bare wire electrode and surface of the base metal in the weld joint

76. What is FCAW?

Ans. Flux Cored Arc Welding- its similar to GMAW, FCAW have the highest deposition rate & semi-automatic welding process w/c coalescence of metal is produced by heat from an electric arc & maintain between the tip of consumable flux filled wire electrode & surface of the base metal in the weld joint

77. What is SAW?

Ans. Submerged Arc Welding- Referred to as (Submerged) because electric arc is actually submerged under the granular flux, currently use for thick metals & heavy steel fabrication

78. What is the acronym GTAW, describe the process?

Ans. Gas Tungsten Arc Welding- which often called TIG (Tungsten Inert Gas) welding, can be manual joining process in w/c coalescence of metal is produced by heat from an electric arc that is maintain between the tip of a tungsten electrode (non consumable) & the surface of base metal in the weld joint

79. What is SMAW?

Ans. Shielded Metal Arc Welding- its commonly called stick welding, widely use arc welding process w/c coalescence of metal is produced by heat from an electric arc that is maintain between the tip of a covered electrode & surface of base metal in the weld joint

80. What is a straight face in a size of 3mm in Bevel?

Ans. Root Face

81. It is need to qualify the welder, if the WPS is pre-qualified in the same project?

Ans. No

82. What NDT which use illumination for testing? (RT not included in the choices)

Ans. Magnetic Particle Test (MT)

83. Give at least 3 “attributes” that could result form tension test.

Ans. Ultimate tensile strength, yield strength, and percent elongation

84. Enumerate at least 5 essential attributes in material test report (MTR).

Ans. Material specification/grade, mechanical properties, chemical properties, heat number, name of manufacturers

85. Why there is a need to specify maximum interpass temperature for austenitic stainless steel?

Ans. To avoid excessive heat input

86. Why is it 3mm root face (in groove preparation) is important in most weld joint?

Ans. To avoid melt through weld, burn through, root concavity.

87. What is the minimum mechanical test required to qualify a welder?

Ans. Bend Test

88. What is the effect of Hydrogen on the weld metal?

Ans. Cracking/Brittleness

89. Define the meaning of Overlap?

Ans. A form of lack of fusion that occurs in the weld face area during the positional welding caused by action of gravity.

90. What is Acid Test?

Ans. It is a Non-Destructive Test applied in clad plate after removing of stainless to carbon steel.

91. What are the 4 grooves joint and each positions?

Ans. 1G – Flat; 2G – Horizontal; 3G – Vertical; 4G – Overhead

92. How do you preserve electrodes after it has been removed from its container before using?

Ans. Holding oven

93. What is Autogenous Weld?

Ans. A type of welding process that do not use filler metal.

94. Where does porosities be obtained?

Ans. Atmospheric contamination; chemical contamination

95. When welding of high nickel content material, the electrode to be used always lower in nickel content than the base metal.

Ans. False

96. What is the most automated NDE process?

Ans. Eddy Current

97. If there is no accessibility to do the weld at the back side of the joint. What welding process can be used?

Ans. GTAW

98. If there is no accessibility to do the weld at the back side of the joint. What discontinuities mostly can be found?
Ans. Lack of fusion; Burn through; Root concavity
99. What is the necessary requirements for the inspection of instruments?
Ans. Calibration Certificates, Check the calibration date.
100. Is it required to Qualify Procedure Specification if there is a change in the Essential Variable?
Ans. Yes
101. Where does hydrogen can be obtained?
Ans. Rust, moisture, oil/grease
102. When you found a weld repair and make a weld report, to whom will you address the report?
Ans. Welding Foreman
103. For non magnetic materials, What NDT method can detect surface cracks?
Ans. PT
104. Where can you find Toe of the weld?
Ans. Junction between face and weld metal.
105. When a vendor received a P.O. from a client which have conflicts from a code and standard requirements. Does the vendor require to accept?
Ans. False
106. What NDT method used to detect Lamination?
Ans. UT
107. What are the important traits of an inspector?
Ans. Informed, impartial,....
108. In AWS D1.1, Pre-qualified Welding Procedure does not need to qualify a welder (true or false)?
Ans. False
109. In AWS D1.1, Pre-qualified Welding Procedure does not need to qualify a welder (true or false)?
Ans. False
110. According to AWS D1.1, all welding procedure needs to be qualified? (True or False)
Ans. False
111. In doing the inspection for size of the fillet weld, what is the reference that you will use to make sure that the you are checking the right size of the fillet weld?
Ans. Fabrication drawing
112. What is the function of Root Face?
Ans. To remove excess heat and act as a heat sink

API 650 and 32-SAMSS-005 – MANUFACTURE OF ATMOSPHERIC TANKS

STANDARD REFERENCES:

SAEP-302

- Instruction for obtaining a waiver of a mandatory Saudi Aramco Engineering requirements.

SAEP- 327	-	Disposal of waste water from cleaning, flushing and hydrostatic test.
SAES-A-007	-	Hydrostatic testing fluids and lay-up procedure
SAES-W-017	-	Welding requirements for Tanks

DESIGN METAL TEMPERATURE – lowest of the following temperatures

1. Lowest One-day Mean Atmospheric Temperature (LODMAT)
2. Minimum Operating temperature
3. Hydrostatic Test Temperature

Bolting

1. Flange bolting shall conformed to ASTM A193 Grade B7 with ASTM A194 Grade 2H Nuts all coated with fluoropolymer / ceramic coating in accordance with 09-SAMSS-107
2. Gaskets shall be non-asbestos according to SAES-L-005

Joints

1. Lap welded joints shall be lap at least 5 times the nominal thickness of the thinner plate joined
2. Double welded lap joints shall not exceed 50mm (2 inch)
3. Single welded lap joints shall not less than 25mm (1 inch)

FOUNDATION DRIP RING – used to prevent the ingress of rainwater or condensation between the tank bottom and foundation

1. Material shall be carbon steel of 3.2mm thick
2. Continuously seal welded to the edge of the tank bottom or annular plate
3. Extend at least 75mm (3 inch) beyond the outer periphery of the concrete ring wall
4. Top of the drip ring and 75mm (3 inch) height of the tank shall be painted with 250-300 micron (10-12 mils) thick epoxy coating in accordance with SAES-H-001
5. Flexible membrane leak barrier (liner) of minimum of 1000 microns (40 mils) thickness compatible with stored products and placed in accordance with SASD AA-36355
6. Reinforcing pads and all other external attachment pads shall have rounded corners of minimum 50mm (2 inch) radius and pad that covers the shell shall be provided with 6mm telltale hole.
7. Bearing plates shall be twice the diameter of the column section with a minimum of 356mm dia. (14 inch), 12.7mm (1/2 inch) thick and attached to the bottom by 4.8mm (3/16 inch) continuous fillet welds.
8. Marking materials shall be free of lead, sulfur, zinc cadmium, mercury, chlorine and other halogens
9. Bottom side of the bottom plate shall be cleaned of all foreign matters and grit-blasted cleaned prior to coating, surface preparation shall be according to APCS-3 or APCS-113
10. Weld crown of the annular plate joints shall be ground flush at the contact areas with the first shell course

SHELL TO BOTTOM WELDS

1. Perform oil penetrant leak test on the entire length of the first weld by applying high flash point penetrant oil such as light diesel oil for a minimum of 4 hours (preferably overnight)
2. Alternative vacuum test at 35 kPa (5 psi) using a vacuum box fit to the shell to bottom junction
3. Inside fillet welds of shell to bottom joint in the cylindrical plate bottom tank shall be examined by either dye-penetrant or wet fluorescent magnetic particle method before hydrotest.

ROOFS

1. Roof column support shall be plumb to 1/200
2. All material clips, lugs, brackets that are used temporarily for construction purposes shall be removed and ground flush and smooth prior to roof installation.

INSPECTION, TESTING AND REPAIR

1. Inspection requirements as per form 175-324900, SAES-W-017
2. NDT shall be as per ASME V
3. Personnel performing NDT shall be certified as per SAEP-1142 and shall be certified to a minimum level II
4. Prior to inspection and final testing the inside and outside of the tank shall be thoroughly cleaned of all slag, scale, dirt, grit, weld spatter, paint and etc.

INSPECTION OF TANK BOTTOM WELDS

1. Only vacuum box is permitted

TESTING OF THE SHELL

1. Tanks shall be hydrostatically tested by filling it with water of quality in accordance with SAES-A-007
2. Hydrostatic testing shall be 24 hours minimum
3. Repair of weld shall be as per SAES-W-017

TANK SETTLEMENT MEASUREMENT

1. Before hydrostatic tstng has been started
2. At the $\frac{1}{2}$ filled point
3. At the $\frac{3}{4}$ filled point
4. After 24 hours of filling the tank at the maximum water fill height
5. After the tank has been emptied of test water

VACUUM TESTING

1. A partial vacuum of 70kPa (10 psi) shall be used for the test

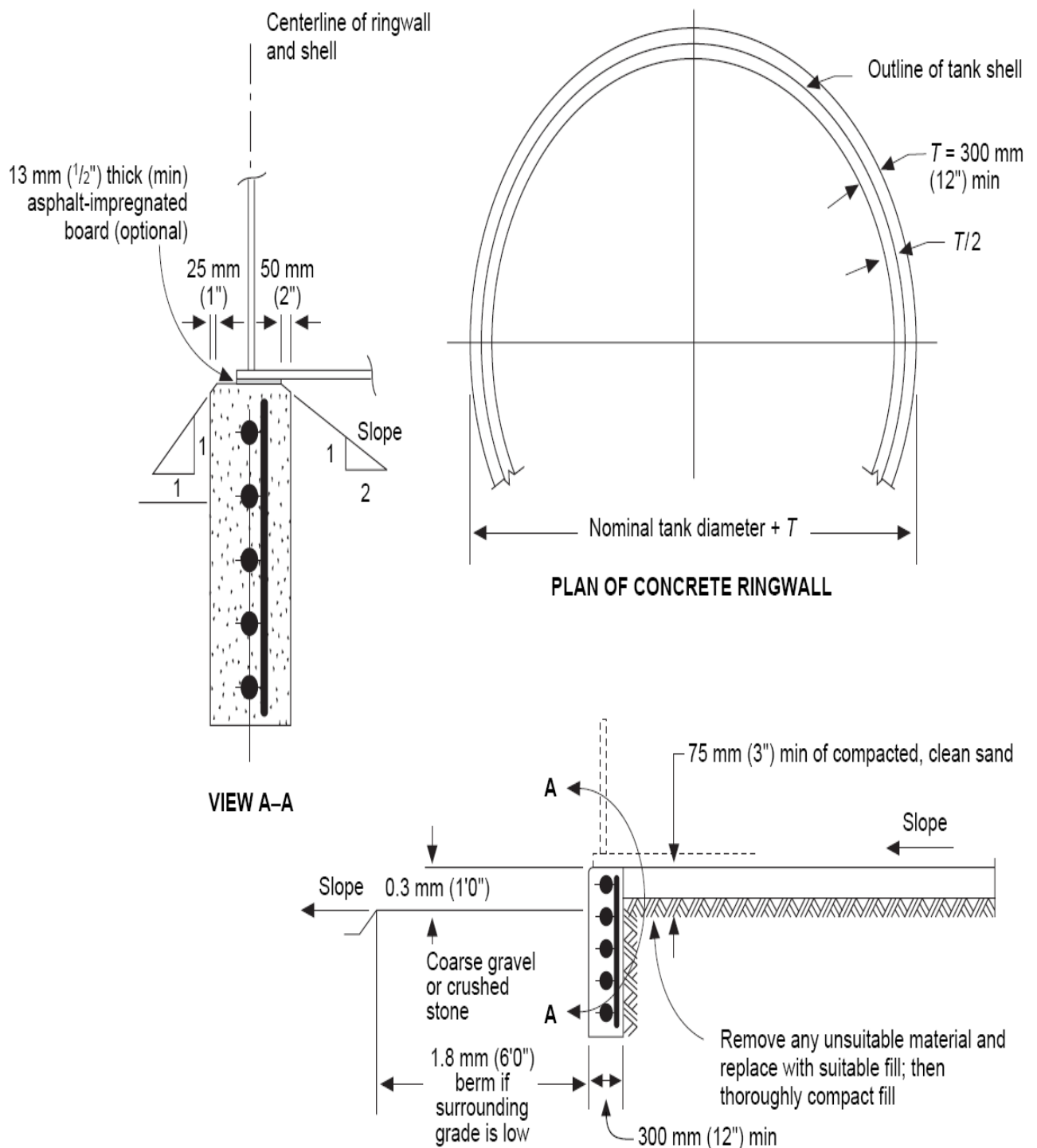
COATING AND PAINTING

1. APCS-3 for tank with maximum operating temperature of 70°C (158°F)
2. APCS-113 for higher operation temperature
3. Tank number and content shall be painted in English and Arabic at 90° around the tanks

32-SAMSS-005 Appendix Recommendations

1. Top fill layer 100 – 150mm (4-6 inch) shall be a mixture of sweet sand and 3% cement (33:1 ratio)
2. Maximum permissible soil content is 0.1% sand shall be dried to a free moisture content of 2% by weight of the dry soil
3. Dry sand must be screened through 6.4mm (1/4 inch) mesh maximum
4. Sand shall be thoroughly mixed with cement with a ratio of 33:1 by weight in a concrete mixer
5. After laying the mixture shall be rolled to a minimum of 6 times by a 3 tons roller
6. Vibratory plate tampers maybe used in lieu of the rollers for areas that cannot be reach or cover
7. Electrical bonding shunt materials shall be type 304 stainless steel
8. Specific gravity shall be 0.7
9. Roofs greater than 91mm (300 ft) in diameter shall be double deck type
10. Minimum inside width of the ladder shall be 710mm (28 inch)
11. Swing type check valve shall be provided at the inlet of the drain
12. Siphon type drains are not acceptable for primary roof drain, however it can be used as secondary roof drain if specified in the tank data sheet
13. Minimum of two overpressure/vacuum bleeder type vents shall be installed, vent shall be sized to handled 125% of the maximum filling/withdrawal rates

14. Bleeder vents shall be designed to open and closed automatically when the roof is 75mm above its low support legs position upon emptying and filling the tank
15. Slope shall be 25mm per 3m
16. Voids under bottom plates are not allowed
17. Three plates lap in bottom shall be 300mm (12 inch) from each other, from the tank shell, from bottom welded annular plate joints, and from joints between annular plates and the bottom
18. When annular plates are used they shall be buttwelded and shall have a radial width that provides at least 600 mm (24 inch) between the inside of the shell and any lap-welded joints in the remainder of the bottom
19. Backing Strip shall be 3mm (1/8 inch) thick tack welded underside of the bottom plate is permitted
20. If square grooves are used root opening shall be not less than 6mm (1/4 inch)
21. Tank Appurtenance (Nozzle & Manways, venting devices, temperature instruments, level gauging systems, sample connections and stairways/ladders and platforms)



Notes:

1. See B.4.2.3 for requirements for reinforcement.
2. The top of the concrete ringwall shall be smooth and level. The concrete strength shall be at least 20 MPa (3000 lbf/in.²) after 28 days. Reinforcement splices must be staggered and shall be lapped to develop full strength in the bond. If staggering of laps is not possible, refer to ACI 318 for additional development requirements.
3. Ringwalls that exceed 300 mm (12 in.) in width shall have rebars distributed on both faces.
4. See B.4.2.2 for the position of the tank shell on the ringwall.

Figure B-1—Example of Foundation With Concrete Ringwall

5.5.5.2 Where foundations true to a horizontal plane are specified, tolerances shall be as follows:

- a. Where a concrete ringwall is provided under the shell, the top of the ringwall shall be level within ± 3 mm ($1/8$ in.) in any 9 m (30 ft) of the circumference and within ± 6 mm ($1/4$ in.) in the total circumference measured from the average elevation.
- b. Where a concrete ringwall is not provided, the foundation under the shell shall be level within ± 3 mm ($1/8$ in.) in any 3 m (10 ft) of the circumference and within ± 13 mm ($1/2$ in.) in the total circumference measured from the average elevation.
- c. Where a concrete slab foundation is provided, the first 0.3 m (1 ft) of the foundation (or width of the annular ring), measured from the outside of the tank radially towards the center, shall comply with the concrete ringwall requirement. The remainder of the foundation shall be within ± 13 mm ($1/2$ in.) of the design shape.

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- 5.1.6 The bottom side of the bottom plates shall be cleaned of all foreign matter and grit-blast cleaned prior to being coated and placed in position for welding. The topside surface of bottom plates, regardless whether coating is required or not, shall also be grit-blast cleaned prior to welding. Surface preparation shall be according to APCS-3 or APCS-113, as applicable.

- 3.3.6.1 Tanks in services other than water shall be provided with under tank leak detection and sub-grade protection according to API STD 650, Appendix I. Acceptable construction details are Figures I-1, I-2, I-3, I-6, I-7, I-8, I-9 and I-10.
- 3.3.6.2 Flexible membrane leak-barrier (liner) of minimum 1000 microns (40 mils) thickness compatible with the stored product shall be specified under the tank bottom. The liner shall be placed in accordance with SASD AA-036355, extending to the internal top edge of the ring foundation.
- 3.3.6.3 Joints in the liner shall satisfy the leak tightness, permeability and chemical resistance requirements for the liner material.

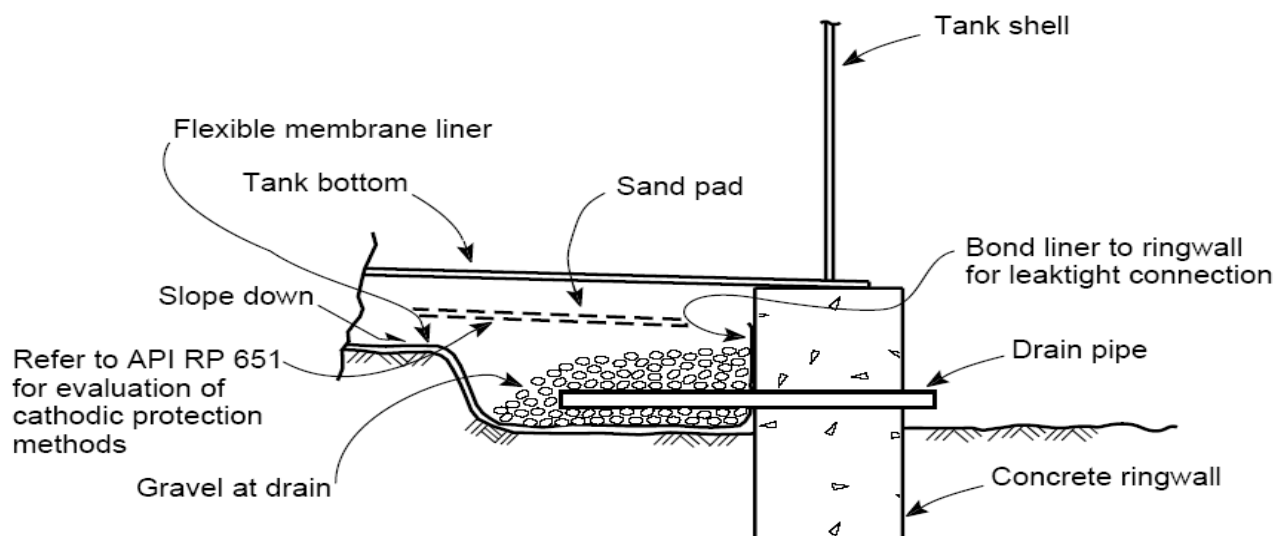


Figure I-1—Concrete Ringwall with Undertank Leak Detection at the Tank Perimeter (Typical Arrangement)

I-1

- **B.3.3** Unless otherwise specified by the owner, the finished tank grade shall be crowned from its outer periphery to its center at a slope of one inch in ten feet. The crown will partly compensate for slight settlement, which is likely to be greater at the center. It will also facilitate cleaning and the removal of water and sludge through openings in the shell or from sumps situated near the shell. Because crowning will affect the lengths of roof-supporting columns, it is essential that the tank manufacturer be fully informed of this feature sufficiently in advance. (For an alternative to this paragraph, see B.3.4.)
- **B.3.4** As an alternative to B.3.3, the tank bottom may be sloped toward a sump. The tank manufacturer must be advised as required in B.3.3.

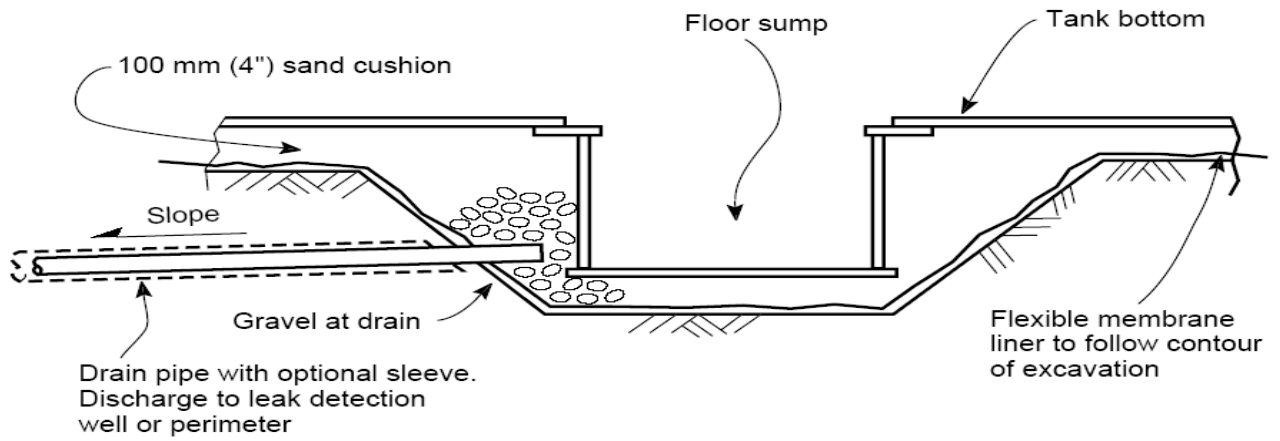


Figure I-8—Typical Drawoff Sump

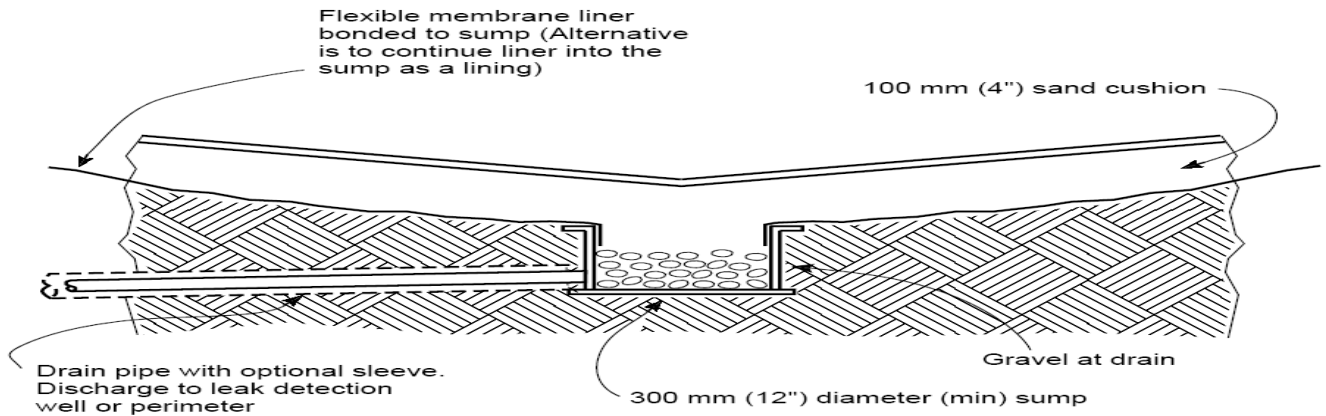


Figure I-9—Center Sump for Downward-Sloped Bottom

3.8.2

Bottom Connections

When specified, bottom connections shall be designed in accordance with API STD 650, Appendix O.

Connections shall be fabricated from elbows; miter joints are prohibited.

Vortex breakers shall be provided for bottom connections.

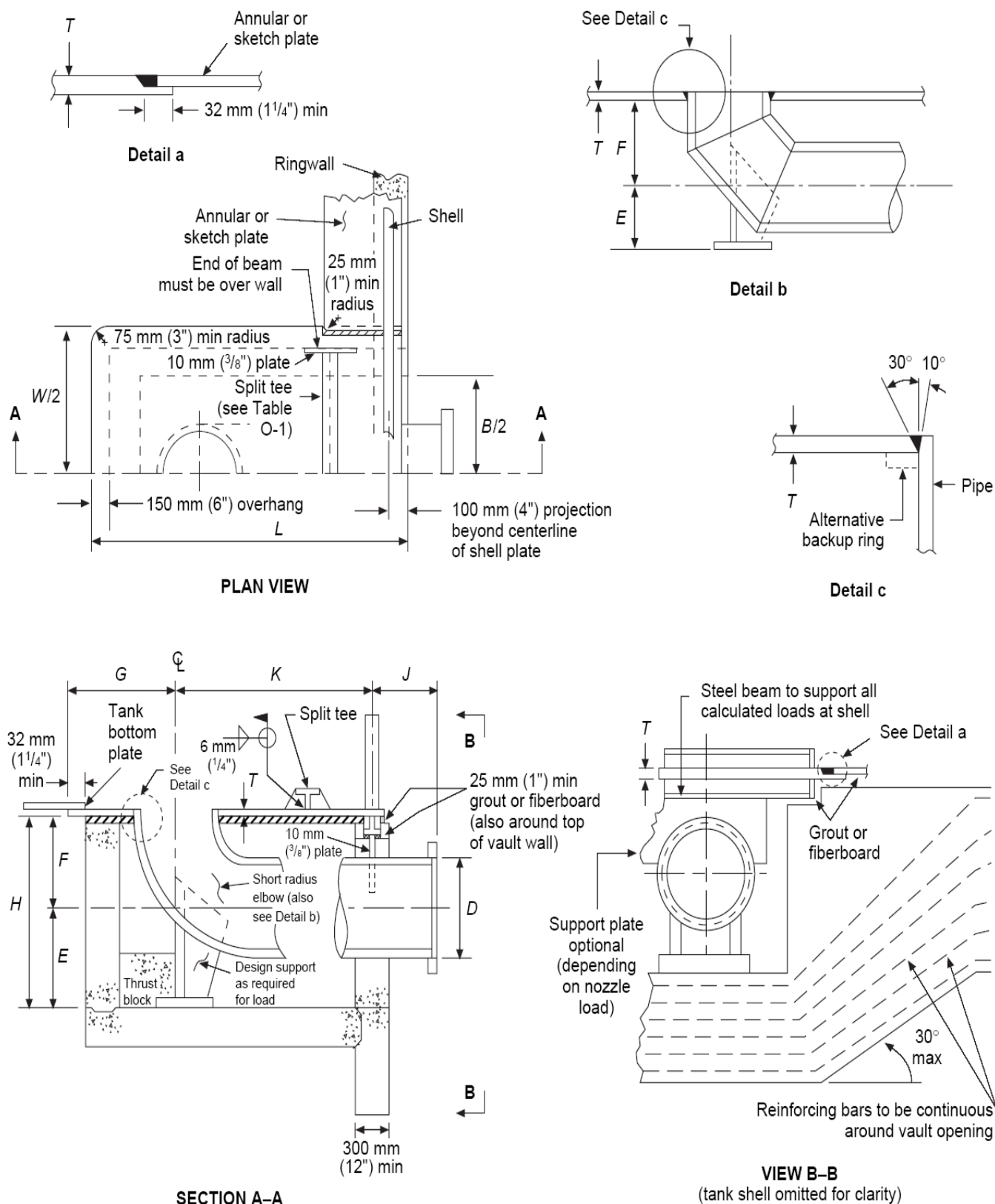


Figure O-1—Example of Under-Bottom Connection With Concrete Ringwall Foundation

GROUTING PROCEDURE FOR EQUIPMENT

Purpose:

These recommended practices (PIP) are intended to provide recommended procedures, practices and checklist for the installation and pre-commissioning of new and reapplied machinery for petroleum, chemical and gas industry services facilities. In general this, recommended practices are intended to supplement vendor instructions and the instruction provided by the original equipment manufacturer (OEM) should be carefully followed with regards to equipment installation and checkout. Most major topic of these recommended practices are subdivided into section of installation Design and Installation with the intent being that each section can be removed and used as needed by the appropriate design or installation personnel.

1. The concrete surface shall be roughened to provide a key for bonding. Any concrete laitance or unsound material must be removed. Removed all dust by suction or compressed air. The roughened and clean surface should then be protected from subsequent contamination.
2. The concrete surface shall be continuously saturated with water for **at least 24 hours** before grouting. Remove all free water before grouting.
3. Before placement, metal surfaces shall be cleaned of all paint, grease, oil, loose rust or other contaminants.
4. If anchor bolts are to be grouted, anchor bolt sleeves, holes and similar items shall be cleaned of all debris, dirt and water using an oil free air compressor or vacuum. Concrete in the hole shall be saturated with water for **24 hours** and the water removed just prior to grouting when using grout.
5. Any anchor bolt sleeve or hole shall be grouted before pouring grout under the plate. This is necessary to ensure that the grout maintains contact with the plate. If total placement is attempted in one pour, air and un-removed water may rise to the grout surface. This will result the grout settlement and reduce the contact areas of the plate.
6. Formworks shall always be rigid, sufficiently tight fitting, and sealed to prevent leakage. It shall extend to **at least 25mm** above the highest grout elevation under the machine base. Form shall be coated with compatible form oil or wax to facilitate form removal. Care shall be taken to prevent contamination of the concrete surface or the underside of the machine base with form release agent.
7. Grout placement shall start from one side of the base plate and flow to the other side. The form shall be constructed to provide a method of developing a head on the placement side. Forms shall have also sufficient clearance to permit rodding and tamping if required. Formwork on the placement side shall extend to the bottom of the plate to form the head box. The head box should begin **50 to 100mm** away from the plate and slope away of about **45°**. The slope allows the grout to be poured under the plate with a minimum of turbulence and air entrapment. The form on opposite side should be **50 to 100mm** from the plate and should extend to **at least 25mm** above the bottom of the plate. The height of the head box depends on the distance the grout must flow. In general, the height of the head box above the bottom of the plate should be **about 1/5 of the travel distance of the grout**.
8. Grout powder and water shall be mixed using method and equipment which will results in a grout with uniform consistency which is free of lumps. For plastic flowable and pourable grouts, horizontal shaft mixers with a stationary drum are preferred. In most instances, initially the dry powder shall be added to **approximately 70%** of the total recommended water content while mixing takes place. The remaining **30% of water** shall be added to the grout at the continues rate while mixing continues. Mixing shall continue until a homogenous grout appears. This usually takes **3 to 5 minutes**. Allow the mix to stand so that any entrapped air is freed before pouring.
9. Portable revolving drum concrete mixers are not recommended.
10. Mixing of small quantities of plastic, flowable, or fluid grout in a bucket using a propeller type mixer and drill is acceptable provided the drill speed is slow enough to prevent air entrapment.
11. Hand mixing is not recommended as it does not provide sufficient energy to disperse constituents and break up lumps.
12. All placements shall be made from one side of the plate. Placement shall begin at one end of the plate and continue at that point until the grout rises above the bottom of the plate on the opposite side of the plate.

13. To facilitate grout compaction and flow, rodding, tamping or flexible strapping in short stroke while maintaining adequate head of grout is recommended. Preferable method to ensure flow and compaction of the grout below the base plate is to use long pieces of double flexible sheet strapping or chains. The forward movements of the strap or chain will assist in the flow of grout into place.
14. After placement of grouts, they shall be protected from excessive moisture loss and from the extremes of temperature. Moisture is retained by the process of curing. Curing can be conducted by keeping exposed areas wet **at least 7 days**. Continuous moist curing after placement results in higher compressive strength of the grout and better durability. Moist curing is generally achieved by continual hosing or sprinklers or by applying wet hessian or plastic sheeting over the exposed surface. The surfaces should be left wet for **at least 7 days** before the surface is permitted to dry.
15. Grouting materials is clean, dry, unopened containers and has been stored at a temperature of approximately **21°C for 48 hours** prior to grouting
16. Expansion joints shall be made from **25mm** thick closed cell neoprene foam rubber and shall be place **1.2m to 2.4m** intervals in line with the anchor bolts and perpendicular with the center line of the base plate
17. Expansion joints shall be glued into position prior to the grout pour with the silicone rubber (RTV) or elastic epoxy seam sealant (liquid rubber)
18. Mounting plate jackscrew shall be liberally coated with paste wax or grease to prevent grout adherence. Liquid waxes and oil are not permitted. Care must be taken to prevent from wax from contacting the concrete foundation or metal surfaces that will be in contact with the grout.
19. All other sole plates are then installed and leveled with respect to the reference plate. Individual sole plate elevation are to be set to a tolerance of $\pm 0.06\text{mm}$ (± 0.0025 inches) with respect to the reference plate
20. Sole plate level is to be set longitudinally and transversely to within 40 micrometers per meter (0.0005 inches per foot) with no more than 13 micrometers (0.005 inches) elevation difference between any two points taken on an individual soleplate. In addition each pair of soleplates (where more than one soleplate is used under an individual piece of equipment) shall be at the same elevation to within 13 micrometers (0.005 inches)
21. Soleplate level can be achieved by adjusting the jacking screw, shimming subsoleplates or dual wedges with adjusting screws and then snugging the anchor bolt nuts to hold the soleplate in place.

PRE GROUT MEETING

A pre-grout meeting with the contractor, operator, and supplier representative should be held to cover everything from safety to job assignment. You must have everyone on the same page, as it is very hectic and fast paced once the job starts. Inform the crew what to do if a mixer goes down or there is a leak in the forms. They should know what to do in case of any foreseeable problem.

It is best to begin with an overall description of the job. Describing what we are trying to accomplish and its importance. Grouting is a non-stop operation. There are no breaks during the job. If someone has a problem, they need to know who tell immediately as well as can replace or back up as needed.

Safety regarding the mixing, transporting and placement should be covered. The epoxy grout are hazardous and very heavy so proper lifting technique as well as dust masks, eye and hand protection per manufacturers recommendations should be covered. A bucket of soapy water should closed by so the crew can clean up as needed during the job. Proper ventilation of the mixing area should also be covered.

Assigned jobs to the individuals in the crew and decide who is back up in case of a problem. Specific jobs, such as mixing liquid and hardener, opening materials, mixing the liquid/hardener and aggregate, transporting, and placing of the material should be assigned. When assigning jobs, cover the particular responsibilities for that job. Make sure everyone knows what the other is doing and how the job inter-relate.

What to do in case of leak, injury or equipment malfunction should laso be covered. The crew should know who tell, what to do, and where to find it, before the job starts.

Proper usage of any special tools such as head boxes, grout pulling tools, or porta packs for bracing forms should be covered as well before the job starts. Any inspection points should be decided in advance and the crew alerted as to whom to notify at critical points in the job.

EPOXY GROUT INSTALLATION TECHNIQUES FOR SKID MOUNTED EQUIPMENT

Concrete Foundation Design

Concrete raw materials vary across the country so it is not possible to use common mix design. The design and placement shall be as per ACI standards. The installer involved with the concrete placement as well as the epoxy grout, should know the physical properties of the concrete used. Standard Portland base concrete takes **28 days** to cure. Testing of physical properties should be done as per ASTM guidelines to ensure the foundation is properly cured and ready for grouting. It is very important to know what you have to work regarding the physical properties of the concrete. If there is problem with the concrete, such as low tensile or compressive strength, it can be address much easier and more cost effective before grouting.

Anchor Bolt design and installation is also important considerations. Most blocks are relatively shallow and free stretch of anchor bolts is sacrifice and impediment depth. This can be solved by going to a two piece bolt. The bottom is on the concrete block and has a coupling set just below grade. The skid beam is reinforced and holes drilled so the top piece of the anchor bolt can project through the top of the skid beam. This is to provide embedment and free stretch. Adjustable canister anchor bolts can help prevent bolt binding from misalignment at installation particularly if an accurate template is not used.

SKID DESIGN

The structural steel design is determined by the manufacturer or packager. Hoe the skid is designed determines the type of grout installation. Some skids are rigid and strong enough to be supported only at the anchor bolt locations on epoxy chocks (typically 10" long x 12" wide x 2" deep). Others require the whole length of the longitudinal I beams to be grouted but not the transverse I beams. Most commonly both the longitudinal and transverse I beams will have to be grouted and at times, the inside cavity beneath the floor plate is also filled with either epoxy or cementitious grout. This is typically done to add mass for vibration reasons.

Access hole for grouting should be provided in the skid floor plate by the OEM or packager. The end user should specify these when purchasing. Access hole are very important when trying to flow any type of grout 10' to 12' across and 20' to 30' down the length of the foundation. The grout deep should be 2" minimum after chipping to provide adequate flow. Access hole also allows you to pour from the middle, cutting the flow distance in half. They also provide inspection points to ensure that all I beams are fully supported. Be sure there are no blind or restricted flow areas in the skid design. One way a packager provided grout placement holes through the neutral axis of the beams. While most skids are designed to only supported by grout under the skid beams, occasionally the inside cavity of a skid will also need to be filled to provide mass. The inside cavity of the skid can be filled with either epoxy grout, cement grout or a concrete. Epoxy grout are more expensive, but perform better than cementitious grouts or concrete. Epoxy grouts are also resistant to most chemical attacks that cement base products cannot handle. Cement based products shrink as the hydrate or cure. This can continue for a year or longer after installation. This shrinkage causes the cementitious grout or concrete to pull away from the inside of the skid. This causes or contributes to mass related vibration problems. This problem can easily be fixed by injecting an epoxy grout to the gap between the cement based product and the skid beams. Mechanical locks can be welded to the inside cavity area to help prevent this problem. Filling the inside Cavity area with epoxy grout is a more expensive method but it is typically better performing and maintenance free. Cement based products are more economical and have limitations but have been used successfully for years. Some premium cementitious grout have built in expansive mechanism to help offset shrinkage.

SKID LEVELING

Jackscrew or other leveling system will be supplied by the OEM or packager. Jackscrews must be wrapped with tape or foam to prevent casting threads in the grout. Jackscrew must be removed after the grout has cured or they can cause cracks in the grout and concrete. As the skid and equipment grow thermally, the stresses they exert on the grout and concrete, if the jack screws are left in place, can cause cracks. Jackscrew landing plates should be made from round stock, sufficiently hard to prevent deformation, and all of the sharp edges should be beveled or radius. If wedges are used, then it is best to form around them for the epoxy grout pour. They must

also be removed, so they should be waxed or protected from bonding with the grout if you cannot form around them.

Be careful to cast any 90° corners (inside or outside corners) in the epoxy grout. Outside corners are blunted by adding a chamfer to the inside corner of the form. Inside corners are rounded by adding a piece of PVC pipe cut in quarters down its length to the outside corner of the form.

The skid bottom in contact with epoxy grout should be sandblasted to NACE 1 white metal for the best bond to epoxy grout. If the bottom is primed, then the primer should be removed for the best bond. The grout bond is only as good as what it sticks to. A weak primer bond equals a weak grout bond. The skid can easily be blasted in the yard prior to installation. There is no problem bonding through a light film of rust. If the primer is compatible and it is to be left on the skid bottom then it must be abraded and the glossy top surface removed. The surface should then be solvent wiped with an evaporative solvent that leaves no residue behind which could act as the bond breaker.

HOW TO PLACE EPOXY GROUT WHEN THE SKID HAS NO GROUT ACCESS HOLES

The warning often seen during television commercials that only trained professional should attempt what is being demonstrated, also applies to skid grouting. Trained supervisors are available and well worth whatever extra it costs. Moving epoxy grout horizontally 12 feet over rough concrete that is 2 inches below the bottom the bottom is the difficult task. In years past when cement based grout were used (usually unsuccessful) for skid grouting, chains and steel banding were used to move the grout from one side to the other. Epoxy grout do not moved much with chains and a new technique has developed where the grout is pulled from one side to the other. Briefly the major steps are as follows:

1. A head box is added to the wood forms on the side where the grouting starts.
2. On the opposite side a 1 inch hole is drilled horizontally through the wood form
3. A pulling tool head is placed inside the wood form and a piece of ¾" conduit, 3 feet longer than the skid is wide is screwed into the tool.
4. Grout is poured into the head box and the pulling tool is pushed horizontally over to the other side until it is under the head box. As the tool is retracted two blades or wings deploy to form a tee. Pulling the tool away from the head box moves the grout from one side over the other. As the tool is pushed back again towards the head box, the wings retract so as not to move the grout back from where it came.

JOB SITE RECEIVING AND INSPECTION

Upon arrival of the machinery or portion thereof at the job site:

1. Visually inspect components for physical damage or contamination by opening crates or packages. Hermetically sealed containers should not be open, but visually inspected for damage and the hermetic seal maintained.
2. Verify that shipping protection has been applied and still in effect.
3. Verify that shop inspection has been completed and that the vendor has supplied the purchase order documentation and packing lists.
4. Verify that loose components and separate packages match the packing list.
5. Verify that special handling instruction are provided and carried out.
6. Verify proper identification of the components.
7. Perform visual inspection of the components for compliance with the project requirements.
8. Inspect carbon steel and other ferrous flange faces damage and coat with type A, B, or D preservative, unless prohibited by process application.
9. Verify that plug and caps are in place, desiccants are unsaturated and equipment are lubricated as required. Non metallic (such as plastic) plugs and caps shall not be used.
10. Verify that enert-gas-purged equipment still has the required pressure applied. Report failure to the manufacturer and request corrective action. This equipment shall remain sealed unless otherwise instructed by designated machinery representative.
11. Inspect grout surfaces for proper factory blasting and coating.
12. Tapped opening on the stuffing boxes and gland plates shall be closed and sealed with pipe plugs.

13. Plug materials shall be of the same or better than the sealed gland plate metallurgy. As a minimum, the plug shall be stainless steel.
14. When specified, impact measuring devices shall be inspected to determine that the equipment has been exposed to excessive shock loads. Where required the manufacturing representative shall be present.
15. Record all the inspection results.

BASE PLATE INSTALLATION AND LEVELING (API 610 and ASME Pump)

1. All base plate elevations shall be set in accordance with the construction drawings
2. Prior to grouting, an initial alignment check in accordance with the alignment section of this document shall be performed to verify that coupling spacing and final alignment can be achieved without modifying the hold down bolt or the machine feet
3. As minimum, base plate level shall be set with a master level or a precision machinist's level. Level should be checked before beginning the plate