

Engineering Standard

SAES-W-012

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Welding Requirements for Pipelines

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Saudi Aramco DeskTop Standards

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1 Scope

1.1 This standard specifies the welding, heat treatment, Nondestructive Testing (NDT), and hardness testing requirements for welding pipelines and equipment (e.g., scraper traps) to ASME B31.4 and ASME B31.8, both onshore and offshore, including shop and field fabrication, repair, or modification. Distribution and other facilities which use B31.4 as the piping design code are also included. These requirements are in addition to the requirements of ASME B31.4, ASME B31.8, API STD 1104, and ASME SEC IX.

For materials outside the scope of ASME B31.4 or ASME B31.8, CSD shall determine if supplementary requirements are required.

1.2 Additional requirements may be contained in Scopes of Work, Drawings, or other Instructions or Specifications pertaining to specific items of work.

1.3 Any reference to Consulting Services Department (CSD) shall be interpreted as the CSD Welding Specialist or a representative designated by CSD. Any reference to "approval" shall be interpreted as written approval.

1.4 This entire standard may be attached to and made a part of purchase orders.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials Systems Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

Unless stated otherwise, all Codes, Standards, and Drawings referenced in this Standard shall be of the latest issue (including revisions, addenda, and supplements) and are considered a part of this Standard.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

<u>SAEP-302</u>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
<u>SAEP-321</u>	<i>Performance Qualification Testing and Certification of Saudi Aramco Welders</i>
<u>SAEP-322</u>	<i>Performance Qualification Testing and Certification of Saudi Aramco Brazers</i>
<u>SAEP-323</u>	<i>Performance Qualification Testing of Contract Welders and Brazers</i>
<u>SAEP-324</u>	<i>Certification Review and Registration of Project Welders and Brazers</i>
<u>SAEP-1140</u>	<i>Qualification of Saudi Aramco NDT Personnel</i>
<u>SAEP-1142</u>	<i>Qualification of Non-Saudi Aramco NDT Personnel</i>
<u>SAEP-1150</u>	<i>Inspection Coverage on Projects</i>

Saudi Aramco Engineering Standards

<u>SAES-A-206</u>	<i>Positive Material Identification</i>
<u>SAES-B-064</u>	<i>Onshore and Nearshore Pipeline Safety</i>
<u>SAES-L-031</u>	<i>Fracture Control of Line Pipe</i>
<u>SAES-L-032</u>	<i>Material Selection of Piping Systems</i>

Saudi Aramco Materials System Specifications

<u>01-SAMSS-035</u>	<i>API Line Pipe</i>
<u>02-SAMSS-005</u>	<i>Butt Welding Pipe Fittings</i>

Saudi Aramco Standard Drawings

<u>AB-036386</u>	<i>Hardness Testing for Welding Procedure Qualifications</i>
<u>AE-036451</u>	<i>Preheat Levels for Welding Carbon Steels</i>

3.2 Industry Codes and Standards

American Petroleum Institute

<u>API STD 1104</u>	<i>Welding of Pipelines and Related Facilities</i>
<u>API RP2A-WSD</u>	<i>Planning, Designing and Constructing Fixed Offshore Platforms-Working Stress Design</i>

American Society of Mechanical Engineers

<i>ASME B31.3</i>	<i>Process Piping</i>
<i>ASME B31.4</i>	<i>Liquid Petroleum Transportation Piping Systems</i>
<i>ASME B31.8</i>	<i>Gas Transmission and Distribution Piping Systems</i>
<i>ASME SEC IIC</i>	<i>Welding Rods, Electrodes and Filler Metals</i>
<i>ASME SEC V</i>	<i>Nondestructive Examination</i>
<i>ASME SEC VIII</i>	<i>Rules for Construction of Pressure Vessels</i>
<i>ASME SEC IX</i>	<i>Welding and Brazing Qualifications</i>

American Society for Testing and Materials

<i>ASTM E747</i>	<i>Standard Test Method for Controlling Quality of Radiographic Testing Using Wire Penetrators</i>
<i>ASTM A833</i>	<i>Indentation Hardness of Metallic Materials by Comparison Hardness Testers</i>

American Welding Society, Inc.

<i>AWS A2.4</i>	<i>Standard Welding Symbols</i>
<i>AWS A3.0</i>	<i>Standard Terms and Definitions</i>
<i>AWS A4.3</i>	<i>Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Weld Metal Produced by Arc Welding</i>

Compressed Gas Association

<i>CGA G-6.2</i>	<i>Specification for Carbon Dioxide</i>
<i>CGA G-11.1</i>	<i>Specification for Argon</i>
<i>BC-C-101</i>	<i>Federal Specification for Carbon Dioxide</i>

British Standards Institution

<i>BS 7570</i>	<i>Code of Practice for Validation of Arc Welding Equipment</i>
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National Association of Corrosion Engineers

<i>NACE RP0472</i>	<i>Methods and Controls to Prevent In-Service Cracking of Carbon Steel Welds in P-1</i>
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*Material in Corrosive Petroleum Refining
Environments*

4 General

- 4.1 AWS A2.4 "Standard Welding Symbols" shall be used for all welding details on all drawings.
- 4.2 AWS A3.0 "Standard Terms and Definitions" shall be used for all specifications and documents.
- 4.3 These requirements apply to all sub-contractors or sub-vendors for items within the scope of this standard.
- 4.4 The ASNT term Nondestructive Testing (NDT) has been used in this standard and shall be considered synonymous with the ASME term Nondestructive Examination (NDE).

5 Approved Welding Processes

The following processes are approved for use with the restrictions and requirements as listed below:

- 5.1 Shielded Metal Arc Welding (SMAW).
 - 5.2 Gas Tungsten Arc Welding (GTAW).
 - 5.2.1 Except for P-No. 1 base materials, all manual GTAW shall use a high frequency start, post-purge gas flow for the torch, and filler metal shall be added.
 - 5.2.2 The GTAW process shall be used for all passes for butt welds in piping and nozzles less than 25.4 mm nominal diameter.
 - 5.2.3 The GTAW process shall be used for the root pass of butt welds in piping and nozzles of 50.8 mm nominal diameter or less, except for vent and drain piping open to the atmosphere or for carbon steel in low pressure water service.
 - 5.2.4 The GTAW process shall be used for the root pass of single-sided groove welds without backing made with stainless steel or nickel-based consumables.
 - 5.2.5 The use of flux-cored GTAW wires for root pass of single-sided groove welds of P-No. 8 or higher with or without backing gas is not permitted unless specifically approved by CSD.
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- 5.3 Submerged Arc Welding (SAW).
- 5.4 Gas Metal Arc Welding (GMAW) [including Flux Cored Arc Welding (FCAW)].
 - 5.4.1 The GMAW short-circuiting (dip) mode shall not be used except for:
 - a) Structural attachments to the outside surface of the pipe, including seal welds.
 - b) Tacking (including continuous tacks) that will be completely removed by backgouging and backwelding.
 - c) The root pass and hot pass only for butt welds in P-No. 1 carbon steels.
 - d) Automatic/machine welding using the GMAW process in the short-circuiting mode requires approval by CSD. A computerized automated ultrasonic inspection system, approved by Inspection Department, must be used. If the welding process is approved, it may be used for all passes in material of any thickness, subject to the limits of the qualification code.

Commentary Notes:

If a computerized automatic ultrasonic system is to be used, additional considerations for the pipe may be required, such as additional grinding of the mill longitudinal seam and additional cutback of any external coating.

For automatic/mechanized welding systems, consideration should be given to more restrictive out-of-roundness tolerances for the pipe. The use of non-standard bevel details may be required and tighter tolerances on the dimensions may also be necessary.

- 5.4.2 GMAW and FCAW shall not be used for the root pass on single-sided tee or corner joints (i.e., branch or nozzle welds).
 - 5.4.3 Flux-Cored Arc Welding (FCAW).
 - a) The FCAW process shall not be used for the root pass on full penetration, groove joints that are welded from one side only without backing (backing may be used if it is removed after welding and weld irregular profile is rectified).
 - b) Self-shielded FCAW shall not be used without the specific approval of CSD.
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- 5.5 Thermit Welding using a copper alloy is permitted for attaching electrical grounding or cathodic protection cables. Thermit welding shall not be used on stainless steel materials.
- 5.6 Stud Welding is permitted for attaching insulation fasteners and heat conductors.
- 5.7 Other processes (such as brazing, Electro-Gas, Electro-slag, Plasma, etc.) may be used only with the approval of CSD. Depending upon the process and application proposed, CSD may require testing in addition to that specified by the Code. Approval to use other processes shall be obtained through the welding procedure review process.
- 5.8 Automatic welding without filler metal additions is not permitted.

6 Welding Consumables

- 6.1 Electrodes, filler wires, and fluxes shall conform to ASME SEC IIC. Other consumables may be used only with the approval of CSD and, depending upon the process and application proposed, may require testing in addition to that specified by API STD 1104 or ASME SEC IX. Approval to use other (unlisted in ASME SEC IIC) consumables shall be obtained through the welding procedure review process. For unlisted consumables, vendor literature, which shall include intended use and approximate chemistry and mechanical properties, shall be submitted with the procedure.
- 6.2 All consumables shall be stored and dried in accordance with the requirements of Table 1 for SMAW electrodes and Table 2 for other consumables.
- 6.3 GTAW filler metal shall have either the AWS/ASME identification or the manufacturer's identification marked on each individual rod by the manufacturer with tags ("flags"), stencil, or stamping.
- 6.4 Welding consumables shall be selected based on their mechanical properties, compatibility with the materials to be joined, their suitability for the intended service, and consideration of polarity, position, and direction of welding. Welding consumables not meeting standard industry practice using the above criteria may be rejected by Saudi Aramco.
 - 6.4.1 Low hydrogen consumables (defined as less than or equal to 8 ml of hydrogen per 100 g of deposited weld metal, measured in accordance with AWS A4.3) shall be used except for applications listed below:
 - a) Girth welds for pipelines and equipment less than 25 mm wall thickness and Grade X60 or less.

- b) The root pass of single-sided groove welds without backing for pipelines and equipment with either a wall thickness greater than 25 mm or Grade X65 and higher.

6.4.2 Dissimilar metal welds (DMW) are defined as:

- i) Any weld joint (excluding weld overlays or strip lining) between ferritic steel and either austenitic stainless steel, duplex stainless steel, or nickel-based alloys, or
- ii) Use of stainless steel or nickel-based filler metals on ferritic steels.

They shall be restricted as follows:

- a) Are not permitted for pressure-containing welds in sour service (welds in clad systems are acceptable if the DMW interface with the ferritic steel is not in contact with the sour fluid).
- b) Are permitted for non-sour hydrocarbon service if made with a nickel-based consumable.
- c) Austenitic stainless steel consumables may be used only for the following applications and if the maximum design temperature is below 300°C:
 - 1) External structural attachments (e.g., pipe supports).
 - 2) Non-sour, non-hydrocarbon (e.g., water) services.

6.4.3 Other than the DMWs listed in paragraph 6.4.2, the selection of filler metal compositions for joining base materials of different P-Numbers or compositions shall be as follows:

- a) For attaching non-pressure parts to pressure parts, the nominal composition of the filler metal shall match the nominal composition of the pressure part.
- b) For other applications, the filler metal shall conform to either base metal composition or to an intermediate composition, whichever is the most appropriate for the application.

6.4.4 For hydrocarbon service, filler metal or deposit chemistries conforming to A-number 2 (ASME SEC IX), i.e., carbon-0.5% Mo, (e.g., E7010-A1 or E7018-A1 for SMAW) shall not be used unless specifically approved by CSD.

6.5 Submerged Arc Welding fluxes

- 6.5.1 Active type Submerged Arc Welding fluxes shall not be used without approval. The approval shall be obtained through the welding procedure review process. The fabricator shall clearly identify the proposed use of active fluxes in their welding procedure submissions.
- 6.5.2 Flux fused during welding shall not be reused (i.e., fluxes that use recrushed slag are not acceptable).
- 6.5.3 SAW fluxes that the flux manufacturer recommends for single pass welding shall not be used for multiple pass welding.

6.6 SMAW electrodes shall be limited as follows:

- 6.6.1 F-Nos. 1 and 2 electrodes shall not be used on materials requiring impact tests either by Code or job specification.
- 6.6.2 F-Nos. 1 and 2 electrodes shall not be used for pressure-retaining welds.

6.7 Shielding Gases

Shielding gases shall conform to the following requirements:

- 6.7.1 Carbon dioxide (CO₂): Federal Specification BC-C-101, Type B or Compressed Gas Association CGA G-6.2, Type F.
- 6.7.2 Argon (Ar): Compressed Gas Association CGA G-11.1, Grade A.
- 6.7.3 The requirements for other gases and gas mixtures shall be submitted to CSD for approval.

7 Welding Procedures

7.1 Documentation

- 7.1.1 All welding procedures to be used shall be submitted to Saudi Aramco as a complete package prior to the start of work. The package of welding procedures, qualification test records, and weld maps/tables shall be submitted for the technical approval by CSD.

After approval by CSD, the package of welding procedures, qualification test records, and weld maps/tables may be approved for additional jobs by the Inspection Department. The project assigned inspector will authorize the use of CSD-approved welding procedures

if the scope and essential variables are acceptable for the applications on his project.

- 7.1.2 For shop fabrication In-Kingdom and all field fabrication, the WPSs and PQRs shall be prepared and submitted on the Saudi Aramco Forms (Attachment A).

Exceptions:

Standardized PQR forms from an approved independent test laboratory are acceptable. Equivalent WPS forms from a contractor may be acceptable if approved by CSD.

- 7.1.3 A Weld and Line Designation Table ("Weld Table") shall be submitted along with the Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) documents for each job (similar jobs may use identical submittals). The Weld Table (Attachment B) provides a listing of the materials, thicknesses, and weld joint types for individual line designations. A welding procedure shall be listed for each different weld type and line designation. All base materials (by specification and grade) and wall thicknesses to be used shall be included in the Weld Table. The Weld Table shall not be reviewed without WPSs and PQRs and vice-versa.

With the approval of CSD, standardized Weld Maps and Weld Descriptions and sets of welding procedures may be submitted by the fabricator for general approval. All of the documentation requirements shall be met except specific line designations are not required (but service descriptions must be included).

- 7.1.4 Each Weld Table must be complete and show all of the line designations, materials, joints, and welding procedures to be used for the complete job or contract.
- 7.1.5 Welding shall not commence until the welding package has been approved for application by Saudi Aramco inspector and returned to the fabricator. Any welding prior to the approval of the welding package is subject to rejection at the sole option of Saudi Aramco inspector. Any rework required as a result of this rejection shall be at the fabricator's expense.
- 7.1.6 After approval by Saudi Aramco inspector, the fabricator shall issue copies of the approved Welding Procedures and Weld Table to the Saudi Aramco Inspector and PMT prior to the start of fabrication.
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- 7.1.7 Approval of welding procedures shall not be construed as authority for deviation from listed specifications or requirements of the relevant codes and standards and shall not relieve the contractor, fabricator, or vendor from correcting any deviations.
 - 7.1.8 All WPSs, PQRs, and Weld Table shall be available at the work site for review at any time by the authorized Saudi Aramco inspector.
 - 7.1.9 All Welding Procedure Specifications and Welding Procedure Qualification Records shall be written in English.
 - 7.1.10 The PQRs shall include certified copies/facsimiles of all test records (for In-Kingdom qualification, the independent testing agency that issued the test record shall certify the copies), which will be permanently retained by Saudi Aramco.
 - 7.1.11 Originals of all test records, mill certificates, etc. including records from the independent test laboratory shall be made available for review by Saudi Aramco upon request.
- 7.2 General Requirements
- 7.2.1 All WPSs and PQRs shall conform to the latest edition of the relevant Code (API STD 1104 or ASME SEC IX, as appropriate). Procedures that comply with a previous edition but not the current edition of the relevant Code are not acceptable, even if the Code permits such procedures. Procedures no longer conforming to the latest Code edition shall be revised and requalified.
 - 7.2.2 For any new or additional qualification tests that are required, Saudi Aramco reserves the right to monitor any and all phases of the procedure qualification, including welding of the coupons and mechanical testing. Saudi Aramco may assign the monitoring to an inspection agency.
 - 7.2.3 All information shown on the PQR, such as amperage, voltage, travel speed, postweld heat treatment time and temperature, as applicable, shall be actual data as recorded using calibrated instruments.
 - 7.2.4 Qualification of welding procedures for all shop fabrication in Saudi Arabia and field erection work shall be performed In-Kingdom. Approval for use of previously qualified welding procedures or Out-of-Kingdom testing sites shall be obtained through the welding procedure review process. Out-of-Kingdom testing will be considered for the following applications:
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- a) If special tests such as Crack Tip Opening Displacement (CTOD) tests are required and need to be conducted by Out-of-Kingdom laboratories.
- b) For offshore lay barges, if the qualification is performed in the Gulf region and is witnessed by either Saudi Aramco Inspection or an approved independent third party inspection agency.

7.2.5 For In-Kingdom qualifications:

- a) The welding of all qualification test coupons shall be monitored by either an approved independent test laboratory, an independent third party approved by Saudi Aramco, or Saudi Aramco Inspection. The monitoring shall include verification of the accuracy of the recorded parameters.
- b) All procedure qualification mechanical tests and examinations shall be performed by an approved independent test laboratory unless the fabricator is specifically approved by Saudi Aramco Inspection to perform their own tests.

7.2.6 For all automatic welding and any process with pulsing, the welding procedure shall include all applicable equipment and controller parameter settings.

7.3 Special qualification tests, such as stress corrosion cracking, may be specified by CSD for special materials not covered by ASME B31.4 or ASME B31.8 or for special applications (as determined by CSD), such as but not limited to severe corrosion service.

API Grades X70 and higher require special stress corrosion cracking tests for sour service applications. These tests shall be specified by CSD.

7.4 Procedure variables

The following additional restrictions shall be considered essential variables for procedure qualification:

7.4.1 The material groupings and restrictions listed in API STD 1104 shall be also be used for qualifications to ASME SEC IX. The following exceptions to API STD 1104 shall apply:

- i) Procedures for Grade B through API SPEC 5L X52 carbon steel pipe may be qualified on any grade in this range and for ASME SEC IX qualifications shall be considered as P-No. 1, Gr. 1 material.

- ii) Procedures for API SPEC 5L Grade X60 and higher shall be qualified for each specific material grade. Qualifications using API SPEC 5L Grade X60 may qualify all lower strength API grades (including Grade B).
- 7.4.2 The following materials shall be considered as P-No. 1 in accordance with ASME SEC IX and do not require separate qualifications as "unlisted" materials:
- A707 L3
 - A707 L5
 - A350 LF6
 - A350 LF787
 - MSS-SP-75 (with grades classified the same as pipe)
- 7.4.3 For ASME P-No. 1 materials, all Group 3 or 4 materials shall be qualified separately for each specific material, unless it is being used in combination with a Group 1 or 2 material and the Group 1 or 2 material strength requirements govern.
- 7.4.4 Separate procedure specifications (but using the same procedure qualification, if appropriate) shall be submitted for each diameter group. The diameter groups shall be as recommended in API STD 1104, unless alternative groupings are approved through the welding review process.
- 7.4.5 Any GMAW electrode to be used for procedures with impact toughness requirements and any SAW flux or FCAW electrode shall be restricted to the specific brand, type, and maximum size as used for the PQR. If so restricted, the brand name and type of flux or electrode shall be specified on both the WPS and PQR.
- 7.4.6 A change in filler metal or deposit chemistry from A-number 1 (based on ASME SEC IX) to A-number 2 and vice-versa is not permitted without approval. The approval shall be obtained through the welding procedure review process. A change from A-no. 1 to A-no. 2 is not permitted for sour service applications without requalification.
- 7.4.7 Any change in the type of current or polarity shall be considered an essential variable.
- 7.4.8 Aluminum flake weldable primers (e.g., "Bloxide", "Deoxaluminite", or other brand approved by CSD) may be used without requalification of the procedure. The welding procedure specification shall indicate the use of the type and brand of weldable primer. The maximum coating thickness shall not exceed 0.050 mm. The use of other
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weldable primers or coatings is not permitted unless specifically approved by CSD. Additional procedure qualification and/or weldability tests may be required by CSD.

7.4.9 Position

7.4.9.1 The direction of welding for the vertical position shall be an essential variable (i.e., a change from vertical-up to vertical-down or vice-versa shall be considered an essential variable). If the procedure was not qualified in the vertical position, then the direction of welding shall be vertical-up.

7.4.9.2 For automatic, semi-automatic, or mechanized welding, the position limitations listed in ASME SEC IX, QW-461.9 shall be considered as an essential variable for procedure qualification.

7.4.10 Procedures using any consumable with a "G" or unlisted designation (ASME SEC IIC) shall be restricted to the brand and type of electrode used for the PQR. The nominal chemistry of the specific brand and type of electrode shall be identified on the WPS.

7.4.11 Deletion of a backing strip in a single-sided groove weld shall be considered an essential variable and shall require requalification.

7.4.12 For single-sided groove welds without backing, the process and electrode type used for the root pass shall be considered an essential variable. The PQR shall be performed as a single-sided groove weld without backing.

7.4.13 For full penetration, double-sided joints, the WPS shall require backgouging (see 10.3.4) for all processes except for the following:

- a) For automatic or mechanized welding processes if additional PQR testing is conducted. The PQR shall include supplementary coupons using the production equipment and joint geometry. The supplementary coupons shall be examined by UT or RT, as appropriate for the joint geometry, and shall be sectioned for examination in at least 3 locations. The NDT results and cross-sections shall show complete fusion, complete penetration, and freedom from cracks.
 - b) For other special processes on butt joints where the production welds will be radiographed. The applications shall be approved by CSD.
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- 7.4.14 Deletion of a backing gas purge or a change in the backing gas composition for a joint welded or brazed from one side without backing material shall require requalification.
- 7.4.15 Any supplementary qualification tests required by this or any other standard or specification (e.g., hardness tests) shall comply with all of the essential and, where applicable, supplementary essential variables of the this standard and either ASME SEC IX or API STD 1104.
- 7.4.16 Repair may be conducted using a welding procedure different than the original welding procedure used to weld the joint with the conditions:
- a) Repair procedures shall be qualified for each base metal thickness range as listed in API STD 1104.
 - b) The weld deposit thickness used for the procedure qualification shall be the maximum qualified deposit thickness unless a full thickness procedure qualification is conducted.
- 7.4.17 For procedures qualified to API STD 1104, the tensile test results shall be considered acceptable if the specimen breaks in the base metal outside of the weld or fusion line, provided the strength is not more than 5% below the specified minimum tensile strength of the base metal.
- 7.4.18 The following are the maximum tolerance limits for procedures qualified in accordance with Section 9 (Automatic Welding) of API STD 1104:
- travel speed: $\pm 20\%$ of the actual PQR value
 - voltage range: $\pm 10\%$ of the actual PQR value
 - current range: $\pm 15\%$ of the actual PQR value
- 7.4.19 Special requirements for procedures requiring impact testing
- 7.4.19.1 Charpy impact testing of P-No. 1 Gr.1 and 2 materials (including API grades through X60) shall have a minimum absorbed energy of 34/27 J (25/20 ft-lb) for full size (10 x 10 mm) specimens for both the weld and heat-affected zone at the minimum design temperature. For other Group Numbers, P-Numbers, and other materials, the impact test criteria shall be established by CSD.
 - 7.4.19.2 If Charpy impact testing of the girth welding procedure is required for procedures qualified to API STD 1104, then the essential variables listed in API STD 1104 Appendix A,
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Section A3.0 shall be mandatory (even when Appendix A in its entirety is not specified or permitted).

7.4.19.3 If Charpy impact testing is required for procedures qualified to ASME SEC IX, the requirements for impact test temperature reduction due to sub-size specimens (less than 10 x 10 mm) shall comply with ASME B31.3, Table 323.3.4.

7.4.19.4 The heat input to be recorded on the PQR and used as the limiting value for the WPS shall be based on the welding parameters used at the location where the impact specimens are removed. If the PQR heat input varies by pass or layer, then additional impact specimens, in addition to those locations specified by the relevant Code, may be required in order to utilize the full range of heat inputs used in the PQR.

7.4.19.5 If multiple processes or consumables are used, separate impact test specimens shall be conducted for each process or consumable. If the impact test specimen size is larger than the deposit thickness of a specific process or consumable, then the impact test specimen shall contain the maximum possible amount of the deposit for that process or consumable (a separate set of specimens is still required for the other process or consumable).

7.5 Welding Procedure Qualification Hardness Testing

7.5.1 Hardness testing of the welding procedure qualification is required for sour service applications and for girth welds of all offshore pipelines. The maximum allowable hardness for sour service is VHN 250. For offshore pipelines in non-sour service, the maximum allowable hardness is VHN 300. The procedure is exempt from hardness testing if it is to be used on external structural attachments only, and the pipe wall at the attachment point is at least 25 mm thick.

7.5.2 For applications where hardness testing is specified (see 7.5.1), the hardness testing shall be in accordance with Standard Drawing [AB-036386](#), Hardness Testing for Welding Procedure Qualifications. Prior hardness test results may be accepted as equivalent to the Standard Drawing only with the approval of CSD and with the following conditions:

- a) Only the Vickers method is acceptable, with a maximum test load of 10 kg.
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- b) The location of the HAZ indents nearest the fusion line can be demonstrated (by specification or actual measurement) to be within 0.2 mm of the fusion line.

Note the additional PQR requirements listed in 12.6 for PWHT for applications requiring hardness testing.

7.6 Preparation of test coupons

For new procedures or procedures that are to be re-qualified (i.e., existing PQRs that are acceptable without any supplementary tests are exempt), the following additional requirements shall apply:

- 7.6.1 The tests shall be made using butt-welded pipe samples in either the 5G or 6G position or the position to be used in production.
- 7.6.2 The qualification test shall include all of the required tests on the same coupon unless size limitations restrict the number and type of specimens that can be reasonably removed from a single coupon. If multiple coupons are required and approved by CSD, each of the coupons shall be of the same material and size and shall be welded with identical parameters. Use of supplementary test coupons for additional tests (e.g., Charpy impact or hardness) to be combined with existing PQRs is not permitted.
- 7.6.3 For groove weld qualifications, the test coupons shall be radiographed and shall meet the acceptance criteria of API STD 1104 or ASME B31.3 Normal Service. If any special NDT is required of production welds (e.g., automatic UT), then the PQR shall be examined by the same method and shall meet the same acceptance criteria.
- 7.6.4 The procedure qualification test weld shall meet all the requirements imposed on production welds.

8 Welder and Welding Operator Qualification

- 8.1 All welders, welding operators, brazers, and brazing operators shall be qualified in accordance with either ASME SEC IX or API STD 1104 and [SAEP-321](#), [SAEP-322](#), [SAEP-323](#), and [SAEP-324](#), as applicable, for all welding, including tack, temporary, and repair welds.
- 8.2 Current production repair rates of each welder shall be made available to Saudi Aramco Inspection upon request. The repair rates shall be calculated on a lineal basis.

- 8.3 Performance qualification tests shall not be performed on production joints on Saudi Aramco work.

9 Joint Details

- 9.1 All pressure containing welds, except for socket welds, shall be made with full penetration groove welds only.
- 9.2 All pressure containing welds shall be made with multiple passes.
- 9.3 Permanent backing rings or strips shall not be used.
- 9.4 Temporary backup strips in weld joints may be used if the backing material is of a composition similar to the base metal or weld metal. Under no circumstances shall rebar or galvanized steel be used. Temporary backup shoes made of non-metallic, non-fusing material may be used.
- 9.5 Consumable inserts may be used for all applications providing the composition matches the weld metal composition.
- 9.6 Full penetration groove joint included angles less than 30 degrees (except for portions of compound bevels) shall not be used without approval. The approval shall be obtained through the welding procedure review process.
- 9.7 For branches with reinforcing pads, the branch attachment weld shall be completed and inspected (see 16.6) prior to installing the reinforcing pad.

10 Technique and Workmanship

- 10.1 The maximum allowable SMAW electrode sizes that can be used are given below. The ability of each welder to use the maximum sizes listed in the table shall be checked by the Inspector as early as possible during fabrication.

- a) Low hydrogen electrodes
5 mm for the 1G/1F position.
4 mm for all other positions.
- b) Non-low hydrogen electrodes
5 mm for all positions.

Sizes larger than those listed are acceptable only if approved by CSD and only if the PQR was performed using the electrode size and positions to be used in production. The approval shall be obtained through the welding procedure review process.

10.2 Welding Environment

- 10.2.1 Wind shields or tents shall be required when the wind is strong enough to affect arc stability or shielding gas coverage or when deemed necessary by Saudi Aramco Inspection. GTAW, GMAW, or gas-shielded FCAW shall not be used for field or yard fabrication unless adequate windshields are used. The wind velocity in the weld area for GTAW, GMAW, or gas shielded FCAW shall not exceed 8 kph (2.2 m/s).
- 10.2.2 Welding shall not be done when surfaces are wet or damp or exposed to rain or snow or when the welders are exposed to inclement conditions.
- 10.2.3 Contamination from the environment, such as wind-blown sand, shall be prevented by the use of adequate shielding.

10.3 Joint Preparation

- 10.3.1 Oil, moisture, rust, scale, sand, paint (except weldable primers for approved applications - refer to paragraph 7.4.8 for restrictions), metallic coatings (e.g., zinc), or other foreign matter shall be removed from the weld surface and at least 25 mm of adjacent base metal prior to welding, including any such coatings on temporary attachments or supports.
 - 10.3.2 Flame cutting and arc-air gouging
 - 10.3.2.1 Ragged and irregular edges shall be ground or machined to bright metal. All holes cut for nozzles, bosses, or branch connections shall be ground smooth and true (+ 3.2 mm of the branch inside diameter for set-on nozzles and -0, +3.2 mm of the nozzle outside diameter for set-in nozzles).
 - 10.3.2.2 Thermally cut or gouged surfaces for all materials, including carbon steels, shall be power brushed or ground prior to welding.
 - 10.3.2.3 Thermal cut surfaces of stainless steel and non-ferrous materials shall be ground to bright (unoxidized) material prior to welding.
 - 10.3.3 Fittings that are re-cut or re-beveled shall have the cut surface examined for laminations before welding. The NDT method to be used shall be determined by Saudi Aramco Inspection.
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10.3.4 All full penetration joints requiring double sided welding shall be ground or gouged to sound metal and inspected by penetrant testing (PT) or magnetic particle testing (MT) prior to welding the reverse side, unless exempted by 7.4.13. For the exempt applications, production results shall demonstrate that acceptable penetration can be reliably achieved. If periodic lack-of-penetration defects are found, then backgouging will be mandatory for joint geometries other than butt welds and either backgouging or 100% radiography will be required for butt welds.

10.3.5 Buttering or weld build-up on joints

10.3.5.1 Buttering or weld build-up on the prepared surfaces shall not exceed the lesser of 1/3 of the base metal thickness or 10 mm without the approval of CSD. If the buttering or build-up exceeds this, then the following requirements shall apply:

- a) The buttering operation shall be witnessed by Saudi Aramco Inspection.
- b) The buttering shall be inspected by penetrant testing (PT) or magnetic particle testing (MT) after completion of the build-up but before final welding of the joint.

10.3.5.2 Buttering of joints between dissimilar metal joints requires prior approval by CSD. The approval shall be obtained through the welding procedure review process.

10.4 Line-up clamps

An internal line-up clamp shall be used if the pipe diameter is 16 inches or larger, except for tie-in welds or cement-lined pipe. Special shoes must be used for internally coated pipe to ensure the coating is not damaged. For pipelines less than 16 inch diameter, either internal or external line-up clamps may be used.

10.4.2 External line-up clamp may be used for pipe diameter 16 inches or larger if approved by CSD Welding Engineer with a condition that 100% radiography is performed to the production welds.

10.4.2 The internal line-up clamp shall not be removed before the completion of the root bead. For external clamps, the root bead must be at least 50% complete prior to removal.

- 10.5 The minimum distance (circumferential offset) between longitudinal welds (including spiral weld seams) of adjacent pipe joints shall be 100 mm, except as noted below:
- a) Longitudinal welds in fittings are exempt.
 - b) Pipelines classified as Class I service (see SAES-L-031) are exempt.
 - c) For all other applications, a situation involving seam alignment less than this is acceptable provided the next five girth weld joints on both sides of the affected joint meet the separation requirement.

10.6 Cleaning

- 10.6.1 Each weld pass shall be thoroughly cleaned and all slag or other foreign matter removed before the next pass is deposited.
- 10.6.2 All slag, flux, and spatter shall be removed from the completed weld and surrounding areas.
- 10.6.3 Stainless steel and nonferrous materials shall be cleaned with grinding wheels or stainless steel brushes not previously used on other materials.

10.7 Sequence

- 10.7.1 For pipelines greater than 16 inch diameter, at least two welders shall be used, operating simultaneously and in opposite quadrants.
- 10.7.2 The second or hot pass shall be added as soon as possible after the completion of the root pass, but shall not exceed 5 minutes for vertical down welding with cellulosic electrodes or 15 minutes for vertical up welding. If a production joint exceeds the specified time lapse, then magnetic particle examination of the root pass shall be conducted and the joint preheated to 60°C minimum or the preheat specified in the procedure, whichever is greater, prior to making the hot pass. If the joint has been completed without MT of the root pass, then supplemental NDT of the joint, as specified by Inspection, shall be conducted.

At the sole discretion of CSD, increased lapse times may be approved if the PQR has been qualified using no less than the maximum specified lapse time. The PQR test coupon thickness must approximate or exceed the WPS maximum thickness and the smallest diameter electrode size must be used.

- 10.7.3 The hot pass shall be made while the pipe is still fully supported by the sideboom tractor or supports.
- 10.7.4 The pipe shall not be lifted or moved during welding.
- 10.7.5 Partially welded joints shall not be lifted or lowered into the ditch.
- 10.7.6 The weld joint shall be completed within 24 hours of starting.
- 10.7.7 Welds shall be made in sequence such that portions of welds do not remain uncompleted before welding subsequent joints.
- 10.8 The working clearance shall not be less than 900 mm all around the pipe.
- 10.9 Tack welds
 - 10.9.1 All tack welds shall be made by qualified welders.
 - 10.9.2 All tacks or temporary welds shall be performed with the same care, materials, electrodes, minimum preheat, and procedures that are used for permanent welds.
 - 10.9.3 Tack welds shall be of sufficient size to maintain joint alignment. The recommended tack size is 3.2-4.8 mm and length is 12.5–25.4 mm. The minimum number of tack welds are:
 - a) Pipe diameter of 101.6m or less: three equally spaced tacks.
 - b) Pipe diameter above 101.6m: minimum of four equally spaced tacks. The designated inspector should determine if more tacks are needed.
 - 10.9.4 Tack welds that are to be incorporated into the final weld shall be thoroughly cleaned, prepared at each end, and inspected for cracks. Any cracked tacks shall be removed before welding the joint.
 - 10.9.5 If the tack welds are to be incorporated into the final weld and are made with a different process or electrode than the root pass, then the desired tack weld process and electrode shall have been used for tacking in the procedure qualification.
 - 10.9.6 Bridge tacks (located above the root area) are acceptable but such tacks must be made completely within the weld groove and shall be completely removed prior to completion of the weld.

- 10.10 Arc strikes, gouges, and other indications of careless workmanship (such as surface porosity, uneven weld profiles, and undercut) shall be removed by grinding.
 - 10.11 Any temporary welded attachments or temporary tack welds shall be ground off. Attachments may be cut off no closer than 3 mm to the base metal surface, prior to the required grinding.
 - 10.12 If any grinding reduces the base metal to less than the design minimum, the ground area shall be rewelded and ground flush with the original base metal surface or the component shall be replaced. Rewelding shall be done only with the prior approval of Saudi Aramco Inspection.
 - 10.13 Inspection by magnetic particle or liquid penetrant methods of areas shall be performed where temporary welds have been removed (see 10.11) or weld repairs to ground areas of the base material have been made (see 10.12) or arc strikes after repair by grinding (see 10.10).
 - 10.14 Temporary attachments, back-up strips, or supports welded to any component shall be made with a compatible material. Under no circumstances shall rebar or galvanized steel be used.
 - 10.15 Coated and clad or overlaid surfaces shall be protected from the welding arc, associated weld spatter, and damage from ground clamps or other associated equipment.
 - 10.16 Peening
 - 10.16.1 Peening shall not be permitted unless approved by CSD and specified in the approved welding procedure. Cleaning of slag is not considered peening.
 - 10.16.2 When peening is specified, the welding procedure specification shall include details of how it will be performed. If the peening is to be done on a component with impact toughness requirements or on any pressure piping or vessels, the welding procedure shall be qualified using peening.
 - 10.17 Adjacent weld beads shall be staggered and not started from the same location.
 - 10.18 Back purging
 - 10.18.1 An inert backing gas shall be used for GTAW or GMAW root passes on single-sided groove welds for materials of ASME P-No. 5 or higher.
 - 10.18.2 The use of nitrogen as a backing gas for stainless steels is prohibited.
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10.18.3 The back purge for carbon and low alloy steel shall reduce the oxygen level below 1%. The method of back purge and the flow rate shall be specified on the WPS.

10.18.4 For P-No. 5 and higher materials, any back purging shall be maintained until at least 10 mm of the weld deposit thickness has been completed.

10.18.5 The back purge for stainless steel and nickel alloys shall reduce the oxygen level below 0.05%.

10.19 Seal welding

10.19.1 All joints and faying surfaces, except those specifically designed and designated as removable bolted connections, shall be seal welded by a continuous fillet weld (required weep holes shall be left unwelded).

10.19.2 Sealing compounds or tapes shall not be used on joints that are to be seal welded.

10.19.3 Seal welding of threaded connections shall cover all exposed threads and shall have a smooth contour between the two surfaces.

10.20 Weld encroachment and minimum distance between welds.

The requirements for minimum separation between adjacent welds are listed in 10.20.1 and 10.20.2. The distances shall be measured between the edges of the adjacent cap passes. These restrictions do not apply if one of the welds has been postweld heat treated prior to making the second weld or both welds have been postweld heat treated and inspected.

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

10.20.2 Pressure containing welds (structural components and reinforcing pads are exempt) shall be separated from other pressure containing welds by no less than 20 mm or three times the joint thickness, whichever is greater. This requirement is intended specifically for nozzles and other attachments that are added onto or adjacent to an existing butt joint. Hot tap split tee end welds which cross the pipe longitudinal seam are exempt. Radiography of the butt welds is required for situations in which the minimum separation is not achieved. For joints other than butt welds, other appropriate inspection methods shall be used, depending on the geometry and material.

10.21 Back welding may be used for any joint. Proper cleaning and, if necessary, grinding of the root shall be done prior to backwelding. Unless specified

otherwise in the welding procedure, the backwelding shall be done using the same process and consumables as used for the fill passes.

- 10.22 Forced or accelerated cooling of welds is prohibited without the specific approval of CSD.

11 Preheat

- 11.1 For carbon steels (all ASME P-No. 1 materials, including API grades up to and including X60), the minimum preheat shall be calculated using Standard Drawing AE-036451, but in no case shall it be less than 10°C or the minimum preheat required or recommended by ASME B31.4 or ASME B31.8. For normal applications, simplified requirements are listed in Tables 3A, 3B, 4A and 4B for the SMAW process.
- 11.2 For API grades X65 or greater or for materials other than carbon steel, the preheat shall be determined by Consulting Services Department.
- 11.3 If a weld joint is wet or has surface moisture or condensation, it shall be dried by heating for a distance of 100 mm from the weld joint and shall be warm to the hand before welding.
- 11.4 Temperature-indicating crayons, thermocouples, or contact pyrometers shall be used to measure preheat and interpass temperatures. Temperature-indicating crayons shall not be used on any weld joint that is to be coated or that will have a heat-shrink sleeve installed on it.
- 11.5 The preheat temperature shall be established over a minimum distance of 75 mm on each side of the weld.
- 11.6 If the wall thickness exceeds 25 mm and preheating is to be done from the same side as the welding, then the heat source shall be removed for 1 minute to allow for temperature equalization prior to measuring the temperature.
- 11.7 Unless specified otherwise, the maximum interpass temperature shall be 177°C for P-No. 8 and P-No. 4x materials and 315°C for P-No. 1 steels.

12 Postweld Heat Treatment

- 12.1 The requirement for postweld heat treatment (PWHT) shall be determined by ASME B31.4 or ASME B31.8, as appropriate. If PWHT is to be applied, then the general requirements of ASME SEC VIII shall apply. A written procedure describing the general PWHT requirements shall be submitted for review and approval. The PWHT procedure shall include descriptions of the equipment, method of heating, location and type of heating elements, temperature
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measurement, and thermocouple locations. The review and approval process shall be the same as described for welding procedures (paragraph 7.1).

- 12.2 Prior to the start of work the contractor or fabricator shall prepare a table listing each joint or component requiring heat treatment, which shall be submitted to Saudi Aramco Inspection for review. The table shall include the following information for each joint or component: location, drawing number, diameter, wall thickness, material, heating rate, cooling rate, soak temperature, and soak time.
- 12.3 The weld joint thickness for unequal thickness butt welds for all applications (B31.4 and B31.8) to be used in determining the postweld heat treatment requirements shall be based on the effective weld throat as defined in ANSI B31.4.
- 12.4 The specified PWHT shall be applied over an area extending at least 3 times the thickness of the material being welded from each edge of the weld but not less than 25 mm from each edge of the weld, whichever is greater.
- 12.5 Code exemptions for postweld heat treatment of ferritic materials based on the use of austenitic or nickel-based electrodes are not permitted.

Commentary Note:

Austenitic or nickel-based electrodes shall not be used for ferritic materials except dissimilar metal welds listed in 6.4.2 and overlays.

- 12.6 For applications where PWHT is required by the service conditions or where hardness limits are specified:
 - a) Any reductions in the PWHT temperature or alternative temperatures below the normal holding temperatures listed in ASME SEC VIII are not permitted.
 - b) The minimum PWHT soak time shall be 1 hour.
 - c) If hardness limits are specified, the soak time for production welds shall not be less than 80% of the PQR soak time.
 - 12.7 All temperatures within the heated zone for furnace or localized PWHT shall exceed the specified minimum holding temperature. The actual temperature range for the soak period, as recorded by thermocouples, shall not have a spread of more than 40°C.
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- 12.8 Welding or heating after the final PWHT is not permitted if the PWHT is required for service. Postweld heat treatment shall follow all welding and repairs but shall be performed prior to any hydrotest or other load test.
- 12.9 PWHT shall be carried out using one or more of the following types of heat sources:
- a) Permanent or semi-permanent furnaces using gas or oil or electric heaters (a vessel itself may be considered a furnace if heated internally and externally insulated).
 - b) Electrical resistance heaters.
- 12.10 If localized PWHT is used, the following minimum number of equally spaced recording thermocouples (T/C) shall be used:
- a) Pipe diameter of 305 mm or less: 1 T/C.
 - b) Pipe diameter above 305 mm up to and including 610 mm: 2 T/C.
 - c) Pipe diameter above 610 mm: 4 T/C.

Additional thermocouples are required if multiple heat control zones are used, in which a control zone is not monitored by any of the primary T/Cs.

- 12.11 Thermocouples and a calibrated temperature chart recorder shall be used to provide an accurate and legible record of all PWHTs. All charts shall be marked with the date and sufficient information to uniquely identify the joint/component being heat treated. Multipoint chart recorders shall clearly differentiate/identify each channel/point by use of different colored inks or automatic number stamping.
- 12.12 Temperature recorders shall be calibrated every three months and a current calibration sticker shall be maintained on the recorder. The calibration frequency may be extended to 12 months with the approval of Saudi Aramco Inspection if the documented calibration checks for that particular recorder demonstrate acceptable accuracy for a suitable period.
- 12.13 Thermocouples

12.13.1 Only Type K (Chromel-Alumel) or Type J (iron-Constantan) thermocouples are permitted. All extension cables, compensating cables, and jumper cables in the measurement or control circuits shall be the specified thermocouple wire or the matching extension wire (i.e., KX or JX, as appropriate). For Type K thermocouples, copper-Constantan (Type T) compensating cables may be used with the following conditions:

- a) The junction between the copper-Constantan compensating cable and the Type K thermocouple lead shall be a minimum of 0.5 m outside the insulated area.
 - b) The acceptable temperature range of the junction between the compensating cable and the thermocouple lead is from 0 to +80°C.
- 12.13.2 The national standard that the thermocouple conforms to shall be indicated in the PWHT procedure. The procedure shall also include a listing of the insulation coloring of each core wire and the overall sheath for both the compensating cable and thermocouple. This information is required for site inspectors to verify that the proper wires have been used and are connected in the proper polarity.
- 12.13.3 Thermocouples shall be attached to the component by capacitive discharge welding only. Other methods of attachment are not permitted. The thermocouples shall not be in direct contact with electrical heating elements or subjected to flame impingement by gas or oil burners.
- 12.14 Prior to the start of the PWHT, components shall be checked to ensure that all restraints are removed and the component is free to expand and contract.
- 12.15 All machined surfaces, such as flange faces, threaded bolt holes, threads, etc., shall be protected from oxidation during the heat treatment by coating with deoxaluminite or other suitable material.
- 12.16 For PWHTs that are not performed in a furnace, insulation shall be applied a minimum of 300 mm on either side of the weld that is to be PWHTed. The insulation shall not be removed before the temperature has cooled to below 150°C. The ends of open lines shall be closed off in order to eliminate drafts or air circulation that could lower the temperature on the inside surface of the joint unless the internal surface is also insulated.
- 12.17 All PWHT chart records shall be submitted to Saudi Aramco Inspection for review and approval. All records shall be submitted as part of the equipment file for permanent record.
- 12.18 After completion of the PWHT all thermocouples shall be removed and the attachment areas ground smooth to clean, sound metal. If specified by the Inspector, the areas shall be examined by MT or PT after grinding.
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13 Production Weld Hardness Testing

- 13.1 Hardness testing of production welds is only required if specified by CSD or if PWHT is applied due to service requirement. If specified, the maximum hardness for P-No. 1 materials is 225 BHN for non-sour service and 200 BHN for sour service.
- 13.2 Testing shall be conducted in accordance with NACE RP0472 and the following requirements. If hardness testing is specified, all welding processes and consumables, including SMAW and GTAW, shall be tested. The testing guidelines listed in Appendix A of NACE RP0472 shall be mandatory.
- 13.3 Hardness indentations shall be made at or near the middle of the deposited weld bead. Readings in the heat-affected zone shall be conducted if specified.
- 13.3 If any reading exceeds the specified limit by no more than 10 BHN, then a minimum of three (3) additional indentations shall be made near the original high reading. If all three (3) retests are below the specified limits, then the joint is acceptable. If any of the retest readings are found to exceed the specified limits, then the weld shall be considered unacceptable.
- 13.4 If any welds are found to be unacceptable, then two additional welds from the same lot shall be tested. If more than one weld in a lot is found to be unacceptable, then all welds in that lot shall be tested.

14 Inspection Access

- 14.1 Saudi Aramco representatives shall have free access to the work at all times.
- 14.2 Saudi Aramco shall have the right to inspect the fabrication at any state or stage and to reject material or workmanship which does not conform to the specified requirements.
- 14.3 Saudi Aramco reserves the right to inspect, photograph, and/or videotape all material, fabrication, coating, and workmanship and any materials, equipment, or tools used or to be used for any part of the work to be performed. Saudi Aramco may reject the use of any materials, equipment, or tools that do not conform to the specification requirements, jeopardize safety of personnel, or impose hazard of damage to Saudi Aramco property.
- 14.4 All of the rights of Saudi Aramco and their designated representatives for access, documentation, inspection, and rejection shall include any work done by sub-contractors or sub-vendors.

- 14.5 The fabricator shall provide the authorized Saudi Aramco inspector all reasonable facilities to satisfy him that the work is being performed as specified.
- 14.6 The fabricator shall furnish, install, and maintain in a safe operating condition all necessary shoring, scaffolding, ladders, walkways, and lighting for a safe and thorough inspection.

15 Weld Identification

- 15.1 All weld joints shall be marked for identification by a weld number and a welder symbol. These identifications shall be made with a suitable weather-proof marking material. The markings shall be placed in a location such that they will remain visible for a time suitable to the authorized Saudi Aramco inspector. The markings shall be compatible with any subsequent coating or heat-shrink sleeve application.
- 15.2 The fabricator shall establish and submit for approval an identification system that shall uniquely identify each member and weld joint. The identification system shall be used to identify all examinations, surveys, inspections, etc.

16 Inspection

- 16.1 General
 - 16.1.1 Nondestructive Testing (NDT) inspection procedures shall be established in accordance with ASME SEC V. A written procedure for each inspection method and technique, including acceptance criteria, to be used shall be submitted to Inspection Department for approval. Qualification of the procedure by the contractor may be required, as determined by Saudi Aramco Inspection. Inspection procedures in conformance with other standards are acceptable only with the approval of Inspection Department. NDT performed without approved procedures shall be considered unacceptable.
 - 16.1.2 Written reports and evaluations of all inspections performed by vendors, contractors, and fabricators shall be made and submitted to Saudi Aramco Inspection, at a frequency to be determined by Saudi Aramco Inspection.
 - 16.1.3 Additional inspection of any weld joint at any stage of the fabrication may be requested by Saudi Aramco Inspection, including re-inspection of previously inspected joints. Saudi Aramco Inspection also has the right to request or conduct independent NDT of any joint. If such testing should disclose gross non-conformance to the Code

requirements, all repair and NDT costs shall be done at the contractor's expense.

- 16.1.4 Inspection at the mill, shop, or fabrication yard shall not release the manufacturer or fabricator from responsibility for repairing or replacing any defective material or workmanship that may be subsequently discovered in the field.
- 16.1.5 All appropriate safety precautions shall be taken for each inspection method.
- 16.1.6 All NDT personnel shall be qualified in accordance with [SAEP-1140](#) or [SAEP-1142](#), as applicable.
- 16.1.7 Surface irregularities, including weld reinforcement, inhibiting accurate interpretation of the specified method of NDT shall be ground smooth.
- 16.1.8 Inspection of all welds shall include a band of base metal at least 25.4 mm wide on each side of the weld.

16.2 Radiography

- 16.2.1 ASME SEC V, Article 2 shall be used to determine the minimum number and required locations of radiographs for circumferential joints.
- 16.2.2 Fluorescent intensifying screens shall not be used. Fluoro-metallic screens shall be approved by Saudi Aramco Inspection prior to use.
- 16.2.3 Tungsten inclusions in Gas Tungsten Arc welds shall be evaluated as individual rounded indications. Clustered or aligned tungsten inclusions shall be removed and repaired.
- 16.2.4 All field radiographic exposures (vendor, shop, and yard radiography are exempt) shall be performed using at least two people: a [SAEP-1140](#) or [SAEP-1142](#) qualified Level II radiographer and an assistant who is qualified to operate all of the equipment.
- 16.2.5 If a pressure-containing weld will not be hydrotested, it shall be radiographed only after approval of a waiver request. If the joint is required to be radiographed for other reasons (e.g., service conditions, design requirements) or if radiography is not technically practical, then other NDT methods shall be specified.

16.3 Ultrasonics

- 16.3.1 Ultrasonic testing may be substituted for radiography if approved by Saudi Aramco Inspection.
- 16.3.2 A computerized automatic ultrasonic system must be used for all welding performed with an automatic/mechanized GMAW welding system operating in the short-circuiting mode. The system must be approved by Inspection Department.
- 16.3.3 When a computerized automatic ultrasonic system is used, it shall be operated within the equivalent of one hour's production from joints currently being welded.

Commentary Note:

This is to insure the number of joints completed prior to inspection is as small as possible so that repetitive defects do not occur for a large number of consecutive welds. For normal jobs, it is expected that the UT system will be within approximately 10 joints of the last completed weld.

16.4 Magnetic particle

- 16.4.1 Permanent magnet yokes are not permitted.
- 16.4.2 Magnetic particle testing shall be conducted on any structural attachment welds on pressurized components made of ferromagnetic material that are not hydrotested after making the attachment weld.
- 16.4.3 Prods are not permitted for use on materials with impact testing requirements or on the fluid side surface of components in sour service.
- 16.4.4 The acceptance criteria for magnetic particle examination shall be ASME SEC VIII, Appendix 6.

16.5 Liquid penetrant

- 16.5.1 Liquid penetrant testing shall be conducted on any structural attachment welds on pressurized components made of non-ferromagnetic material that are not hydrotested after making the attachment weld.
- 16.5.2 The acceptance criteria for liquid penetrant particle examination shall be ASME SEC VIII, Appendix 8.

16.6 NDT

The minimum extent of nondestructive testing (NDT) for various applications are listed below. The minimum percent coverage of the specified NDT method may be increased (at any level up to 100%) if, in the opinion of the authorized Saudi Aramco inspector, the welds are of questionable workmanship or if NDT indicates an excessive number of defects. The listed extent of NDT shall be applied using the following methods:

Butt welds - radiography

Other pressure containing welds (including branch connections such as weldolets, sockolets, and welding bosses) -

Magnetic particle (MT) for ferromagnetic materials.

Liquid penetrant (PT) for non-ferromagnetic materials.

Additional or alternative NDT methods may be used at the discretion of the authorized Saudi Aramco inspector in order to assist in determining the type or extent of defects.

Exception:

For girth welds made with an automatic/mechanized GMAW process using the short-circuiting mode, 100% inspection using a computerized automated ultrasonic inspection system is required. For applications using an automated/mechanized welding process and inspected using an automated UT system, an alternative defect acceptance criteria using an ECA (Engineering Critical Assessment) method may be submitted for approval by CSD. Any proposal to be submitted to CSD shall include the assessment method, all relevant calculations, proposed qualification requirements, and production welding requirements (e.g., supplementary essential variables). Approval of the ECA alternative is at the sole option of CSD.

16.6.1 Girth Welds

The following lists the minimum extent of radiography for girth butt welds. However, the extent of coverage of radiography may be increased (to any level up to 100%) if, in the opinion of the authorized Saudi Aramco inspector, the welds are of questionable workmanship or if inspection indicates an excessive number of defects. Additional or alternative nondestructive testing (NDT) methods may be used at the discretion of the authorized Saudi Aramco inspector in order to assist in determining the type or extent of defects. The radiographic interpretation shall be to API STD 1104. The extent of inspection shall apply only to carbon steels, including API grades up to and including X60 (Inspection Department should be consulted for inspection of

material grade higher than X60). The extent of coverage listed means the stated percentage of welds completed that day shall be inspected over their entire length. The joints to be radiographed shall be selected to include a representative selection from all welders. Additional emphasis may be used for welders with repair rates higher than the current job average.

16.6.1.1 Onshore

A minimum of 10% of the welds made each day. An increased percentage of radiography is required if a higher percentage of radiographic coverage is established by either of the following methods listed in 16.6.1.1.1 or 16.6.1.1.2 (both methods shall be calculated and the higher percentage rate shall govern).

16.6.1.1.1 Lineal basis

$$\% \text{ RAD} = \frac{(318 \times L)}{(N \times D)} \quad (1)$$

where:

% RAD is the percent minimum radiographic coverage to be applied to the production the following day.

L = total length of repairs, mm

N = total number of weld joints radiographed in one day

D = pipe diameter, mm

The amount of RAD shall be rounded to the nearest amount divisible by ten (10). Any value ending in five (5) shall be rounded up.

16.6.1.1.2 Joint basis

The following repair rates are calculated on a joint basis, i.e., the number of joints requiring repairs divided by the total number of joints radiographed that day.

- a) An increase to 50% RAD is required when the repair rate exceeds 30%. This increase
-

shall be required for both the same day's (i.e., additional joints must be radiographed to increase the RAD for that day to 50%) and the next day's production.

- b) An increase to 100% RAD is required when the repair rate exceeds 50%. This increase shall be required for both the same day's (i.e., all other joints for that day must be radiographed) and the next day's production.

16.6.1.1.3 Additional radiography

The following weld joints are also required to be radiographed, in addition to the extent of NDT previously specified. If additional radiography is required by these provisions, these radiographs shall not count towards the required radiographic coverage for the remaining joints of that day's production. However, all of the joints radiographed that day shall be used in calculating the repair rate and the required radiographic coverage for the following day.

- a) All welds of the first day's production for a particular job or a minimum of the first forty (40) production joints, whichever is greater. For consecutive, similar jobs (e.g., multiple flowlines), the first five (5) joints on the subsequent jobs shall be radiographed.
 - b) Repaired welds (except for superficial grind repairs).
 - c) The joint preceding and the joint succeeding a repaired weld, if not previously radiographed.
 - d) The ten preceding and the ten succeeding welds of a cracked weld, if not previously radiographed.
-

- e) All welds within 60 m of paved road, railroad, and airport crossings (for the carrier pipe only).
- f) All welds in Class 3 or 4 locations, as defined in [SAES-B-064](#).
- g) All welds over water, over tidal flats, or within 30 m of the shoreline.
- h) All welds that cannot be hydrostatically tested.
- i) All hook-up or tie-in welds.
- j) All expansion loop fitting welds.

16.6.1.2 Offshore

All welds on submarine and offshore pipelines, risers, and associated spool pieces shall be 100% radiographed, except for open non-pressure vents and drains which shall be radiographed 10%.

16.6.2 Branch connections

Branch connection welds (including sockolets, weldolets, and welding bosses) shall be inspected by magnetic particle testing. The minimum inspection rate shall be 10% except for the following applications which shall be inspected 100%:

- a) Offshore lines
- b) All welds within 60 m of road, railroad, and airport crossings (for the carrier pipe only).
- c) All welds in Class 3 or 4 locations, as defined in [SAES-B-064](#).
- d) All welds over water, over tidal flats, or within 30 m of the shoreline.
- e) All welds that cannot be hydrostatically tested.
- f) All hook-up or tie-in welds.

16.6.3 General (all applications)

16.6.3.1 All welds shall be visually examined. Visual examination shall be performed prior to other NDT.

16.6.3.2 All branch connection welds shall be visually examined from the root side to ensure that proper penetration and fusion have been achieved.

16.6.4 All crater cracks shall be ground out.

16.6.5 Internal root reinforcement

The visual and radiographic acceptance criteria for maximum root reinforcement shall be per the following table:

Maximum Root Reinforcement

Service	Maximum Reinforcement	Acceptable Length
General	3 mm or less 3-6 mm Over 6 mm	Any 25 mm maximum None
Internally Coated	2.5 mm or less Over 2.5 mm	Any None

16.6.6 Wire penetrameters in accordance with ASTM E747 may be used for all radiographic applications. The equivalent wire sensitivity shall be at least equal to that required by the applicable code or specification.

17 Repairs

17.1 Welds may be repaired twice. If the weld is still not acceptable after the second repair, then Saudi Aramco Inspection has the sole authority for the decision to permit additional repair attempts or to require that the entire weld be cut out. The limitation on the number of repairs does not include adjacent sequential repairs where the length of the area to be repaired is limited by structural strength or other considerations.

17.2 Cracked welds (except for crater cracks) shall be cut-out unless a repair is approved by CSD. If a repair to a crack is approved, then special repair and inspection procedures shall be submitted to CSD for review and approval prior to undertaking any repairs, including excavation of the defect. Crater cracks shall be ground out.

17.3 Repair welding shall be performed using a properly qualified and approved procedure. A repair procedure must include a method statement regarding the excavation, NDT, and welding requirements. The repair procedure may utilize a welding procedure previously approved by CSD in conjunction with a separate method statement or it may be a separate detailed welding procedure that incorporates the method statement. In-process repairs (i.e., repairs performed prior to completion of the joint using the same welding procedure as for the

original fabrication) during production do not require a separate repair procedure except for cracks (see 17.2).

- 17.4 All repaired welds shall, as a minimum, be inspected using the original testing method. Additional test methods may also be required, if deemed necessary by the authorized Saudi Aramco inspector. Replacement welds (cut-outs) shall be examined as a repair.
- 17.5 Damage to the base metal or welds, including dimensional changes, caused by external forces (intentional or accidental) requires special repair and inspection procedures be submitted to CSD for review and approval prior to undertaking the repairs.
- 17.6 Any weld not meeting the acceptance criteria of the applicable code or standard shall be cut out or repaired. Other methods, such as sleeving, shall not be permitted.
- 17.7 Repairs to offshore pipeline girth welds shall be limited as follows:
 - 17.7.1 Full thickness repair openings shall be limited in length to 25% of the pipe diameter.
 - 17.7.2 Partial thickness repair excavations less than 50% of the wall thickness shall be limited in length to 30% of the pipe diameter.
 - 17.7.3 Incremental excavations can be used to repair long surface or subsurface defects.
- 17.8 Onshore pipelines locations that are subject to significant bending stresses during repair shall also have repair limitations as listed above (17.7).

18 Miscellaneous Requirements

- 18.1 For field welding, remote Current controls shall be used if the welding is more than 30 m from the welding power source or when the welders are working in "remote" locations.
 - 18.2 Welding power supplies shall be calibrated in accordance with BS 7570 or an approved equivalent if impact toughness test is required by the applicable company or industry specifications or codes. Calibration records shall be available to Saudi Aramco Inspection upon request.
 - 18.3 Welding on offshore piping from workboats requires proper grounding to prevent stray current corrosion during welding. The welding ground connections shall comply with API RP2A-WSD, paragraph 12.7.
-

- 18.4 The heat input (HI) of each production weld must be calculated, if notch-toughness tests are specified, and then confirmed not to exceed the heat input limits listed in the welding procedure specifications. The HI formula is:

$$\text{HI (kJ/cm)} = \text{Voltage X Amperage X 60/Travel Speed (cm/min)} \quad (2)$$

31 December, 2002 **Revision Summary**
Major revision.

**Table 1 – Conditioning, Storage, and Exposure of SMAW Electrodes
(Notes 1, 2, 3, 4)**

Low Hydrogen Electrodes to A5.1

Drying

Prior to use all electrodes shall be dried at 260-430°C for 2 hours minimum. The drying step may be deleted if the electrodes are supplied in the dried condition in a hermetically sealed metal can with a positive indication of seal integrity.

Storage

After drying, the electrodes shall be stored continuously in ovens at 120°C minimum.

Exposure

Upon removal from the drying or storage oven or hermetically sealed containers, the electrodes may not be exposed to the atmosphere for more than 4 hours. The exposure may be extended to 8 hours if the electrodes are continuously stored in a portable electrode oven heated to 65°C minimum. Electrodes exposed to the atmosphere for less than the permitted time period may be re-conditioned. Electrodes exposed in excess of the permitted time period must be re-dried. Electrodes that have become wet or moist shall not be used and shall be discarded.

Re-conditioning

Electrodes exposed to the atmosphere for less than the permitted time period may be returned to a holding oven maintained at 120°C minimum; after a minimum holding period of four hours at 120°C minimum the electrodes may be reissued. After any exposure in excess of the permitted time period, the electrodes must be re-dried. Electrodes may be re-dried only once. Electrodes that have become wet or moist shall not be used and shall be discarded.

Low Hydrogen Electrodes to A5.5

Drying

Prior to use all electrodes shall be dried at 370-430°C for 2 hours minimum. For E70xx and E80xx electrodes, the drying step may be deleted if the electrodes are supplied in the dried condition in a hermetically sealed metal can with a positive indication of seal integrity.

Storage

After drying, the electrodes shall be stored continuously in ovens at 120°C minimum.

Exposure

Upon removal from the drying or storage oven or hermetically sealed containers, the electrodes may not be exposed to the atmosphere for more than 2 hours for E70xx or E80xx electrodes and 30 minutes for any higher strength electrodes. The exposure times may be doubled (to 4 hours and 1 hour, respectively) if the electrodes are continuously stored in a portable electrode oven heated to 65°C minimum. Electrodes exposed to the atmosphere for less than the permitted time period may be re-conditioned. Electrodes exposed in excess of the permitted time period must be re-dried. Electrodes that have become wet or moist shall not be used and shall be discarded.

Re-conditioning

After any atmospheric exposure, the electrodes must be re-dried. Electrodes may be re-dried only once. Electrodes that have become wet or moist shall not be used and shall be discarded.

Non-Low Hydrogen Electrodes to A5.1 or A5.5

The electrodes shall be stored in a dry environment. Any electrodes that have become moist or wet shall not be used and shall be discarded.

Stainless Steel and Non-Ferrous Electrodes

Drying

Prior to use all electrodes shall be dried at 120-250°C for 2 hours minimum. The drying step may be deleted if the electrodes are supplied in the dried condition in a hermetically sealed metal can with a positive indication of seal integrity.

Storage

After drying, the electrodes shall be stored continuously in ovens at 120-200°C minimum.

Exposure

Upon removal from the drying or storage oven or hermetically sealed containers, the electrodes may not be exposed to the atmosphere for more than 4 hours. The

exposure may be extended to 8 hours if the electrodes are continuously stored in a portable electrode oven heated to 65°C minimum.

Re-conditioning

After any atmospheric exposure, the electrodes must be re-dried. Electrodes may be re-dried only once after atmospheric exposure. Electrodes that have become wet or moist shall not be used and shall be discarded.

Notes:

- 1) Storage and rebake ovens shall have a calibrated temperature gauge to continuously monitor the temperature.
- 2) Portable electrode storage ovens with a minimum temperature of 120°C are considered equivalent to storage ovens. Proper use of the oven (e.g., closed lid, continuously on while in use) and periodic checks of the temperature achieved with each portable oven are required.
- 3) Some applications may require higher drying temperatures and shorter atmospheric exposure times.
- 4) Electrode types are listed in accordance with ASME SEC IIC.

Table 2 – Conditioning, Storage, and Exposure of Wires and Fluxes

SAW fluxes:

All fluxes shall be stored in sealed containers in a dry environment. Opened SAW flux containers shall be stored continuously in ovens at 65°C minimum or the manufacturer's recommendation, whichever is greater. Any flux that has become moist or wet shall not be used and shall be discarded.

SAW, GTAW, GMAW, and FCAW electrodes and wires:

All electrodes and wires shall be stored in sealed containers in a dry environment. Any wires that have visible rusting or contamination shall not be used and shall be discarded.

**Table 3A – Preheat Temperatures for Vertical-Up SMAW Butt Welds
 (Notes 1, 2)
 (SI Units)**

Carbon Equivalent (Note 3)

Wall Thickness Range (4)	0.40	0.42	0.46	0.48	0.50	Pipe	Wall Thickness Range (4)
< 9.5 mm	10°C	10°C	10°C	10°C	10°C	10°C	< 9.5 mm
9.6 - 12.7	10°C	10°C	10°C	38°C	66°C	10°C	9.6 - 12.7
12.8 - 15.9	10°C	10°C	52°C	79°C	93°C	10°C	12.8 - 15.9
16.0 - 19.0	10°C	24°C	93°C	107°C	121°C	10°C	16.0 - 19.0
19.1 - 22.2	24°C	66°C	107°C	121°C	135°C	10°C	19.1 - 22.2
22.3 - 25.4	66°C	93°C	135°C	149°C	163°C	10°C	22.3 - 25.4
25.5 - 31.8	93°C	121°C	149°C	163°C	177°C	79°C	25.5 - 31.8
31.9 - 38.1	121°C	135°C	163°C	177°C	191°C	93°C	31.9 - 38.1
38.2 - 44.5	135°C	149°C	177°C	191°C	191°C	93°C	38.2 - 44.5
44.6 - 50.8	149°C	163°C	191°C	204°C	204°C	135°C	44.6 - 50.8

**Table 3B – Preheat Temperatures for Vertical-Up SMAW Butt Welds
 (Notes 1, 2)
 (Conventional Units)**

Carbon Equivalent (Note 3)

Wall Thickness Range (4)	0.40	0.42	0.46	0.48	0.50	Pipe	Wall Thickness Range (4)
< 0.375 inch	50°F	50°F	50°F	50°F	50°F	50°F	< 0.375 inch
0.376 - 0.500	50°F	50°F	50°F	100°F	150°F	50°F	0.376 - 0.500
0.501 - 0.625	50°F	50°F	125°F	175°F	200°F	50°F	0.501 - 0.625
0.626 - 0.750	50°F	75°F	200°F	225°F	250°F	50°F	0.626 - 0.750
0.751 - 0.875	75°F	150°F	225°F	250°F	275°F	50°F	0.751 - 0.875
0.876 - 1.000	150°F	200°F	275°F	300°F	325°F	50°F	0.876 - 1.000
1.001 - 1.250	200°F	250°F	300°F	325°F	350°F	175°F	1.001 - 1.250
1.251 - 1.500	250°F	275°F	325°F	350°F	375°F	200°F	1.251 - 1.500
1.501 - 1.750	275°F	300°F	350°F	375°F	375°F	200°F	1.501 - 1.750
1.756 - 2.000	300°F	325°F	375°F	400°F	400°F	275°F	1.756 - 2.000

Notes to Tables 3A and 3B:

- 1) This table assumes a minimum heat input of 1.2 kJ/mm (30 kJ/inch) and is valid only for:
 - a) All positions except vertical-down.
 - b) E6010 or E7010 root pass and E7018 or E8018-C3/C3 fill and cap electrodes, 3.2 mm minimum diameter.
 - c) Carbon steel materials up through Grade X60.
- 2) Except for split tee longitudinal welds, other hot-taps installation welds are exempt from these requirements.
- 3) $CE = C + (Mn/6) + (Cr+Mo+V)/5 + (Ni+Cu)/15$

General instructions for selecting the CE value if the actual value (by Mill Test Report or if the CE value is marked on the fitting) is not known:

 - a) For pipe to [01-SAMSS-035/332/333](#), use the column labeled "PIPE" (valid only for pipe-to-pipe joints; for pipe-to-fitting joints, use the fitting CE).
 - b) For pipe to 01-SAMSS-038, use CE = 0.42.
 - c) For flanges, assume CE = 0.46.
 - d) For fittings (other than flanges):
 - i) If unknown vintage, assume CE = 0.50
 - ii) If prior to [02-SAMSS-005](#) (August, 1988), assume CE = 0.46
 - iii) If to [02-SAMSS-005](#) (August, 1988), assume CE = 0.50
 - iv) If to [02-SAMSS-005](#) (May, 1993), assume CE = 0.42
- 4) General instruction for selecting the Wall Thickness value:
 - a) For pipe-to-pipe joints, use the actual wall thickness.
 - b) For pipe-to-fitting or fitting-to-fitting:
 - i) For fittings (other than flanges), use the next higher wall thickness range greater than the nominal wall thickness.
 - ii) For flanges, use the thickness corresponding to two higher wall thickness ranges greater than the nominal wall thickness.
 - iii) For fitting to fitting joints (including flanges), use the sum of the number of increased ranges for each member (i.e., 1 range for fittings, 2 ranges for flanges). Example, a flange to elbow fitting would use three ranges higher than the nominal wall thickness.

**Table 4A – Preheat Temperatures for Vertical-Down SMAW Butt Welds
 (Notes 1, 2)
 (SI Units)**

Carbon Equivalent (Note 3)

Wall Thickness Range (4)	0.40	0.42	0.46	0.48	0.50	Pipe	Wall Thickness Range (4)
< 9.5 mm	10°C	10°C	10°C	10°C	10°C	10°C	< 9.5 mm
9.6 – 12.7	10°C	10°C	10°C	38°C	66°C	10°C	9.6 - 12.7
12.8 – 15.9	10°C	10°C	52°C	79°C	93°C	10°C	12.8 - 15.9
16.0 – 19.0	10°C	24°C	93°C	107°C	121°C	10°C	16.0 - 19.0
19.1 – 22.2	24°C	66°C	107°C	121°C	135°C	10°C	19.1 - 22.2
22.3 – 25.4	66°C	93°C	135°C	149°C	163°C	10°C	22.3 - 25.4
25.5 – 31.8	93°C	121°C	149°C	163°C	177°C	79°C	25.5 - 31.8
31.9 – 38.1	121°C	135°C	163°C	177°C	191°C	93°C	31.9 - 38.1
38.2 – 44.5	135°C	149°C	177°C	191°C	191°C	93°C	38.2 - 44.5
44.6 - 50.8	149°C	163°C	191°C	204°C	204°C	135°C	44.6 - 50.8

**Table 4B – Preheat Temperatures for Vertical-Down SMAW Butt Welds
 (Notes 1, 2)
 (Conventional Units)**

Carbon Equivalent (Note 3)


Wall Thickness Range (4)	0.40	0.42	0.46	0.48	0.50	Pipe	Wall Thickness Range (4)
< 0.375 inch	50°F	50°F	50°F	50°F	50°F	50°F	< 0.375 inch
0.376 - 0.500	50°F	50°F	50°F	100°F	150°F	50°F	0.376 - 0.500
0.501 - 0.625	50°F	50°F	125°F	175°F	200°F	50°F	0.501 - 0.625
0.626 - 0.750	50°F	75°F	200°F	225°F	250°F	50°F	0.626 - 0.750
0.751 - 0.875	75°F	150°F	225°F	250°F	275°F	50°F	0.751 - 0.875
0.876 - 1.000	150°F	200°F	275°F	300°F	325°F	50°F	0.876 - 1.000
1.001 - 1.250	200°F	250°F	300°F	325°F	350°F	175°F	1.001 - 1.250
1.251 - 1.500	250°F	275°F	325°F	350°F	375°F	200°F	1.251 - 1.500
1.501 - 1.750	275°F	300°F	350°F	375°F	375°F	200°F	1.501 - 1.750
1.756 - 2.000	300°F	325°F	375°F	400°F	400°F	275°F	1.756 - 2.000

Notes to Tables 4A and 4B:

- 1) This table assumes a minimum heat input of 0.8 kJ/mm (20 kJ/inch) and is valid only for:
 - a) Vertical-down.
 - b) E6010/E7010 for all passes, 3.2 mm minimum diameter.
 - c) Carbon steel materials up through Grade X60.
 - d) When the hot pass is made within 5 minutes of completing the root pass.
- 2) Except for split tee longitudinal welds, other hot-taps installation welds are exempt from these requirements.
- 3) $CE = C + (Mn/6) + (Cr+Mo+V)/5 + (Ni+Cu)/15$

General instructions for selecting the CE value if the actual value (by Mill Test Report or if the CE value is marked on the fitting) is not known:

 - a) For pipe to [01-SAMSS-035/332/333](#), use the column labeled "PIPE" (valid only for pipe-to-pipe joints; for pipe-to-fitting joints, use the fitting CE).
 - b) For pipe to 01-SAMSS-038, use CE = 0.42.
 - c) For flanges, assume CE = 0.46.
 - d) For fittings (other than flanges):
 - i) If unknown vintage, assume CE = 0.50
 - ii) If prior to [02-SAMSS-005](#) (August, 1988), assume CE = 0.46
 - iii) If to [02-SAMSS-005](#) (August, 1988), assume CE = 0.50
 - iv) If to [02-SAMSS-005](#) (May, 1993), assume CE = 0.42
- 4) General instruction for selecting the Wall Thickness value:
 - a) For pipe-to-pipe joints, use the actual wall thickness.
 - b) For pipe-to-fitting or fitting-to-fitting:
 - i) For fittings (other than flanges), use the next higher wall thickness range greater than the nominal wall thickness.
 - ii) For flanges, use the thickness corresponding to two higher wall thickness ranges greater than the nominal wall thickness.
 - iii) For fitting to fitting joints (including flanges), use the sum of the number of increased ranges for each member (i.e., 1 range for fittings, 2 ranges for flanges). Example, a flange to elbow fitting would use three ranges higher than the nominal wall thickness.

REQUEST FOR WELDING PROCEDURE APPROVAL		 أرامكو السعودية Saudi Aramco
It is requested that the following Welding Procedure Specification (WPS) be reviewed and approved. The listed WPS has been qualification tested in accordance with SAES-W-010/SAES-W-012. It has been edited for clerical completeness and technical content.		
Company	Project	J.O./BI/PO/CONTRACT #
WELDING PROCEDURE SPEC. NO.		PROCEDURE QUALIFICATION RECORD (PQR) #
CODE / SPEC B31.3 B31.4 B31.8	DESIGN CONDITIONS: MAX. TEMP. _____ SERVICE FLUID _____ MIN. TEMP. _____ SOUR SERVICE ? YES NO CVN IMPACTS _____ HARDNESS _____ REQUIRED? YES NO TESTS? YES NO	
QUALIFICATION ASME SEC IX API STD 1104 AWS D1.1 OTHER: _____	SAMSS (Where Applicable)	LINE CLASS(es)
Submitting Saudi Aramco Organization		
		Date _____
Name: _____		Department: _____
Signature: _____		Address: _____
Telephone: _____		_____
FAX: _____		_____
Inspection Department Approval		
Name _____		Unit/Div/Dept: _____
Signature _____		Date: _____

SAES-W-011/012
 ATTACHMENT A

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WELDING PROCEDURE SPECIFICATION (WPS)

Company Name _____ By: _____			
Welding Procedure Specification No. _____	Date _____ Supporting PQR No.(s): _____		
Revision No. _____	Date: _____		
Welding Process(es) _____ Types _____			
CODE: ASME IX _____	API 1104 _____ AWS D1.1 _____ Other _____		
BASE METALS (QW-403)			
P-No. _____	Group No. _____ to P-No. _____ Group No _____		
Specification type and grade _____			
to Specification type and grade _____			
Chem. Analysis and Mech. Prop _____			
to Chem. Analysis and Mech. Prop. _____			
Base Metal: Groove _____	Fillet _____		
Deposited Weld Metal _____			
Pipe Dia. Range: Groove _____	Fillet _____		
Other _____			
JOINTS (QW-402) Details			
Joint Design _____			
Backing: Yes No Type _____			
FILLER METALS (QW-404)			
F-No.	_____	_____	_____
A-No.	_____	_____	_____
Spec. No. (SFA)	_____	_____	_____
AWS No. (Class.)	_____	_____	_____
Size of filler metals	_____	_____	_____
Electrode-Flux (Class.) ..	_____	_____	_____
Flux Trade Name	_____	_____	_____
Consumable Insert	_____	_____	_____
Other	_____	_____	_____
SAUDI ARAMCO APPROVAL		CSD Log. No. _____	
Name _____	Unit/Dept. _____		
Signature _____	Date _____		

SAES-W-011/012
 ATTACHMENT A

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PROCEDURE QUALIFICATION RECORD (PQR)

Company _____ PQR Number _____ Date _____

Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load (lb)	Ultimate Unit Stress (psi)	Type of Failure & Location

Guided Bend Tests (QW-160)

Type and Figure No.	Result

Toughness Tests (QW-170)

Specimen No.	Notch Location	Specimen Size	Test Temperature	Impact Values		
				Ft. lbs	% Shear	Mils

Comments _____

Fillet-Weld Test (QW-180)

Result-Satisfactory: Yes No Penetration into Parent Material Yes No
 Macro -- Results _____

Other Tests

Type of Test _____
 Deposit Analysis _____
 Other _____

Welder's Name _____ Clock No. _____ Stamp No. _____
 Tests conducted by: _____ Laboratory Test. No. _____

We certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code.

Manufacturer _____

Date _____ By _____

**SAUDI ARAMCO
 WELD AND LINE DESCRIPTION TABLE**

Piping Class or Designation or Service Description	Weld joint type			Material (P-No. or Grade)	Pipe Size Range	Wall Thickness Range	Service Requirements (check if yes)			Welding Procedure	Remarks
	Butt Weld	Branch connection	Fillet				Hardness	Charpy Impact	PWHT		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
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