



# Engineering Standard

SAES-W-012

7 July 2013

Welding Requirements for Pipelines

Document Responsibility: Welding Standards Committee

## Saudi Aramco DeskTop Standards

### Table of Contents

1	Scope.....	<a href="#">2</a>
2	Conflicts and Deviations.....	<a href="#">2</a>
3	References.....	<a href="#">2</a>
4	General.....	<a href="#">5</a>
5	Approved Welding Processes.....	<a href="#">6</a>
6	Welding Consumables.....	<a href="#">8</a>
7	Welding Procedures.....	<a href="#">11</a>
8	Welder and Welding Operator Qualification....	<a href="#">19</a>
9	Joint Details.....	<a href="#">20</a>
10	Technique and Workmanship.....	<a href="#">20</a>
11	Preheat.....	<a href="#">27</a>
12	Postweld Heat Treatment.....	<a href="#">27</a>
13	Production Weld Hardness Testing.....	<a href="#">30</a>
14	Inspection Access.....	<a href="#">31</a>
15	Weld Identification.....	<a href="#">31</a>
16	Inspection.....	<a href="#">32</a>
17	Repairs.....	<a href="#">39</a>
18	Miscellaneous Requirements.....	<a href="#">40</a>
19	Safety.....	<a href="#">41</a>
	Appendix 1 – Conditioning, Storage, and Exposure of SMAW Electrodes.....	<a href="#">42</a>
	Appendix 2 – Conditioning, Storage, and Exposure of Wires and Fluxes.....	<a href="#">45</a>
	Appendix 3 – Preheat Temperatures Tables.....	<a href="#">46</a>
	Attachment A – Request for Welding Procedure Approval.....	<a href="#">50</a>
	Attachment B – Weld and Line Description Table.....	<a href="#">51</a>

## 1 Scope

- 1.1 This standard specifies the welding, heat treatment, Nondestructive Testing (NDT), Charpy impact testing, and hardness testing requirements for welding pipelines and equipment (e.g., scraper traps) to ASME B31.4 and ASME B31.8. It covers both onshore and offshore pipelines, including shop and field fabrication, repairs, and modification. Distribution and other facilities which use ASME 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

<a href="#"><u>SAEP-302</u></a>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
<a href="#"><u>SAEP-321</u></a>	<i>Performance Qualification Testing and Certification of Saudi Aramco Welders</i>
<a href="#"><u>SAEP-323</u></a>	<i>Performance Qualification Testing of Contract Welders and Brazers</i>
<a href="#"><u>SAEP-324</u></a>	<i>Certification Review and Registration of Project Welders and Brazers</i>
<a href="#"><u>SAEP-352</u></a>	<i>Welding Procedure Review and Approval</i>
<a href="#"><u>SAEP-1140</u></a>	<i>Qualification of Saudi Aramco NDT Personnel</i>
<a href="#"><u>SAEP-1142</u></a>	<i>Qualification of Non-Saudi Aramco NDT Personnel</i>

#### Saudi Aramco Engineering Standards

<a href="#"><u>SAES-A-206</u></a>	<i>Positive Material Identification</i>
<a href="#"><u>SAES-B-064</u></a>	<i>Onshore and Nearshore Pipeline Safety</i>
<a href="#"><u>SAES-L-131</u></a>	<i>Fracture Control of Line Pipe</i>
<a href="#"><u>SAES-W-010</u></a>	<i>Welding Requirements for Pressure Vessels</i>

#### Saudi Aramco Materials System Specifications

<a href="#"><u>01-SAMSS-035</u></a>	<i>API Line Pipe</i>
<a href="#"><u>01-SAMSS-038</u></a>	<i>Small Direct Charge Purchases of Pipe</i>
<a href="#"><u>01-SAMSS-333</u></a>	<i>High Frequency Welded Line Pipe</i>
<a href="#"><u>02-SAMSS-005</u></a>	<i>Butt Welding Pipe Fittings</i>

#### Saudi Aramco Standard Drawings

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

#### Saudi Aramco Construction Safety Manual

### 3.2 Industry Codes and Standards

#### American Petroleum Institute

<a href="#"><u>API SPEC 5L</u></a>	<i>Specification for Line Pipe</i>
<a href="#"><u>API STD 1104</u></a>	<i>Welding of Pipelines and Related Facilities</i>
<a href="#"><u>API RP2A-WSD</u></a>	<i>Planning, Designing and Constructing Fixed Offshore Platforms-Working Stress Design</i>

#### American Society of Mechanical Engineers

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

#### American Society for Testing and Materials

<a href="#"><u>ASTM A707</u></a>	<i>Standard Specification for Forged Carbon and Alloy Steel Flanges for Low-Temperature Service</i>
<a href="#"><u>ASTM A833</u></a>	<i>Indentation Hardness of Metallic Materials by Comparison Hardness Testers</i>
<a href="#"><u>ASTM E747</u></a>	<i>Standard Test Method for Controlling Quality of Radiographic Testing Using Wire Penetrimeters</i>

#### American Welding Society

<a href="#"><u>AWS A2.4</u></a>	<i>Standard Welding Symbols</i>
<a href="#"><u>AWS A3.0</u></a>	<i>Standard Terms and Definitions</i>
<a href="#"><u>AWS A4.3</u></a>	<i>Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Weld Metal Produced by Arc Welding</i>
<a href="#"><u>AWS A5.01</u></a>	<i>Procurement Guidelines for Consumables</i>
<a href="#"><u>AWS A5.32</u></a>	<i>Specification for Welding Shielding Gases</i>
<a href="#"><u>AWS D1.1</u></a>	<i>Structural Welding Code- Steel</i>

---

British Standards Institution

- [BS EN ISO 14175](#)      *Welding Consumables - Gases and Gas Mixtures for Fusion Welding and Allied Processes*
- [BS EN ISO 14344](#)      *Welding and Allied Processes - Flux and Gas Shielded Electrical Welding Processes - Procurement Guidelines for Consumables*
- [BS EN50504](#)      *Validation of Arc Welding Equipment*

Manufacturers Standardization Society of the Valve and Fittings Industry

- [MSS-SP-75](#)      *Specification for High Test, Wrought, Butt Welding Fittings*

National Association of Corrosion Engineers

- [NACE SP0472](#)      *Methods and Controls to Prevent In-Service Cracking of Carbon Steel Welds in P-1 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).
- 4.5 The terms “shall,” “should” and “may” have the following significance:

Provisions that use “shall” are mandatory unless specifically modified in contract documents by the Engineer.

The word “should” is used to recommend practices that are considered beneficial but are not requirements.

The word “may” in a provision allows the use of optional procedures or practices that can be used as an alternative to the Standard requirement.

## 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, groove welds and socket welds less than 33.4 mm outside diameter (1" NPS).
    - 5.2.3 The GTAW process shall be used for the root pass of butt welds, groove welds and socket welds of 60.3 mm outside diameter (2" NPS) 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.
    - 5.2.6 When internal coatings are specified on pipelines, the GTAW process shall be used for the root pass of butt welds for inaccessible piping diameters, i.e., those below 24-inches diameter. Other processes may be used if the level of weld spatter and the weld profile are acceptable for coating or if measures in removing weld spatter are proven to be effective. Internal copper shoes may be effective for controlling weld spatter.
  - 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) Mechanized welding using the GMAW process in the short-circuiting or pulsing mode requires 100% ultrasonic inspection. 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.
  - e) The modified short circuit mode of GMAW may only be used for root **pass** welding. It is not applicable to fill passes.
- 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.
- 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 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.
- 5.8 Welding without filler metal additions is not permitted.
-

## 6 Welding Consumables

### 6.1 General

- 6.1.1 Electrodes, filler wires, and fluxes shall conform to [ASME SEC II-C](#). 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 II-C](#)) 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.
- 6.1.2 All consumables shall be stored and dried in accordance with the requirements of [Appendix 1](#) for SMAW electrodes and [Appendix 2](#) for other consumables.
- 6.1.3 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.
- 6.1.4 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.
- 6.1.5 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) Cellulosic electrodes may be used in all passes for girth welds for pipelines and equipment for grades up to and including X60 and wall thickness less than or equal to 25 mm. Cellulosic electrodes shall not be used for hot tapping operation or for in-service welding.
  - b) Cellulosic electrodes may be used for the root and hot passes of single-sided groove welds without backing for pipelines and equipment for all grades and wall thicknesses.
- 6.1.6 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.

DMWs shall be restricted as follows:

- a) DMWs are not permitted for any welds exposed to 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) DMWs 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, air) services.
- d) Hydrogen addition in the shielding gas is not permitted for DMW.

6.1.7 Other than the DMWs listed in paragraph 6.1.6, 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.

6.1.8 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. E7010-P1 may be used.

6.1.9 All electrodes shall be purchased with certified lot testing in accordance with [AWS A5.01](#) or [BS EN ISO 14344](#). The Lot classification shall be S2, T2, C2, F2 or higher. The schedule of testing shall be “4 or I” or higher for [AWS A5.01](#) and “Schedule 4” or higher for [BS EN ISO 14344](#).

---

6.1.10 If ER70S-6 is to be used for sour service the chemistry of the wire shall not exceed the requirements of [NACE SP0472](#) (as follows):

- Carbon (C) 0.10 wt% max;
- Manganese (Mn) 1.60 wt% max;
- Silicon (Si) 1.00 wt% max.

This must be verified for all lots of wire.

6.1.11 If a consumable has an AWS classification which has a minimum tensile strength lower than the minimum required tensile strength of the material being welded, it is potentially under-matching. All of the lots of this type of consumable shall be checked to confirm that they have tensile and yield strengths exceeding the minimum required for the base material being welded.

## 6.2 Submerged Arc Welding Fluxes

6.2.1 Active type Submerged Arc Welding fluxes shall not be used without CSD 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.

6.2.2 Flux fused during welding shall not be reused (i.e., fluxes that use recrushed slag are not acceptable).

6.2.3 Reclaimed flux can be used provided following the conditions below:

- Sieved to remove fused flux.
- Separated to remove fines.
- Magnetically separated.
- Mixed with the percentage of new flux recommended by the flux manufacturer.
- Baked out prior to use per manufacturer recommendations.

6.2.4 SAW fluxes that the flux manufacturer recommends for single pass welding shall not be used for multiple pass welding.

## 6.3 SMAW electrodes shall be limited as follows:

6.3.1 F-Nos. 1 and 2 electrodes shall not be used on materials requiring impact tests either by Code or job specification.

6.3.2 F-Nos. 1 and 2 electrodes shall not be used for pressure-retaining welds.

#### 6.4 Shielding Gases

6.4.1 Shielding gases shall conform to the requirements of [AWS A5.32](#) or [BS EN ISO 14175](#).

6.4.2 The requirements for other gases and gas mixtures shall be submitted to CSD for approval.

6.5 The following table gives the minimum strength levels for consumables that can be used to weld the various grades of pipe.

Pipe	Root Consumable Minimum	Fill Consumable Minimum	Note
X52 and below	60XX	70XX	
X56 and X60	70XX	70XX	Must have mill certs for 70XX fill consumable showing that it meets 75 ksi tensile
X65	70XX	80XX	
X70	70XX	80XX	

**Notes:**

- This table applies to manual and semiautomatic welding. It does not apply to automatic GMAW welding.
- This table must be used in conjunction with electrode selection requirements in Section 6.1.5.

6.6 For sour service application, all welding related requirements of ISO 15156 shall be followed. Note that for sour service, carbon steel welding consumables containing more than 1.1% mass fraction nickel are not acceptable.

## 7 Welding Procedures

### 7.1 Documentation

7.1.1 All welding procedures to be used shall be submitted to Saudi Aramco PMT or the proponent as a complete package prior to the start of work (refer to [SAEP-352](#) for details). The package of welding procedures, qualification test records, and Weld and Line Description Tables shall be submitted for the technical approval by CSD. Only the welding procedure will be approved.

---

Welding procedures approved by CSD or Saudi Aramco Welding Representatives may be used for additional jobs if approved by a Saudi Aramco assigned PID or VID inspector. The welding procedure shall meet all of the requirements of the new job as a minimum the following shall be checked:

- Material of new job shall be covered by WPS
- Diameter of new job shall be covered by WPS
- Thickness of new job shall be covered by WPS
- PWHT condition of new job shall be covered by WPS
- If new job is for Sour service then the review sheet shall indicate “for sour service” or the hardness values in the PQR shall be checked.
- If the new job has “impact requirements” then the review sheet shall be checked for impact approval and the MDMT.

And the ranges of variables on the new project fall within the ranges of the approved procedures. A Line Description Tables for the new work shall be submitted to the assigned inspector. Welding procedures for external structural supports that do not attach to the pressure-containing component do not require CSD approval and they may be qualified to [AWS D1.1](#).

- 7.1.2 The forms for the WPSs and PQRs shall be as suggested in the respective code being used.
  - 7.1.3 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.
  - 7.1.4 After approval by Saudi Aramco inspector, the fabricator shall issue copies of the approved Welding Procedures and Weld and Line Description Tables to the Saudi Aramco Inspector and PMT prior to the start of fabrication.
  - 7.1.5 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.
-

- 7.1.6 All WPSs, PQRs, and Weld and Line Description Tables shall be available at the work site for review at any time by the authorized Saudi Aramco inspector.
  - 7.1.7 All Welding Procedure Specifications and Welding Procedure Qualification Records shall be written in English.
  - 7.1.8 For in-Kingdom contractors the PQRs shall include the original testing certificates, a copy of the original certificates that has been certified by the testing agency, or a color copy of the original certificates. For Out-of-Kingdom qualifications the contractor shall stamp all PQR records certifying them to be true copies.
  - 7.1.9 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 Welding procedures for pipelines designed to ASME B31.4 or ASME B31.8 shall be qualified in accordance with [API STD 1104](#) or ASME SEC IX. All mechanized welding procedures shall be qualified in accordance with [API STD 1104](#) Section 12 Mechanized Welding with Filler Metal.
  - 7.2.2 Welding procedures for “in Service” welding shall be qualified in accordance with [API STD 1104](#) Appendix B. In service welding includes the attachment of repair sleeves, hot tap sleeves, and weld patches. Qualification testing shall be performed of the same or higher carbon equivalent.  
  
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 re-qualified.
  - 7.2.3 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.
  - 7.2.4 All information shown on the PQR, such as amperage, voltage, travel speed, post-weld heat treatment time and temperature, as applicable, shall be actual data as recorded using calibrated instruments.
-

7.2.5 For all qualifications:

- a) The welding of all qualification test coupons shall be monitored by either an independent third party 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 ISO 17025 certified test laboratory

**Note:** *For all PQR testing, the ISO 17025 document shall be submitted along with welding submittal as a mandatory requirement prior review and approval.*

7.2.6 For all mechanized 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 are not normally permitted in sour service and 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 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) for both API STD 1104 and ASME SEC IX.

7.4.2 A350 LF6 material shall be considered as P-No. 1 in accordance with [ASME SEC IX](#) and does not require separate qualifications as “unlisted” material.

7.4.3 The following materials are unlisted in ASME SEC IX and shall require separate qualifications:

A350 LF787

A707 L5

**Note:** *Both flange materials above require a higher preheat refer to the notes in Tables 3A/B and 4A/B.*

- 7.4.4 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.
- 7.4.5 For procedures with impact toughness requirements, 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 number 2 shall not be used.
- 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 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 II-C](#)) 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.
- 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 “**12 Mechanized Welding with Filler Metal**” 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

Procedure should be qualified on the thinnest and thickest materials to be welded. This establishes the range of qualification. If a procedure is qualified on only one thickness, the qualified thickness is  $\pm 3.2$  mm of the actual PQR value.

- 7.4.19 Special requirements for impact testing of welding procedures:

7.4.19.1 All welding procedures for ASME B31.8 and all offshore pipelines shall be impact tested. The impact testing shall be conducted at the minimum design metal temperature (MDMT) or  $0^{\circ}\text{C}$  whichever is lower.

7.4.19.2 Charpy impact testing of P-No. 1 Gr.1 and 2 materials (including API grades through X70) shall have a minimum absorbed energy of 34/27 J (25/20 ft-lb) for Gr. 1 and 40/32 J (30/24 ft-lb) for Gr. 2 for full size (10 x 10 mm) specimens for both the weld and heat-affected zone. The minimum absorbed energy for sub-size specimens shall comply with ASTM A370, Table 9.

7.4.19.3 If Charpy impact testing of the girth welding procedure is required for procedures qualified to [API STD 1104](#), then the supplementary essential variables of [ASME SEC IX](#) shall be mandatory.

7.4.19.4 If Charpy impact testing is required for procedures, 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. Note that the temperature penalty for sub-sized samples only occurs if the sample size is less than 80% of the actual wall thickness.

7.4.19.5 The heat input shall be recorded on the PQR and used as the limiting value for the WPS and it shall be based on the

average value of welding parameters used. If the PQR heat input varies by position, 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.

7.4.19.6 If the PQR thickness exceeds 12 mm and 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).

7.4.19.7 The specimens will be held at test temperature for at least 10 min in liquid media and 1 hour in gaseous media.

## 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 test load of 10 kg.
- 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.
- 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 SEC IX](#) depending on the code being used for the qualification. 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-323](#), and [SAEP-324](#), as applicable, for all welding, including tack, temporary, and repair welds.
- 8.2 Welders and Welder Operators performance shall be based on [SAEP-323](#) and [SAEP-324](#) Section 6.
- 8.3 Performance qualification tests shall not be performed on production joints on Saudi Aramco work.
- 8.4 For the welders to be qualified in accordance with ASME SEC IX, after the effectiveness of this standard revision, all short-circuit transfer mode GMAW processes (including STT, RMD, etc.) shall be qualified in accordance with ASME SEC IX, that is UT or bend test. RT is not acceptable. The welders who are qualified in accordance with API 1104 for short-circuit mode processes

(including STT, RMD, etc.) may be qualified by RT or UT or mechanical test as permitted by the code.

## 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, including socket welds, shall be made with multiple passes.
- 9.3 Permanent backing rings or strips shall not be used except for the backing strips on sleeve longitudinal welds.
- 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 joints with included angles less than 60 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 7.4.7 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 (-0, + 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 (un-oxidized) 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 by MT or PT.
-

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 7.4.12. 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 Battering or Weld Build-Up on Joints

10.3.5.1 Battering 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 battering or build-up exceeds this, then the following requirements shall apply:

- a) The battering operation shall be witnessed by Saudi Aramco Inspection.
- b) The battering 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 Battering 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.

10.4.1 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-131](#)) 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 shall not be permitted unless approved by CSD and specified in the approved welding procedure. Cleaning of slag is not considered 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.
- 10.18.3 For P-5 materials, the back purge 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 Back purging shall be maintained until completion of root, hot and 1<sup>st</sup> fill passes.
- 10.18.5 For stainless steel and nickel alloys, the back purge 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 un-welded).
-

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 girth 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. The length of the intersecting joint that must be inspected is 3 times the branch opening or 200mm whichever is greater.

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.

10.23 The maximum permitted misalignment shall be the lesser of 3mm or what is shown on the WPS. If an Engineering Critical Assessment is being used to determine the weld acceptance criteria then the misalignment in it shall govern. Any weld with mismatch exceeding the maximum shall be cut, refit and re-welded.

## 11 Preheat

- 11.1 For carbon steels (all ASME P-No. 1 materials, including API grades up to and including X70), the minimum preheat shall not be less than the greater of the following:
- 10°C.
  - The required preheat in [ASME B31.4](#) or [ASME B31.8](#) as appropriate
  - The preheat calculated in Standard Drawing [AE-036451](#).

For normal applications, simplified requirements are listed in Tables 3A, 3B, 4A and 4B in [Appendix 3](#).

- 11.2 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.
- 11.3 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.
- 11.4 The preheat temperature shall be established over a minimum distance of 75 mm on each side of the weld.
- 11.5 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.
- 11.6 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 measurement, and thermocouple locations. The review and approval process shall be the same as described for welding procedures ([Section 7.1](#)).
- 12.2 PWHT is required due to some service conditions. Hydrogen, caustic (including caustic carryover) and amine services will require review by CSD to determine
-

PWHT requirements. This is not normally applicable to pipelines.

- 12.3 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.
  - 12.4 The weld joint thickness for unequal thickness butt welds for all applications ([ASME B31.4](#) and [ASME B31.8](#)) to be used in determining the postweld heat treatment requirements shall be based on the effective weld throat as defined in [ASME B31.4](#).
  - 12.5 The specified PWHT temperature shall be applied over an area extending at least 6 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.
  - 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.
  - 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

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.

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.

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.

### **13 Production Weld Hardness Testing**

- 13.1 Hardness testing according to [ASTM A833](#) 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 SP0472](#) 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 SP0472](#) 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.
- 13.4 If any reading exceeds the specified limit by no more than 10 BHN, then a minimum of three (3) additional indentations shall be made near the original high reading. If all three (3) retests are below the specified limits, then the joint

is acceptable. If any of the retest readings are found to exceed the specified limits, then the weld shall be considered unacceptable.

- 13.5 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.

*Commentary Note:*

*If telebrinell hardness tester cannot be applied due to the weld geometry then alternative hardness tester may be used after approval by CSD welding engineer.*

## **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 Technique

- 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, ultrasonically inspected and magnetic particle inspected as configuration permits.
- 16.2.6 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.

## 16.3 Ultrasonic Testing Technique

- 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 systems operating in the short-circuiting or pulsing mode. The system must be approved by the 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 Technique

- 16.4.1 Permanent magnet yokes are not permitted.
- 16.4.2 Prods are not permitted for use on materials with impact testing requirements or on the fluid side surface of components in sour service.
- 16.4.3 The acceptance criteria for magnetic particle examination shall be [ASME SEC VIII](#), Appendix 6.

#### 16.5 Liquid Penetrant Technique

The acceptance criteria for liquid penetrant particle examination shall be [ASME SEC VIII](#), Appendix 8.

#### 16.6 Extent of NDT

The minimum extent of nondestructive testing (NDT) shall be in accordance with [ASME B31.4](#) or [ASME B31.8](#) as applicable. 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. Additional 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.

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

#### 16.7 Extent of NDT for Butt (Girth) Welds

##### 16.7.1 Radiography and Ultrasonic Inspection

The minimum extent of Radiographic or Ultrasonic testing shall be in accordance with [ASME B31.4](#) or [ASME B31.8](#) as applicable.

- 16.7.1.1 For girth welds made with an automatic/mechanized GMAW process using the short-circuiting or pulsing 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.

- 16.7.1.2 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%.
- 16.7.1.3 The radiographic and ultrasonic testing interpretation shall be to [API STD 1104](#).
- 16.7.1.4 When random radiography or ultrasonic testing is permitted for onshore lines the percentage of radiography must be increased if the repair rate is not below an acceptable level. The extent of coverage (RAD) listed means the percentage of welds completed that day that shall be inspected over their entire length. The joints to be inspected shall be selected to include a representative selection from all welders. Additional emphasis may be placed on welders with repair rates higher than the current job average.
- 16.7.1.5 The minimum extent of Radiographic or Ultrasonic testing shall be in accordance with [ASME B31.4](#) or [ASME B31.8](#) as applicable. An increased percentage is required if a higher percentage of coverage is established by either of the following methods listed in 16.7.1.5.1 or 16.7.1.5.2 (both methods shall be calculated and the higher percentage rate shall govern).

16.7.1.5.1 Linear Basis

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

where:

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

L = total length of repairs, mm

N = total number of joints welded 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.

#### 16.7.1.5.2 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 inspected for that day's welds.

- 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 inspected 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 inspected) and the next day's production.

**Note:** *The linear basis percentage radiography must be rounded up to the next number divisible by 10. The intent of the linear basis formula is that the following day's X-ray rate will be a minimum of the greater of the required X-ray rate or 10 times the previous days linear X-ray defect percentage.*

#### 16.7.1.6 Additional Welds requiring 100% radiographic or ultrasonic inspection

The following weld joints are also required to be 100% radiographically or ultrasonically inspected. If additional radiography or ultrasonic inspection is required by these provisions, these radiographic or ultrasonic inspections shall not count towards the required coverage for the remaining joints of that day's production. However, all of the joints inspected that day shall be used in calculating the repair rate and the required inspection 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 inspected.

- b) Repaired welds (except for superficial grind repairs).
- c) The joint preceding and the joint succeeding a repaired weld, if not previously inspected.
- d) The ten preceding and the ten succeeding welds of a cracked weld, if not previously inspected.
- 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.
- k) The first three production welds of each new welder.

16.7.2 All Girth welds will be visually examined externally.

16.8 Extent of NDT for Branch connections (including branch weldolets, sockolets, and welding bosses)

16.8.1 Visual Inspection

All Branch connection welds will be visually inspected. For welds with a reinforcing pad the weld between the branch and the header shall be inspected prior to installing the reinforcing pad and again after installing the reinforcing pad.

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

16.8.2 Magnetic Particle or Liquid Penetrant Inspection

Branch connection welds (including sockolets, weldolets, and welding bosses) shall be inspected by magnetic particle or liquid penetrant

---

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 lateral branch connections.

Note that branch connection details that have a reinforcing pad or sleeve shall have the branch to header weld inspected prior to installation of the reinforcing pad or sleeve and again after installing the reinforcing pad or sleeve.

#### 16.8.3 Ultrasonic Inspection of Lateral Branch Connections

The branch to header weld shall be ultrasonically or radiographically inspected for all lateral branch connections in hydrocarbon service. 10% of all non-hydrocarbon lateral branch connections must be inspected. This must be performed prior to installing the reinforcing pad or sleeve. After installation of the reinforcing pad, radiographic inspection shall be used to insure that the full body of the weld is inspected. PID can determine the accessibility for conducting radiographic testing of the reinforcing pad.

#### 16.9 Extent of Testing for Attachment Welds

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. 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.

#### 16.10 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	Any
	3-6 mm	25 mm maximum
	Over 6 mm	None
Internally Coated	2.5 mm or less	Any
	Over 2.5 mm	None

#### 16.11 Positive Material Identification (PMI)

PMI shall be conducted for the materials listed in Table 1 of [SAES-A-206](#).

## 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 validated in accordance with [BS EN50504](#) or an approved equivalent if impact toughness test is required by the applicable company or industry specifications or codes. Validation 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:

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



## 19 Safety

All welding operations and relevant activities (e.g., grinding, cutting, etc.) will be conducted in accordance with the SAUDI ARAMCO CONSTRUCTION SAFETY MANUAL. Due to the nature of cutting and welding, care must be taken when working in environments where hydrocarbons are present. Particular notice must be taken to hot work permit requirements.

7 July 2013	<b>Revision Summary</b> Major revision.
-------------	--

## **Appendix 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 or vacuum sealed package. Electrodes may be re-dried only once.

#### **Storage**

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

#### **Exposure**

Upon removal from the drying or storage oven, hermetically sealed containers, or vacuum sealed package, 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.

### **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 or vacuum sealed package. Electrodes may be re-dried only once.

### **Storage**

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

### **Exposure**

Upon removal from the drying or storage oven, hermetically sealed containers, or vacuum sealed package, 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. E70xx or E80xx 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.

## **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 or vacuum sealed package. Electrodes may be re-dried only once.

### **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, hermetically sealed containers, or vacuum sealed package, 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.

### **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 II-C](#).

## **Appendix 2 – Conditioning, Storage, and Exposure of Wires and Fluxes**

### **SAW Fluxes**

Fluxes for material with a minimum specified tensile strength less than or equal to 482 MPa:

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.

Fluxes for material with a minimum specified tensile strength exceeding 482 MPa:

Fluxes will be dried, stored and handled in accordance with the manufacturer's recommendations in order to achieve a dissolved hydrogen content of less than 8 ml H<sub>2</sub>/100g metal. A written procedure giving the handling requirements will be submitted to inspection.

### **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.

### Appendix 3 – Preheat Temperatures Tables

**Table 3A – Preheat Temperatures for Vertical-Up Butt Welds**

(Notes 1, 2)  
 (SI Units)

Carbon Equivalent (Note 3)

Wall Thickness Range (4)	Pipe Components, i.e. Fittings, Sleeves, and Flanges					PIPE (6)	Wall Thickness Range (4)
	0.40	0.42	0.46	0.48	0.50		
< 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 Butt Welds**

(Notes 1, 2)  
 (Conventional Units)

Carbon Equivalent (Note 3)

Wall Thickness Range (4)	Pipe Components, i.e. Fittings, Sleeves, and Flanges					PIPE (6)	Wall Thickness Range (4)
	0.40	0.42	0.46	0.48	0.50		
< 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 vertical up welding
    - b) Carbon steel materials up through Grade X70.
  - 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-035/01-SAMSS-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.
  - 5) All [ASTM A707](#) L5 and A350 LF787 flanges shall be considered to have a carbon equivalent 0.50%. This is irrespective to the actual chemistry of the flange as shown in the Mill Test Certificate.
  - 6) The preheat for pipe only applies to pipe purchased in accordance with [01-SAMSS-035](#) or [01-SAMSS-333](#). This does not apply to fittings or flanges.
-

**Table 4A – Preheat Temperatures for all Welding except Vertical Up**

(Notes 1, 2)

(SI Units)

Carbon Equivalent (Note 3)

Wall Thickness (Note 4)	Pipe Components, i.e. Fittings, Sleeves, and Flanges					PIPE (6)	Wall Thickness Range (4)
	0.40	0.42	0.46	0.48	0.50		
<9.5 mm	10°C	10°C	52°C	66°C	93°C	10°C	<9.5 mm
9.6-12.7	10°C	52°C	93°C	121°C	135°C	10°C	9.6-12.7
12.8-15.9	38°C	66°C	121°C	135°C	149°C	10°C	12.8-15.9
16.0-19.0	66°C	93°C	135°C	149°C	163°C	10°C	16.0-19.0
19.1-22.2	93°C	121°C	149°C	163°C	177°C	10°C	19.1-22.2
22.3-25.4	121°C	135°C	163°C	177°C	191°C	10°C	22.3-25.4
25.5-31.8	121°C	149°C	177°C	177°C	191°C	79°C	25.5-31.8
31.9-38.1	135°C	163°C	191°C	191°C	204°C	93°C	31.9-38.1
38.2-44.5	149°C	177°C	191°C	204°C	204°C	121°C	38.2-44.5
44.6-50.8	177°C	191°C	204°C	204°C	204°C	149°C	44.6-50.8

**Table 4B – Preheat Temperatures for all Welding except Vertical Up**

(Notes 1, 2)

(Conventional Units)

Carbon Equivalent (Note 3)

Wall Thickness Range (4)	Pipe Components, i.e. Fittings, Sleeves, and Flanges					PIPE (6)	Wall Thickness Range (4)
	0.40	0.42	0.46	0.48	0.50		
<0.375 inch	50°F	50°F	125°F	150°F	200°F	50°F	<0.375 inch
0.376-0.500	50°F	125°F	200°F	250°F	275°F	50°F	0.376-0.500
0.501-0.625	100°F	150°F	250°F	275°F	300°F	50°F	0.501-0.625
0.626-0.750	150°F	200°F	275°F	300°F	325°F	50°F	0.626-0.750
0.751-0.875	200°F	250°F	300°F	325°F	350°F	50°F	0.751-0.875
0.876-1.000	250°F	275°F	325°F	350°F	375°F	50°F	0.876-1.000
1.001-1.250	250°F	300°F	350°F	350°F	375°F	175°F	1.001-1.250
1.251-1.500	275°F	325°F	375°F	375°F	400°F	200°F	1.251-1.500
1.501-1.750	300°F	350°F	375°F	400°F	400°F	250°F	1.501-1.750
1.756-2.000	350°F	375°F	400°F	400°F	400°F	300°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) All welding except vertical up.
    - b) Carbon steel materials up through Grade X70.
    - c) 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-035/01-SAMSS-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.

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.
  - 5) All [ASTM A707](#) L5 and A350 LF787 flanges shall be considered to have a carbon equivalent 0.50%. This is irrespective to the actual chemistry of the flange as shown in the Mill Test Certificate.
  - 6) The preheat for pipe only applies to pipe purchased in accordance with [01-SAMSS-035](#) or [01-SAMSS-333](#). This does not apply to fittings or flanges.
-

**Attachment A – Request for Welding Procedure Approval**

<b>REQUEST FOR WELDING PROCEDURE APPROVAL</b>		 <b>أرامكو السعودية Saudi Aramco</b>
<b>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-011/SAES-W-012. It has been edited for clerical completeness and technical content.</b>		
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 REQUIRED? YES NO HARDNESS TESTS? YES NO	
QUALIFICATION ASME SEC IX API STD 1104 AWS D1.1 OTHER: _____	SAMSS (Where Applicable)	LINE CLASS(es)
<b>Submitting Saudi Aramco Organization</b>		
Name: _____		Date: _____
Signature: _____		Department: _____
Telephone: _____		Address: _____
FAX: _____		
<b>Inspection Department Approval</b>		
Name _____		Unit/Div/Dept: _____
Signature _____		Date: _____

