

Engineering Standard

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Welding Requirements for Offshore Structures

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Saudi Aramco DeskTop Standards

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1 Scope

- 1.1 This standard specifies the welding, heat treatment, Nondestructive Testing (NDT), and hardness testing requirements for welding of offshore structures. These requirements are in addition to the requirements of API RP2A and AWS D1.1.

For materials outside the scope of API RP2A, 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 System 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

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

- 3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

<u>SAEP-321</u>	<i>Performance Qualification Testing and Certification of Saudi Aramco Welders</i>
<u>SAEP-322</u>	<i>Performance Qualification Testing and Certification of Saudi Aramco Brazers</i>
<u>SAEP-323</u>	<i>Performance Qualification Testing of Contract Welders and Brazers</i>
<u>SAEP-324</u>	<i>Certification Review and Registration of Project Welders and Brazers</i>
<u>SAEP-1140</u>	<i>Qualification of Saudi Aramco NDT Personnel</i>
<u>SAEP-1142</u>	<i>Qualification of Non-Saudi Aramco NDT Personnel</i>
<u>SAEP-1150</u>	<i>Inspection Coverage on Projects</i>

Saudi Aramco Standard Drawings

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

3.2 Industry Codes and Standards

American Petroleum Institute

<i>API RP2A-WSD</i>	<i>Planning, Designing, and Constructing Fixed Offshore Platforms - Working Stress Design</i>
<i>API RP2X</i>	<i>Recommended Practice for the Ultrasonic Inspection of Tubular Joints</i>
<i>API SPEC 5L</i>	<i>Specification for Line Pipe</i>

American Welding Association

<i>AWS A2.4</i>	<i>Standard Welding Symbols</i>
<i>AWS A3.0</i>	<i>Standard Terms and Definitions</i>
<i>AWS A4.3</i>	<i>Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Weld Metal Produced by Arc Welding</i>
<i>AWS D1.1</i>	<i>Structural Welding Code</i>

American Society of Mechanical Engineers/Boiler & Pressure Vessel Code

<i>ASME SEC IIC</i>	<i>Welding Rods, Electrodes and Filler Metals</i>
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<i>ASME SEC V</i>	<i>Nondestructive Examination</i>
<i>ASME SEC IX</i>	<i>Welding and Brazing Qualifications</i>

American Society for Testing and Materials

<i>ASTM A578</i>	<i>Straight-beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications</i>
<i>ASTM A833</i>	<i>Indentation Hardness of Metallic Materials by Comparison Hardness Testers</i>

Compressed Gas Association, Inc.

<i>CGA G-6.2</i>	<i>Compressed Gas Association (CGA) Specification for Carbon Dioxide</i>
<i>CGA G-11.1</i>	<i>Compressed Gas Association (CGA) Specification for Argon</i>
<i>BC-C-101</i>	<i>Federal Specification for Carbon Dioxide</i>

British Standards Institution

<i>BS 4360</i>	<i>Weldable Structural Steels</i>
<i>BS 7191</i>	<i>Weldable Structural Steels for Fixed Offshore Structures</i>
<i>BS 7570</i>	<i>Code of Practice for Validation of Arc Welding Equipment</i>

4 General

- 4.1 All of the fabrication and inspection requirements or recommendations listed in API RP2A are mandatory unless specified otherwise in this standard.
- 4.2 AWS A2.4 "Standard Welding Symbols" shall be used for all welding details on all drawings.
- 4.3 AWS A3.0 "Standard Terms and Definitions" shall be used for all specifications and documents.
- 4.4 These requirements apply to all sub-contractors or sub-vendors for items within the scope of this standard.

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 Filler metal shall be added.
 - 5.2.2 The use of flux-cored GTAW wires for the root pass of single-sided groove welds of P-No. 8 or higher materials with or without backing gas is not permitted unless specifically approved by CSD.
 - 5.3 Submerged Arc Welding (SAW).
 - 5.4 Gas Metal Arc Welding (GMAW) [including Flux Cored Arc Welding (FCAW)].
 - 5.4.1 The short-circuiting (dip) mode shall be used only for:
 - a) Tacking (including continuous tacks) that will be completely removed by backgouging and backwelding
 - b) Structural applications with a wall, plate, or flange thickness of 10 mm or less [Note that the short-circuiting mode (dip transfer) is not prequalified to AWS D1.1].
 - c) Seal welds for structural applications of any thickness.
 - 5.4.2 Flux-Cored Arc Welding (FCAW).
 - 5.4.2.1 The self-shielded FCAW process may be used for the root pass of T-,K-,Y-joints welded from one side without backing.
 - 5.4.2.2 For all other applications, 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).
 - 5.5 Thermit Welding using a copper alloy is permitted for attaching electrical grounding or cathodic protection cables. Thermit welding shall not be used on stainless steel materials.
 - 5.6 Stud Welding is permitted for attaching insulation fasteners and heat conductors.
 - 5.7 Other processes (such as brazing, Electro-Gas, Electro-slag, Plasma, etc.) may be used only with the approval of CSD. Depending upon the process and application proposed, CSD may require testing in addition to that specified by the Code. Approval to use other processes shall be obtained through the welding procedure review process.
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6 Welding Consumables

- 6.1 Electrodes, filler wires, and fluxes shall conform to ASME SEC IIC. Other consumables may be used only with the approval of CSD and, depending upon the process and application proposed, may require testing in addition to that specified by AWS D1.1. Approval to use other (unlisted in ASME SEC IIC) consumables shall be obtained through the welding procedure review process. For unlisted consumables, vendor literature, which shall include intended use and approximate chemistry and mechanical properties, shall be submitted with the procedure.
- 6.2 All consumables shall be stored and dried in accordance with the requirements of Table 1 for SMAW electrodes and Table 2 for other consumables.
- 6.3 GTAW filler metal shall have either the AWS/ASME identification or the manufacturer's identification marked on each individual rod by the manufacturer with tags ("flags"), stencil, or stamping.
- 6.4 Welding consumables shall be selected based on their mechanical properties, compatibility with the materials to be joined, their suitability for the intended service, and consideration of polarity, position, and direction of welding. Welding consumables not meeting standard industry practice using the above criteria may be rejected by CSD.
- 6.4.1 Low hydrogen consumables (defined as less than or equal to 8 ml of hydrogen per 100 g of deposited weld metal, measured in accordance with AWS A4.3) shall be used except for:
- a) Self-shielded FCAW consumables with a weld hydrogen content up to 15 ml of hydrogen per 100 g of deposited weld metal may be used if approved by CSD.
 - b) If approved by CSD, the root pass of field repairs of joints accessible from one side only.
- 6.4.2 For joining base materials of different P-Numbers or compositions, the filler metal selected shall be approved by CSD.
- 6.5 Submerged Arc Welding fluxes
- 6.5.1 Active type Submerged Arc Welding fluxes shall not be used without approval. The approval shall be obtained through the welding procedure review process.
- 6.5.2 Flux fused during welding shall not be reused (i.e., fluxes that use recrushed slag are not acceptable).
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6.5.3 SAW fluxes that the flux manufacturer recommends for single pass welding shall not be used for multiple pass welding.

6.6 SMAW electrode F-Nos. 1, 2, and 3 shall not be used on materials requiring impact tests either by Code or job specification.

6.7 Shielding Gases

Shielding gases shall conform to the following requirements:

6.7.1 Carbon dioxide (CO₂): Federal Specification BC-C-101, Type B or Compressed Gas Association (CGA) Specification G-6.2, Type F.

6.7.2 Argon (Ar): Compressed Gas Association (CGA) specification G-11.1, Grade A through E. The argon gas purity should be 99.9% minimum

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

7 Welding Procedures

7.1 Documentation

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

7.1.2 A Weld Map with Weld Descriptions shall be submitted along with the Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) documents for each structure or sub-structure. The Weld Map should, as a minimum, provide a simple single-line sketch of the structure. All welds except minor attachments shall be identified by a separate letter or number. Each different weld, including minor attachment welds, shall be described on a Weld Description form (Attachment B). All base materials (by specification and grade) and wall thicknesses to be used shall be listed in the Weld Map or Weld Descriptions. Weld Map or Weld Descriptions shall not be reviewed without WPSs and PQRs or vice-versa.

With the approval of CSD, standardized Weld Maps and Weld Descriptions and sets of welding procedures may be submitted by the fabricator for general approval. All of the documentation requirements

shall be met except specific platform identifications are not required and generic weld identifications may be used.

- 7.1.3 Each Weld Map must be complete and show the Saudi Aramco structure identification number and the BI or purchase order number. Identical structures may be combined on one set of forms.
- 7.1.4 Welding shall not commence until the Weld Maps, Weld Descriptions, and WPSs have been approved by Saudi Aramco and returned to the fabricator. Any welding prior to the approval of these welding documents is subject to rejection at the sole option of Saudi Aramco. Any rework required as a result of this rejection shall be at the fabricator's expense.
- 7.1.5 After approval by Saudi Aramco, the fabricator shall issue copies of the approved Weld Maps and Weld Descriptions to the Saudi Aramco Inspector prior to the start of fabrication.
- 7.1.6 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.
- 7.1.7 All WPSs, Weld Maps, and Weld Descriptions shall be available at the work site for review at any time by the authorized Saudi Aramco inspector.
- 7.1.8 All Welding Procedure Specifications and Welding Procedure Qualification Records shall be written in English.
- 7.1.9 The PQRs shall include certified copies/facsimiles of all test records (for In-Kingdom qualification, the independent testing agency that issued the test record shall certify the copies), which will be permanently retained by Saudi Aramco.
- 7.1.10 Originals of all test records, mill certificates, etc. including records from the independent test laboratory shall be made available for review by Saudi Aramco upon request.

7.2 General Requirements

- 7.2.1 All WPSs and PQRs shall conform to the latest edition of AWS D1.1. Procedures that comply to a previous edition but not the current edition of the relevant Code are not acceptable, even if the Code permits such procedures. Procedures no longer conforming to the latest Code edition shall be revised and requalified.
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- 7.2.2 For any new or additional qualification tests that are required, Saudi Aramco reserves the right to monitor any and all phases of the procedure qualification, including welding of the coupons and mechanical testing. Saudi Aramco may assign the monitoring to an inspection agency.
- 7.2.3 All information shown on the PQR, such as amperage, voltage, travel speed, postweld heat treatment time and temperature, as applicable, shall be actual data as recorded using calibrated instruments.
- 7.2.4 Qualification of welding procedures for all shop fabrication in Saudi Arabia and field erection work shall be performed In-Kingdom. Approval for use of welding procedures qualified Out-of-Kingdom shall be obtained through the welding procedure review process.
- 7.2.5 For In-Kingdom qualifications:
- a) The welding of all qualification test coupons shall be monitored by either an approved independent test laboratory, an independent third party approved by Saudi Aramco, or Saudi Aramco Inspection. The monitoring shall include verification of the accuracy of the recorded parameters.
 - b) All procedure qualification mechanical tests and examinations shall be performed by an approved independent test laboratory unless the fabricator is specifically approved by Saudi Aramco Inspection to perform their own tests.
- 7.2.6 For all automatic welding and any process with pulsing, the welding procedure shall include all applicable equipment and controller parameter settings.
- 7.2.7 All procedures must be qualified (i.e., procedures considered "prequalified" in accordance with AWS D1.1 are not permitted), except for Category D-to-Cat. D applications.
- 7.2.8 Additional testing is required for all procedures to be used for primary joints (defined as Category A-to-Cat. A or Cat. B-to-Cat. A joints, see Table 3) and shall meet the following requirements:
- 7.2.8.1 Hardness tests shall be conducted in accordance with Standard Drawing W-[AB-036386](#) (see 7.5.1). The maximum hardness shall not exceed VHN 325.
 - 7.2.8.2 The procedures shall be restricted to materials with a carbon equivalent (CE-IIW) value not higher than that used for the procedure qualification coupon. Material supplied by Saudi
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Aramco on a "free-issue" basis to the vendor/contractor is exempt from this requirement.

- 7.2.8.3 Charpy impact testing of the weld metal and heat-affected zone shall be conducted. The test temperature shall be no higher than -29°C for Group I and II materials. Full size (10 x 10 mm) specimens shall be used whenever the base material is of sufficient thickness to allow full size specimen to be taken. If subsize specimens are used, they shall be the maximum possible size. The minimum absorbed energy for full sized (10 x 10) specimens for Group I and II materials shall be 34 J average with no single specimen exhibiting less than 27 J individual. If Group III materials are used, the test temperature and required absorbed energy shall be determined by CSD.

7.3 Special Qualification Requirements

- 7.3.1 For corrosion resistant overlays and linings (e.g., Monel sheathing), the procedures shall be qualified in accordance with ASME SEC IX.
- 7.3.2 For other materials or applications not included in the scope of API RP2A or AWS D1.1, the qualification requirements, including any special qualification tests, and any supplementary essential variables shall be determined by CSD.

7.4 Procedure variables

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

- 7.4.1 Any GMAW electrode to be used for procedures with impact toughness requirements and any SAW flux or FCAW electrode shall be restricted to the specific brand, type, and maximum size as used for the PQR. If so restricted, the brand name and type of flux or electrode shall be specified on both the WPS and PQR.
- 7.4.2 A change in filler metal or deposit chemistry from A-number 1 (based on ASME SEC IX) to A-number 2 and vice-versa is not permitted without approval. The approval shall be obtained through the welding procedure review process.
- 7.4.3 AWS D1.1 material Groups III, IV, V and any unlisted material shall be qualified separately for each specific material, unless:
- a) It is being used in combination with a Group I or II material and the Group I or II material strength requirements govern.

- b) Base materials to either BS 4360 or BS 7191 are being used and equivalency to listed base materials is documented.

7.4.4 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.

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

7.4.6 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.

7.4.7 For full penetration, double-sided joints, the WPS shall require backgouging (see 10.3.3) 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.

7.4.8 Impact testing

7.4.8.1 For procedures with Charpy impact test requirements, the following shall be considered essential variables:

- a) The qualified base metal range shall be from 0.5 to 1.5 times the qualification test coupon thickness. For test coupons with unequal base material thicknesses (e.g.,
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6GR), the thinner material shall be considered as the governing thickness.

- b) Any change in the type of current or polarity.
- c) Any change in the AWS filler metal classification except for a change between Exx15/16/18 designations or a change in the supplemental hydrogen designation.
- d) An increase in the heat input of more than 10% than the maximum value used for the qualification test.

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

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

7.4.9 For single layer weld overlays (corrosion resistant or hardfacing), any increase in spacing between adjacent beads shall be requalified. The overlap must be measured and recorded on the PQR and specified on the WPS.

7.4.10 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 AWS D1.1 and this standard.

7.5 Welding Procedure Qualification Hardness Testing

7.5.1 For applications where hardness testing is specified (see 7.2.8.1), the hardness testing shall be in accordance with Standard Drawing W-[AB-036386](#), Hardness Testing for Welding Procedure Qualifications. The maximum allowable hardness is VHN 325. Prior hardness test results

may be accepted as equivalent to the Standard Drawing only with the approval of CSD and with the following conditions:

- a) Only the Vickers method is acceptable, with a maximum test load of 10 kg.
- 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.

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 qualification test shall include all of the required tests on the same coupon unless size limitations restrict the number and type of specimens that can be reasonably removed from a single coupon. If multiple coupons are required and approved by CSD, each of the coupons shall be of the same material and size and shall be welded with identical parameters. Use of supplementary test coupons for additional tests (e.g., Charpy impact or hardness) to be combined with existing PQRs is not permitted.
- 7.6.2 Procedure qualification test welds shall be performed in a simulated production environment with equipment identical to that used for production welding.
- 7.6.3 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 AWS D1.1 and [SAEP-1150](#), [SAEP-321](#), [SAEP-322](#), [SAEP-323](#), and [SAEP-324](#), as applicable, for all structural welding, including tack, temporary, and repair welds.
 - 8.1.1 For corrosion resistant overlays and linings (e.g., Monel sheathing), all welders, welding operators, brazers, and brazing operators shall be qualified in accordance with ASME SEC IX.
 - 8.1.2 For other materials or applications not included in the scope of AWS D1.1, the qualification requirements, including any special qualification
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tests, and determination of any supplementary essential variables shall be determined by CSD.

- 8.2 Current production repair rates of each welder shall be made available to Saudi Aramco Inspection upon request.
- 8.3 Performance qualification tests shall not be performed on production joints on Saudi Aramco work.

9 Joint Details

- 9.1 All major lifting lugs shall be made with full penetration groove welds.
- 9.2 Unless specified otherwise, all intersecting and abutting parts to be welded shall be joined by complete penetration groove welds.
- 9.3 Permanent backing rings or strips shall not be used unless specified in the design and approved by CSD.
- 9.4 Temporary backup strips in weld joints may be used providing the backing material is of a composition similar to the base metal or weld metal. Under no circumstances shall rebar or galvanized steel be used. Temporary backup shoes made of non-metallic, non-fusing material may be used.
- 9.5 Consumable inserts may be used for all applications providing the composition matches the weld metal composition.
- 9.6 Full penetration groove joint included angles less than 30 degrees (except for portions of compound bevels) shall not be used without approval. The approval shall be obtained through the welding procedure review process.

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 (not normally used)
 - 5.5 mm for the 1G/1F position.
 - 5 mm for all other positions.
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- c) Sizes larger than those listed are acceptable only if approved by CSD. The approval shall be obtained through the welding procedure review process and requires qualification for the electrode sizes and positions to be used in production.
- d) Gravity-fed electrodes size limitations shall be evaluated by CSD on an individual basis.

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, and 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. Any wet or damp surfaces must be dried by heating for a distance of 100 mm from the weld joint and shall be warm to the hand before welding.
- 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 7.4.4 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.
 - 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 A minimum of 1.5 mm depth shall be removed by grinding or machining from thermally cut or gouged surfaces of air-hardenable materials (e.g., Chrome-Moly steels). Additional nondestructive examination may be required on the cut surface, at the option of the authorized Saudi Aramco inspector.
- 10.3.2.4 Thermal cut surfaces of stainless steel and non-ferrous materials shall be ground to bright (unoxidized) material prior to welding.
- 10.3.3 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. The automatic SAW process is exempt from this requirement if procedure qualification and production results demonstrate that acceptable penetration can be reliably achieved (see 7.4.7).
- 10.3.4 Buttering or weld build-up on joints
 - 10.3.4.1 Buttering or weld build-up on the prepared surfaces shall not exceed the lesser of 19 mm or two times the base metal thickness, whichever is less.
 - 10.3.4.2 If the buttering or build-up exceeds 1/3 of the base metal thickness or 10 mm, then the following requirements shall apply:
 - a) The buttering operation shall be witnessed by Saudi Aramco Inspection.
 - b) The buttering shall be inspected by PT or MT after completion of the build-up but before final welding of the joint.
 - 10.3.4.3 Buttering shall not be used on a routine basis for correction of dimensional tolerances.
- 10.4 Radial offset of butt joints, including field deck-to-pile or deck column-to-deck column joints, shall not exceed 3 mm for joints welded from one side, with or without a backing strip (including stabbing guides). The contractor shall either trial fit or make detailed measurements for each member, including out-of-roundness, as part of the fabrication dimensional checks for each component in order to insure the radial offset limit will not be exceeded.

10.5 Cleaning

- 10.5.1 Each weld pass shall be thoroughly cleaned and all slag or other foreign matter removed before the next pass is deposited.
- 10.5.2 All slag, flux, and spatter shall be removed from the completed weld and surrounding areas.
- 10.5.3 Stainless steel and nonferrous materials shall be cleaned with grinding wheels or stainless steel brushes not previously used on other materials.
- 10.6 Tack welds
- 10.6.1 All tack welds shall be made by qualified welders.
- 10.6.2 All tacks or temporary welds shall be performed with the same care, materials, electrodes, minimum preheat, and procedures that are used for permanent welds.
- 10.6.3 Tack welds shall be of sufficient size to maintain joint alignment. The recommended tack size is 3.2-4.8mm and length is 12.5–25.4mm. The minimum number of tack welds are:
- Pipe diameter of 101.6m or less: three equally spaced tacks.
 - Pipe diameter above 101.6m: minimum of four equally spaced tacks. The designated inspector should determine if more tacks are needed.
- 10.6.4 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.
- 10.6.5 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 tack weld process or electrode shall have been used as the root pass for an appropriate procedure qualification.
- 10.6.6 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.
- 10.7 Arc strikes, gouges, and other indications of careless workmanship (such as surface porosity, uneven weld profiles, and undercut) shall be removed by grinding.
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- 10.8 Any temporary welded attachments or temporary tack welds shall be ground off. Attachments may be thermally cut off no closer than 3 mm to the base metal surface, prior to the required grinding
 - 10.9 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.
 - 10.10 Inspection by magnetic particle or liquid penetrant methods of areas shall be performed for any structural steel above 42 ksi SMYS where temporary welds have been removed (see 10.8) or weld repairs to ground areas of the base material have been made (see 10.9) or arc strikes on Cat. A materials after repair by grinding (see 10.7).
 - 10.11 Temporary attachments, grounding lugs, or supports welded to any component shall be made with a compatible material. Under no circumstances shall rebar or galvanized steel be used.
 - 10.12 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.
 - 10.13 Peening
 - 10.13.1 Peening shall not be permitted unless approved by CSD and specified in the approved welding procedure. Cleaning of slag is not considered peening.
 - 10.13.2 When peening is specified, the welding procedure specification shall include details of how it will be performed. If the peening is to be done on a component with impact toughness requirements or on any pressure piping or vessels, the welding procedure shall be qualified using peening.
 - 10.14 Adjacent weld beads shall be staggered and not started from the same location.
 - 10.15 Back purging
 - 10.15.1 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.
 - 10.15.2 The use of nitrogen as a backing gas for austenitic stainless steels is prohibited.
-

10.15.3 The back purge shall be sufficient to reduce the oxygen level below 1%. The method of back purge and the flow rate shall be specified on the WPS.

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

10.16 Seal welding

10.16.1 All joints and faying surfaces, except for mudmats or those specifically designed and designated as removable bolted connections, shall be seal welded by a continuous fillet weld.

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

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

10.17 Weld encroachment and minimum distance between welds.

The requirements for minimum separation between adjacent welds are listed in 10.17.1 and 10.17.2. 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.

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

10.17.2 For braces on T-,K-,Y-joints that intersect or are within 50 mm of either a longitudinal or circumferential weld seam of the chord member, the weld seam shall be inspected by radiography or UT over the entire length of the intersected area. The weld seam shall be ground flush for a distance of 50 mm on all sides of the intersection (this does not include the portion more than 50 mm within the brace member outline). A gradual transition shall be made between the ground and unground areas.

10.17.3 Pile-to-deck leg transition pieces shall have the girth welds separated by 150 mm or more.

10.18 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, consumables, and preheat as used for the fill passes.

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

11 Preheat

- 11.1 Preheat shall be in accordance with the AWS D1.1 and this Standard. For materials not covered by the Code or this Standard, the preheat and postweld heat treatment shall be as specified in the approved welding procedure.
- 11.2 The minimum preheat shall not be less than the greater of the following (Note: The listed preheats are minimum requirements. The actual preheat temperature selected and used by the fabricator must be sufficient to prevent cracking):
- a) 10°C.
 - b) The required or recommended preheat listed in AWS D1.1.
 - c) For field fabrication or repair of P-No. 1 carbon steel materials, the preheat listed in Standard Drawing AE-036451.
- 11.3 For steels with specified minimum yield strengths above 60 ksi, the preheat shall be as specified in the approved welding procedure. Special applications may require special weldability tests to evaluate the preheat.
- 11.4 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.
- 11.5 Temperature-indicating crayons, thermocouples, or contact pyrometers shall be used to measure preheat and interpass temperatures.
- 11.6 The preheat temperature shall be established over a minimum distance of 75 mm on each side of the weld.
- 11.7 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.
- 11.8 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 For most applications within the scope of API RP2A and AWS D1.1, postweld heat treatment (PWHT) is not normally required. If PWHT is specified or if it is performed, then the PWHT shall conform to the following requirements.
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- 12.2 Postweld heat treatments (PWHT) shall be in accordance with AWS D1.1. 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 (paragraph 7.1).
- 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 and approval. 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 specified PWHT shall be applied over an area extending at least 3 times the thickness of the material being welded from each edge of the weld but not less than 25 mm from each edge of the weld, whichever is greater.
- 12.5 Exemptions for postweld heat treatment of ferritic materials based on the use of austenitic or nickel-based electrodes are not permitted.
- Commentary Note:*
- Austenitic or nickel-based electrodes shall not be used for joining ferritic materials.*
- 12.6 For applications where PWHT is required when hardness limits are specified:
- a) Any reductions in the PWHT temperature or alternative temperatures below the normal holding temperatures listed in the applicable Code are not permitted.
 - b) Unless approved by CSD, the soak time for production welds shall not be less than 80% of the PQR soak time.
 - c) The minimum PWHT soak time shall be 1 hour.
- 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 without the approval of CSD. Postweld heat treatment shall follow all welding and repairs.
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- 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 component itself may be considered a furnace if heated internally and externally insulated).
 - b) Electrical resistance heaters.
- 12.10 For components with wall thicknesses in excess of 75 mm, the postweld heat treatment procedure shall include thermocouple locations on both the inside and outside surfaces of the component.
- 12.11 Localized PWHT
- 12.11.1 If localized PWHT is used, it shall be monitored using at least four sets of thermocouples, with each set consisting of one thermocouple each on the inside and outside surfaces. Each set shall be placed at 90 degree intervals around the component circumference. Additional thermocouple sets are required if multiple heat control zones are used, in which a control zone is not monitored by one of the four primary sets.
 - 12.11.2 Localized PWHT of tubular members shall have the following minimum number of thermocouples. Members with a diameter of 305 mm or less shall have at least one thermocouple. At least two equally spaced thermocouples shall be used for circumferential welds on member diameters above 305 mm through 610 mm. Members larger than 610 mm diameter shall have at least four thermocouples equally spaced around the circumference.
- 12.12 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.
- 12.13 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.
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- 12.14 Only Type K (Chromel-Alumel) thermocouples are permitted. All extension cables, compensating cables, and jumper cables in the measurement or control circuits shall be either Type K or Type KX thermocouple wire, except that copper-Constantan 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. The acceptable temperature range of the junction between the compensating cable and the thermocouple lead is from 0 to +80°C.
 - b) The national standard that the thermocouple conforms to shall be indicated in the PWHT procedure. The procedure shall also include a listing of the insulation coloring of each core wire and the overall sheath for both the compensating cable and thermocouple. This information is required for site inspectors to verify that the proper wires have been used and are connected in the proper polarity.
- 12.15 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.
- 12.16 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.
- 12.17 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.
- 12.18 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.
- 12.19 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.
- 12.20 After completion of the PWHT all thermocouples shall be removed and the attachment areas ground smooth to clean, sound metal. If specified by the Inspector, the areas shall be examined by MT or PT after grinding.
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13 Inspection Access

- 13.1 Saudi Aramco representatives shall have free access to the work at all times.
- 13.2 Saudi Aramco shall have the right to inspect the fabrication at any stage or state and to reject material or workmanship which does not conform to the specified requirements.
- 13.3 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 or damage to Saudi Aramco property.
- 13.4 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.
- 13.5 The fabricator shall provide the authorized Saudi Aramco inspector all reasonable facilities to satisfy him that the work is being performed as specified.
- 13.6 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 which is satisfactory to Saudi Aramco Inspection.

14 Weld Identification

- 14.1 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.
- 14.2 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. This identification system shall also be used to identify the final position of each piece of Cat. A and B material (including heat numbers) in the completed structure.

15 Inspection

- 15.1 General
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- 15.1.1 Inspection procedures shall be established in accordance with the appropriate Code or standard. 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.
 - 15.1.2 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.
 - 15.1.3 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.
 - 15.1.4 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.
 - 15.1.5 All appropriate safety precautions shall be taken for each inspection method.
 - 15.1.6 All NDT personnel shall be qualified in accordance with [SAEP-1140](#) or [SAEP-1142](#), as applicable
 - 15.1.7 Surface irregularities, including weld reinforcement, inhibiting accurate interpretation of the specified method of NDT shall be ground smooth.
 - 15.1.8 Inspection of all welds shall include a band of base metal at least one inch wide on each side of the weld.
 - 15.1.9 All welds shall be examined visually. Visual examination shall be performed prior to other NDT.
 - 15.1.10 The various component categories to be used for establishing inspection requirements are listed in Table 3. The required inspection methods and minimum inspection frequencies for specific applications and locations are listed in Table 4.
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15.1.11 Saudi Aramco Inspection shall witness and approve all TKY joint fit-ups on Category A or B materials.

15.2 Radiography

15.2.1 Fluorescent intensifying screens shall not be used. Fluoro-metallic screens shall be approved by Saudi Aramco Inspection prior to use.

15.2.2 Tungsten inclusions in Gas Tungsten Arc welds shall be evaluated as individual rounded indications. Clustered or aligned tungsten inclusions shall be removed and repaired.

15.2.3 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.

15.3 Ultrasonic

15.3.1 Ultrasonic testing may be substituted for radiography if approved by Saudi Aramco Inspection.

15.3.2 Ultrasonic inspection procedures shall be established in accordance with API RP2X. A mock-up is required for TKY joints. The mock-up shall be approved by Inspection. UT operators shall be qualified in accordance with [SAEP-1140](#) or [SAEP-1142](#), as applicable.

15.3.3 The UT acceptance criteria for major lifting lugs shall be API RP2X Level A. Unless specified otherwise, the acceptance criteria for all other ultrasonic inspection shall be API RP2X Level C.

15.3.4 If a lamination check is specified, the area to be welded shall be ultrasonically inspected for laminations in accordance with ASTM A578 prior to installing the connecting member. The area to be inspected shall be along the intersecting weld length and shall include a width on both sides of the weld at least three times the intersecting member thickness or 50 mm, whichever is greater. Any recordable laminations shall be marked and recorded and submitted to Saudi Aramco for resolution prior to fit-up or welding.

15.4 Magnetic particle

15.4.1 Permanent magnet yokes are not permitted.

15.4.2 Prods are not permitted for use on materials with impact testing requirements (e.g., Category A and B materials).

16 Repairs

- 16.1 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.
- 16.2 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.
- 16.3 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 16.2).
- 16.4 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.
- 16.5 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.
- 16.6 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 Miscellaneous Requirements

- 17.1 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.
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- 17.2 Welding on offshore structures 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.
- 17.3 Welding power supplies shall be calibrated in accordance with BS 7570 or an approved equivalent. Calibration records shall be available to Saudi Aramco Inspection upon request.

Revision Summary

31 August, 2002 Major revision.

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

Low Hydrogen Electrodes to A5.1

Drying

Prior to use all electrodes shall be dried at 260-430°C for 2 hours minimum. The drying step may be deleted if the electrodes are supplied in the dried condition in a hermetically sealed metal can with a positive indication of seal integrity. 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 or hermetically sealed containers, the electrodes may not be exposed to the atmosphere for more than 4 hours. The exposure may be extended to 8 hours if the electrodes are continuously stored in a portable electrode oven heated to 65°C minimum. Electrodes exposed to the atmosphere for less than the permitted time period may be re-conditioned. Electrodes exposed in excess of the permitted time period must be re-dried. Electrodes that have become wet or moist shall not be used and shall be discarded.

Re-conditioning

Electrodes exposed to the atmosphere for less than the permitted time period may be returned to a holding oven maintained at 120°C minimum; after a minimum holding period of four hours at 120°C minimum the electrodes may be reissued.

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

Re-conditioning

E70xx and E80xx 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. 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 or hermetically sealed containers, the electrodes may not be exposed to the atmosphere for more than 4 hours. The exposure may be extended to 8 hours if the electrodes are continuously stored in a portable electrode oven heated to 65°C minimum. Electrodes exposed to the atmosphere for less than the permitted time period may be re-conditioned. Electrodes exposed in excess of the permitted time period must be re-dried. Electrodes that have become wet or moist shall not be used and shall be discarded.

Re-conditioning

Electrodes exposed to the atmosphere for less than the permitted time period may be returned to a holding oven maintained at 120°C minimum; after a minimum holding period of four hours at 120°C minimum the electrodes may be reissued.

Notes:

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

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

SAW fluxes:

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

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

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

**Table 3 – Component Categories and Definitions
 (Notes 1, 2)**

Category and Component	Definition or Example
Category A	
Chord	Any joint can in a jacket leg (including cans for jacket-to-pile connection), deck leg, or deck column (including cans for major beam connection) (Note 3).
Transition piece	The pile-to-deck leg transition section.
Major lifting lugs	For entire structure or major substructure.
Crane support pedestal	Any support structure for a permanent heavy crane.
TKYX joint can on a major-brace	-
Box beam or shape at major intersections if the WT > 50 mm (2 in)	-
Category B	
Jacket leg	-
Jacket-to-pile connection pieces	Crown plate or shims.
Deck column/leg	Includes tubular, structural shape, and fabricated beams
Pile	-
Major brace	A tubular member with a nominal diameter > 12 inches (OD > 12.75 in) except tubular member of boat landing (Note 2)
Major beam	A non-tubular member that is either: 1) A plate girder 2) The deepest beam in a major structural unit 3) Any beam with a nominal depth > 24 inches.
Internal stiffeners or diaphragms at joint cans	-
Category C	
Minor brace	A tubular member with a nominal diameter > 4 inches (OD > 4.5 in) and ≤ 12 inches. (Note 2)
Minor beam	Any beam that is not considered major.
Stiffener rings or diaphragms	Other than internal stiffeners diaphragms at joint cans.
Beam stiffeners or gussets or cover plates	-
Secondary lifting lugs	-
Category D	
Other	Any other tubular or structural shape or size not listed above, e.g., deck plate, angle stiffeners, grout lines, pile guides, etc.

Notes:

- 1) Jacket-to-boatlanding standoffs or other members that are fabricated cone sections shall be considered as braces with a diameter equivalent to the tubular used to fabricate the component.
- 2) Braces for bridge sections shall be considered major if the nominal diameter > 8 inches.
- 3) The designation of chord still applies if the leg has been designed using a single wall thickness and material specification. The chord is defined as the section at an intersection which is within the distance limits (D/4 or 12 inches, whichever is greater) as defined in API RP2A.

**Table 4 – NDT Requirements
 (Notes 1,2,3,4,5,6,7,8)**

Category and Joint Design	RT	UT	MT	Notes
Category A to Category A				
Full penetration butt weld	100	-	100	(9)
Other full penetration groove weld	-	100	100	(10)
Partial penetration groove or fillet weld	-	-	100	
Category A to Category B				
Full penetration butt weld	100	-	100	(9),(11)
Other full penetration groove weld	-	100	100	(10)
Partial penetration groove or fillet weld	-	-	100	
Category A to Category C				
Full penetration butt weld	10	-	100	(9)
Other full penetration groove weld	-	10	100	(10)
Partial penetration groove or fillet weld	-	-	100	
Category A to Category D				
Full penetration butt weld	-	-	100	
Other full penetration groove weld	-	-	100	
Partial penetration groove or fillet weld	-	-	100	
Category B to Category B				
Full penetration butt weld	100	-	100	(9),(11)
Other full penetration groove weld	-	100	100	(10),(11)
Partial penetration groove or fillet weld	-	-	100	
Category B to Category C				
Full penetration butt weld	10	-	25	(9)
Other full penetration groove weld	-	10	25	
Partial penetration groove or fillet weld	-	-	25	
Category B to Category D				
Full penetration butt weld	-	-	25	
Other full penetration groove weld	-	-	25	
Partial penetration groove or fillet weld	-	-	25	
Category C to Category C				
Full penetration butt weld	10	-	-	(9)
Other full penetration groove weld	-	10	-	
Partial penetration groove or fillet weld	-	-	10	
Category C to Category D				
Full penetration butt weld	-	-	10	
Other full penetration groove weld	-	-	10	
Partial penetration groove or fillet weld	-	-	10	
Category D to Category D				
Full penetration butt weld	-	-	-	None
Other full penetration groove weld	-	-	-	None
Partial penetration groove or fillet weld	-	-	-	None

Notes to Table 4:

- 1) All welds shall be visually inspected.
- 2) For situations not covered, the joint shall be inspected according to the requirements of the most critical member.
- 3) Additional inspection may be required, even if no inspection is listed, if any defects are found, including by visual inspection.
- 4) Overlapping TKY joints shall be inspected along the entire weld(s) according to the requirements of the most critical portion of the most critical connection.
- 5) For NDT purposes only, all tubular section longitudinal seams shall be considered as one category lower (e.g., pile longitudinal seams shall be considered as a Category C to Category C joint, rather than a Category B to Category B joint). The ends of each longitudinal seam shall also be inspected for a length of 300 mm for each fabricated length unless the tubular was fabricated and inspected to the API SPEC 5L specification.
- 6) Any specified extent of NDT less than 100% shall be interpreted as a random rate, e.g., 10% NDT means 10% of the total number of welds in that category shall be examined over their entire length.
- 7) Primary joints are defined as Category A-to-Category A or Category A-to-Category B joints.
- 8) UT may be substituted for RT if approved by Saudi Aramco.
- 9) UT is acceptable in lieu of radiography for field joints.
- 10) UT lamination check to ASTM A578 required prior to installing connecting member. UT check for lamellar tearing required after installing member if either attaching member thickness or weld throat is greater than 12.7 mm (0.5 in).
- 11) MT can be reduced to 10% if the submerged arc weld (SAW) process is used with a nominal heat input greater than 3.0 kJ/mm (75 kJ/in).

Attachment B

**WELD DESCRIPTION
 SAUDI ARAMCO
 OFFSHORE STRUCTURE**

Vendor Name:
 Saudi Aramco Purchase Order No.:
 Structure No.:
 Vendor Order No.:

Weld Type

- | | | |
|--|---|---|
| <input type="checkbox"/> Tubular - longitudinal | <input type="checkbox"/> Plate - butt | <input type="checkbox"/> Monel sheathing |
| <input type="checkbox"/> Tubular - circumferential | <input type="checkbox"/> Plate - tee groove | <input type="checkbox"/> Plate to tubular |
| <input type="checkbox"/> TKY | <input type="checkbox"/> Plate - fillet | <input type="checkbox"/> Other (describe) |

Material

ASME/ASTM: _____ Thickness: _____ Cat.: _____
 ASME/ASTM: _____ Thickness: _____ Cat.: _____

Vendor Welding Procedure Specification

WPS No.: _____ Rev. No.: _____ Date: _____

Weld Type

- | | |
|---|--|
| <input type="checkbox"/> Welded from both sides | <input type="checkbox"/> Fillet |
| <input type="checkbox"/> Welded from one side | <input type="checkbox"/> Overlay |
| <input type="checkbox"/> With backing | <input type="checkbox"/> Without backing |

Joint Sketch (show bevel angles, land, gap, sequence, and backing)

Process and Filler Metal

Pass	Process						Filler Metal	
	SMAW	SAW	GTAW	GMAW	FCAW	Other	AWS Classification	Trade Names
Root	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____
Fill 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____
Fill 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____
Backweld	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____	_____

Backgouging Yes No

Shielding Gas: _____ Back purge gas: _____

Postweld Heat Treatment: Yes No

Preheat Temperature: _____