

Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications



American Welding Society



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Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications

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AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides the requirements for welds in tubing systems in dairy and other food processing plants. The document addresses qualifications, fabrication, extent of visual examination, acceptance criteria, and documentation requirements.



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This standard is subject to revision at any time by the AWS D18 Committee on Welding in Sanitary Applications. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are required and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS D18 Committee on Welding in Sanitary Applications and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS D18 Committee on Welding in Sanitary Applications to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Dedication

The D18 Committee on Welding in Sanitary Applications dedicates this edition of the D18.1/D18.1M:2009, *Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications*, to Mr. Garrett M. Naughton, a charter member of the D18 Committee. Garrett was a true friend and advocate of the American Welding Society. His dedicated efforts did much to advance the art and science of welding stainless steel materials for the food and food processing industry, as well as the education and training of welders for the welding industry.

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Foreword

This foreword is not part of AWS D18.1/D18.1M:2009, *Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications*, but is included for informational purposes only.

The formation of D18 Committee was approved in October and November 1995 by the Technical Activities Committee and the Board of Directors, respectively. The Committee was formed to respond to the request of the 3-A Sanitary Standards Committee for help in preparing welding standards for use in the manufacture and construction of dairy and food product processing plants. The 3-A Sanitary Standards Inc. (3-A SSI) Committees develop and promulgate sanitary design standards for dairy and food processing, packaging, and handling equipment and systems. Several members of the Committee are active members of 3-A, and the Committee has maintained liaison with 3-A.

This document supersedes AWS D18.1:1999, *Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications*. Principal changes in the second edition involve enhancements to the sections on welding procedure qualifications and qualification records.

The D18 Committee has adopted AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, as a basis for welding procedure and welding performance qualifications. Exceptions as they relate to sanitary applications are included in this document. It should be noted that the terms “essential variable” and “nonessential variable” have been changed to “qualification variable” and “welding variable” to be consistent with AWS B2.1.

A vertical line in the margin indicates a revision from the previous 1999 edition.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D18 Committee on Welding in Sanitary Applications, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications

1. Scope

This specification covers the requirements for Gas Tungsten Arc Welding and Plasma Arc Welding of stainless steels and nickel alloy tube and pipe 1/4 in [6 mm] diameter and larger in the fabrication and construction of new sanitary (hygienic) processing systems. This specification includes the welding of tube and pipe for the transportation of sanitary (hygienic) system products and cleaning or sanitizing solutions. It includes manual welding as well as automatic or mechanized welding, such as orbital welding. This specification addresses welding qualification and visual examination requirements for as-welded surfaces as well as finished surfaces.

This specification is intended for new construction. However, the requirements may also be applied to maintenance and repair of food processing equipment. When there is a conflict between this specification and a design specification to which the equipment is being constructed, the applicable code shall govern on issues that apply to structural design or structural integrity. This specification does not address requirements designed to prevent corrosion damage during service or any structural design or integrity aspects of components or systems used for sanitary (hygienic) applications.

Sanitary processing systems are intended to include those systems handling products for human and animal consumption, or for cleaning and sanitizing solutions used in these systems. Such products include dairy, meat, poultry, vegetables, beverages, personal care items (such as shampoo, soap, toothpaste, cosmetics), and other products consumed or used by humans or animals, which require freedom from contamination.

When this specification is stipulated in contract documents, conformance with all provisions of this specification are required, except for those provisions that the Owner, their representative, or contract documents specifically modifies or exempts. The Owner or their representatives shall provide a complete specification for the piping or tubing system.

This specification makes use of both U.S. Customary Units and the International System of Units (SI). The latter are shown within brackets [] or in appropriate columns in tables or figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

Safety and health issues are beyond the scope of this standard, and therefore are not fully addressed herein. Safety and health information is available from other sources, including, but not limited to federal, state, and local regulations as well as other safety standards such as ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*.

2. Normative References

The following standards contain provisions which, through reference in this text, constitute mandatory provisions of this AWS standard. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply.

AWS Standards¹:

AWS A3.0, *Standard Welding Terms and Definitions*;

¹ AWS standards are published by the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

AWS B2.1, *Specification for Welding Procedure and Performance Qualification*;

AWS B4.0, *Standard Methods for Mechanical Testing of Welds*; and

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*.

ASME Standard²:

ASME B46.1, *Surface Texture*.

3. Terms and Definitions

The terms listed are used in various sections of this document and require definition for correct interpretation. Most of these terms are not contained in AWS A3.0, *Standard Welding Terms and Definitions*, or if they are listed in AWS A3.0, their definitions have been enhanced to clarify their use in this document.

automatic welding. Welding with equipment that requires only occasional or no observation of the welding, and no manual adjustment of the equipment controls.

discoloration. Any change in surface color from that of the base metal, usually associated with oxidation. Discoloration may occur on the weld, heat-affected zone, or base metal of the weld joint such as a result of heating the metal during welding. Colors may range from pale bluish-gray to deep blue, and from pale straw color to a black crusty coating.

fabricator. Includes contractors, subcontractors, erectors, or any organizations that produce weldments that are intended to meet the requirements of this specification.

heat tint. A nonstandard term for **discoloration**.

mechanized welding. Welding with equipment that requires manual adjustment of the equipment controls in response to visual observation of the welding, with the torch, gun, or electrode holder held by a mechanical device.

nonproduct contact surface. An exposed surface other than a product contact surface.

orbital welding. Automatic or mechanized welding of tube or pipe in which a welding arc rotates (orbits) around a stationary weld joint.

Owner. Organization that will operate the sanitary (hygienic) processing system, or the organization's authorized representative.

pit. A surface discontinuity the depth of which exceeds 25% of the smallest surface dimension, and whose length does not exceed three (3) times its width.

product contact surface. Any surface that is exposed to the product or any surface from which materials may drain, drop, or be drawn into the product.

qualification variable. A variable in which a change beyond that described in 4.1.7, *Welding Variables*, is considered to affect the mechanical properties of the weldment, and shall require requalification of the Welding Procedure Specification (WPS). Previously termed "essential variable."

sanitary (hygienic) applications. Those applications where the metal surface condition is such that it can be cleaned to meet the requirements of products consumed or used by humans or animals, which require freedom from contamination.

termination. Completion point of a weld pass. Other terms commonly used are tail off, slope down (also called downslope), sign off, and feather out.

verification test (procedure). A sample weldment intended to confirm that a WPS revision to a verification variable meets the requirements of 6.2, *Visual Examination Acceptance Criteria*.

² ASME standards are published by the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990.

verification test (performance). A sample weldment intended to confirm the welder's or welding operator's ability to meet the requirements of 6.2, Visual Examination Acceptance Criteria.

verification variable. A variable in which a change as described in 4.1.7, Welding Variables, may prevent the weld from meeting 6.2, Visual Examination Acceptance Criteria. Such a change may be made only after successfully completing a verification test.

weld finishing. A postweld process that leaves the weld area in a noticeably different condition than as welded. Finishing processes include, but are not limited to mechanical (grinding, polishing, glass bead blasting, and so forth), chemical (passivating or pickling), or electrochemical (electropolishing).

4. Qualification

4.1 Procedure Qualification

4.1.1 A written qualified Welding Procedure Specification (WPS) shall be followed for each weld in sanitary applications. The welding procedure specification may be in any convenient format provided all welding procedure specification data required by this document and applicable sections of AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, are addressed.

4.1.2 Standard welding procedure specifications, welding procedures qualified to AWS B2.1, or earlier editions of this document, may be used provided all data required by the latest edition of this document and AWS B2.1, are addressed and a successful documented verification test to ensure the visual examination criteria of the document can be achieved.

4.1.3 The welding procedure specification data required to be addressed for each procedure shall be those specified in 4.1.6 in addition to those listed in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*.

4.1.4 The evaluation of procedure qualification test weldments shall be as listed in 4.1.4.1 through 4.1.4.4. The actual welding variables used during the qualification tests shall be recorded in addition to the results of the destructive and visual examination. The welding procedure qualification record may be in any convenient format provided all the applicable welding variables of AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, and 4.1.6 and 4.1.7, and the results of all tests are recorded.

4.1.4.1 Procedure qualification shall be by standard test weldment as required in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, except that the qualification and verification variables of 4.1.6 apply.

4.1.4.2 Procedure qualification test weldments shall be visually examined on all surfaces.

4.1.4.3 The destructive test sample preparation shall be as required in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, or B4.0, *Standard Methods for Mechanical Testing of Welds*, except that bend specimens shall not be machined flat. The maximum radius at the edge of the bend specimens is 1/16 in [1.6 mm].

4.1.4.4 If any test fails, the procedure fails, and a new welding procedure qualification test shall be conducted.

4.1.5 Acceptance Criteria of Procedure Qualification Test Welds

4.1.5.1 Visual examination may be conducted with or without magnification. The results of visual examination shall meet the acceptance criteria of 6.2 Visual Examination Acceptance Criteria.

4.1.5.2 After visual examination, two transverse tensile specimens, two root-bend, and two face-bend specimens shall be tested in accordance with AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, or AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

4.1.5.3 Each tensile test specimen shall have a tensile strength not less than the following:

- (1) The specified minimum tensile strength of the base metal, or of the weaker of the two base metals if metals of different minimum tensile strength are used; or
- (2) The specified minimum tensile strength of the weld metal when the referencing document provides for the use of weld metal having a lower tensile strength than the base metal; or

(3) If the specimen breaks in the base metal outside of the weld or weld interface, the test shall be accepted, provided the strength is not more than 5% below the specified minimum tensile strength of the base metal; or

(4) If the base metal has no specified minimum tensile strength, then failure in the base metal shall be acceptable.

4.1.5.4 Bend specimens shall be bent in one of the guided bend test fixtures shown in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, or AWS B4.0, *Standard Methods for Mechanical Testing of Welds*. For transverse specimens, the weld metal and heat-affected zone shall be completely within the bent portion of the specimen after bending. Bend specimens shall have no openings greater than 1/16 in [1.6 mm] or 1/2 T, whichever is less, where T equals the base metal thickness qualified.

4.1.6 Welding Procedure Specification Data. The following matrix indicates the welding data to be included in a WPS for each welding process and is in addition to the data listed in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*. A WPS may be presented in any format, written or tabular, provided the data required in this matrix and the matrix in AWS B2.1 are included. The WPS may list variables recorded on the PQR within the full range permitted for a qualification variable and practical limits determined by the employer for other than qualification variables.

	<u>GTAW</u>	<u>PAW</u>
4.1.6.1 Filler Metals		
(1) Use of filler metal. ³	X	X
(2) A change in filler metal diameter.	X	X
4.1.6.2 Shielding Gas		
(1) Backing (purge) gas.	X	X
4.1.6.3 Electrical Characteristics		
(1) Pulsing parameters.	X	X
4.1.6.4 Other Variables		
(1) Cup or nozzle size.	X	X
(2) Use of a collet body or gas lens.	X	X
(3) A change in the cup or nozzle size.	X	X
(4) A change from a collet body to a gas lens or vice versa.	X	X
(5) A change in the cleaning method.	X	X

4.1.7 Procedure Qualification Variables. The following matrix lists the welding data required to be addressed on both the welding procedure qualification record and welding procedure specification and is in addition to the procedure qualification variables in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*. The types of welding procedure specification data found in this matrix are qualification (Q) and verification (V) variables, as defined in Clause 3, Terms and Definitions.

A change in a qualification variable beyond that allowed in 4.1.7 requires requalification of the WPS. A change in a verification variable beyond that allowed in 4.1.7 requires successful completion of a Verification Test.

	<u>GTAW</u>	<u>PAW</u>
4.1.7.1 Joint Design		
(1) Any change in groove type.	Q	Q
(2) An increase in the root opening beyond that used in the qualification test.	Q	Q

³ Filler metal shall not be used except as allowed in 5.1.3.

	<u>GTAW</u>	<u>PAW</u>
4.1.7.2 Base Metal		
(1) A change in the base metal thickness range exceeding 1/2T to 2T where T equals the thickness qualified.	Q	Q
4.1.7.3 Filler Metals		
(1) Use of filler metal. ⁴	Q	Q
(2) A change in filler metal A-Number. ⁵	Q	Q
4.1.7.4 Shielding Gas		
(1) Addition or deletion of torch or welding head shielding gas.	Q	Q
(2) A change in the specified nominal composition of the torch or welding head shielding gas.	Q	Q
(3) A change in the torch (weld head) shielding gas flow rate greater than $\pm 25\%$ from that qualified.	V	V
(4) A change in the backing gas flow rate greater than $\pm 10\%$ from that qualified.	V	V
(5) The addition, deletion, or change in the nominal composition of backing (purge) gas.	Q	Q
4.1.7.5 Electrical Characteristics		
(1) The addition or deletion of pulsing current.	Q	Q
(2) Any change in pulsing parameters from that qualified.	V	V
(3) A change in current type or polarity.	Q	Q
(4) A change in the current range greater than $\pm 10\%$ from that qualified.	V	V
(5) A change in tungsten diameter.	V	V
4.1.7.6 Other Variables		
(1) A change in the type of welding (manual, semiautomatic, mechanized or automatic).	V	V
(2) A change exceeding $\pm 10\%$ in travel speed for mechanized or automatic welding.	Q	V

4.2 Performance Qualification

4.2.1 Performance qualification shall be by standard test in accordance with AWS B2.1. The welder/welding operator performance qualification shall be documented and may be in any convenient format provided all the test results and the welding variables of 4.2.8, Performance Qualification Variables, and AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, are recorded.

Welders qualified to AWS B2.1 or earlier editions of this document may be considered qualified to weld to this document within the range of qualification established by the latest edition of this document and AWS B2.1 after a successful documented verification test to ensure the visual examination criteria of the document can be achieved.

4.2.2 Visual examination of standard test weldments shall meet the acceptance criteria of 6.2.1 and 6.2.3.

4.2.3 Bend specimens shall be bent in one of the guided bend test fixtures shown in AWS B2.1 or AWS B4.0. For transverse specimens, the weld metal and heat-affected zone shall be completely within the bent portion of the specimen after bending. Bend specimens shall have no openings greater than 1/16 in [1.6 mm] or 1/2 T, whichever is less, where T equals the base metal thickness qualified.

⁴ Filler metal shall not be used except as allowed in 5.1.3.

⁵ A-Number defines the weld metal chemical composition. See AWS B2.1, *Specification for Welding Procedure and Performance Qualification*.

4.2.4 As an alternate to 4.2.3, radiography may be performed for evaluation of performance qualification test welds. The radiographic procedure shall be as listed in AWS B2.1. For acceptance, the weld shall have no discontinuities exceeding 1/16 in [1.6 mm] or 1/2 T, whichever is less. Slag-like surface impurities shall not be considered relevant indications for this test.

4.2.5 The performance qualification shall remain in effect indefinitely unless the welder or welding operator is not engaged in the process qualified for a period exceeding six (6) months or there is a specific reason to question the ability of the welder or welding operator.

4.2.6 Documentation should be maintained that shows the qualified welder or welding operator has welded in the six (6) month period listed in 4.2.5.

4.2.7 Verification performance test welds may be required by the Owner or Owner's Authorized Representative at any time during the duration of the contract (see Clause 3, Terms and Definitions).

A welder or welding operator who fails the verification performance test may be retested using (1) or (2) below.

(1) If a verification performance retest is permitted without further training or practice, it shall consist of two consecutive verification performance test weldments for each position failed. Both verification performance test weldments shall be acceptable for the welder or welding operator to qualify. If either verification performance test weldment does not meet the requirements of 5.2.2, the welder or welding operator shall be retested in accordance with 4.2.1.

(2) Provided that the welder or welding operator has had further training or practice, one verification performance test weld for each position failed is permitted. If the verification performance test weldment does not meet the requirements of 5.2.2, the welder or welding operator shall be retested in accordance with 4.2.1.

4.2.8 Performance Qualification Variables

4.2.8.1 Qualification with one WPS will also qualify for welding with any other WPS within the limits given in the following performance qualification variables in addition to those listed in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*.

4.2.8.2 Welders. A change in any variable listed below from that which was used in a welder's qualification test in addition to those listed in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, will require requalification of that welder.

- (1) A change in the welding process
- (2) A change from manual to semiautomatic or vice versa
- (3) The deletion of backing (welding from both sides is considered welding with backing)
- (4) The addition or deletion of filler metal
- (5) The addition or deletion of consumable inserts
- (6) A change in current type or polarity
- (7) The addition or deletion of pulsing current

4.2.8.3 Welding Operators. A change in any variable listed below from that which was used in a welding operator's qualification test in addition to those listed in AWS B2.1, *Specification for Welding Procedure and Performance Qualification*, will require requalification of that welding operator.

- (1) A change in the welding process
- (2) The addition or deletion of filler metal
- (3) The addition or deletion of consumable inserts
- (4) A change from automatic to mechanized welding or vice versa

5. Fabrication

5.1 Material Preparation. Tubular products for use may be cut by any method that produces an edge that meets the criteria of 5.1.1.

5.1.1 Material Preparation. Edges shall be cut square. All visible discoloration (also known as heat tint), cutting flash, and burrs shall be removed. Butt joint tube edges shall not be beveled deeper than 10% of the tube wall thickness when used for autogenous welding.

5.1.2 Joint Fit Up. Butt joints should have a zero root opening around the tube circumference except as permitted by the WPS.

5.1.3 Filler Metal. Filler metal shall not be used except for:

- (1) The manufacture of commercially available fittings; or
- (2) Field- or shop-fabricated connections which require filler metal because of fit-up problems, such as wall thickness, diameter, or alignment; or
- (3) Base metals that require overmatching filler metal composition (including consumable inserts).

The requirements of 6.1.4 shall be met. In addition, the Owner's permission is required for items (2) and (3) above, prior to welding.

5.1.4 Weld Finishing. If a weld meets the visual examination requirements of 6.2 in the as-welded condition then the weld may be used without additional finishing. If the requirements of 6.2 are not met in the as-welded condition then the product contact surface of the weld shall be finished to exhibit a maximum Ra of 32 micro inch [0.8 micron] when measured according to ANSI/ASME B46.1, *Surface Texture*.

5.1.5 Tack Welds. Tack welds shall be fully consumed on the product contact surface. Tack welds shall meet the discoloration requirements of 6.2.3.3. Any welds which show unconsumed tack welds on the non product-contact surface shall be internally examined and shall meet the requirements of 6.2; otherwise they are rejected.

5.2 Preconstruction Weld Samples (PWS)

5.2.1 Prior to any field welding on a project, each welder or welding operator shall prepare three verification tests. Each verification test weld shall be visually examined on all surfaces.

5.2.2 All surfaces shall meet the requirements of 6.2.1, Visual Examination Acceptance Criteria for All Welds, and the inside surface shall meet the requirements of 6.2.3, Visual Examination Acceptance Criteria for Product Contact Surfaces.

5.2.3 Each PWS shall be permanently marked with the welder's or welding operator's identification, and the PWSs shall be distributed to the welder or welding operator, the welding supervisor, and the Owner's Representative.

5.2.4 Additional workmanship samples may be required during the life of the project by agreement between the Owner and the Contractor.

6. Visual Examination Requirements

The requirements of this section apply to welds prior to any postweld finishing or conditioning operations.

6.1 Extent of Examination

6.1.1 Welders and welding operators shall examine each weld they make. The start, termination, and width of the weld shall be consistent with that of their PWS. Supervisors shall examine a representative sample of each welder's and welding operator's production using the welder's or welding operator's PWS and the requirements of this section to verify that the work is satisfactory. The Owner's Representative should monitor both the welding production and the welding supervisor's examination practices.

6.1.2 Outside surfaces of all welds shall be visually examined by the fabricator. Welds that do not meet the requirements of 6.2.1, Visual Examination Acceptance Criteria for All Welds, and 6.2.2, Visual Examination Acceptance Crite-

ria for Non-Product Contact Surfaces, shall be examined internally. Internal examination of weld surfaces shall be performed with a borescope or other device acceptable to the Owner, and the weld surface shall meet the requirements of 6.2.3, Visual Examination Acceptance Criteria for Product Contact Surfaces. Alternatively, the internal weld quality may be verified by a procedure agreed upon by the Owner and the fabricator.

6.1.3 Internal welds which are product contact surfaces in easily accessible areas (such as elbows, ferrules, etc.) and can easily be examined with simple tools (such as inspection mirrors and flashlights) shall be visually examined. The internal weld surfaces shall meet the requirements of 6.2.1, Visual Examination Acceptance Criteria for All Welds, and 6.2.3, Visual Examination Acceptance Criteria for Product Contact Surfaces.

6.1.4 All welds fabricated with the addition of filler metal (these welds require the Owner's approval per 5.1.3) shall be visually examined on all product contact surfaces. The product contact surface of such welds shall meet the requirements of 6.2.1 and 6.2.3.

6.2 Visual Examination Acceptance Criteria. The examination of the outside (nonproduct surface) weld can provide an indication of the quality of the inside (product contact surface) weld. Welds whose product contact surfaces meet the criteria of 6.2.1 and 6.2.3 shall not be rejected solely based on the criteria of 6.2.2. If the requirements of either 6.2.1 or 6.2.3 cannot be verified, then the weld must conform to all criteria under 6.2.2.

6.2.1 Visual Examination Acceptance Criteria for All Welds

6.2.1.1 Welds shall have no incomplete penetration. All welds shall have continuous complete (full) penetration.

6.2.1.2 Welds shall not contain cracks, undercut, crevices, pits, or embedded or protruding material.

6.2.1.3 Offset or misalignment shall not exceed 15% of the wall thickness as illustrated in Figure 1A.

6.2.2 Visual Examination Acceptance Criteria for Non-Product Contact Surfaces

6.2.2.1 Maximum allowable concavity shall be 0.006 in [0.15 mm] as illustrated in Figure 1B.

6.2.2.2 Maximum allowable convexity shall be 0.012 in [0.3 mm] as illustrated in Figure 1C.

6.2.2.3 Manual welds shall have a minimum weld face width of 2T where T is the tube wall thickness as illustrated in Figure 1D.

6.2.2.4 The weld face should be uniform in width. The minimum face width of each weld shall be at least 75% of the maximum face width as illustrated in Figure 1E.

6.2.2.5 The start, termination, and width of the weld shall be consistent with the welder's PWS.

6.2.3 Visual Examination Acceptance Criteria for Product Contact Surfaces

6.2.3.1 Maximum allowable convexity shall be 0.012 in [0.3 mm] as illustrated in Figure 1F.

6.2.3.2 Maximum allowable concavity shall be 0.012 in [0.3 mm] as illustrated in Figure 1G.

6.2.3.3 The weld surface shall not contain excessive discoloration. Oxidation indicated by discoloration shown in Examples 4 through 10 of Figure 2 is unacceptable in the as-welded condition, unless otherwise agreed upon by the Owner and the fabricator.

6.2.3.4 Slag-like surface impurities greater than 1/16 in [1.6 mm] diameter, as illustrated in Figure 1H, shall be unacceptable. No more than four (4) slag-like surface impurities shall be present in any 4 linear inches [100 mm] of weld. Slag-like surface impurities less than 1/64 in [0.4 mm] shall be disregarded.

7. Documentation

7.1 The fabricator shall maintain copies of Procedure Qualification Records, Verification Test Records, and Welding Procedure Specifications for each type of joint welded for the life of the project (see Annex B for form samples).

7.2 The fabricator shall maintain copies of Performance Qualification Test Records and preconstruction weld samples for the life of the project.

7.3 The manufacturer or fabricator should prepare, certify, and deliver a document to the Owner that states that all welds meet all of the requirements of this specification.

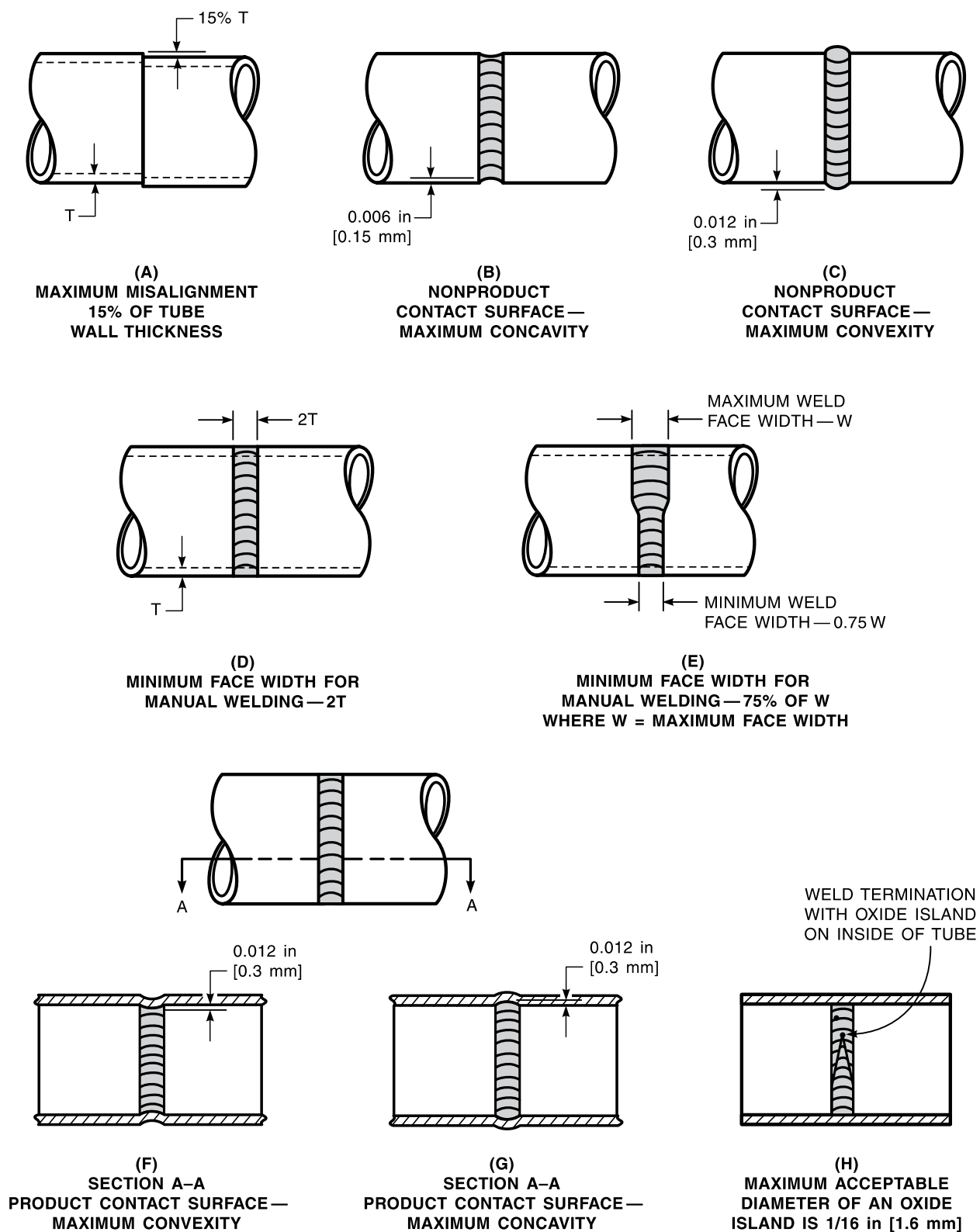
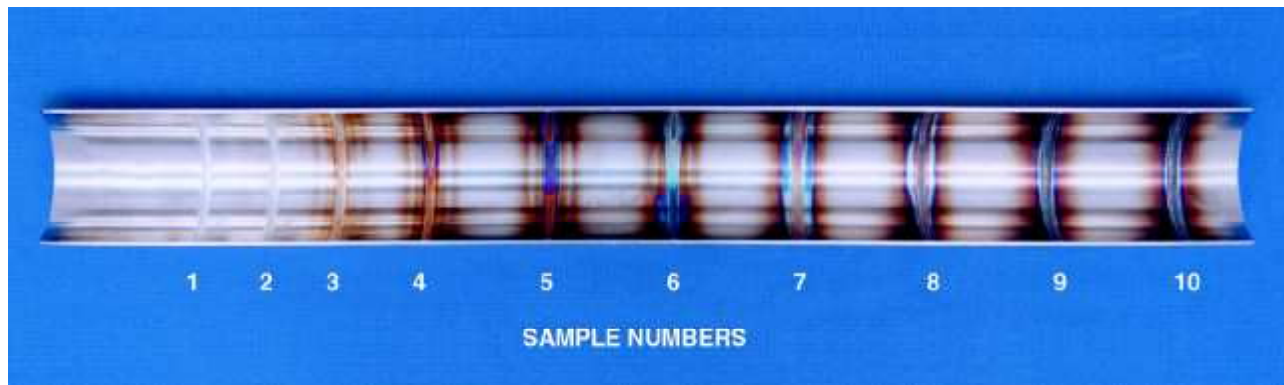


Figure 1—Examples of Maximum Allowable Discontinuities



Notes:

1. The tube sample was prepared using an automatic orbital “bead-on-plate” weld on the outside diameter of a 2 in [50.8 mm] stainless steel tube. The weld penetrated through the tube wall. The concentration of oxygen in ppm added to the pure argon backing gas for each weld was as follows:

No. 1—10	No. 3—50	No. 5—200	No. 7—1000	No. 9—12 500
No. 2—25	No. 4—100	No. 6—500	No. 8—5000	No. 10—25 000
2. The illustration is most useful as a reference to identify the degree of discoloration rather than to specify oxygen limits in the backing gas. The amount of discoloration and its appearance can be influenced by factors other than oxygen such as:
 - (a) High levels of moisture in the backing gas will increase the degree of discoloration.
 - (b) Contaminants such as hydrocarbons, moisture, and some types of particulate on the surface prior to welding can influence discoloration levels.
 - (c) Hydrogen gas in the argon backing gas can significantly reduce the amount of discoloration.
 - (d) The metal's surface finish can affect the appearance of discoloration.

Figure 2—Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube

Annex A (Informative)

Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS D18.1/D18.1M:2009, Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications, but is included for informational purposes only.

A1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed through the AWS staff member who works with that committee. The policy requires that all requests for an interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the complexity of the work and the procedures that must be followed, some interpretations may require considerable time.

A2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

A2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

A2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

A2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

A2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

A3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS technical committee. The secretary of the committee refers all inquiries to the chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon approval by the committee, the interpretation is an official interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

A4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

A5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The AWS Board of Directors' policy requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be obtained only through a written request. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

A6. AWS Technical Committees

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) points not specifically covered by the standard. In such cases, the inquirer should seek assistance from a competent engineer experienced in the particular field of interest.

Annex B (Informative)

Documentation Sample Forms

This annex is not part of AWS D18.1/D18.1M:2009, *Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications*, but is included for informational purposes only.

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B1. Sample of Welder Qualification Test Record

Welder or Welding Operator Qualification Test Record

☐ Welder Qualification ☐ Verification Test

Welder's Name _____ Identification No. _____

WPS Followed _____ Revision _____

Base Metal Specification _____ ☐ PLATE or ☐ PIPE

Welder Qualification Variables	Actual Values	Range Qualified
Welding process(es)		
Type used	☐ Manual, ☐ Semiautomatic, or ☐ NA	☐ Manual, ☐ Semiautomatic, or ☐ NA
Mode of Transfer (GMAW)	☐ Short circuiting, ☐ Globular, ☐ Spray, ☐ Pulses spray, or ☐ NA	☐ Short circuiting, ☐ Globular, ☐ Spray, ☐ Pulses spray, or ☐ NA
Base metal M-No. (see AWS B2.1)		
Thickness		
Diameter (if pipe or tube)		
Backing	☐ With or ☐ Without	☐ With or ☐ Without
Consumable inserts	☐ With or ☐ Without	☐ With or ☐ Without
Current type and polarity	☐ DCEN, ☐ DCEP, ☐ Alternating, ☐ Pulsing, or ☐ NA	☐ DCEN, ☐ DCEP, ☐ Alternating, ☐ Pulsing, or ☐ NA
Filler metal specification and class		
Filler metal F-No. (see AWS B2.1)		
Welding position	☐ 1G, ☐ 2G, ☐ 3G, ☐ 4G, ☐ 5G, ☐ 6G ☐ 1F, ☐ 2F, ☐ 3F, ☐ 4F, ☐ 5F ☐ OTHER	☐ F, ☐ H, ☐ V, ☐ OH, ☐ ALL ☐ FILLET, ☐ GROOVE ☐ OTHER
Vertical progression	☐ Uphill, ☐ Downhill, or ☐ NA	☐ Uphill, ☐ Downhill, or ☐ NA
Welding Operator Qualification Variables	Actual Values	Range Qualified
Welding process(es)		
Type used	☐ Machine, ☐ Mechanized, ☐ Automatic, or ☐ NA	☐ Machine, ☐ Mechanized, ☐ Automatic, or ☐ NA
Control	☐ Direct visual, ☐ Remote visual, or ☐ NA	☐ Direct visual, ☐ Remote visual, or ☐ NA
Mode of transfer (GMAW)	☐ Short circuiting, ☐ Globular, ☐ Spray, ☐ Pulsed spray, or ☐ NA	☐ Short circuiting, ☐ Globular, ☐ Spray, ☐ Pulsed spray, or ☐ NA
Base metal M-No. (see AWS B2.1)		
Consumable inserts	☐ With or ☐ Without	☐ With or ☐ Without
Welding position	☐ 1G, ☐ 2G, ☐ 3G, ☐ 4G, ☐ 5G, ☐ 6G ☐ 1F, ☐ 2F, ☐ 3F, ☐ 4F, ☐ 5F ☐ OTHER	☐ F, ☐ H, ☐ V, ☐ OH, ☐ ALL ☐ FILLET, ☐ GROOVE ☐ OTHER

RESULTS

Visual Examination: Acceptable ☐ Yes or ☐ No

Guided Bend Test Results

Identification No.	Type	Result	Identification No.	Type	Result

Fillet Weld Test Results

Bend-Break Test Result _____	Fillet Size _____
Macroetch Result _____	Remarks _____

Inspected by _____ Test Number _____
 Organization _____ Date _____

Radiographic Examination

Identification No.	Result	Remarks	Identification No.	Result	Remarks

Interpreted by _____ Certification Level _____
 Organization _____ Test Number _____ Date _____

We the undersigned certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of AWS D18.1.

Date _____ Manufacturer or Contractor _____
 Authorized By _____

B2. Sample of Welding Procedure Specification (WPS)

COMPANY NAME _____ BY _____

WPS No. _____ DATE _____

WPS REV. No. _____ REV. DATE _____

SUPPORTING PQR Nos. _____

WELDING PROCESS(ES) _____ TYPE _____

Manual, Semiautomatic, Automatic, Robotic

JOINTS

JOINT TYPE _____

BACKING _____

BACKING MATERIAL (TYPE) _____

GROOVE ANGLE _____

ROOT OPENING RADIUS ☐ U or ☐ J

ROOT FACE _____

BACKGOUGING ☐ YES or ☐ NO

BACKGOUGING METHOD _____

Joint Details

Sketches, production drawings, welding symbols, or written description should show the general arrangement of the parts to be welded. Where applicable, the root spacing details of the weld groove may be specified.

BASE METAL(S)

M-No. _____ GROUP No. _____ OR TO M-No. _____ GROUP No. _____

SPECIFICATION TYPE AND GRADE _____

TO SPECIFICATION TYPE AND GRADE _____

THICKNESS RANGE _____

OF BASE METAL	GROOVE _____	FILLET _____
DEPOSITED METAL	GROOVE _____	FILLET _____
PIPE DIAMETER RANGE	GROOVE _____	FILLET _____

OTHER _____

FILLER METALS

FILLER METAL F-No. _____ OTHER _____

AWS CLASSIFICATION _____

AWS SPECIFICATION _____

WELD METAL ANALYSIS A-No. _____ OTHER _____

FILLER METAL SIZE _____

ELECTRODE-FLUX (CLASS) _____

FLUX TRADE NAME _____

CONSUMABLE INSERT _____

OTHER _____

B2. Sample WPS Form (Continued)

WPS NUMBER (PAGE 2) _____

POSITIONS

POSITION(S) OF GROOVE _____

WELD PROGRESSION _____

POSITION(S) OF FILLET _____

PREHEAT

PREHEAT TEMP. (MINIMUM) _____

INTERPASS TEMP. (MAXIMUM) _____

PREHEAT MAINTENANCE _____

CONTINUOUS OR SPECIAL HEATING OR MAINTENANCE _____

POSTWELD HEAT TREATMENT

TEMPERATURE _____

TIME _____

SHIELDING

	SHIELDING	BACKING	TRAILING
GAS(ES)			
COMPOSITION			
FLOW RATE			

FLUX ☐ YES or ☐ NO

FLUX TYPE/TRADE NAME _____

ELECTRICAL CHARACTERISTICS

CURRENT TYPE AND POLARITY _____

PULSING ☐ YES or ☐ NO

CURRENT (RANGE) _____

VOLTAGE (RANGE) _____

WIRE FEED SPEED (RANGE) _____

TUNGSTEN ELECTRODE SIZE AND TYPE _____

PULSING PARAMETERS _____

OTHER _____

OTHER VARIABLES

CUP OR NOZZLE SIZE _____

COLLET BODY ☐ or GAS LENS ☐

CLEANING METHOD _____

NUMBER OF ELECTRODES _____

OTHER _____

WELDING PARAMETERS

LAYERS	PROCESS	FILLER METAL		ELECTRICAL			TRAVEL SPEED RANGE
		Class	Diameter	Type and Polarity	Current Range	Voltage Range	

B3. Sample of Procedure Qualification Record (PQR)1. Procedure Qualification ☐ or 2. Procedure Verification ☐

COMPANY NAME _____ BY _____

PQR No. _____ DATE _____

PQR REV. No. _____ REV. DATE _____

SUPPORTING WPS Nos. _____

WELDING PROCESS(ES) _____ TYPE _____

Manual, Semiautomatic, Automatic, Robotic

JOINTS

JOINT TYPE _____

BACKING _____

BACKING MATERIAL (TYPE) _____

GROOVE ANGLE _____

ROOT OPENING RADIUS ☐ U or ☐ J

ROOT FACE _____

BACKGOUGING ☐ YES or ☐ NO

BACKGOUGING METHOD _____

Joint Details

Sketches, production drawings, welding symbols, or written description should show the general arrangement of the parts to be welded. Where applicable, the root spacing details of the weld groove may be specified.

BASE METAL(S)

M-No. _____ GROUP No. _____ OR TO M-No. _____ GROUP No. _____

SPECIFICATION TYPE AND GRADE _____

TO SPECIFICATION TYPE AND GRADE _____

THICKNESS RANGE _____

OF BASE METAL GROOVE _____ FILLET _____

PIPE DIAMETER RANGE GROOVE _____ FILLET _____

OTHER _____

FILLER METALS

FILLER METAL F-No. _____ OTHER _____

AWS CLASSIFICATION _____ AWS SPECIFICATION _____

WELD METAL ANALYSIS A-No. _____ OTHER _____

FILLER METAL SIZE _____

ELECTRODE-FLUX (CLASS) _____

FLUX TRADE NAME _____

CONSUMABLE INSERT _____

OTHER _____

B3. Sample PQR Form (Continued)

PQR NUMBER (Page 2) _____

POSITIONS

POSITION(S) OF GROOVE _____ WELD PROGRESSION _____

POSITION(S) OF FILLET _____

PREHEAT

PREHEAT TEMPERATURE _____ INTERPASS TEMPERATURE _____

POSTWELD HEAT TREATMENT

TEMPERATURE _____ TIME _____

SHIELDING

	SHIELDING	BACKING	TRAILING
GAS(ES)			
COMPOSITION			
FLOW RATE			

FLUX ☐ YES or ☐ NO FLUX TYPE/TRADE NAME _____**ELECTRICAL CHARACTERISTICS AND WELDING PARAMETERS**CURRENT TYPE AND POLARITY _____ PULSING ☐ YES or ☐ NO

CURRENT (RANGE) _____ VOLTAGE (RANGE) _____

WIRE FEED SPEED (RANGE) _____ TRAVEL SPEED (RANGE) _____

TUNGSTEN ELECTRODE SIZE AND TYPE _____

PULSING PARAMETERS _____

OTHER _____

OTHER VARIABLESCUP OR NOZZLE SIZE _____ ☐ COLLET BODY or ☐ GAS LENSCLEANING METHOD _____ TECHNIQUE: ☐ STRINGER or ☐ WEAVE

NUMBER OF ELECTRODES _____ NUMBER OF PASSES PER SIDE _____

OTHER _____

TEST RESULTS

VISUAL TEST RESULTS _____

B3. Sample PQR Form (Continued)

PQR NUMBER (Page 3) _____

TENSILE TESTS

Specimen No.	Width	Thickness	Area	Results				Failure Type and Location
				Yield Load	Yield Strength	Tensile Load	Tensile Strength	

GUIDED BEND TESTS

Type and Figure Number	Results

WELDER'S NAME _____

ID or SS No. _____

TESTS CONDUCTED BY _____

LAB TEST No. _____

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of AWS D18.1.

MANUFACTURER OR CONTRACTOR _____

DATE _____ BY _____

Please Print

Signature

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List of AWS Documents on Welding in Sanitary Applications

Designation	Title
D18.1/D18.1M	<i>Specification for Welding of Austenitic Stainless Steel Tubing in Sanitary (Hygienic) Applications</i>
D18.2	<i>Guide to Weld Discoloration Levels on Inside of Austenitic Stainless Steel Tube</i>
D18.3/D18.3M	<i>Specification for Welding of Tanks, Vessels, and Other Equipment in Sanitary (Hygienic) Applications</i>

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