

Specification for Soldering Procedure and Performance Qualification



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An American National Standard

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American National Standards Institute
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Specification for **Soldering Procedure and** **Performance Qualification**

3rd Edition

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Prepared by the
American Welding Society (AWS) B2 Committee on Procedure and Performance Qualification

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides the requirements for qualification of soldering procedure specifications, solderers, and soldering operators for manual, mechanized, and automatic soldering. The soldering processes included are torch soldering, furnace soldering, induction soldering, resistance soldering, dip soldering, iron soldering, and infrared soldering. Base metals, soldering filler metals, soldering fluxes, soldering atmospheres, and soldering joint clearances are also included.



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Foreword

This foreword is not part of this standard but is included for informational purposes only.

The AWS B2 Committee on Procedure and Performance Qualification was formed in 1979. The first edition of B2.1, *Specification for Welding Procedure and Performance Qualification*, was published in 1984. This standard introduced the concept of Standard Welding Procedure Specifications (SWPSs) in addition to a set of rules for qualifying welding procedures, welders, and welding operators. The B2 Committee has published seventy-four SWPSs, B2.2/B2.2M, *Standard for Brazing Procedure and Performance Qualification*, B2.4/B2.4M, *Specification for Welding Procedure and Performance Qualification for Thermoplastics*, and most recently B2.3/B2.3M, *Specification for Soldering Procedure and Performance Qualification*.

This is the third edition of AWS B2.3/B2.3M, *Specification for Soldering and Performance Qualification*. This standard originated in the B2E Subcommittee on Soldering Qualification. The B2E Subcommittee was formed in 2000 in order to explicitly address the unique requirements of soldering procedure and soldering performance qualification outside the spectrum of B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*.

NOTE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights. By publication of this standard, no position is taken with respect to the validity of any such claim(s) or of any patent rights in connection therewith. If a patent holder has filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, then details may be obtained from the standards developer.

A vertical line in the margin or underlined text in clauses, tables, or figures indicates an editorial or technical change from the 2012 edition.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS B2 Committee on Procedure and Performance Qualification, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Specification for Soldering Procedure and Performance Qualification

1. General Requirements

1.1 Scope. This specification provides the requirements for qualification of soldering procedure specifications. This specification also provides requirements for the performance qualification of solderers and soldering operators and is intended for use where referenced by a product standard or contract document. This specification is not applicable to the soldering of electrical or electronic components, including connections and terminations.

Employers shall be responsible for the soldering done by their organization, including the use of qualified soldering procedures, qualified solderers, and qualified soldering operators. It is the Employer's responsibility to assure that soldering procedure specifications meet any additional requirements of the Referencing Document. Each Employer shall maintain the applicable soldering procedure specifications, soldering procedure qualification records, and soldering performance qualification records.

When not otherwise specified by the Referencing Document, the edition of the specification to be used should be established in accordance with the following:

(1) Editions may be used at any time after the effective date of issue.

(2) Latest edition of this document should be used for new contracts.

(3) Editions established by contract date may be used during the entire term of the contract, or the provisions of later editions may be used when agreed upon by the contracting parties.

This document is intended primarily for use with the following soldering processes:

(1) Torch soldering (TS)

(2) Furnace soldering (FS)

(3) Induction soldering (IS)

(4) Resistance soldering (RS)

(5) Dip soldering (DS)

(6) Iron soldering (INS)

(7) Infrared soldering (IRS)

1.1.1 Base Metals. The grouping of base metals by Base Metal Number (BM No.) in Table B.1 has been made on the basis of metallurgical compatibility, chemical composition, and solderability to decrease the number of required soldering qualifications. The grouping does not imply that base metals may be indiscriminately substituted within the same BM No. without consideration of their applicability. For some materials or combinations of materials, additional tests may be required by the procuring activity or the design engineer.

Base metals are identified by their ASTM,¹ ABS,² or UNS³ designations. Cross reference specifications, listed in the Unified Numbering System for Metals and Alloys opposite a given UNS No., are included in the same BM No. group as the given UNS Number.

¹ ASTM—American Society for Testing and Materials.

² ABS—American Bureau of Shipping.

³ UNS—Unified Numbering System.

Eight categories are included as follows:

- (1) Ferrous metals (BM Nos. 100 through 180)
- (2) Aluminum and aluminum alloys (BM Nos. 200 through 220)
- (3) Copper and copper alloys (BM Nos. 300 through 360)
- (4) Nickel and nickel alloys (BM Nos. 400 through 430)
- (5) Titanium and titanium alloys (BM No. 500)
- (6) Zirconium and zirconium alloys (BM No. 600)
- (7) Magnesium alloys (BM No. 700)
- (8) Cobalt alloys (BM No. 800)

Reference [AWS B2.1/B2.1M-BMG](#), *Base Metal Grouping for Welding Procedure and Performance Qualification*.

1.1.2 Filler Metals. The soldering compositions of [ASTM B32](#) and [ASTM B907](#) are provided in Tables A.5 through A.8 of this specification. Solder compositions are grouped by filler metal number (FM No.) in this standard on the basis of chemical composition to decrease the number of required soldering qualifications. The grouping does not imply that filler metals may be indiscriminately substituted within the same FM No. without consideration of their applicability. [ASTM B32](#), *Standard Specification for Solder Metal*, and [ASTM B907](#), *Standard Specification for Zinc, Tin, and Cadmium Base Alloys used as Solders*, provide detailed requirements and general applicability of filler metals.

Filler metals other than those listed in [ASTM B32](#) and [ASTM B907](#) may be used provided such filler metal meets the qualification requirements of this specification. For such filler metals, the term “special” shall be included as the “FM No.” on the SPS and SPQR.

1.1.3 Fluxes. [ASTM B813](#), *Specification for Liquid and Paste Fluxes*, provides detailed requirements for fluxes, also reference Table A.9.⁴

1.2 Units of Measure. This standard 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 and figures. The measurements may not be exact equivalents; therefore, each system must be used independently.

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard and therefore are not addressed herein. Safety and health information is available from the following sources:

American Welding Society:

- (1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- (2) AWS Safety and Health Fact Sheets
- (3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

- (1) Safety Data Sheets supplied by materials manufacturers
- (2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

Work performed in accordance with this standard may involve the use of materials that have been deemed hazardous, and may involve operations or equipment that may cause injury or death. This standard does not purport to address all safety and health risks that may be encountered. The user of this standard should establish an appropriate safety program to address such risks as well as to meet applicable regulatory requirements. ANSI Z49.1 should be considered when developing the safety program.

⁴ Source: Reproduced from AWS *Soldering Handbook*, 3rd ed., Table 4.5, Miami: American Welding Society.

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.

American Welding Society (AWS) Documents:⁵

[AWS A3.0M/A3.0](#), *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*;

[AWS B4.0](#), *Standard Methods for Mechanical Testing of Welds*; and

[AWS B4.0M](#), *Standard Methods for Mechanical Testing of Welds (Metric Customary Units)*.

Other Documents:

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*;⁶

[ASTM B32](#), *Standard Specification for Solder Metal*;⁷

[ASTM B813](#), *Specification for Fluxes for Soldering and Braze Welding*;

[ASTM B907](#), *Specification Zinc, Tin and Cadmium Base Alloys used as Solders*;

[ASTM E29](#), *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications*; and

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*.⁸

3. Terms and Definitions

[AWS A3.0M/A3.0](#), *Standard Welding Terms and Definitions*, provides the basis for terms and definitions used herein. However, the following terms and definitions are included below to accommodate usage specific to this document.

Employer. The contractor or manufacturer of the production soldered assembly for which soldering procedure and performance qualifications are required. Whenever approval, signature, or certification by the employer is required by this specification, it shall mean the Employer or a designated employee within the employer's organization. Closely related companies, including those with different names for which effective control of soldering is as one organization, shall be considered as one Employer.

qualification variable. A soldering variable which, if changed beyond the limitations specified, requires requalification of the procedure.

qualified solderer. One who is qualified to the requirements of this specification to perform manual soldering.

qualified soldering operator. One who is qualified to the requirements of this specification to operate furnace, mechanized, or automatic soldering equipment.

Qualifier. The Employer, organization, or individual specified by the Referencing Document as responsible for conducting and supervising qualification testing.

Referencing Document. The product standard or contract document that invokes this specification.

soldered test assembly. Workpieces joined by soldering for the purpose of qualifying soldering procedures, solderers, or soldering operators.

⁵ AWS standards are published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

⁶ ANSI Z49.1 is published by the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

⁷ ASTM standards are published by [ASTM International](#), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

⁸ NFPA standards are published by the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169.

soldering procedure qualification record (SPQR). A record of soldering variables used to produce an acceptable soldering test assembly and the results of tests conducted on the assembly to qualify a soldering procedure specification.

soldering procedure specification (SPS). A document specifying the required soldering variables for a specific application.

soldering variable. Any controllable detail of a soldering procedure which is required to be addressed on the SPS.

specimen. The soldered test assembly or portion thereof that is evaluated for qualification purposes.

specimen blank. That portion of a soldered test assembly that is removed for the production of a specimen. In some cases, the specimen blank is also the specimen.

4. Soldering Procedure Qualification

4.1 General. A soldering procedure qualification provides test data for assessing the properties of a soldered joint. It is the obligation of manufacturers to produce soldered assemblies that have properties suitable for the application. The proof of production solder soundness is determined by the type and extent of testing and examination applied, which is the responsibility of the Referencing Document.

4.1.1 Each soldering procedure shall be qualified to establish the properties that are expected to result from its application to production soldered joints. To qualify a soldering procedure, the following steps are necessary:

(1) The employer shall prepare a preliminary soldering procedure specification (SPS) to be used in making a soldered test assembly. Any format may be used for the SPS, provided all qualification variables and other applicable information are included.

(2) The actual conditions used in making the soldered test assembly and the results of the required examination and specimen testing shall be recorded on a soldering procedure qualification record (SPQR). Any format may be used, provided all essential and nonessential qualification variables are addressed.

(3) When the results meet the acceptance criteria of this document, the qualifying company shall certify by signature and date that the soldering and testing for procedure qualification are in accordance with [AWS B2.3/B2.3M](#).

(4) If the results do not meet the acceptance criteria, a new soldered test assembly shall be prepared. Soldered test assemblies shall not be repaired.

(5) Procedures qualified by one employer are not transferable to another employer.

4.1.2 During the making of procedure test assemblies for qualification (see Table A.1), the solderer or soldering operator shall be under the full supervision and control of the Qualifier. The Qualifier is responsible for ensuring proper:

- (1) Preparation of workpieces for soldering,
- (2) Documentation of the soldering test assembly variables,
- (3) Preparation of specimens from the completed soldered test assembly,
- (4) Performance of examination and mechanical tests, and
- (5) Documentation of results.

4.1.3 A change in qualification variable beyond the allowed limits of 4.3 Qualification Variables shall require requalification of the SPS and preparation of a new SPS. Changes in other variables shall not require requalification, provided such changes are documented in a revised SPS.

4.1.4 SPQRs shall not be revised, except to correct errors or add omitted information. However, all such changes shall be identified and dated on the SPQR.

4.1.5 SPSs and SPQRs shall be identified according to a system that allows traceability between the SPS and SPQR.

4.1.6 An SPS may require the support of more than one SPQR; while alternatively, one SPQR may support a number of SPSs.

4.2 Soldering Test Assemblies and Acceptance Criteria. Each soldering procedure shall be qualified by making one or more test assemblies. These may be either standard soldered test assemblies, or when permitted by the Referencing Document, workmanship soldered test assemblies. Standard test assemblies are illustrated in Figures C.1 through C.4. Typical workmanship soldered test assemblies are shown in Figure C.5.

4.2.1 Visual Examination. All soldered test assemblies shall be inspected by visual means prior to cutting for mechanical and macroetch specimens.

4.2.2 Acceptance Criteria for Visual Examination. The results of the visual examination shall meet the following requirements:

- (1) Solder metal shall be present at all edges of a joint.
- (2) No unmelted filler metal shall be present.
- (3) No cracks shall be visible in the joint.
- (4) No evidence of base metal melting shall be present.

4.2.3 Tension Test. The cutting plan for the blanks for the tension specimens from standard test assemblies is shown in Figures C.1 through C.4, except that the specimen for pipe and tube with an outside diameter of 3 in [76 mm] or less shall be in accordance with 4.2.3.4.

4.2.3.1 Tension specimens shall be prepared as shown in Figure C.9 for butt joints in plate.

4.2.3.2 Tension specimens shall be prepared as shown in Figure C.10 for lap joints, spliced butt joints, and rabbet joints in plate. Specimens shall be tested with no restraining device to prevent distortion. Where a peel test with a flanged member is substituted for the macroetch test, as described in 4.2.5, the tension specimen shall be tested without removal of the flanges.

4.2.3.3 For pipe and tubes with an outside diameter greater than 3 in [76 mm], tension specimens as shown in Figure C.9 or C.10, except for the curvature of the specimen transverse axis, shall be tested with no restraining device to prevent distortion during testing. Where a peel test with a flanged member is substituted for the macroetch test, as described in 4.2.5, the tension specimen shall be tested without removal of the flanges.

4.2.3.4 For pipe and tubes with an outside diameter of 3 in [76 mm] or less, a tension specimen consisting of a length of the entire joint may be tested as shown in Figure C.11.

4.2.3.5 Acceptance Criteria for Butt Joints. The specimen shall have a minimum tensile strength established by the Referencing Document or responsible engineer. When the Referencing Document or engineer does not establish a minimum tensile strength, the tensile test is not required.

4.2.3.6 Acceptance Criteria for Lap Joints, Spliced Butt Joints, and Rabbet Joints. The specimen shall have a minimum tensile strength established by the Referencing Document or responsible engineer. When the Referencing Document or responsible engineer does not establish a minimum tensile strength, the tensile test is not required. The tensile strength of the specimen shall be computed by dividing the ultimate load by the cross-sectional area of the base metal. For dissimilar metal joints, the divisor shall be the cross-sectional area of the joint member in which the failure occurred or of the joint in the case of joint failure.

4.2.4 Bend Test. The cutting plan for the blanks for the bend specimens from standard soldered test assemblies is shown in Figures C.1 and C.4. Figure C.4 applies to pipe and tubes of all diameters.

4.2.4.1 Bend specimens as shown in Figure C.12 shall be tested for butt joints in plate and pipe and tube.

4.2.4.2 The bend specimens shall be bent in accordance with [AWS B4.0, Standard Methods for Mechanical Testing of Welds](#).

4.2.4.3 Acceptance Criteria for Bend Tests. The specimen shall meet one of the following criteria:

- (1) The specimen does not separate.
- (2) The specimen separates in the base metal.
- (3) If the specimen separates at the soldered joint it is acceptable providing:

(a) the total area of discontinuities such as pores, voids, unsoldered areas, and inclusions, does not exceed 15% of the area of either fracture surface; and

(b) no discontinuity dimension, or combination of discontinuity dimensions, extends more than 20% along any line that would provide a leak path from one plate or pipe and tube surface to the opposing surface.

4.2.5 Macroetch Test. The cutting plan for the blanks for the macroetch specimens from the standard soldered test assemblies is shown in Figures C.2 and C.4. The blanks shall be 1-1/2 in [38 mm] in width; except that for pipes and tubes with an outside diameter of 3 in [76 mm] or less, the blanks shall be two opposing quadrants.

4.2.5.1 Both sides of each blank shall be smoothed and etched with a reagent to give a clear definition of the solder and examined with a three to ten power magnifying glass.

4.2.5.2 Acceptance Criteria for Macroetch Tests. None of the cross sections, when considered individually, shall have a total length of discontinuities, such as pores, voids, unsoldered areas, or inclusions, greater than 20% of any single lap length. No cracks shall be present in the joint or in the base metal.

4.2.6 Peel Test. Peel tests of standard soldered test assemblies with lap or spliced butt joints in plate or pipe and tube with an outside diameter greater than 3 in [76 mm] may be substituted for the macroetch test. The peel sample shall separate within the solder filler metal, at the solder interface, or a combination of the two sites.

4.2.6.1 The cutting plan for the peel specimens from standard test soldered assemblies is shown in Figures C.3 and C.4. The blanks shall be approximately 1-1/2 in [38 mm] in width.

4.2.6.2 The inclusion of a flange on one member of a lap joint, or the splice member of a spliced butt joint as illustrated in Figure C.3, to facilitate peel testing is optional.

4.2.6.3 No preparation of the specimen blank is necessary.

4.2.6.4 Acceptance Criteria for Peel Tests. None of the exposed surfaces, when considered individually, shall have a total area of discontinuities, such as pores, voids, unsoldered areas, and inclusions, greater than 15% of the faying surface. No discontinuity dimension, or combination of discontinuity dimensions, shall extend more than 15% along any line that would provide a leak path from one plate or pipe and tube surface to the opposing surface.

4.2.7 Workmanship Soldered Test Assemblies. For joints other than those identified in Table A.1 as standard test assembly, one workmanship test assembly representative of the design details of the joint to be qualified is required. Typical workmanship soldered test assemblies are shown in Figure C.5.

4.2.7.1 Test assemblies of linear joints shall be 10 in [255 mm] in length or the entire joint to be qualified, whichever is less. The test assembly shall be cut perpendicular to the soldered joint into five equal parts. The two parts adjacent to the center part shall be selected as macroetch specimen blanks.

4.2.7.2 Soldered test assemblies of circular joints shall be cut into quadrants. Two opposing quadrants shall be selected as macroetch specimen blanks.

4.2.7.3 The four cut sides of the two macroetch specimen blanks shall be smoothed and etched with a reagent to give a clear definition of the solder, and examined with a three to ten power magnifying glass.

4.2.7.4 Acceptance Criteria for Workmanship Tests. None of the cross sections, when considered individually, shall have a total length of discontinuities, such as pores, voids, unsoldered areas, and inclusions, greater than 20% of any single solder length of each joint member. No cracks shall be present in the joint or in the base metal.

4.3 Qualification Variables

4.3.1 Soldering Process. An SPS shall be requalified when there is any change in qualification variables as follows:

- (1) A change from one soldering process to any other.
- (2) The addition or deletion of any other soldering process other than the one already qualified. For example, the use of an oxyacetylene torch to finish joints soldered by the soldering iron process.

4.3.2 Base Metal (BM). An SPS shall be requalified when there is any change in qualification variables as follows:

- (1) A change from a base metal given under one BM No. in Table B.1 to a base metal given under another BM No. or to a base metal not included in the table.
- (2) A change from a base metal not included in Table B.1 to any other base metal.
- (3) Criteria (1) and (2) apply to any single metal of dissimilar metal or metal/ceramic soldered joint as well as any substantive changes to the soldering process.

4.3.3 Base Metal Thickness (T). A change made in base metal thickness to a value outside the range qualified in accordance with Table A.2, requires requalification.

4.3.4 Base Metal Preparation. A change made in methods of preparing the base metal, such as cleaning, coating, plating, or surface treatment by mechanical means, requires requalification of the SPS.

4.3.5 Solder Filler Metal. An SPS shall be requalified when there is any change in qualification variables as follows:

- (1) A change from a filler metal given in Tables A.5 through A.8 under one FM No. to a filler metal given under another FM No. or to a filler metal not included in the table.
- (2) A change from a filler metal not included in Tables A.5 through A.8 to any other filler metal.
- (3) A change from any form of filler metal to another form; for example, rod, preplaced inserts, preplaced foils, etc.
- (4) A change from preplaced filler metal or mechanically-fed filler metal to manually-fed filler metal and vice versa.

4.3.6 Soldering Flux. An SPS shall be requalified when there is any change in qualification variables as follows:

- (1) A change from a soldering flux as grouped in Table A.9.
- (2) A change from a soldering flux not included in Table A.9 to any other flux.
- (3) A change from fluxless soldering to flux soldering or vice versa.

4.3.7 Bath Composition. A change made in the nominal flux composition of the soldering medium for dip soldering requires requalification of the SPS.

4.3.8 Soldering Atmosphere. An SPS shall be requalified when there is any change in qualification variables as follows:

- (1) A change in the soldering atmosphere from one AWS type given in Table A.10 to any other AWS type or to any other atmosphere.
- (2) A change from a soldering atmosphere not included in Table A.10 to any other atmosphere.

4.3.9 Solder Temperature. Except for torch soldering, an SPS shall be requalified when there is a change in the soldering temperature to a value more than 72°F [40°C] above the liquidus temperature specified in Tables A.5 through A.8.

4.3.10 Soldering Time. A change in the soldering time at temperature of more than 10% requires requalification for mechanized or automatic soldering.

4.3.11 Joint Design. An SPS shall be requalified when there is any change in qualification variables as follows:

- (1) A change from a butt or scarf to a lap, to socket, or rabbet from that qualified. The addition or deletion of a flange for the joint types of Figure C.3 is not considered a change in joint type.
- (2) An increase in lap length of 1/4 in [6 mm] or 2T, whichever is less. For joints of dissimilar base metal thickness, the applicable thickness (T) is that of the thinner joint member (see Figures C.2 and C.3).

4.3.12 Joint Clearance. An SPS shall be requalified when there is any change in qualification variables as follows:

(1) For a qualified joint clearance of 0.001 in to 0.002 in [0.02 mm to 0.05 mm] a change in joint clearance greater than 0.001 in [0.02 mm].

(2) For a qualified joint clearance of 0.003 in to 0.005 in [0.08 mm to 0.13 mm] a change in joint clearance of 0.002 in [0.05 mm].

(3) For a qualified joint clearance of 0.006 in to 0.010 in [0.15 mm to 0.25 mm] a change in joint clearance of 0.003 in [0.08 mm].

(4) For a qualified joint clearance greater than 0.010 in [0.25 mm], the maximum allowable change to that clearance that requires requalification shall be stated in the Referencing Document.

4.3.13 Solder Flow Position. A change from one of the four soldering flow positions included in Figure C.7 to another one of those positions requires requalification, except for that shown in Table A.4.

4.3.14 Postsolder Heat Treatment (PSHT). The SPS shall be requalified when there is a change in the following:

- (1) The addition or deletion of a PSHT.
- (2) A change in the postsolder heat treatment time and temperature.

4.3.15 Precoating (Tinning). The SPS shall be requalified when there is a change from a precoated to a non-precoated state prior to soldering the joint or vice versa.

5. Soldering Performance Qualification

5.1 General. Soldering performance qualification tests determine the ability of qualified solderers to make sound soldered joints following a soldering procedure specification (SPS) and under conditions that will be encountered in production applications.

Soldering operator performance qualification tests determine the ability of soldering operators to operate furnace, mechanized, or automatic soldering equipment in accordance with an SPS.

5.1.1 Qualification under this section requires completion of test soldered assemblies in accordance with a qualified SPS, acceptance by the Qualifier of the test soldered assemblies, and the results of the specimen tests.

5.1.2 Acceptance of performance test soldered assemblies may be allowed by either one of the two methods:

- (1) Qualification by visual examination (see 5.2), when allowed by Referencing Document.
- (2) Qualification by specimen testing (see 5.3).

5.1.3 Performance qualification by specimen testing shall qualify the individual to perform production soldering, where qualification by either specimen testing or visual examination is specified. Performance qualification by visual examination shall qualify the production work only where qualification by visual examination is permitted by the Referencing Document.

5.1.4 A solderer or soldering operator who completes an acceptable procedure or performance qualification test assembly shall be qualified for production work within the limits of variables specified in 5.4.

5.1.5 Qualification as a solderer does not qualify the individual as a soldering operator or vice versa.

5.1.6 Qualification is permitted on production soldered assemblies provided that such qualification is not prohibited by the Referencing Document.

5.1.7 Test assemblies shall not be repaired.

5.1.8 The solderer or soldering operator undertaking performance qualification tests shall be under the full supervision and control of the Qualifier during the making of test soldered assemblies. Acceptance or rejection and documentation of test results are the responsibility of the Qualifier. Performance qualification documentation shall be dated and signed by the Qualifier. Any format may be used provided that all qualification variables and other applicable information are included.

5.1.9 The performance qualification shall remain in effect indefinitely unless the solderer or soldering operator does not solder with the qualified process for a period exceeding six months or if there is some specific reason to question the ability of a solderer or soldering operator.

5.1.10 A solderer or soldering operator who fails the performance test required by this section may be retested at the option of the Qualifier.

5.2 Qualification by Visual Examination

5.2.1 Qualification by only visual examination shall be permitted if allowed by the Referencing Document.

5.2.2 Qualification by visual examination requires completion of a workmanship test soldered assembly representative of the design details of the joint qualified, which shall be accepted or rejected by visual examination. Typical workmanship test assemblies are shown in Figure C.5.

5.2.3 Unless otherwise included in the Referencing Document, the workmanship test assembly shall be visually examined and shall meet the following requirements:

- (1) Solder metal shall be present at all edges of a joint.
- (2) No unmelted solder filler metal shall be present.
- (3) No cracks shall be visible in the joint.
- (4) No base metal melting shall be present.

5.3 Qualification by Specimen Testing

5.3.1 Performance qualification by specimen testing shall be conducted whereby acceptance is based upon (a) visual examination and either (b) macroetch test of standard soldered test assembly or (c) peel test of standard soldered test assembly.

5.3.2 Visual Examination. All test assemblies shall be inspected by visual means prior to cutting. The results of the visual examination shall meet the requirements of 5.2.3.

5.3.3 Macroetch Test of Standard Soldered Test Assembly. The test assembly shall be one of the joint types shown in Figure C.2, C.3, or C.4 in either plate or in pipe of any diameter with a minimum joint length of 3 in [76 mm]. Multiple specimens and coupons may be used.

(1) Plate joints shall be cut perpendicular to the soldered axis into three 0.75 in [19 mm] wide specimens. Pipe and tube joints shall be cut into quadrants, and two opposing quadrants shall be selected as macroetch specimen blanks.

(2) Both sides of each specimen blank shall be smoothed to give a clear definition of the solder filler metal and examined with a three to ten power minimum magnifying glass. If the solder filler metal is not evident after polishing, the specimen shall be etched with the proper reagent.

(3) None of the cross sections, when considered individually, shall have a total length of discontinuities, such as pores, voids, unsoldered areas, or inclusions, greater than 20% of the macroetch surface. No cracks shall be present in the joint or in the base metal.

5.3.4 Peel Test of Standard Soldered Test Assembly. Peel tests of test assemblies with lap or spliced butt joints in plate or pipe and tube with an outside diameter greater than 3 in [76 mm] may be substituted for the macroetch test, provided that the peel specimen separates entirely at the soldered joint.

(1) The test soldered assembly shall be selected from those shown in Figure C.2, C.3, or C.4. The inclusion of a flange on one member of the lap joint to facilitate peel testing is optional. The inclusion of flanges on the splice members of the spliced butt joints similar to the flange of the lap joint is also optional.

(2) Plate joints shall be cut perpendicular to the soldered axis into five equal parts, and the two parts adjacent to the center part shall be selected as peel specimen blanks. For pipe and tube joints, two peel specimen blanks, each 0.75 in [19 mm] in width, shall be cut at locations 180° apart.

(3) No preparation of the specimen blank is necessary. Using any peeling technique, the specimen shall be separated through the solder filler metal at either solder interface or a combination thereof.

(4) None of the exposed surfaces, when considered individually, shall have a total area of discontinuities, such as pores, voids, unsoldered areas, and inclusions, greater than 15% of the faying surface. No discontinuity dimension, or combination of discontinuity dimensions, shall extend more than 15% along any line that would provide a leak path from one plate or pipe surface to the opposing surface.

5.3.5 Workmanship Soldered Test Assemblies. The test assembly shall be representative of a production joint, with a minimum length of 3 in [76 mm] for linear joints or the entire joint for circular joints. Typical workmanship test assemblies are shown in Figure C.5.

(1) Linear joints shall be cut perpendicular to the soldered joint into five equal parts. The two parts adjacent to the center part shall be selected as macroetch specimen blanks. Circular joints shall be cut into quadrants. Two opposing quadrants shall be selected as macroetch specimen blanks.

(2) The four cut sides of the two macroetch specimen blanks shall be smoothed and etched with a suitable reagent to give a clear definition of the solder and examined with a three to ten power minimum magnifying glass.

(3) None of the cross sections, when considered individually, shall have a total length of discontinuities, such as pores, voids, unsoldered areas, and inclusions, greater than 20% of any single joint length. No cracks shall be present in the joint or in the base metal.

5.4 Qualification Variables for Solderers and Soldering Operators. Solderers and soldering operators must be requalified when there is any change in qualification variables as described below:

5.4.1 Soldering Process

- (1) A change from one soldering process, as identified in Clause 1. Scope, to any other.
- (2) The addition of any other soldering process to that or those already qualified.

5.4.2 Base Metal

- (1) A change from a base metal given under one BM No. in Table B.1 to a base metal given under another BM No., with the exceptions as given in Table A.3.
- (2) A change from a base metal not included in Table B.1 to any other base metal.
- (3) The soldering of dissimilar metal joints does not need to be requalified if the base metals involved are included in only one of the eight categories given in 1.1 Base Metals and if the soldering conditions for the dissimilar metal joints are the same as for each of the base metals involved and are within the limitations of the procedure qualification variables.

5.4.3 Base Metal Thickness. A change in base metal thickness to a value outside the range qualified in accordance with Table A.2 requires requalification.

5.4.4 Solder Filler Metal

- (1) A change from a filler metal given in Table A.5 under one FM No. to a filler metal given under another FM No. or to a filler metal not included in the table.
- (2) A change from a filler metal not included in Table A.5 to any other filler metal.
- (3) A change from preplaced filler metal or mechanically-fed filler metal to manually-fed filler metal.

5.4.5 Soldering Position. A change in position qualified in Table A.4. Soldering positions qualified by test soldered assemblies are indicated by an X.

(1) *Other Positions.* When production soldering is performed in a position that does not conform to any of the soldering positions included in Figure C.7, qualification test soldered assemblies shall be made in the production soldering position. Such qualifications are valid only for the position actually tested except that an angular deviation of 15° is allowed.

(2) If the filler metal is preplaced in the joint so that there is no major flow, the joint may be soldered in any position without requalification.

5.4.6 Joint Design

- (1) A change from a butt joint to any joint with overlapping members or vice versa.
- (2) An increase in lap length of 1/16 in [2 mm] or 25%, whichever is greater. This does not apply to pipe and tube lap joints when ANSI B16.22 or MSS SP-73 fittings are used.
- (3) See Figure C.6 for typical joint design.

5.4.7 Precoating. The SPS shall be requalified when there is a change between precoated to a non-precoated base material prior to soldering the joint or if the coating composition changes.

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Annex A (Normative)

Soldering Tables

This annex is part of this standard and includes mandatory elements for use with this standard.

Table A.1
Procedure Qualification Soldered Test Assembly
(see 4.1.2 and 4.2.7)

Soldered Test Assembly	Joint Type	Specimens ^a
Standard	Butt (including scarf)	Tension and bend
	Lap	Tension and macroetch or tension and peel
	Single spliced butt	Tension and macroetch or tension and peel
	Double spliced butt	Tension and macroetch or tension and peel
	Rabbit	Tension and macroetch
Workmanship	Other (see 4.2.6)	Macroetch

^a Two specimens are required for each test.

Source: Adapted from AWS B2.2, *Standard for Brazing Procedure and Performance Qualification*, Table 1, American Welding Society.