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Specification for Qualification of Welding Procedures and Welders for Piping and Tubing

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Specification for Qualification of Welding Procedures and Welders for Piping and Tubing

Superseding AWS D10.9-69

Prepared by
AWS Committee on Piping and Tubing

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors, October 6, 1980

AMERICAN WELDING SOCIETY, INC.
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Table of Contents

Personnel v

Foreword vii

Introduction viii

1. General Provisions 1
1.1 Scope 1
1.2 Levels of Qualification 1
1.3 Responsibility of the Contractor 1
1.4 Test Positions 2
1.5 Definitions 3
1.6 Pipe Sizes 4
1.7 Safety and Health 4

2. AR-1 Level of Welding Procedure Qualification 4
2.1 General Notes on Welding Procedure Qualification for Groove Welds 4
2.2 Tests Required for Sample Groove Welds 4
2.3 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of a Welding Procedure to the AR-1 Level 11

3. AR-1 Level of Welder Qualification 27
3.1 General Notes on Welder Qualification for Groove Welds 27
3.2 Tests Required for Sample Groove Welds 30
3.3 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of a Welder to the AR-1 Level 33

4. AR-3 Level of Welding Procedure and Welder Qualification 34
4.1 General Notes on Welding Procedure and Welder Qualification for Groove Welds 34
4.2 Tests Required for Sample Groove Welds 36
4.3 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of a Welding Procedure to the AR-3 Level 41
4.4 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of a Welder to the AR-3 Level 45

5. Welding Procedure and Welder Qualification for Fillet Welds Only 46
5.1 General Notes on Qualification for Fillet Welds 46
5.2 Preparation of Sample Fillet Welds 46
5.3 Tests Required for Sample Fillet Welds 46
5.4 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of Welding Procedures for Fillet Welds Only 48
5.5 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of a Welder for Fillet Welds Only 50

CONTENTS

Appendix A: Purpose and Mechanics of Welding Procedure and Welder Qualification 51

Appendix B: Definitions 54

Appendix C: Testing Options 55
C1. Qualification with Job Size Pipe 55
C2. Impact Tests 55
C3. Bend Tests 55
C4. Microstructure Examinations 55

Appendix D: Etchants 56

Appendix E: Commercial Pipe Sizes and Wall Thicknesses 58

Appendix F: Sample Forms 60

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Foreword

This specification was prepared by the American Welding Society Committee on Piping and Tubing as a service to the piping industry. This document sets forth the requirements that must be met to qualify welding procedures and welders for joining pipe, tube, and related components.

The Committee believes that the development and application of proven or qualified welding procedures and the qualification of welders to these procedures play a significant role in the making of reproducible, sound welds.

It is recognized that the contractor must provide competent supervision, reliable equipment, and a quality control program during production welding. This specification covers only the qualification of welding procedures and welders; the purchaser shall specify the inspection required during fabrication as part of his contract.

The qualification tests take into account such factors as the diameter of the product, as well as the wall thickness, the positions involved in pipe welding, and the fact that, in most cases, all welding and inspection must be performed from the face side of the weld.

Eight positions related to pipe welding have been set forth, and the nondestructive and destructive tests of the sample welds are tailored to pipe and tube welds.

It should be recognized that there are differences between this document and other codes and standards. Contractors may revise existing welding procedures and welder qualifications to conform with this specification by performing any additional tests required to comply with this document.

Introduction

This specification provides two distinct levels of quality for welding procedure and welder qualification for joining pipe, tube, and related components. The two levels are called Acceptance Requirements 1 and 3 and are hereafter abbreviated AR-1 and AR-3, respectively. Qualification to the AR-1 level provides a higher level of confidence in welding procedures and welders than does qualification to the AR-3 level. The difference between the two levels lies in the type of tests and the acceptance requirements for results that are specified for sample test welds.

The specification is divided into five sections, plus appendices. Section 1 covers general provisions. Section 2 describes welding procedure qualification for groove welds for the AR-1 level. Section 3 describes welder qualification for groove welds for the AR-1 level. Section 4 covers welding procedure and welder qualification for groove welds for the AR-3 quality level. Section 5 covers welding procedure and welder qualification for the welding of fillet welds only.

Appendix A includes information useful in applying this document. Specifically, it is an attempt at explaining the purpose and mechanics of welding procedure and welder qualification.

This specification sets forth two series of standardized tests and minimum acceptable test results for qualification of welding procedures and welders. The AR-3 level series is directed at noncritical piping systems and is dicusssed at the end of the Appendix. The AR-1 level test series is fairly typical of other national codes and standards for welding procedure and welder qualification, except that it is not directed at any specific application. It may be used as a guide for those developing welding requirements for new applications of piping systems. It may also assist in the understanding of the welding qualification requirements of other standards.

This first revision incorporates major changes and improvements over the 1969 edition to facilitate wider application of the specification. The 1969 edition contained three levels of qualification called Acceptance Requirements 1, 2, and 3, abbreviated as AR-1, AR-2, and AR-3. In this revised edition, the AR-1 and AR-2 Acceptance Requirements have been combined and modified into one level of qualification called Acceptance Requirement 1, abbreviated AR-1. This revised AR-1 level and a revised AR-3 level of Acceptance Requirements comprise the present specification.

A major revision to the specification allows the exclusive use of nondestructive examination for welder qualification without the performance of additional destructive testing if certain criteria are met. Material tables have been updated and regrouped to agree with other standards.

The format has been rearranged to make each section easier to use.

Specification for Qualification of Welding Procedures and Welders for Piping and Tubing

Issued, 1969; Revised, 1980

1. General Provisions

1.1 Scope

1.1.1 This specification sets forth the requirements for qualifying welding procedures and welders[1] for joining ferrous and nonferrous metals and applicable combinations of these materials using any of the processes applicable to tubular products. It covers groove and fillet welds but excludes longitudinal seams involved in pipe and tube manufacture.

1.1.2 By referencing this specification and specifying the desired level of Acceptance Requirements, any organization may make it the governing document for qualifying welding procedures and welders for the welding of piping and tubing.

1.1.3 Provision is made in this specification for qualifying welding procedures and welders for both groove and fillet welds. Qualification with groove welds qualifies for welding both groove and fillet welds; whereas, qualification with fillet welds qualifies only for the welding of fillet welds.

1.1.4 Welding procedures and welders previously qualified to the AR-1 or AR-2 levels of the 1969 edition of this specification are now considered as qualified to the AR-1 level of the present edition of this specification. Welding procedures and welders previously qualified to the AR-3 level or for fillet welds only, in accordance with the 1969 edition, are also considered as qualified to the AR-3 level of the present edition of the specification or for fillet welds only.

1.2 Levels of Qualification

1.2.1 Each of the two levels of welding procedure qualification has a corresponding level of welder qualification. Qualification to the AR-1 level automatically qualifies the procedure and the welder for both the AR-1 and AR-3 levels. Qualification of a welding procedure and a welder to the AR-3 level qualifies only for AR-3.

1.2.2 Generally, the welder is qualified to the same level as the welding procedure. However, the contractor may use a welding procedure of a different level than that for which the welder is being qualified within the following restrictions:

(1) An AR-1 welding procedure shall be used to qualify a welder for the AR-1 level.

(2) An AR-1 or AR-3 welding procedure may be used to qualify a welder for the AR-3 level.

1.2.3 When selecting one of the two levels, the tests and Acceptance Requirements specified for each level should be carefully reviewed. Consideration should be given to the service conditions, particularly to the consequences if the system fails to contain the liquid or gas. The level selected should be compatible with such factors as refinement of the design and rigorousness of the inspection and testing procedures specified. The object is to provide the desired degree of confidence in the integrity of the system.

1.2.4 Typical applications are as follows:

1.2.4.1 **AR-1.** This level applies to systems where a high degree of weld quality is required. Typical applications are lines in nuclear, chemical, cryogenic, gas, or steam systems.

1.2.4.2 **AR-3.** This level applies to systems where an average degree of weld quality is required. Applications are lines such as those for low-pressure heating, air conditioning, sanitary water, and some gases or chemicals.

1.3 Responsibility of the Contractor

1.3.1 **Qualification Testing.** Prior to production welding, the contractor shall qualify both his welding procedures and welders in accordance with this specification. Appendix A discusses the purpose and mechanics of welding procedure and welder qualification testing.

1. The term "welder(s)" as used in this document includes both welders and welding operators.

1.3.2 Welding Procedure Specification. To qualify a welding procedure, the contractor shall prepare a tentative written welding procedure specification. Sample Form A (see Appendix F) is an example of an acceptable format. The contractor should review paragraph 2.3 to ascertain that the proposed welding procedure specification sets forth all of the controlled welding variables applicable to it. He shall prove the adequacy of this welding procedure by making sample welds, subjecting these welds to the tests, and complying with the Acceptance Requirements set forth herein. Welding procedure qualification test records shall be kept to document the welding variables and record the test results. Sample Form B (see Appendix F) illustrates the items that should be recorded. If the sample welds satisfy the test requirements, a written welding procedure specification shall be prepared, similar to Form A, covering all welding variables significant to the production of sound welds. The welder who makes satisfactory sample welds for the procedure qualification shall be considered qualified to that welding procedure without further testing.

1.3.3 Duration of Welding Procedure Specification. The welding procedure shall remain in effect indefinitely, unless one or more of the welding variables undergoes a change greater than that allowed by the limits controlling the qualification (see paragraph 2.3).

1.3.4 Information for Welders. The contractor shall make a copy of the welding procedure available to the welder prior to his welder qualification test.

1.3.5 Welder Qualification. To qualify a welder, the contractor shall have the welder prepare sample welds using a qualified welding procedure. The contractor shall then subject the welds to tests to verify compliance with the Acceptance Requirements prescribed by this specification. The contractor shall maintain a record of each welder's qualification test, similar in format to Sample Form C (Appendix F). This qualification record shall identify all of the controlled welding variables and contain information on the results of all destructive and nondestructive tests performed on the welder's sample welds.

1.3.6 Welder Identification. Each welder qualified shall be assigned an identification number, letter, or symbol that shall be used to identify all of his work.

1.3.7 Welder Qualification Retest. A welder whose sample welds fail to meet the Acceptance Requirements of this specification may be retested, at the contractor's discretion, after he has had further training. The retest shall consist of one sample weld in each position in which the welder failed in his previous test.

1.3.8 Welder Requalification. Requalification of a welder may be required whenever there is reason to question his ability to make welds that meet the requirements of this specification or when he has not welded for some period of time agreed upon between the purchaser and the contractor.

1.3.9 Previously Qualified Welding Procedures and Welders

1.3.9.1 Welding procedures and welders previously qualified to the AR-1 or AR-2 levels of the 1969 edition of AWS D10.9 are now considered qualified to the AR-1 level of the present edition. Welding procedures and welders previously qualified to the AR-3 level, or for fillet welds only, are also considered as similarly qualified to the present edition. In addition, welding procedures and welders previously qualified in accordance with another standard may also be considered qualified to this specification if the results of such qualification tests meet all of the Acceptance Requirements set forth herein for the level of qualification selected.

1.3.9.2 If tests required by this specification have not previously been performed, the contractor may update the welding procedure and welder qualifications by successful completion of only those additional tests needed to comply with the Acceptance Requirements of this specification. If radiographic, liquid penetrant, or magnetic particle examination are the only additional tests needed for compliance with this specification, they may be made on the next production welds.

1.3.9.3 Bend tests, successfully completed to the Acceptance Requirements of this specification but using a smaller radius than specified by this specification for the material in question, are considered to meet the requirements of this specification.

1.4 Test Positions

1.4.1 The welding of piping and tubing systems often involves welding in several different positions. The proper conditions for welding in each position must be established as a part of the procedure qualification. To facilitate testing, standard positions have been defined for both groove and fillet welds.

1.4.2 For groove welds in pipe, the four standard positions are the 1G, 2G, 5G, and 6G positions, as shown in Fig. 1.4.2. Qualification in one groove weld position qualifies for welding in other positions as follows:

(1) Qualification in the 1G position qualifies only for that position.

(2) Qualification in the 2G position qualifies for welding in the 1G and 2G positions only.

(3) Qualification in the 5G position qualifies for welding in the 1G and 5G positions only.

(4) Qualification in both the 2G and 5G positions qualifies for welding in any position.

(5) Qualification in the 6G position qualifies for welding in any position because it includes elements of all positions.

(6) Qualification in a position other than the four standard positions described above is valid only for that position (plus or minus 15 degrees).

1.4.3 For fillet welds in pipe, the four standard positions are the 1F, 2F, 4F, and 5F positions as shown in Fig. 1.4.3 Qualification in any of the fixed G positions, using sample groove welds in pipe, qualifies

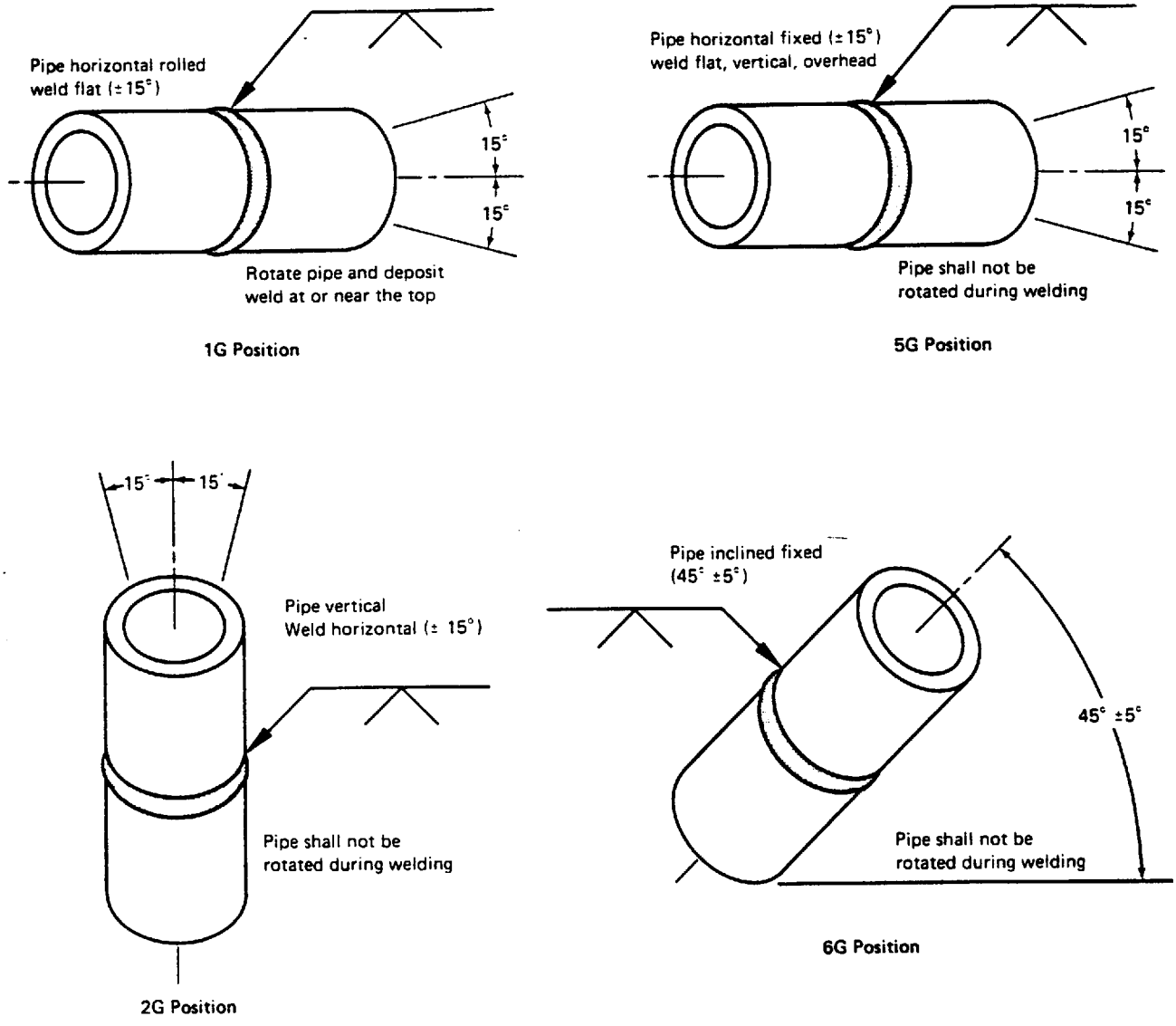


Fig. 1.4.2–Test positions for groove welds in pipe

for the welding of any fillet weld in pipe. If only fillet welds are required in production, qualification testing for fillet welds only may be conducted in accordance with Section 5. Qualification in one fillet weld position qualifies for welding in other positions as follows:

(1) Qualification in the 1F position qualifies only for this fillet weld position.

(2) Qualification in the 2F position qualifies for fillet welding in the 1F and 2F positions.

(3) Qualification in the 4F position qualifies for fillet welding in the 1F, 2F, and 4F positions only.

(4) Qualification in the 5F position qualifies for fillet welding in any position because it includes elements of all of those positions.

(5) Qualification in a position other than the four standard positions described above is valid only for that position (plus or minus 15 degrees).

1.4.4 When production welding is to be performed in close quarters, the welding procedure and the welders should be qualified under similarly restrictive conditions.

1.5 Definitions. The nomenclature herein conforms to AWS A3.0, Terms and Definitions for Welding. Other terms not included in that document but commonly used in welding pipe and tube are defined in Appendix B. For the purpose of this document, the term 'contractor' refers to any organization undertaking to qualify welding procedures and welders in accordance with this specification.

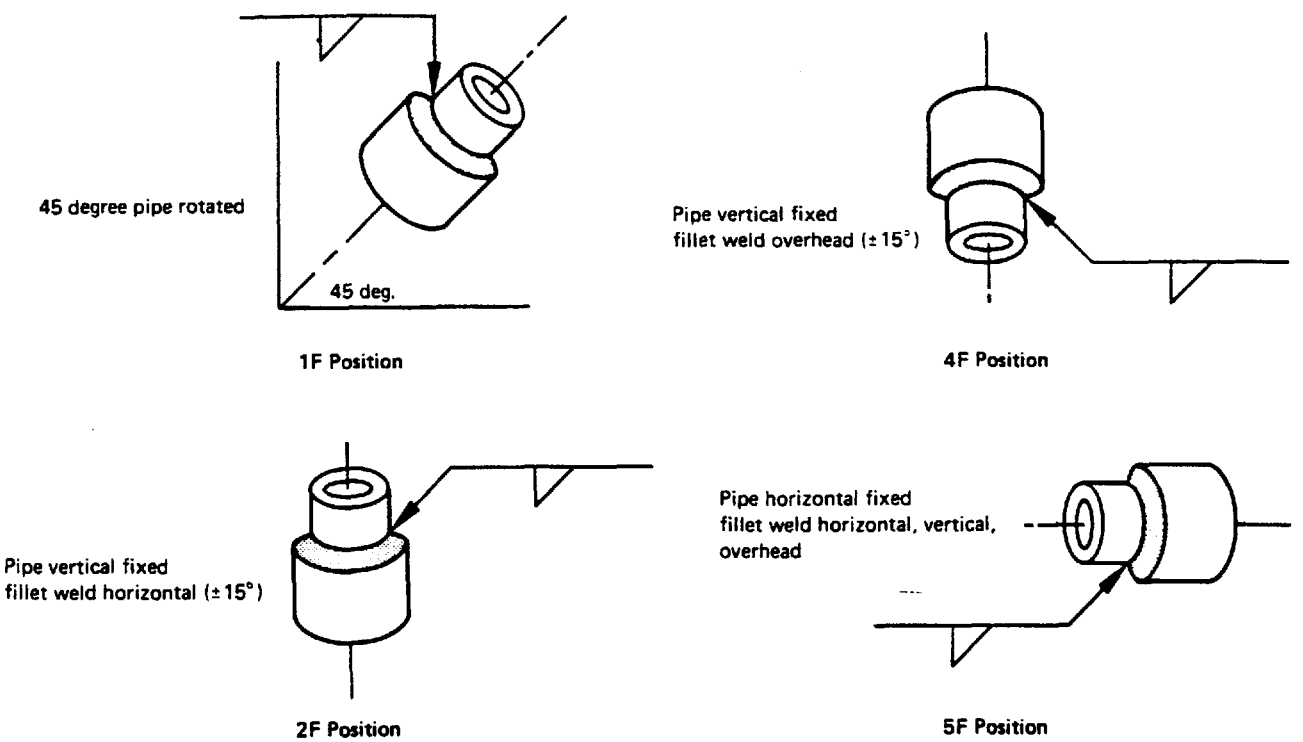


Fig. 1.4.3—Test positions for fillet welds in pipe

1.6 Pipe Sizes. For the convenience of the users of this specification, a table of data on commercially available pipe sizes, wall thicknesses, and schedules is included as Appendix E.

1.7 Safety and Health. The contractor shall ensure the safety and health of the welders and protect the workplace from fire and explosion by complying with the safety procedures recommended in ANSI Z49.1, Safety in Welding and Cutting, and in ANSI Z49.2/NFPA 51B, Safe Usage of the Cutting and Welding Processes.

2. AR-1 Level of Welding Procedure Qualification

2.1 General Notes on Welding Procedure Qualification for Groove Welds

Refer to Table 1 for sample welds and tests required for AR-1 welding procedure qualification. Prepare only those welds required to qualify the pipe or tube diameter-wall thickness ranges and positions of welding that will be involved in production welding.

If it becomes apparent that the welding conditions set forth in the tentative welding procedure will not produce a joint that meets the requirements, the test should be discontinued. One such indication is the need for an excessive number of repairs to produce an acceptable weld. In such a case, new conditions must be established and their validity proven by a new test weld.

Specimen preparation, testing techniques, and acceptance requirements for the tests prescribed in Table 1 are presented in the paragraphs following the table. The length of the sample welds should be sufficient to assure enough material to grip in the tensile test machine.

Paragraph 2.3 should be referred to prior to starting the procedure qualification testing to determine all of the variables that need to be controlled and documented. Also refer to the limits on changes allowable in welding variables controlling the qualification of an AR-1 welding procedure in paragraph 2.3 to determine when modification of an existing welding procedure requires the performance of new qualification tests.

2.2 Tests Required for Sample Groove Welds. Details regarding specimen preparation, testing techniques, and acceptance requirements for qualification of a welding procedure to the AR-1 level follow:

2.2.1 Visual Inspection. Each sample weld shall be inspected visually with the unaided eye:

(1) *Prior to assembly* of the test pieces, to assure that the proper materials are being used, that parts have been cleaned, and that the end preparation is correct.

(2) *After fit-up,* to check the joint clearances.

(3) *During welding,* to inspect for cracks, porosity, undercut, incomplete fusion, surface roughness, and poor crater conditions. Each weld bead should be inspected as deposited and after any normal mechanical cleaning prior to depositing subsequent passes. Brushing, filing, or grinding may be used when necessary on starts and stops,

Table 1
Sample welds and tests required for AR-1 level of welding procedure qualification

Sample welds					Tests required on sample welds[a]						
Pipe size of sample welds[b]	Pipe or tube[c] wall thicknesses qualified min, in.	max, in.	Number of sample welds per position	Pipe or tube size qualified, NPS, in.[a]	Visual inspection[d]	Penetrant inspection optional[e]	Radiography[f] optional	Tensile test[g], no. of specimens	Bend test[h], number of specimens Face	Root	Side
				Wall thicknesses 0.750 in. and under							
1/2 in. Sch. 40	0.065	0.400	1	Through 1-1/2	Yes	Yes	Yes	1	0	0	0
2 in. Sch. 80 or 3 in. Sch. 40	0.065	0.674	1	1 through 4	Yes	Yes	Yes	1	1	1	0
6 in. Sch. 40	0.109	0.750	1	Over 4	Yes	Yes	Yes	2	2	2	0
				Wall thicknesses over 0.750 in.							
6 in., 8 in. or 10 in. Sch. 120	0.375	Any	1	6 and over	Yes	Yes	Yes	2	0	0	4

a. See Appendix C for optional impact tests for low temperature service applications and microstructural examinations.
b. See Appendix C for option of job size pipe.
c. For pipe and tube having a wall thickness less than 0.065 in., individual qualification is required for each thickness by visual, penetrant, x-ray, and tensile testing.
d. See 2.2.1.
e. See 2.2.2. Required only if production welds are to be liquid penetrant or magnetic particle inspected.
f. See 2.2.3.
g. See 2.2.4 and 2.2.5.
h. See 2.2.4 and 2.2.6. Side bends shall be used instead of face and root bends for sample weld wall thicknesses of more than 0.375 in.

SI Equivalents

in.	mm
0.065	1.65
0.109	2.77
0.375	9.52

in.	mm
0.400	10.16
0.674	17.12
0.750	19.05

in.	mm
1/2	13
1-1/2	38
2	51
3	76

in.	mm
4	102
6	152
8	203
10	252

STD·AWS D10·9-ENGL 1980 ■ 0784265 0510735 281 ■

and to remove local defects appearing on the outer surface of the weld reinforcement. If production welding is to be accomplished from the outside of the pipe only, no repair of the root of the sample weld from the inside of the pipe is permitted.

(4) *After welding has been completed* (including any postheating), to detect any surface defects.

The following is required for a sample weld to pass Acceptance Requirements for visual inspection:

(a) The specified base metal and filler metal shall have been used.

(b) The weld shall be free of cracks.

(c) All craters shall be filled to the full cross section of the weld and shall be free of cracks upon completion of the welding.

(d) The face of the weld shall be at least flush with the outside surface of the pipe, and the weld shall merge smoothly with the base metal. Depth of weld undercut shall not exceed 1/32 in. (0.8 mm), irrespective of length. Weld reinforcement shall not exceed the following:

Sample weld pipe size, in.	mm	Face reinforcement, in.	mm
1/2	13	3/32	2.4
2 or 3	51-76	1/8	3.2
4 and over	102	3/16	4.8

(e) The root of the weld shall be examined, and there shall be complete joint penetration and no cracks, nor incomplete fusion. A concave root surface is permitted within the limits shown in (f) below, provided the total weld thickness is equal to or greater than that of the base metal.

(f) A concave root surface and root reinforcement are permitted within the limits shown below:

Limits of surface imperfections on the inside surface of the joint

Sample weld pipe size, in.	mm	Maximum root surface concavity, in.	mm	Maximum root reinforcement, in.	mm
1/2	13	1/32	0.08	1/16	1.6
2 or 3	51-76	1/16	1.6	1/16	1.6
4 and over ≤ 0.75 in. wall	102	1/16	1.6	3/32	2.4
6 and over > 0.75 in. wall	152	1/16	1.6	1/8	3.2

2.2.2 Liquid Penetrant or Magnetic Particle Inspection. This test is required only for those welds that are to be subjected to this type of examination in production. Each sample weld shall be examined by liquid penetrant in accordance with Procedure A-2 or B-3 of ASTM E165. The weld shall be examined as required by the welding procedure, such as after the completion of the root pass or the entire weld, including any postheating. Dry powder magnetic particle examination in accordance with ASTM E109 may be used for magnetic materials in lieu of the liquid penetrant examination.

Acceptance requirements are as follows: Cracks are not acceptable; random porosity and slag not exceeding 1/32 in. (0.8 mm) in size are acceptable. No more than four indications 1/64 in. (0.4 mm) in size, or larger, in a line are acceptable when they are less than 1/16 in. (1.6 mm) apart.

2.2.3 Radiographic Examination. The weld reinforcement on the outside surface of each sample weld shall be mechanically removed to the extent that surface ripples cannot mask or be confused with the image of any internal defects in the radiographs. The weld reinforcement may be removed flush with the surface of the pipe, but if it is only partially removed, its height shall not exceed 3/32 in. (2.4 mm). No removal of metal on the inside surface of the pipe is permitted, except for sample welds representing large diameter pipe where the inside surface of production welds will also be ground or back-welded.

2.2.3.1 General radiographic techniques are as follows:

(1) All completed sample welds shall be radiographed for their full circumference.

(2) In order to obtain the required sensitivity, it is usually necessary to use an x-ray machine as the source of radiation for sample welds in pipe 3-1/2 in. (89 mm) and under. Either an x-ray machine or a radioactive source may be used for sample welds in pipe 4 in. (102 mm) and over, except for aluminum pipe, where only an x-ray machine should be used for all thicknesses.

(3) A penetrameter shall be used to verify the adequacy of radiographic technique. The penetrameter shall conform to the requirements of ASTM E142, level 2-2T, or any other equivalent penetrameter giving 2 percent sensitivity.

(4) The material of the penetrameter shall be radiographically similar to the filler metal. The penetrameter is normally placed over the base metal near the weld, but if the filler metal is not radiographically similar to the base metal, then the penetrameter may be placed over the weld metal.

(5) The weld shall be radiographed with a technique having sufficient sensitivity to reveal internal defects and indicate the features of the penetrameter.

(6) Each penetrameter shall represent an area of essentially uniform radiographic density as judged by density comparison strips or a densitometer. An additional penetrameter shall be required if the film density varies more than −15 or +30 percent from the density through the penetrameter. The film density through acceptable weld metal shall be 2.0 minimum for single film viewing.

(7) The images of the identifying numbers, the penetrameter outline, and the 2T hole are all essential indexes of image quality, and they shall appear clearly on the radiograph. The difference in density between the images of the holes and the penetrameter shall be the