

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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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 discussed 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 welders¹ 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.

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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

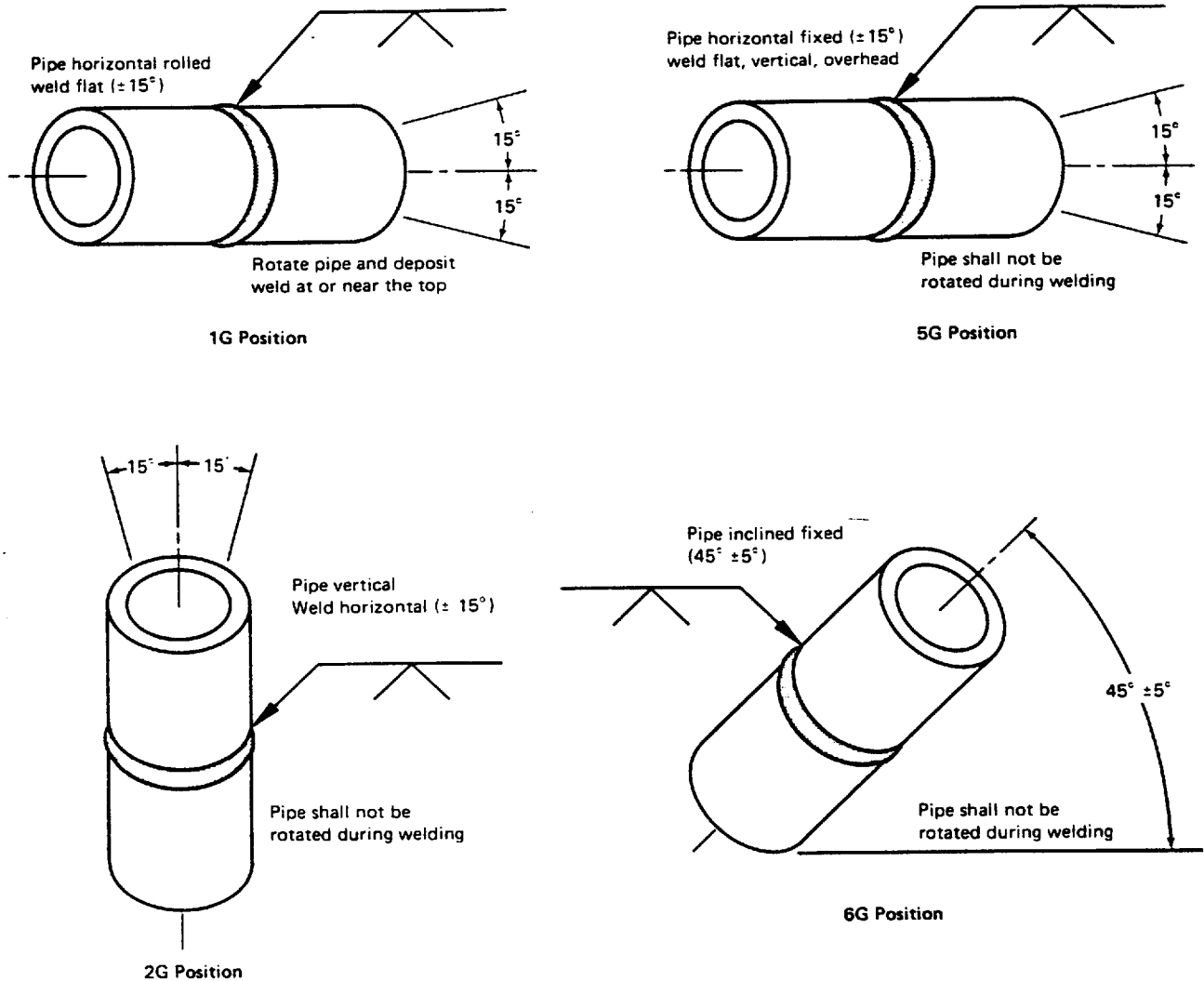


Fig. 1.4.2—Test positions for groove welds in pipe

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.

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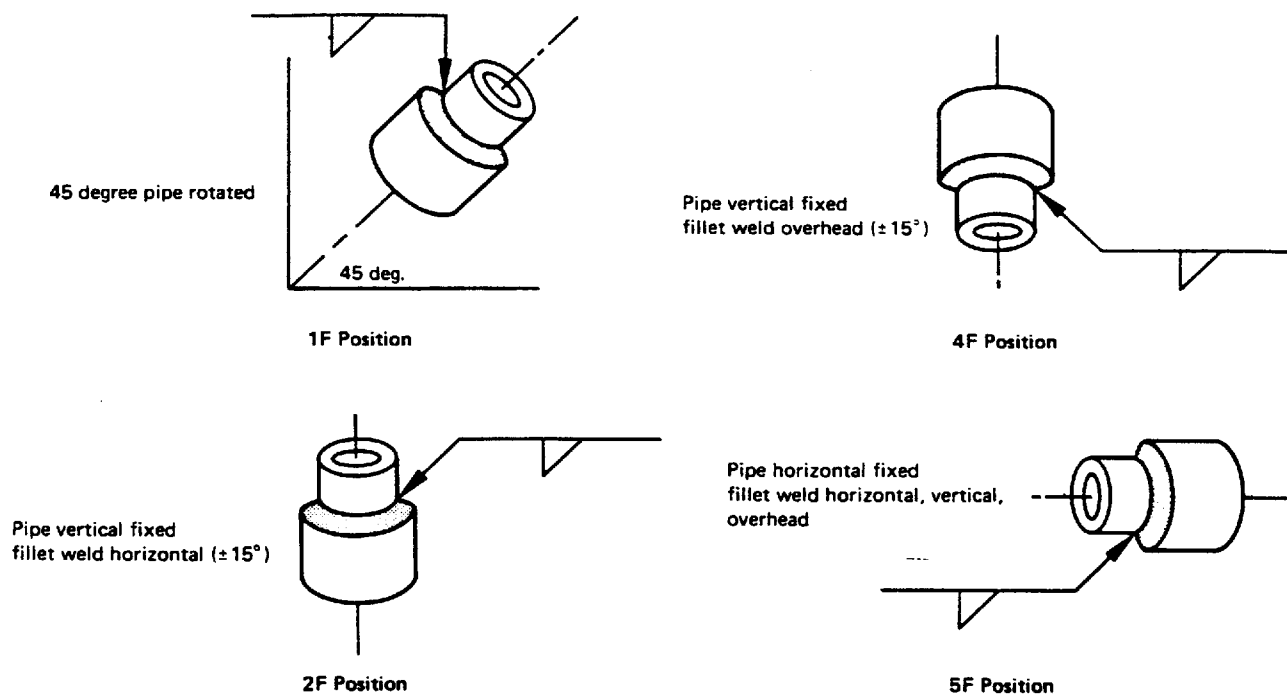


Fig. 1.4.3—Test positions for fillet welds in pipe

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		in.		mm		in.		mm	
0.065	1.65	0.400	10.16	1/2	13	4	102	4	102	6	152
0.109	2.77	0.674	17.12	1-1/2	38	8	203	8	203	10	252
0.375	9.52	0.750	19.05	3	76						

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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,		Face reinforcement,	
in.	mm	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,		Maximum root surface concavity,		Maximum root reinforcement,	
in.	mm	in.	mm	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	102	1/16	1.6	3/32	2.4
< 0.75 in. wall					
6 and over	152	1/16	1.6	1/8	3.2
> 0.75 in. wall					

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

(4) The material of the penetrometer shall be radiographically similar to the filler metal. The penetrometer 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 penetrometer 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 penetrometer.

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

(7) The images of the identifying numbers, the penetrometer 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 penetrometer shall be the

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same as that between the edge of the penetrameter and the adjacent film area.

(8) If the reinforcement of the backing is not removed, a shim of a material radiographically similar to the filler metal shall be placed under the penetrameter. The thickness of the shim shall be the same as the reinforcement and any backing not removed.

(9) Identification markers, the images of which shall appear on the film, shall be placed on the base metal adjacent to the weld, not on the film, and their locations shall be marked on the surface near the weld in such a manner that a defect appearing on a radiograph may be accurately located. The markers shall be located in a manner that will indicate on the film that complete radiographic coverage of the weld has been obtained.

(10) The following shall appear on each radiograph or in the records accompanying each radiograph: identity of the organization making the sample weld, the date, test weld number, welder's stamp number, welding procedure specification number, and material designation.

(11) All radiographs shall be free from excessive mechanical, chemical, or other processing defects that could interfere with proper interpretation of the radiograph.

2.2.3.2 Specific radiographic techniques for sample welds are as follows:

(1) *Small (1/2 to 3-1/2 in. [13 to 89 mm]) diameter sample welds.* A technique shall be used in which the radiation passes through two walls of the pipe at such an angle that the weld in each wall is viewed for acceptance on the same film. Three views are required approximately 120 degrees apart.

The penetrameter shall be on the source side of the outside surface of the pipe with the long dimension parallel to the axis of the pipe, and it shall be positioned so that it does not interfere with the film interpretation of any portion of the weld. The penetrameter thickness shall be based on twice the pipe wall thickness.

(2) *4, 5, and 6 in. (102, 127, and 152 mm) sample welds.* A technique shall be used in which the radiation passes through two walls of the pipe at an angle, but only the portion of the weld closest to the film shall be viewed for acceptance. Four views are required.

The penetrameter shall be on the source side of the outside surface of the pipe with the long dimension parallel to the axis of the pipe, and it shall be positioned so that it does not interfere with the film interpretation of any portion of the weld. The penetrameter thickness shall be based on twice the pipe wall thickness.

(3) *8 in. (203 mm) and larger sample welds.* The weld shall be radiographed using a technique in which the source is either inside or outside the pipe, and the radiation passes through only one wall to reach the film.

When the source is outside the pipe, six views are required. The penetrameter shall be placed on the source side in all cases and shall be normal to the radiation. The long dimension of the penetrameter shall be parallel to the long axis of the weld. The penetrameter thickness shall be based on one pipe wall thickness.

2.2.3.3 Sample welds having any of the following defects shall be judged unacceptable:

- (1) Any type of crack
- (2) Incomplete fusion between the weld metal and base metal
- (3) Incomplete fusion between any of the weld passes
- (4) Lack of complete joint penetration
- (5) Slag inclusions greater than those listed in the table below

Limits of permissible slag inclusions

Sample weld pipe size, in.	mm	Length of slag inclusion in the full circumference of the weld, max,	
		in.	mm
1/2	12.7	1/8 Single	3.2
2 or 3	51-76	3/16 Single	4.8
		1/2 Total	13.0
6-8	152-203	1/4 Single	6.4
		1/2 Total	13.0
10 and over	254	1/4 Single	6.4
		3/4 Total	19.0

(6) Porosity and tungsten inclusions in excess of the amounts shown in Fig. 2.2.3.3(6)

2.2.4 Preparation of Sample Welds for Destructive Tests

2.2.4.1 1/2 in. (13 mm) Sample Welds. Prepare the sample weld for the full size tensile test by removing the weld reinforcement until it is flush with the base metal.

2.2.4.2 2 or 3 in. (51 or 76 mm) Sample Welds. Remove and prepare from the sample weld one tensile, one face-bend, and one root-bend specimen as shown.

2.2.4.3 6, 8, and 10 in. (152, 203, and 254 mm) Sample Welds. Remove and prepare from the sample weld two tensile, two face-bend, and two root-bend specimens as shown. Four side-bend specimens may be substituted for the face-bend and root-bend specimens for wall thicknesses of 3/8 in. (9.5 mm).

2.2.5 Tensile Tests. The tensile specimen shall be ruptured under tensile load. The tensile strength shall be computed by dividing the maximum load by the least cross-sectional area of the specimen as measured before the load is applied. The 1/2, 3/4, 1, and 1-1/2 in. (13, 19, 25, and 38 mm) full pipe size sample welds shall be tested using the fixture shown in Fig. 2.25 after the outside diameter and the wall thickness have been measured.

In order to pass the tensile test, the specimen shall have a tensile strength not less than the minimum tensile strength value given in column 2 of Table 2 for the material involved. The tensile strength values specified are for welded assemblies. For welds of dissimilar metals, the specimen shall have a tensile strength not less than the value given for the weaker of the two materials.

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Permissible porosity indications for various weld thickness are illustrated in the following charts. The test radiographs shall be compared with these charts visually to form a basis for acceptance or rejection. In cases of dispute, the detailed requirements in the following paragraphs will govern:

- (1) Dark images of a generally circular or oval shape shall be interpreted as porosity. Light images of a generally circular nature shall be interpreted as tungsten inclusions in gas tungsten arc welds. For simplicity, porosity and tungsten inclusions are called "pores" in the charts, and the combined indications shall not exceed the number and size shown in the charts.
- (2) The maximum pore dimensions shall be 20 percent of t , where t is the wall thickness of the sample weld, or 1/8 in. (3.2 mm), whichever is smaller.
- (3) The following porosity charts illustrate various types of assorted and uniform, randomly dispersed porosity indications. These charts for each thickness represent the maximum acceptable porosity. The charts represent full-scale six inch (152 mm) radiographs and shall not be enlarged or reduced. The porosity distributions shown are not necessarily the patterns that may appear on the radiographs but are typical of the number and size of indications permitted.
- (4) Aligned porosity shall be acceptable, providing the summation of the diameters of the pores is no more than T in a length $12T$, or 1/2 in. (12.7 mm) in 6 in. (152 mm), whichever is less, providing each pore is separated by a distance of at least six times the diameter of the largest adjacent pore.
- (5) Permissible porosity indications for weld thicknesses intermediate to those illustrated may be evaluated by comparison with the next thinner material.

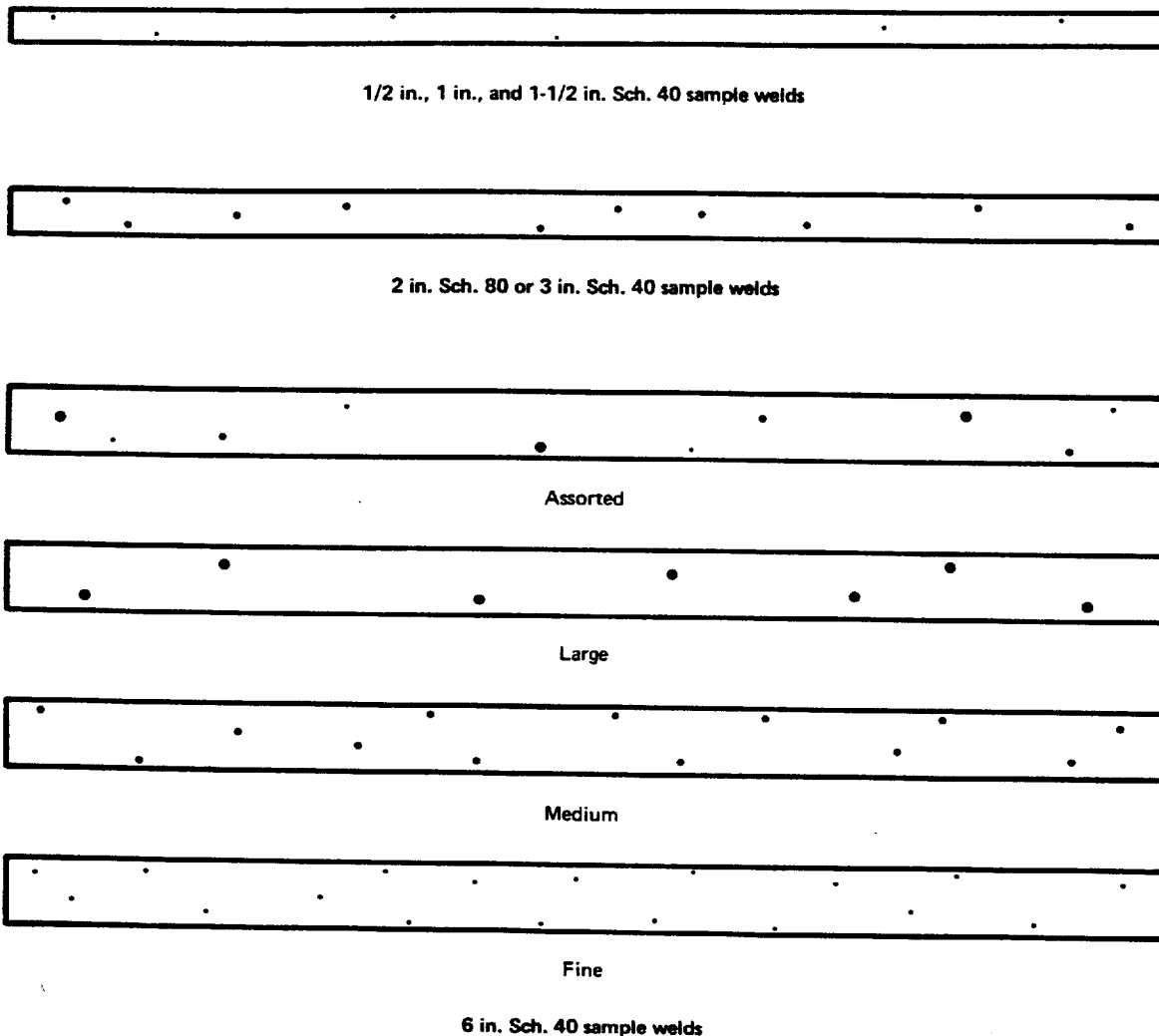
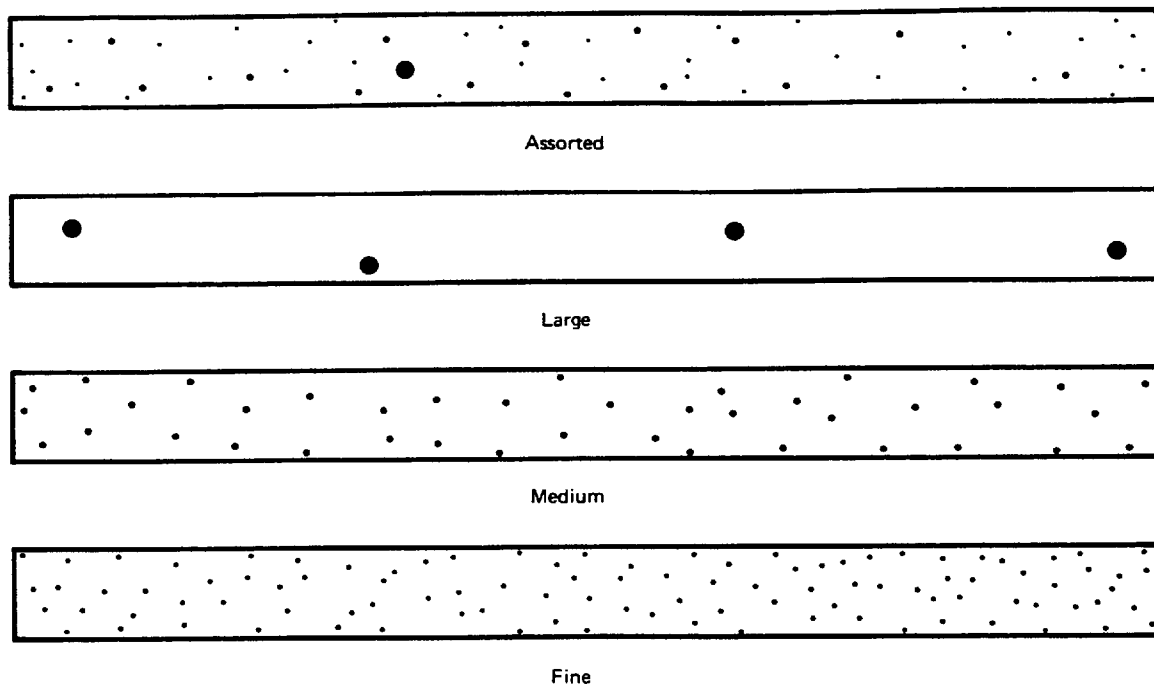


Fig. 2.2.3.3 (6)—Porosity charts for radiographically-determined porosity and tungsten inclusions in welds

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8 in. Sch. 80 and 10 in. Sch. 40 sample welds

Fig. 2.2.3.3 (6) (continued)—Porosity charts for radiographically-determined porosity and tungsten inclusions in welds

2.2.6 Guided-Bend Test

(1) Bend specimens shall be tested in a guided-bend jig or the wraparound jig of the general type shown in Fig. 2.2.6.

(2) The B and D dimensions of the guided-bend jig and the B dimension of the wraparound jig shall be as follows, depending upon the material and thickness:

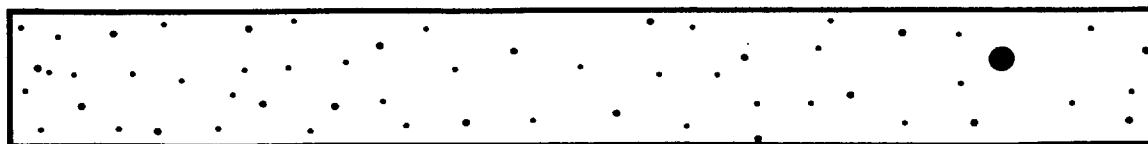
Sample thicknesses and jig dimensions^{a,b}

(See Table 2)	Sample thickness,		Specimen thickness,		Radius of bend, B,		Radius of die, D,	
	in.	mm	in.	mm	in.	mm	in.	mm
All except P23	t		t		3-1/3t		4-1/3t - 1/16	1.6
	0.375	9.5	0.375	9.5	1-1/4	32.0	1-11/16	43.0
P23 (and F23)	t < 0.125	3.2	t		8-1/4t		9-1/4t + 1/16	1.6
	t > 0.125	3.2	0.125	3.2	1-1/32	26.0	1-7/32	31.0

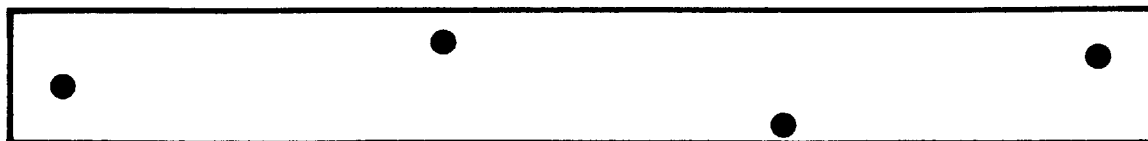
a. t = the wall thickness of the sample weld.

b. For sample welds in P23 materials whose thickness exceeds 0.125 in. (3.2 mm), remove and bend specimens of 0.125 in. (3.2 mm) thickness as required to cover the wall thickness under test.

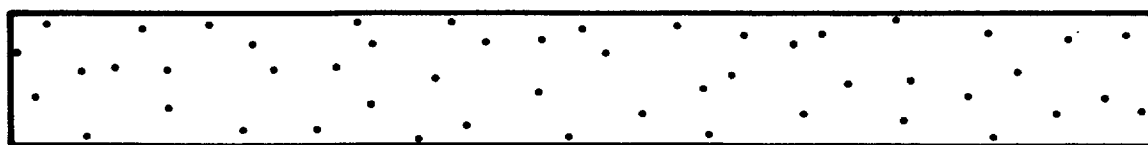
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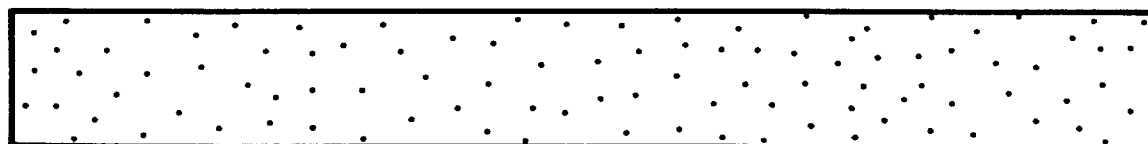
Assorted



Large



Medium



Fine

SI Equivalents

in.	mm
1/2	13
1	25
1-1/2	38
2	51
3	76
6	152
8	203
10	254

8 in. and 10 in. Sch. 120 sample welds

Fig. 2.2.3.3 (6) (continued)—Porosity charts for radiographically-determined porosity and tungsten inclusions in welds

(3) When using the guided-bend jig, the specimen shall be placed on the die with the weld at midspan. Face-bend specimens shall be placed with the face of the weld directed toward the gap; root-bend specimens shall be placed with the root of the weld directed toward the gap, and side-bend specimens with the surface having the greater defects, if any, toward the gap.

(4) The plunger shall force the specimen into the die until the specimen becomes U-shaped and a 1/8 in. (3.2 mm) diameter wire cannot be inserted between the

die and the specimen. The weld and heat-affected zones shall be centered and completely within the bent portion of the specimen after testing.

(5) When using the wraparound jig, the specimen shall be firmly clamped on one end so that there is no sliding of the specimen during the bending operation. The weld and heat-affected zones shall be completely in the bent portion of the specimen after testing. Test specimens shall be removed from the jig when the outer roll has been moved 180 degrees from the starting point.

In order to pass the acceptance requirements for the test, the bent specimens shall have no cracks or other open defects exceeding 1/8 in. (3.2 mm) measured in any direction on the convex surface of the specimen, except that cracks occurring at the corners shall not be considered unless there is definite evidence that they result from slag inclusions or other internal defects.

Note: Details for optional bend tests are described in Appendix C.

2.3 Limitations on Changes Allowable in Welding Variables Controlling the Qualification of a Welding Procedure to the AR-1 Level

Information concerning all of the following applicable welding variables shall be recorded when a welding procedure is first qualified. Changes, other than those given below, may be made without the necessity for qualifying a new welding procedure, provided the existing welding procedure specification is revised to show these changes. The welding procedure shall be requalified and set up as a new procedure when any of the changes listed below are made in the welding variables.

2.3.1 Base Metal. The grouping of materials by P-number classification is based on chemical and metallurgical characteristics. The grouping of filler metals by F-number classification is based on usability characteristics. These groupings are intended to reduce the number

of welding procedure qualifications required.

(1) A change from a base metal listed under one P-number in Table 2 to material listed under another P-number, or to any other base metal, shall require requalification.

(2) A change from a base metal listed under Group 9A to one listed under Group 9B in P-number 9 shall require requalification (see footnotes in Table 2).

(3) A change from a base metal listed under one letter subgroup to one listed under another subgroup in P-number 10 shall require requalification.

(4) A change from a similar metal joint to a dissimilar metal joint (two different P-numbers), even though welding procedures have been developed for each of the metals welded to itself, shall require requalification.

2.3.2 Pipe Size and Wall Thickness. A change from one diameter wall grouping to another, as shown in Table 1, shall require requalification.

2.3.3 Joint Design. A change from a single-V-groove or a single-U-groove to a single-bevel-groove, single-J-groove, or square-groove; or from a single-bevel-groove or a single-J-groove to a square-groove shall require requalification.

An increase or decrease of 1/16 in. (1.6 mm) or more in root opening and root-face dimensions beyond those specified in the welding procedure shall require requalification.

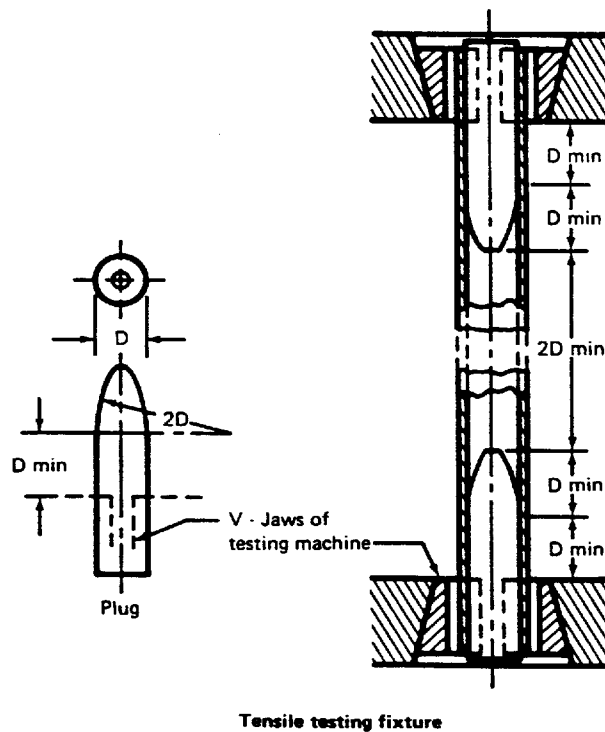
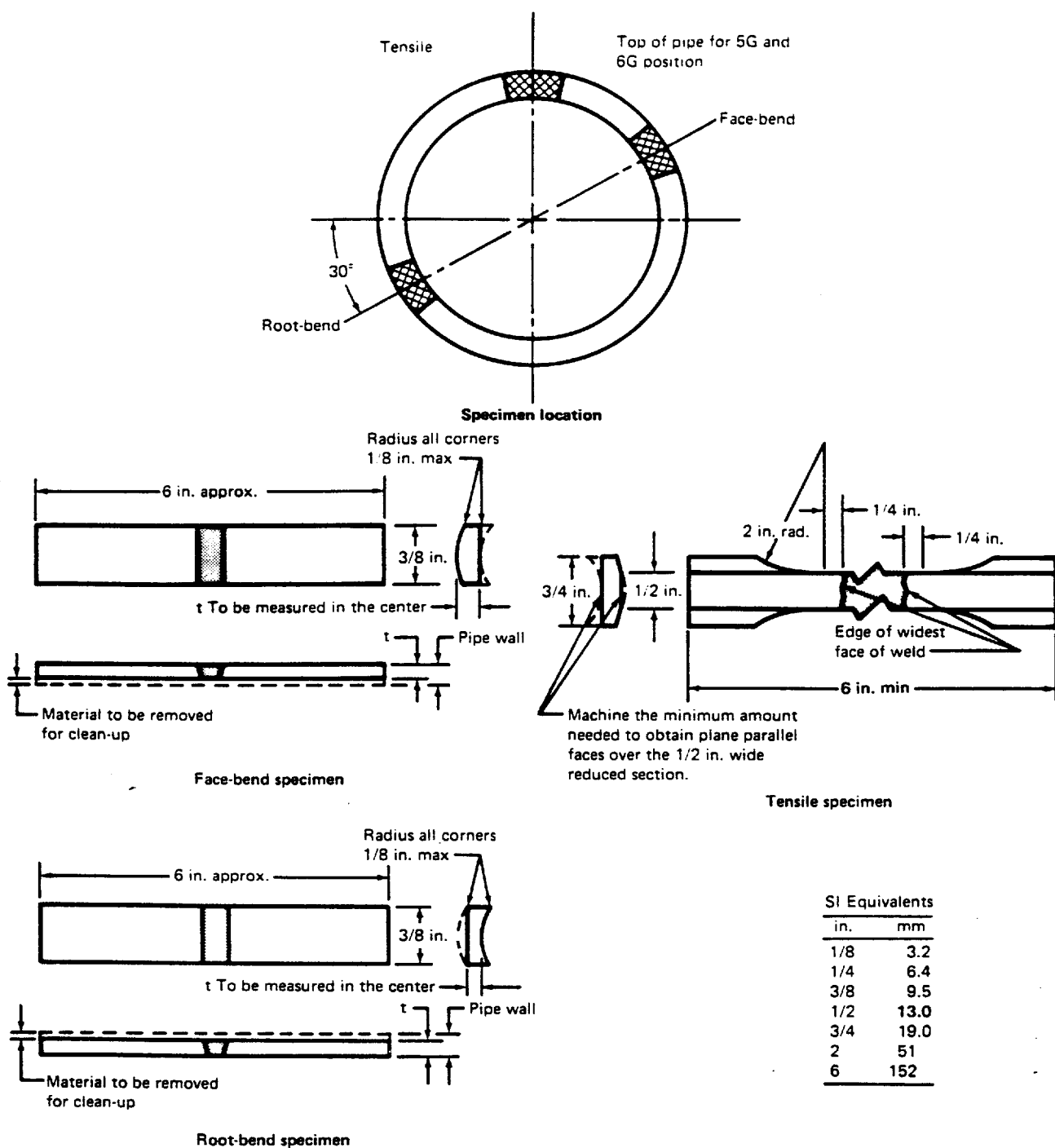


Fig. 2.2.5—Details of destructive tests

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Notes:

1. All dimensions in inches.
2. Weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. Cut surfaces shall be smooth and parallel.

Fig. 2.2.5 (continued)—Details of destructive tests

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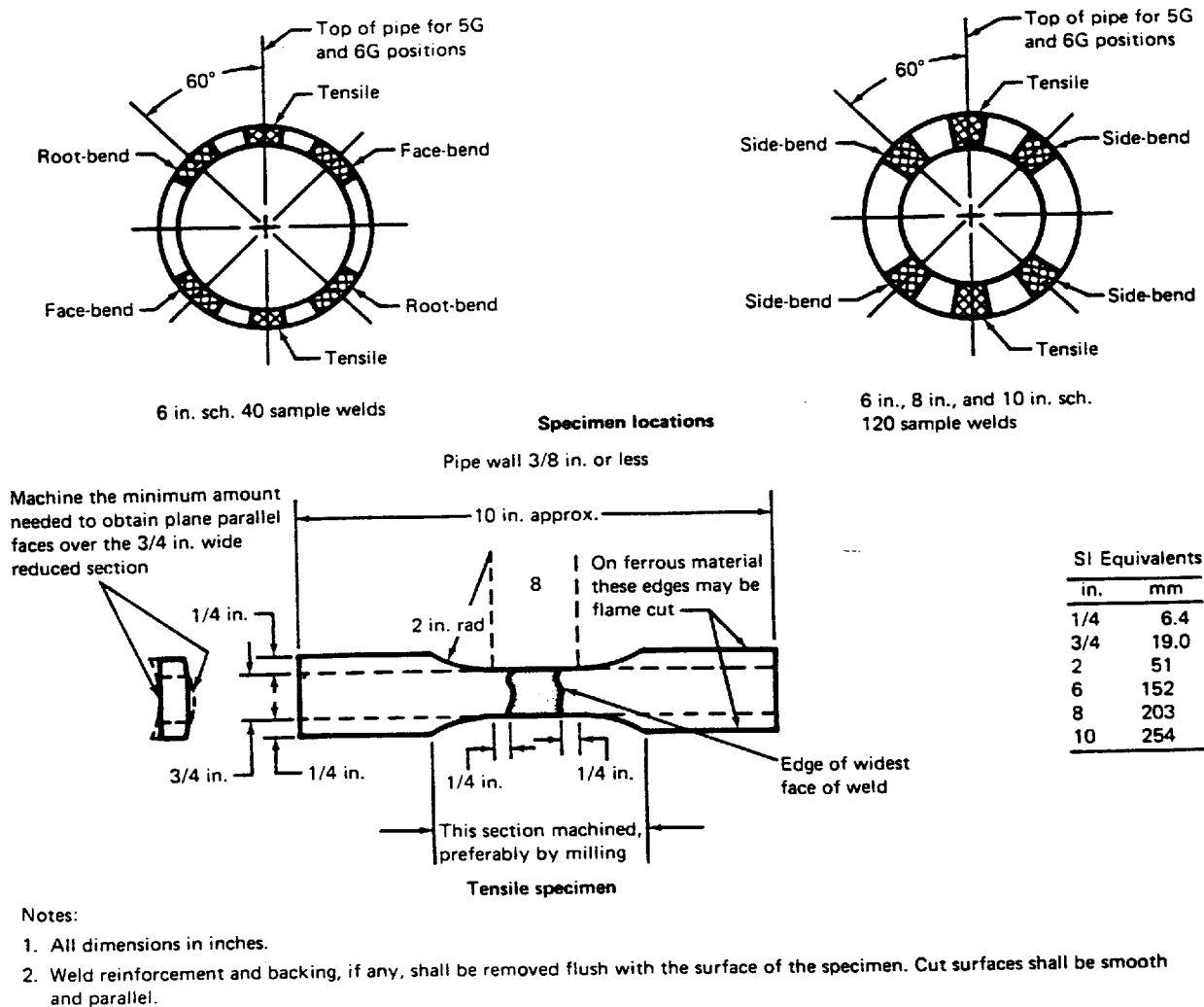


Fig. 2.2.5 (continued)—Details of destructive tests

2.3.4 Backing (for complete joint penetration groove welds only).

- (1) The omission of a backing ring for welds made from one side only shall require requalification.
- (2) For copper alloys, the addition of a backing ring shall require requalification.
- (3) The addition or omission of a preplaced consumable insert shall require requalification.
- (4) The omission of a removable material as a backing device shall require requalification.
- (5) The addition or omission of a gas or flux as a means of backing shall require requalification.
- (6) The omission of a backing weld shall require requalification.

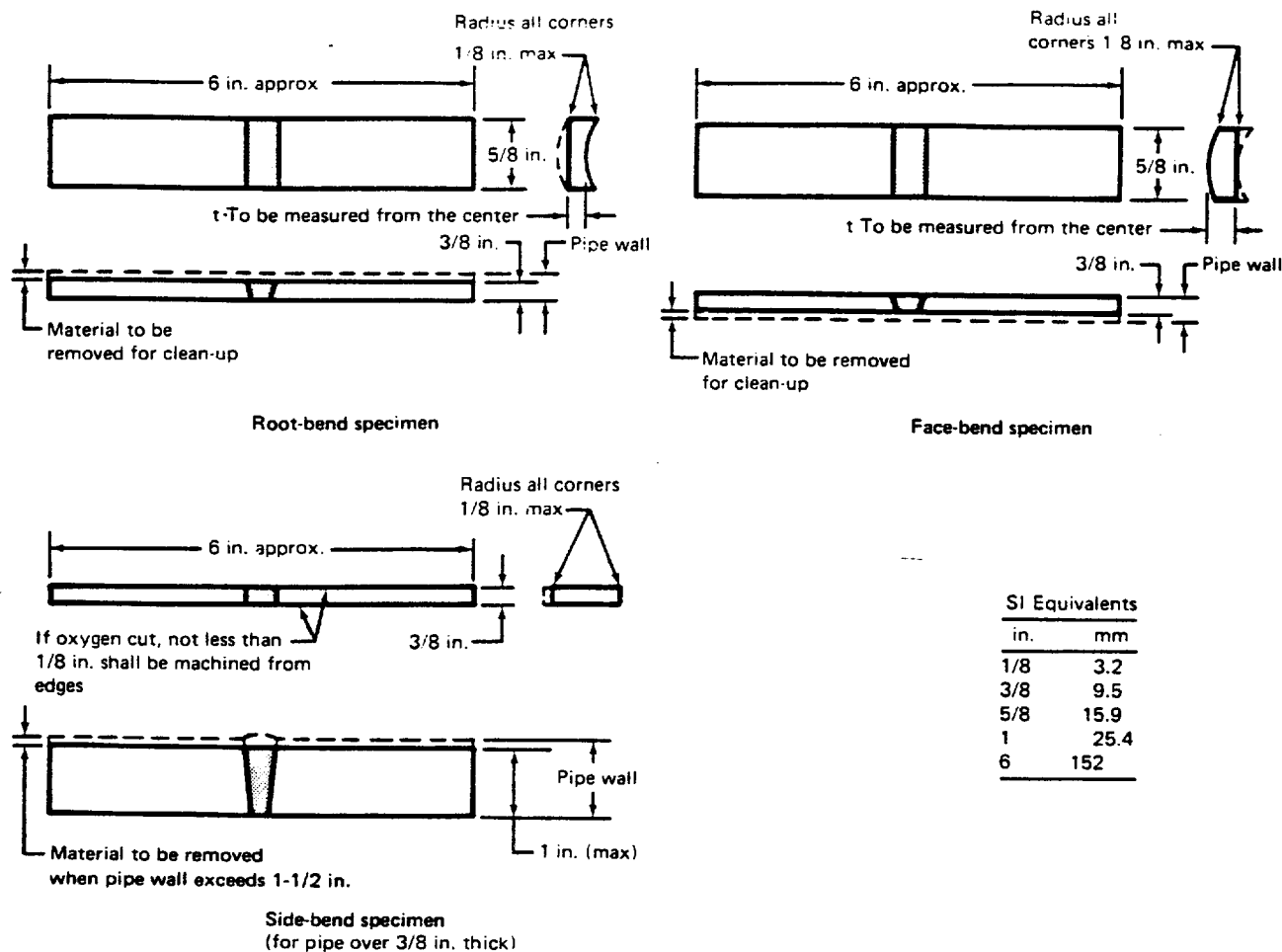
2.3.5 Filler Metal

2.3.5.1 Composition. For ferrous materials, a change in the chemical composition of the weld deposit from one A-number to any other A-number shown in Table 3 requires requalification.

Filler metal or deposited weld metal compositions other than those listed in Tables 3, 4, and 5 shall require separate qualification.

2.3.5.2 Usability. For both ferrous and nonferrous filler metals, a change from one F-number to another F-number in Tables 4 and 5 requires requalification.

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Notes:

1. All dimensions in inches.
2. Weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. Cut surfaces shall be smooth and parallel.

Fig. 2.2.5 (continued) - Details of destructive tests

2.3.6 Welding Process. A change from one welding process to another, for making either the entire weld or part thereof, shall require requalification. Within a given process, a change from fully automatic to semiautomatic or manual or a change from semiautomatic to manual (or vice versa) shall require requalification. Additional requirements or exceptions for various welding processes are listed below.

2.3.6.1 Oxyacetylene or Oxyhydrogen Process

(1) The maximum thickness qualified using the oxyacetylene or oxyhydrogen welding process for pipe 4 in. (102 mm) and under is the thickness of the sample weld plus 20 percent.

(2) For pipe sizes over 4 in. (102 mm), the maximum pipe size and wall thickness qualified are the sample weld pipe size and wall thickness plus 20 percent.

(3) The addition of backing rings or backing material shall require requalification.

2.3.6.2 Gas Tungsten Arc Process

(1) The addition or omission of filler metal shall require requalification.

(2) The omission of high frequency stabilization shall require requalification.

(3) For single-pass welding, the maximum thickness welded in production shall not exceed the thickness of the test pipe.