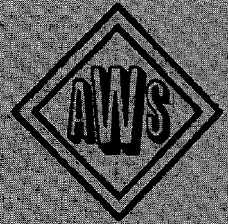


CHAPTER 8:**WELDING PROCEDURE
AND
WELDER QUALIFICATION****Introduction to Welding
Procedure Qualification**

A welding procedure details the steps by which the welding of a specific joint or weldment is to be accomplished. It gives the prescribed values or ranges of values for all the controllable variables in the process and specifies all materials to be used. A welding procedure determines the mechanical properties of a welded joint.

It must be realized from the outset that the generation of a welding procedure is the specific responsibility of the welding engineer and not the welding inspector. According to AWS QC1, the CWI "Verifies that the welding procedures are as specified and qualified and that the welding is performed in accordance with the applicable procedure." So, the information which follows is included to address the various contents of welding procedures and is not intended to imply that the CWI is responsible for the generation of that information.

Almost every welding job needs a welding procedure. Commonly, the contract or the specifications require that a written procedure be prepared. The requirements often are those of a general specification or standard, which the fabricator may be following as a quality control standard.

When the governing specifications or standards comprise a code that has been adopted by a governing agency such as a city, state, or

province, then the welding procedure becomes a legal entity under that code.

The purpose of this section is fourfold:

- To define the welding procedure specification, including its types, content, documentation, and application.
- To explain the qualification of the welding procedure specification.
- To define circumstances when certain parts of the specification may require requalification.
- To define the welding inspector's responsibilities during the qualification process and later during the fabrication inspection process.

Welding Procedure Specification

The purpose of a welding procedure specification is to define and document the details that are to be carried out in welding specific materials or parts.

Many companies prepare a quality assurance manual that establishes the responsibilities for preparation, review, and approval of the welding procedures to be used, although the procedures themselves will not ordinarily be included in the quality assurance manual.

Contents

The written welding procedure specification should be arranged in accordance with the contract or purchase requirements. The specifications

8-2

should be sufficiently detailed to ensure that the welding will meet all requirements of the applicable code, standard or specification.

The topics that follow in this section are the most common and generally the most essential in welding procedure specifications. Every item will not apply to every process or application, and some items that are familiar to you may not be listed at all. The list is given for illustration, to provide guidance to the welding inspector in reviewing welding procedure specifications or in determining whether or not production welding is being performed in accordance with welding procedure specifications. It must be emphasized that the welding inspector is not responsible for producing the welding procedure specification. The following can serve as an outline for a checklist for the welding inspector when reviewing a welding procedure specification produced by a welding engineer or other responsible individual.

Scope: Have the types of welding, the materials, and the governing specifications been clearly stated?

Base Metals and Applicable Specifications: Are suitable base metals specified? They should be identified by their chemical composition and applicable specifications. The procedure should indicate what condition the base metal should be in before welding (that is, normalized, annealed, quenched and tempered, solution treated, etc.). There may also be a requirement that the fabricator know the identity of all material. Full plates or sections can be identified by the mill numbers; small portions cut from full plates or sections should be marked with the same numbers. The rolling direction of the plate should also be identified.

Welding Process: What welding process is to be used?

SHIELDED METAL
ARC WELDING

GAS TUNGSTEN
ARC WELDING

OXYFUEL
WELDING

GAS METAL
ARC WELDING

ELECTROSLAG
WELDING

FLUX CORED
ARC WELDING

SUBMERGED
ARC WELDING

BRAZING

STUD
WELDING

Type, Classification and Composition of Filler Metals: The welding process should be clearly named, and the composition, identifying type, or classification designation of the filler metal should always be spelled out to ensure proper use. In addition, the sizes of filler metals or electrodes that can be used when welding different thicknesses of material in different positions must be designated. Some types of filler metals are even identified on each individual pass or layer.

AWS ELECTRODE CLASSIFICATION SYSTEM		
DIGIT	SIGNIFICANCE	EXAMPLE
1st two or 1st three	Min. tensile strength (stress relieved)	
2nd last	Welding position	E-60XX = 60,000 p.s.i. (min) E-110XX = 110,000 p.s.i. (min)
Last	Power supply, type of slag, type of arc, amount of penetration, presence of iron powder in coating	E-xx1x = all positions E-xx2x = horizontal and flat E-xx3x = flat
Note: Prefix "E" (to left of a 4 or 5 - digit number) signifies arc welding electrode		
LAST DIGIT INTERPRETATION AWS ELECTRODE CLASSIFICATION SYSTEM		
DESIGNATION	CURRENT	COVERING TYPE
E6010 E6011 E6012	DCEP only DCEP or AC DCEN or AC	Organic Organic Rutile
E6013 E7014	DCEN, DCEP, or AC DCEN, DCEP, or AC	Rutile Rutile, Iron-powder (approx 30%)
E7015	DCEP only	Low hydrogen
E7016 E7018	DCEP or AC DCEP or AC	Low hydrogen Low hydrogen, iron powder (approx 25%)
E6020	DCEN, DCEP or AC	High iron oxide
E7024	DCEN, DCEP OR AC	Rutile, Iron powder (approx 50%)
E6027	DCEN, DCEP or AC	Mineral, Iron powder (approx 50%)
E7028	DCEP or AC	Low hydrogen, Iron powder (approx 50%)

Identification of filler metals may be lost when original containers are discarded. Electrode marking, moreover, does not guarantee that the electrode is in satisfactory condition. For example, low hydrogen electrodes that have been exposed to the atmosphere must be baked in an oven to restore their low moisture content. Such baking requirements should be included in the welding procedure, following the manufacturer's specification.

Type of Current and Current Ranges:

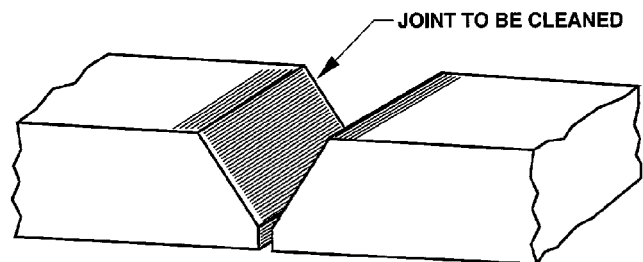
What type of current is to be used? Some electrodes work well on either ac or dc. If dc is needed, the proper polarity should be specified (DCEP or DCEN). In addition, current ranges for different electrode sizes, different procedure positions, and various thicknesses of materials should be listed.

Welder Qualification Requirements: The procedure specification may designate the requirements for welder or welding operator qualification. Applicable welder qualification specifications or paragraphs of the governing specifications may be referenced in the welding procedure specification. The latter portion of this Chapter is devoted to the topic of welder qualification.

Joint Designs and Tolerances: Permissible joint design details as well as the designated welding sequence should be identified. Use of cross-sectional sketches that show the thickness of material and details of the joint or references to

standard drawings or specifications are suitable ways of expressing this information. Tolerances for all dimensions must be listed.

Joint Preparation and Cleaning of Surfaces to be Welded: What methods may be used to prepare the joints? How are the surfaces to be cleaned? Joint preparation methods such as oxyfuel cutting, air carbon arc cutting, and plasma arc cutting (with or without after-cleaning) should be called out. Any required machining or grinding, and any special cleaning such as vapor, ultrasonic, dip, or lint-free cloth cleaning must be specified. There may also be mention of whether or not weld anti-spatter compounds may be used. Be sure that methods or practices specified for production work are specified for qualifying the welding procedure.

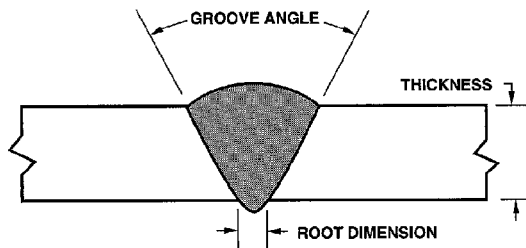


Joint Preparation and Cleaning of Surfaces for Welding.

Tack Welding: What tack welding practices are to be followed? The applicable code should be referenced to determine whether tack welders must be qualified.

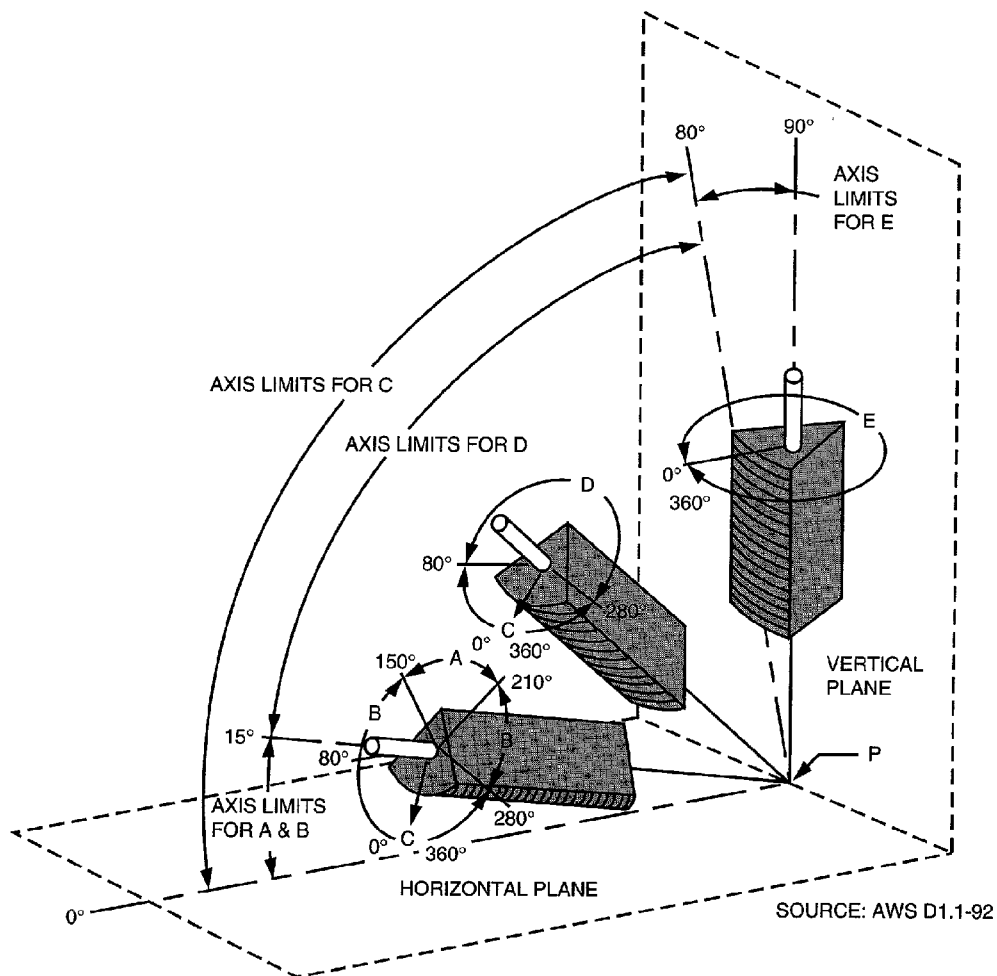
Joint Welding Details: Details of electrode sizes for the different portions of each welding position, the arrangement of weld passes for filling the joints, the thickness of each pass, pass width or electrode weave limitations, amperage ranges, and whatever other details are important for each particular joint and must be specified.

Positions of Welding: In which positions may welding be done? (See illustrations page 8-4, 8-5)



Joint Design and Tolerances

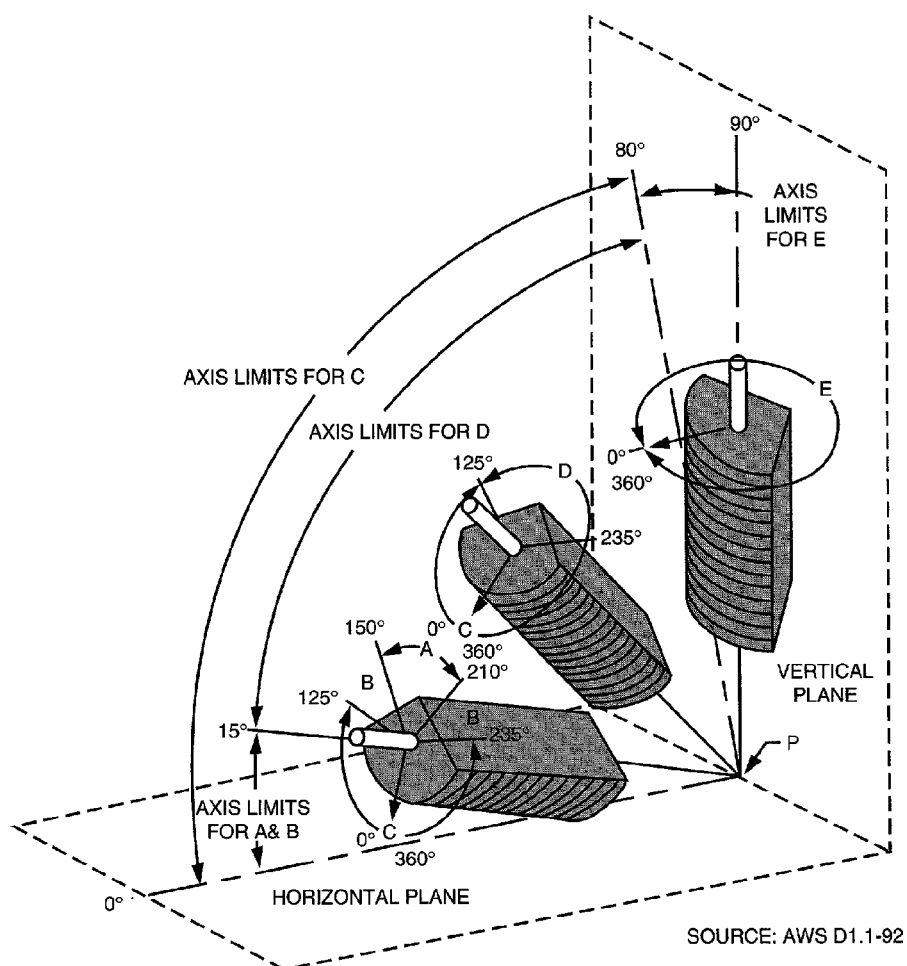
Tabulation of positions of groove welds			
Position	Diagram reference	Inclination of axis	Rotation of face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	80° to 150° 210° to 280°
Overhead	C	0° to 80°	0° to 80° 280° to 360°
Vertical	D	15° to 80°	80° to 280°
	E	80° to 90°	0° to 360°



Notes:

1. The horizontal reference plane is always taken to lie below the weld under construction.
2. The inclination of axis is measured from the horizontal reference plane toward the vertical reference plane.
3. The angle of rotation of the face is determined by a line perpendicular to the theoretical face of the weld which passes through the axis of the weld. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. When looking at point P, the angle of rotation of the face of the weld is measured in a clockwise direction from the reference position (0°).

POSITIONS OF GROOVE WELDS



SOURCE: AWS D1.1-92

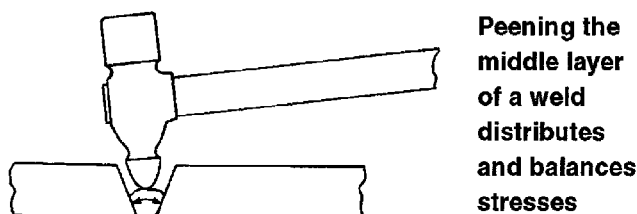
Tabulation of positions of fillet welds			
Position	Diagram reference	Inclination of axis	Rotation of face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	125° to 150°
Overhead	C	0° to 15°	210° to 235°
Vertical	D	15° to 80°	0° to 125°
	E	80° to 90°	235° to 360°

POSITIONS OF FILLET WELDS

Preheat and Interpass Temperatures:

What are the temperature limits for any preheat or interpass temperature?

Peening: Peening is a mechanical treatment utilized to reduce the effects of welding heat cycles which could produce excessive residual stresses, distortion and even cracking. Indiscriminate use of peening should not be permitted; however, it is sometimes applied to highly restrained or thick welds to avoid warpage or cracking of the weld or base metal. If peening is to be used, details of its application must be specified in the welding procedure specification.



Heat Input: With heat-treated alloy steels and austenitic stainless steel alloys, the energy input during welding must not heat the work adjacent to the weld above certain temperatures. To control this, there must be specification of the preheat and interpass temperatures, arc voltage, current, and travel speed within well defined ranges, as determined during the procedure qualifications. This will allow for maintenance of the desirable properties in the heat-affected zone of the base metal.

Root Preparation Prior to Welding Second Side: In joints welded from both sides, there should be a description of how the root of the first weld is or may be prepared for back welding. The procedure specification should state whether chipping, grinding, air carbon arc cutting, oxyacetylene gouging, etc. is to be used.

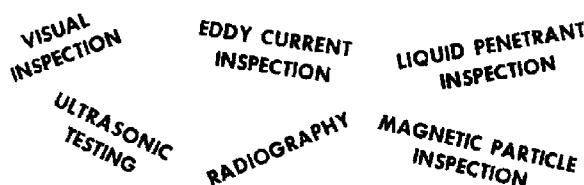
Removal of Weld Sections for Repair:

What methods are to be used for removing welds or sections of welds for repair? The methods may

well be the same ones used for preparing the root of the first pass for welding from the second side.

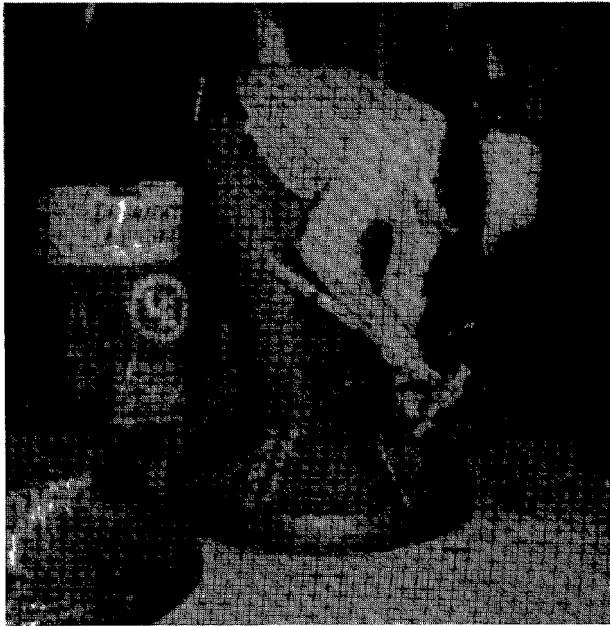
Repair Welding: Details of any repair welding methods and procedures which may differ from the standard methods to be used to create a welded joint should be identified.

Examination: What type and extent of examination is each weld joint to receive? The examination may include radiography, magnetic particle, ultrasonic, penetrant, or other types of testing. Visual examination of every weld is routinely required, but that should be spelled out in the procedure.



Postheat Treatment: What heat treatment or stress relief will be required after welding? It should be the same treatment that is applied to all procedure qualification test welds. A full description of the heat treatment should be specified or a suitable heat treating note, drawing or document should be referenced. Check to see that postheat treatment of heat treated alloy steels will not exceed the final tempering temperature that was given the base metal. If a full reheal treatment is intended, it may be desirable to do the welding with the metal in the annealed condition.

Marking: Some codes require that welder identification marks be made on or near each weld, or a record of welds made by the welders is maintained. The identification marking should be made with low-stress steel die stamps rather than sharp-edged stamps.



Marking a completed weldment.

Records: There should be details of what welding records will be required, and the specific requirements for these records.

Welding Procedure Specification Sample:

Samples of a general welding procedure and several joint welding procedure specifications are illustrated in Appendix B. These should be considered as illustrating only the general form in which welding procedure specification details may be treated, not the specific details to follow for any particular application. The data given for electrode size, welding current and voltage, preheat and interpass temperature, location and sequence of weld passes, etc., have been filled in solely for illustration, not for actual use.

Welding Procedure Qualification

The purpose of procedure qualification testing is to demonstrate that the materials and methods

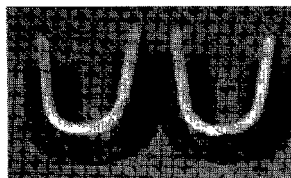
prescribed in a procedure specification will in fact produce weld joint mechanical properties that meet the application and specification requirements.

There are four steps in the qualification of a welding procedure:

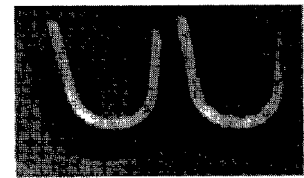
- Preparation and welding of suitable samples.
- Testing of representative specimens.
- Evaluation of overall preparation, welding, testing, and end results.
- Approval (if the results are favorable).

Preparation of Procedure Qualification

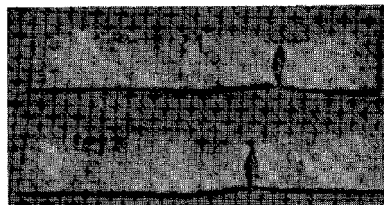
Sample Joints: Test assemblies usually have a representative joint in their middle. The size, type and thickness are related to the type and thickness of material to be welded in production and the number, type and size of specimens to be removed for testing. The materials to be used as well as the welding details are governed by the particular welding procedure specifications that are to be qualified.



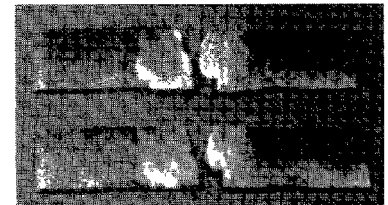
FACE-BEND



ROOT-BEND



TENSILE



NICK-BREAK



REDUCED TENSILE

Testing of Procedure Qualification Welds:

Specified tests and examinations are made on the sample joints. The type and number of specimens to be removed for destructive tests will depend upon the requirements of the particular application or specification. Such tests may include: tensile, bend, nick-break, charpy, fillet-break, etc. Often nondestructive examinations will also be applied. The welding inspector should be certain that the records show how the procedure qualification welds were made and tested.

Evaluation of Test Results: The test results for a procedure qualification sample weld, with the records of joint preparation, welding and testing, should be made available for review. These results will be analyzed by the responsible parties to determine whether the test details and results meet the requirements of the applicable specification.

Approval of Qualification Tests and Procedure Specifications: As a rule, the inspection agency or customer must approve the procedure qualification tests, the test results, and the procedure specifications before any production welding is done.

Qualification is accomplished when the required tests have been completed and approval has been obtained. However, authentic documentary evidence must be available to show that the joints were indeed satisfactory. The welding inspector should witness the welding and testing of all specimens, if possible.

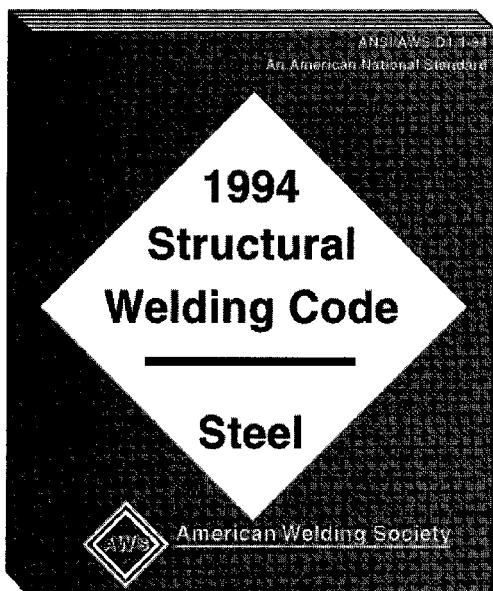
At any time during the use of some qualified procedure, the welding inspector may request requalification of that procedure if production use shows that it is not producing consistently reliable results.

Code Qualification Requirements

AWS D1.1 Structural Welding Code - Steel: AWS D1.1 covers the welding of various structures, including buildings, bridges and tubular structures. It features a unique welding procedure concept referred to as prequalified weld joints. As long as the welding is performed in accordance with the design, workmanship and technique requirements set forth in the Code, no actual procedure qualification testing is required. Section 5.1 outlines the limitations of these prequalified procedures.

Use of procedures operating outside these prescribed limitations will require actual qualification testing. Section 5.5 places limitations on the variables for these qualified procedures. Section 5.10 describes the type and number of specimens that must be tested to qualify a welding procedure. Section 5.11 talks about the methods to be used for testing the various types of specimens, and the results of these tests must meet the requirements of Section 5.12.

Sample forms approved by the AWS Structural Welding Committee for recording



procedure qualifications are reproduced in Appendix B.

ASME Boiler and Pressure Vessel Code - Section IX: The ASME Boiler and Pressure Vessel Code covers the welding of pressure vessels. Any welding performed in accordance with this Code must be done using welding procedures which have been qualified using the guidelines set forth in Section IX of that Code. It is entitled "*Welding and Brazing Qualifications*." This Code section also applies to qualification for welding pressure piping in accordance with ANSI B31.1.

Unlike the AWS Structural Welding Code, Section IX always requires procedure qualification testing. It covers both the welding and brazing of virtually all types of construction alloys using a wide variety of processes.

Documentation for a welding procedure qualified in accordance with ASME Section IX consists of both a Welding Procedure Specification (QW-482) as well as a Procedure Qualification Record (QW-483). Copies of these two forms appear in Appendix B.

API Standard 1104: The welding of cross-country pipelines and other types of petroleum equipment is controlled by the requirements set forth in API 1104, *Standard for Welding Pipelines and Related Facilities*. This Standard describes how each welding procedure will be qualified. It is somewhat unique in that it also describes the inspection and quality requirements for the production welding. Like ASME Section IX, each procedure requires actual qualification testing. Appendix B contains a sample welding procedure qualification form approved by API 1104.

Changes in a Qualified Welding Procedure

If a fabricator who has qualified a welding procedure desires at some later date to make a change in that procedure, it may be necessary to conduct additional qualifying tests. Re-qualification is necessary when any one of the

essential variables listed in the governing standard or code is changed beyond the limits which have been established.

For example, one such variable is the heat treatment that follows welding. Heat treatment has a profound effect on most welds. Its omission (when called for) or its addition to a welding procedure (when not called for) would be a change in an important essential variable, requiring requalification of the procedure.

In ASME Section IX, there is reference to both essential and nonessential variables. Changes in essential variables requires requalification of the procedure. However, a change in a nonessential variable only requires modification of the documentation to reflect the desired change, so no retest is necessary.

Welding Inspector Responsibilities

Welding Procedure Qualification: Before any production welding is started under a contract, it is the welding inspector's duty to verify that welding procedures have been established and that they are capable of producing welded joints of the type and quality required. To be certain of this, the welding inspector should witness the welding and testing of the qualification weld specimens. There must be authentic documentary evidence available that the joints were satisfactory. As mentioned earlier, the welding inspector should try to witness the tests to increase his familiarity with the details of the procedure.

Welding Inspection: It should be kept in mind that the passing of a qualification test does not ensure proper application of the procedure. Adequate inspection is necessary to verify how the qualified procedure is being applied. The welding inspector will find it to his advantage to prepare a checklist for each procedure specification, to guide him in performing this inspection.

Once the welding procedures have been reviewed and found to be acceptable, the task now becomes one of assuring that the production

welding is performed in accordance with those procedures. Qualified welding procedures are useless if not followed. The welding inspector should also note any changes in any welding procedure in excess of the limits prescribed for the essential variables. In that case, see that the procedure specification is changed accordingly and determine whether requalification of the procedure is required. If requalification is required, see that the modified procedure is not applied to production work until requalification testing has been completed and the change has been proven satisfactory.

Make certain that weldments needing repair are corrected using qualified welding procedures. The welding and quality requirements for the repair are the same as those for the original welding.

Welder and Brazor Qualification

Performance qualification tests determine the ability of welders, welding operators and brazers to produce acceptably sound welds and brazes with the processes, materials and techniques defined in the qualified welding or brazing procedures. Qualification of these personnel is the

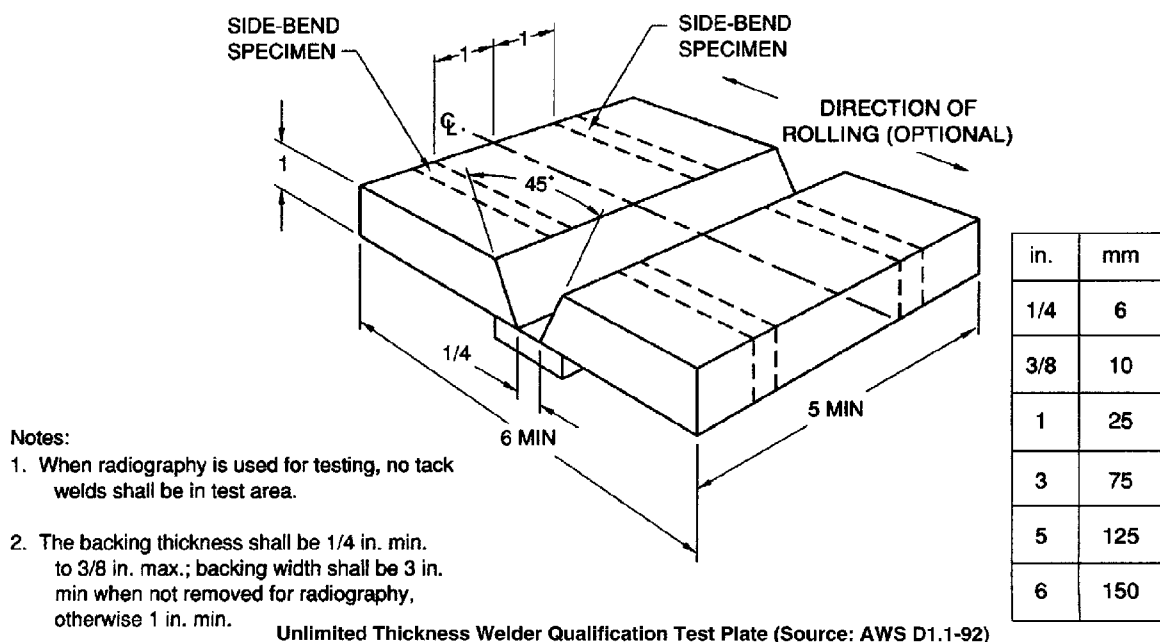
legal responsibility of the employer of that individual.

The manufacturer, contractor, fabricator, erector, and owner are responsible for the quality of their work. They should establish quality assurance programs that utilize in-house and outside experience and qualifications to assure that they meet or exceed the minimum specified requirements.

Qualification requirements for these personnel are usually defined in the governing standard or the contract specification. The welding inspector's responsibility is to verify that every welder, welding operator or brazer who works under the standard or specification has been properly qualified for the work to be done.

Qualification Testing

Performance qualification tests improve the probability of obtaining satisfactory welds in finished products. However, test welds are made with special attention and effort. They show whether the welder, welding operator or brazer can produce acceptably sound joints, but they do not tell whether he or she normally will do so under every production condition. For that reason,



complete reliance should not be placed on qualification testing of welders, welding operators and brazers. Production welds and brazes should be inspected during, and following, the actual welding.

Tests prescribed by most codes, specifications and governing rules are similar for the most part. The types of tests that are most common will be described for the following applications:

- Plate and structural member welding
- Pipe welding
- Sheet metal welding
- Brazing

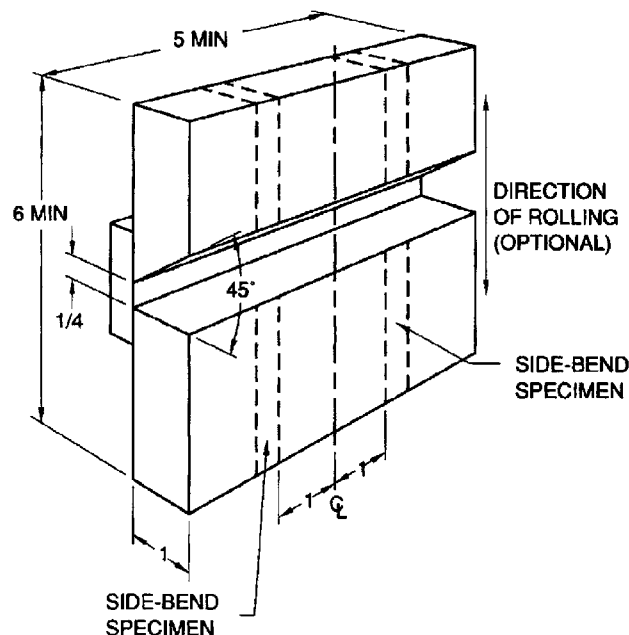
In addition, there will also be mention of the various test methods used to examine the

qualification test welds or braze joints. Another factor which has a great impact on the ability of a welder or brazer to produce a satisfactory weld or braze is the position in which the test is performed. This will depend on the position, or positions, in which production welding or brazing will be done.

Plate and Structural Member Welding:

Qualification requirements for welders of plate and structural parts usually have the welder or welding operator make one or more test welds on plate or pipe in accordance with the requirements of the qualified welding procedure. Each qualification weld is tested in a specific manner, often both destructively and nondestructively. The requirements prescribe the thicknesses of material and the test positions that qualify for production work.

in.	mm
1/4	6
3/8	10
1	25
3	75
5	125
6	150

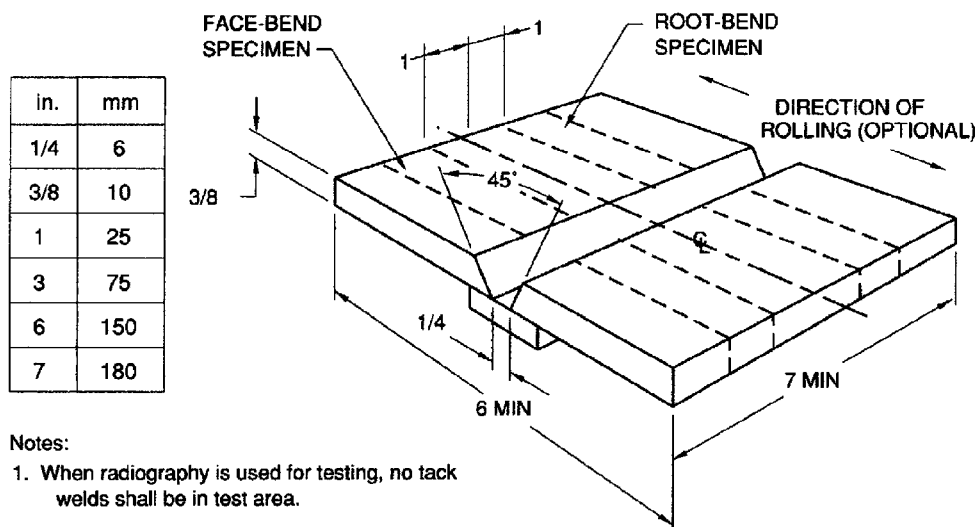


Notes:

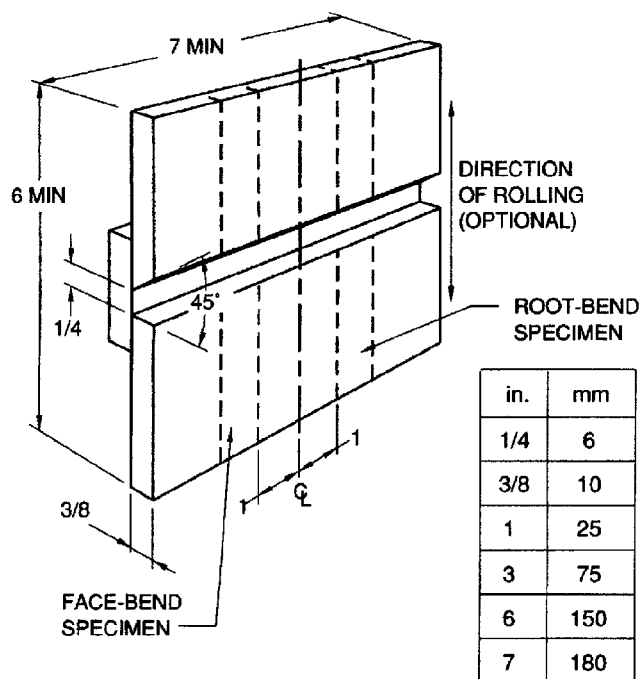
1. When radiography is used for testing, no tack welds shall be in test area.
2. The backing thickness shall be 1/4 in. min to 3/8 in. max; backing width shall be 3 in. min when not removed for radiography, otherwise 1 in. min.

Optional Test Plate for Unlimited Thickness - Horizontal Position - Welder Qualification (Source: AWS D1.1-92)

8-12

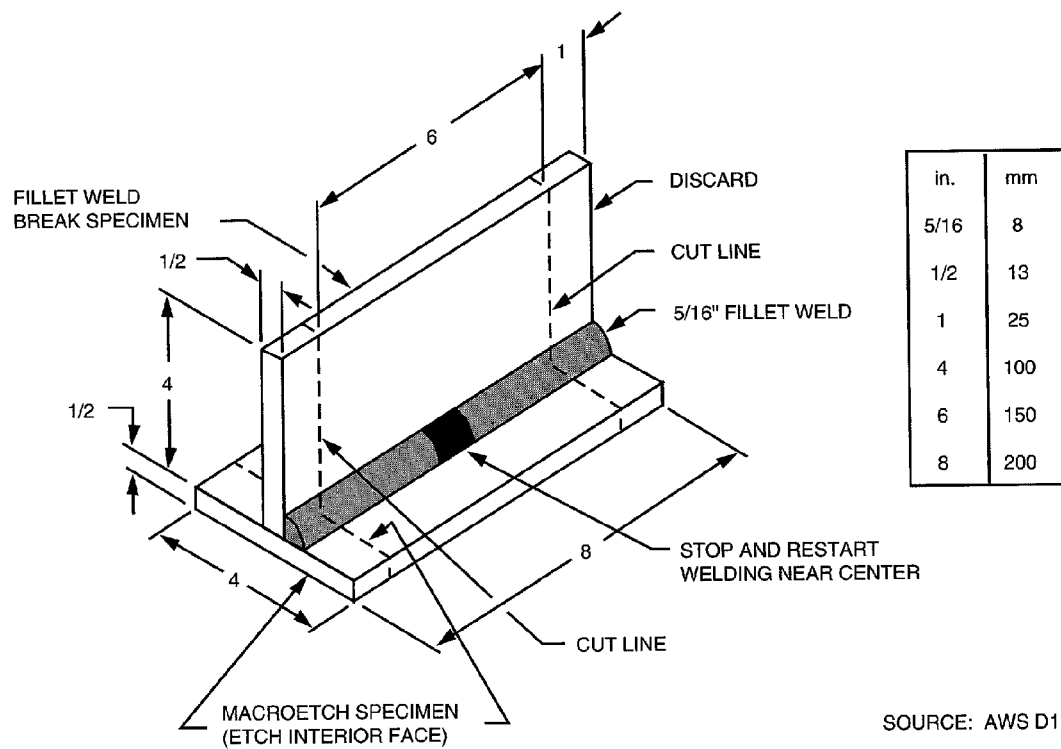
**Notes:**

1. When radiography is used for testing, no tack welds shall be in test area.
2. The backing thickness shall be 1/4 in. min to 3/8 in. max; backing width shall be 3 in. min when not removed for radiography, otherwise 1 in. min.

Test Plate for Limited Thickness - All Positions - Welder Qualification (Source: AWS D1.1-92)**Notes:**

1. When radiography is used for testing, no tack welds shall be in test area.
2. The backing thickness shall be 1/4 in. min to 3/8 in. max; backing width shall be 3 in. min when not removed for radiography, otherwise 1 in. min.

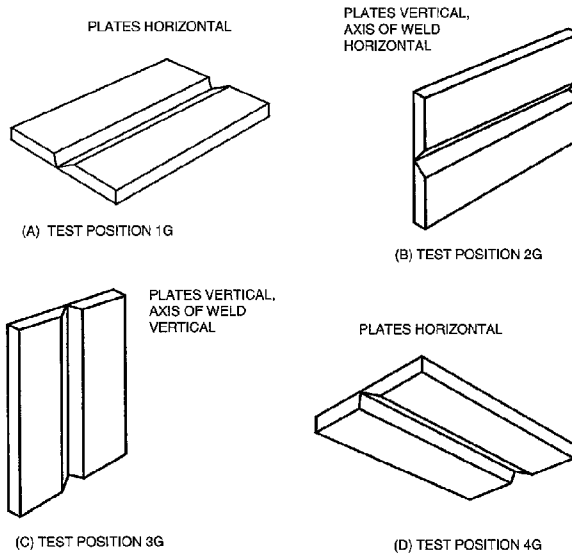
Optional Test Plate for Limited Thickness - Horizontal Position - Welder Qualification (Source: AWS D1.1-92)



SOURCE: AWS D1.1-92

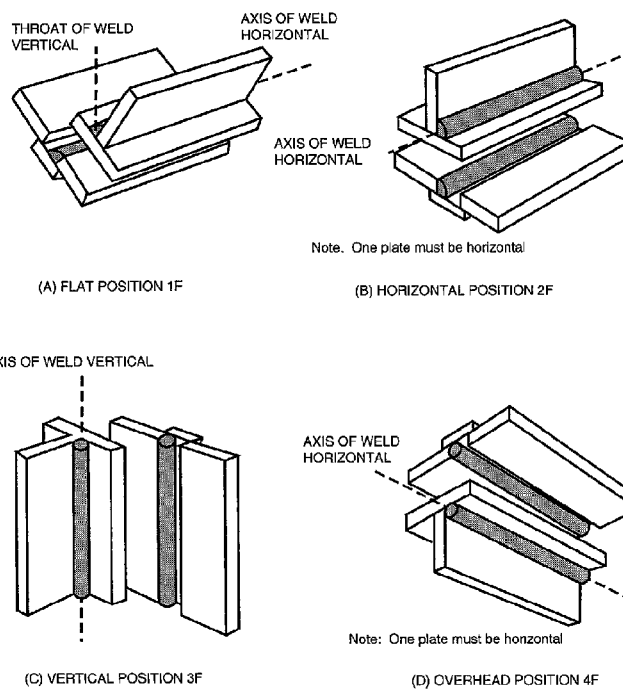
Note:
1. Plate thickness and dimensions are minimum

**FILLET WELD BREAK AND MACROETCH TEST PLATE
WELDER QUALIFICATION - OPTION 1**



SOURCE: AWS D1.1-92

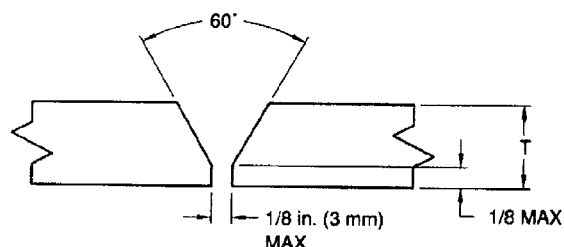
POSITIONS OF TEST PLATES FOR GROOVE WELDS



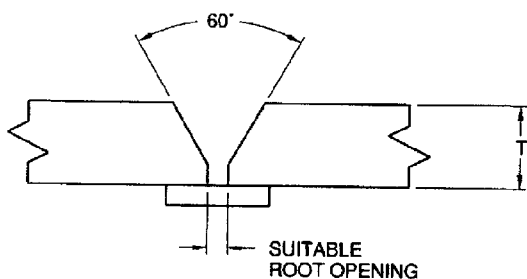
SOURCE: AWS D1.1-92

POSITIONS OF TEST PLATE FOR FILLET WELDS

Other details cover groove welds with or without backing and the direction of welding when



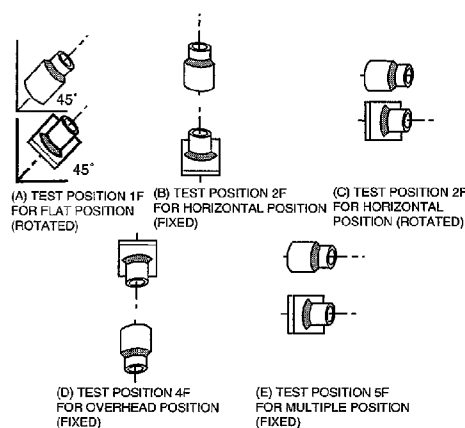
Typical Tubular Butt Joint Welder Qualification
(without backing)



Typical Tubular Butt Joint Welder Qualification (with backing)

Pipe Welding: Qualification requirements for welding pipe differ from those for welding plate and structural members chiefly in the type of test assemblies and test positions. Another major difference with pipe welding is the fact that often there is no practical access to the root surface, requiring the use of some backing ring or consumable insert or the production of a one-side weld with an open root (no backing). This requires a more skilled individual than the welding of plate or structural joints with backing.

To simulate the difficulties of production welding, the pipe weld qualification tests utilize pipe coupons which are welded in the position, or positions, for which the welder wishes to be qualified. There may also be space restrictions placed on the welder during the test which measures the individual's ability to produce a satisfactory weld in locations where joint access is limited. (Illustrations above, at right and on page 8-17.)

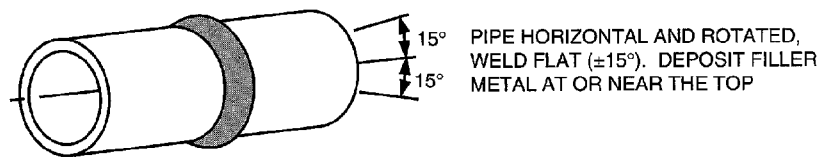


POSITIONS OF TEST PIPES FOR FILLET WELDS (SOURCE: AWS D1.1-92)

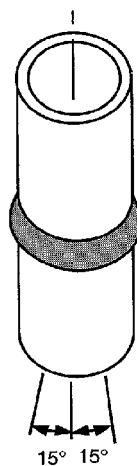
Sheet Metal Welding: The welding of sheet metal requires special skills simply because the thin members tend to melt rapidly, which could result in burning holes rather than joining parts together. Consequently, the qualification tests will examine the ability of the welder to produce sound welds in these thin sheet metal thicknesses. You will note that all codes place limits on the minimum thicknesses which a welder can weld in production. Quite often, the minimum thickness qualified is that thickness used during qualification. (See illustrations page 8-18)

Brazing: Like welders, brazers also require some type of qualification testing. The test usually consists of the production of some type of joint arrangement which is positioned in a manner similar to that expected in production. The evaluation of the test results is normally accomplished by cross sectioning the brazed joint and measuring the amount of bonding that has resulted.

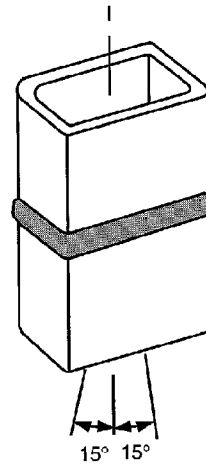
Positions of Welding and Brazing: Welder and brazer qualification tests usually must be made in the most difficult positions that will be encountered in production (for example, vertical, horizontal and overhead) if the production work involves other than flat position welding and brazing. Qualification in a more difficult position usually qualifies for welding or brazing in less



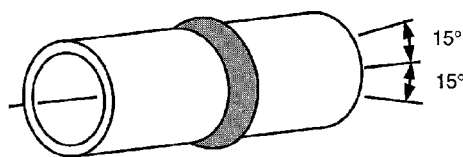
(A) TEST POSITION 1G ROTATED



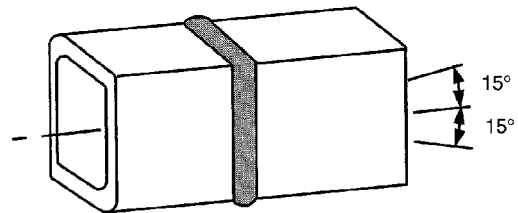
PIPE OR TUBE VERTICAL AND NOT ROTATED DURING WELDING. WELD HORIZONTAL ($\pm 15^\circ$).



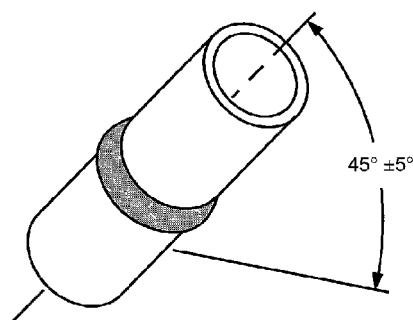
(B) TEST POSITION 2G



PIPE OR TUBE HORIZONTAL FIXED ($\pm 15^\circ$) AND NOT ROTATED DURING WELDING. WELD FLAT, VERTICAL, OVERHEAD.



(C) TEST POSITION 5G

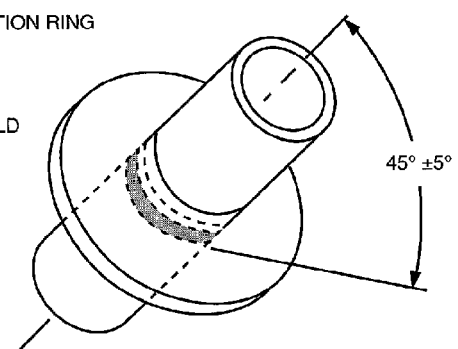


PIPE INCLINATION FIXED ($45^\circ \pm 5^\circ$) AND NOT ROTATED DURING WELDING

(D) TEST POSITION 6G

RESTRICTION RING

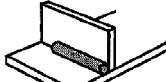
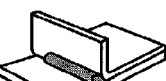
TEST WELD



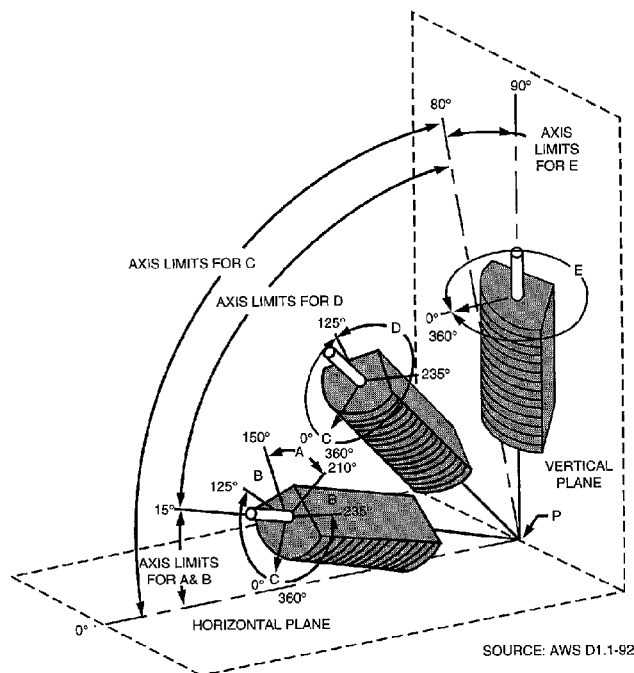
(E) TEST POSITION 6GR (T-, Y- OR K- CONNECTIONS)

SOURCE: AWS D1.1-92

POSITIONS OF TEST PIPE OR TUBING FOR GROOVE WELDS

Test Assemblies Shown in Figure:	Type of:		Qualifies for:			Number of Tests	Type of Test
	Welded Joint	Welding Position	Welding Position	Type of Welded Joint	Thickness		
 6.1	Square groove butt joint, sheet to sheet	F H V OH	F FH FHV FHOH	Square groove butt joint, sheet to sheet	Thickness tested (except as modified by 6.8.2(2))	2	Bend
 6.2	Arc spot weld, sheet to supporting member	F	F	Arc spot weld and arc seam weld, sheet to supporting mem- ber	Thickness tested	2	Twist
 6.3A	Arc seam weld, sheet to supporting member	F	F	Arc seam weld, sheet to supporting member	Thickness tested	2	Bend
 6.3B	Arc seam weld, sheet to sheet	H	H	Arc seam weld, sheet to sheet	Thickness tested	2	Bend
 6.4	Fillet welded lap joint, sheet to sheet	F H V OH	F FH FHV FHOH	Fillet welded lap joint, sheet to sheet, or sheet to supporting mem- ber	Thickness tested and thicker	2	Bend
 6.4	Fillet welded lap joint, sheet to supporting mem- ber	F H V OH	F FH FHV FHOH	Fillet welded lap joint, sheet to sheet, to supporting member	Thickness tested and thicker	2	Bend
 6.4	Fillet welded T-joint, sheet to sheet	F H V OH	F FH FHV FHOH	Fillet welded T- or lap joint, sheet to sheet, or sheet to supporting member	Thickness tested and thicker	2	Bend
 6.4	Fillet welded T-joint, sheet to supporting member	F H OH	F FH FHOH	Fillet welded T- or lap joint, sheet to supporting member	Thickness tested and thicker	2	Bend
 6.4A	Flare bevel, sheet to sheet	F H V OH	F FH FHV FHOH	Flare-bevel-groove weld, sheet to sheet, or sheet to support- ing member; or flare-V-groove weld, sheet to sheet	Thickness tested and thicker	2	Bend
 6.4B	Flare-bevel, sheet to supporting member	F H V	F FH FHV	Flare-bevel-groove weld, sheet to supporting member	Thickness tested and thicker	2	Bend
 6.4C	Flare-V, sheet to sheet	F H V OH	F FH FHV FHOH	Flare-V-groove weld, sheet to sheet, or flare-bevel- groove weld, sheet to sheet, or sheet to supporting member.	Thickness tested and	2	Bend

SOURCE: AWS/AWS D1 3-89



SOURCE: AWS D1.1-92

Position	Diagram reference	Inclination of axis	Rotation of face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	125° to 150°
Overhead	C	0° to 15°	210° to 235°
Vertical	D	15° to 80°	125° to 235°
	E	80° to 90°	0° to 360°

POSITIONS OF FILLET WELDS

difficult positions; e.g., qualification in the vertical, horizontal or overhead positions usually qualifies for welding or brazing in the flat position. Also, qualification tests on groove welds will normally qualify that welder for the production of fillet welds in the same position. The code in force will dictate the exact limits on production welding and brazing positions, depending on the qualification test position(s).

Testing of Qualification Welds and Brazes:

All codes and specifications have definite rules for testing qualification welds and brazes. Most frequently, for welds, mechanical bend tests are made on specimens cut from specific locations in the welds. Some codes will permit welder

qualification testing using radiography instead of mechanical bend testing. This radiographic examination may be permitted, either alone or in conjunction with mechanical or other tests. Other types of nondestructive test methods, such as penetrant testing may also be applied to measure the apparent soundness of the qualification weldment. All codes will require that the test welds be sound and thoroughly fused to the base metal.

Examination of braze qualification coupons is normally accomplished by cutting through the joint and measuring the degree of bonding between the members being joined.

Other properties required of procedure qualification welds, such as tensile strength and fracture toughness of the weld metal, are not usually specified in welder qualification.

Welders or brazers whose test welds or brazes meet the prescribed requirements are qualified to apply the process and to weld or braze with filler metals and procedures similar to those used in testing. The prescribed limits of similarity of the substitute filler metals and procedures must be stated.

Retests

When do welders or welding operators require retesting? Some of the circumstances are as follows:

- Failure of the initial test welds.
- A significant change in the welding procedure.
- A welder has not been engaged in a particular welding process for an extended period (usually three or six months).
- There is reason to question a welder's or welding operator's ability.

Refer to the applicable code or specification for the specifics of such retests.

Standardization of Tests

The purpose of welder and welding operator qualification testing is to determine whether this person will be able to make satisfactory welds in production. The test is not perfect, nor will it guarantee that all production welds will be defect-free. The specimen welds used for qualification do not usually correspond in detail to all of those that will be encountered in production welding. They are standardized welds, which do therefore permit uniform evaluation of the welder's skill. However, additional tests add little information about a welder's or welding operator's ability.

Relation of Qualification Tests to Welder Training

Welders and welding operators should not be trained merely to the extent necessary to pass a prescribed qualification test. Because those tests are standardized, training should cover a broader and more extensive range of procedures and joint details to prepare for conditions that will be encountered in production. Training is the responsibility of the manufacturer or fabricator for whom the welder works.

Code and Standard Requirements

AWS D1.1, Structural Welding Code - Steel: The AWS Structural Welding Code (AWS D1.1) requires that all welders, welding operators and tackers to be employed under this code shall have been qualified by tests as specified in Section 5, Parts C, D and E. The tests are often administered by you, the welding inspector. If the welder, welding operator or tacker has previously demonstrated his qualification under other acceptable supervision, you may, at your option, make certain of that fact and then consider the applicant qualified for the present job.

ASME Boiler and Pressure Vessel Code: The ASME Boiler and Pressure Vessel Code specifies that only welders, welding operators and

brazers who are qualified in accordance with Section IX shall be used. In addition, Section III, Division 1 (Nuclear Components) and Section VIII, Division 2 (Pressure Vessels, Alternate Rules) specify that tack welds must also be made by qualified welders.

The ASME qualification tests for welders and welding operators call for the same kinds of bend specimens as used for procedure qualification.

Any welder, welding operator or brazer who makes a procedure qualification test that passes satisfactorily is automatically qualified for that process, within the limitations prescribed in Section IX. Welders and welding operators making repair welds shall be qualified in accordance with Section IX. Qualification is limited in duration, to the extent that it is dependent upon continued satisfactory use of the process by the welder with no lapses exceeding 90 days, or it may be extended for an additional 90 days if the welder has welded with another process.

API Standard 1104: The API Standard 1104 relies on visual examination and destructive tests (optionally, on radiographic examination) to qualify welders. Since this standard deals with the requirements for welding pipelines and related equipment, all qualification tests are performed on pipe. No limitations are placed on the persons doing the testing, except the radiographer. The company, represented in practice by the inspector, is required to keep records of qualified welders and welding operators.

Destructive Test Qualification

Destructive tests and examinations are made in-house or outside by personnel who are qualified through training, education or the manufacturer's certification standards. Many fabricators do not have properly trained or qualified people nor the proper testing equipment, so they call on a contract laboratory to run the tests. On the other hand, fabricators with the necessary equipment

may arbitrarily declare that certain of their technicians, inspectors or engineers are qualified, and the tests are then run in-house.

Destructive tests may be made without qualification of personnel. It is the welding inspector's responsibility to verify that the tests were conducted according to the governing code, specification or other reference documents. For example, the AWS Structural Welding Code requires the all-weld-metal tension test (paragraph 5.11.4) to be performed in accordance with ASTM A370, "*Mechanical Testing of Steel Products*."

Summary

The welding inspector will likely be involved to some degree in the qualification of welding procedures and welders. He may be responsible for administering the tests or simply reviewing the documentation to determine if the qualifications are applicable and accurate.

The most important aspect of the welding inspector's job relative to qualification is the evaluation of production welding to determine whether or not the procedures and welders are producing welds of acceptable quality.

8-22

REVIEW - CHAPTER 8 WELDING PROCEDURE AND WELDER QUALIFICATION

- Q8-1** Who is normally responsible for the qualification of welding procedures and welders?
- welder
 - architect
 - welder's employer
 - independent test lab
 - Code body
- Q8-2** Of the following types of test specimens, which is used only by API for procedure and welder qualification testing?
- face bend
 - root bend
 - side bend
 - nick-break
 - tensile
- Q8-3** What is the pipe welding position where the pipe remains fixed with its axis horizontal, so the welder must weld around the joint?
- 1G
 - 2G
 - 5G
 - 6G
 - 6GR
- Q8-4** What is the pipe welding position where the axis of the pipe lies fixed at a 45 degree angle?
- 1G
 - 2G
 - 5G
 - 6G
 - none of the above

- Q8-5** What is the necessary pipe position test for welders who are trying to qualify to weld T-, K-, and Y- connections?
- a. 1G
 - b. 2G
 - c. 5G
 - d. 6G
 - e. 6GR
- Q8-6** With relation to procedure and welder qualification, what is the most important part for the welding inspector?
- a. watching the welding qualification test
 - b. identifying samples
 - c. cutting test specimens
 - d. testing specimens
 - e. monitoring production welding
- Q8-7** For most codes, if a welder continues to use a particular procedure, how long does his qualification remain in effect?
- a. indefinitely
 - b. 6 months
 - c. 1 year
 - d. 3 years
 - e. until he produces a rejectable weld
- Q8-8** What document describes the requirements of welder qualification in accordance with ASME?
- a. ASME Section III
 - b. ASME Section II, Part A
 - c. ASME Section IX
 - d. ASME Section XI
 - e. ASME Section V
- Q8-9** Qualification to weld cross country pipelines is normally done in accordance with:
- a. ASME Section III
 - b. AWS D1.1
 - c. AWS D14.3
 - d. API 1104
 - e. API 650