

AWS D16.4M/D16.4:2005
An American National Standard

Specification for the Qualification of Robotic Arc Welding Personnel



American Welding Society®



Key Words—Robot, robotic arc welding, welder qualification, robot welding systems, robotic welding operator, qualified robot technician

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Specification for the Qualification of Robotic Arc Welding Personnel

2nd Edition

Supersedes AWS D16.4:1999

Prepared by
AWS D16 Committee on Robotic and Automatic Welding

Under the Direction of
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification provides requirements for the qualification of robotic arc welding support personnel at three different levels—CRAW-L1, CRAW-O, and CRAW-T. The revisions in this edition align education and experience requirements more realistically with those in industry.



American Welding Society

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Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126 (see Annex A). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. However, such opinions represent only the personal opinions of the particular individuals giving them. These individuals do not speak on behalf of AWS, nor do these oral opinions constitute official or unofficial opinions or interpretations of AWS. In addition, oral opinions are informal and should not be used as a substitute for an official interpretation.

This standard is subject to revision at any time by the AWS D16 Committee on Robotic and Automatic Welding. It must be reviewed every five years, and if not revised, it must be either reaffirmed or withdrawn. Comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this standard are required and should be addressed to AWS Headquarters. Such comments will receive careful consideration by the AWS D16 Committee on Robotic and Automatic Welding and the author of the comments will be informed of the Committee's response to the comments. Guests are invited to attend all meetings of the AWS D16 Committee on Robotic and Automatic Welding to express their comments verbally. Procedures for appeal of an adverse decision concerning all such comments are provided in the Rules of Operation of the Technical Activities Committee. A copy of these Rules can be obtained from the American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

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Foreword

(This Foreword is not a part of AWS D16.4M/D16.4:2005, *Specification for the Qualification of Robotic Arc Welding Personnel*, but is included for informational purposes only.)

The AWS D16 Committee on Robotic and Automatic Welding was organized in 1985 to provide centralized source for the exchange of technical information between manufacturers, installers, and operators of robotic and automated equipment.

The first edition of AWS D16.4 (AWS D16.4:1999, *Specification for the Qualification for Robotic Arc Welding Personnel*) provided guidelines for the qualification of arc welding personnel. This second edition includes revisions required to harmonize this standard with the certification document for robotic arc welding personnel that is currently in use. This edition reduces the levels of qualification from four to three and aligns education and experience requirements more realistically with those in industry.

Comments and suggestions for the improvement of this standard are welcome. They should be sent to the Secretary, AWS D16 Committee on Robotic and Automatic Welding, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the Managing Director, Technical Services Division, American Welding Society. A formal reply will be issued after it has been reviewed by the appropriate personnel following established procedures. See Annex A for details on the full procedure of obtaining interpretations.

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Specification for the Qualification of Robotic Arc Welding Personnel

1. Scope

This standard provides specifications for the qualification of robotic arc welding personnel. This standard does not prevent a manufacturer, fabricator, or contractor from continuing to qualify robotic welding personnel according to other standards.

Qualification is limited to those performance variables provided in Tables 1 through 4 in this standard. There are three different levels in which qualification can be achieved. The work of operators, technicians, and maintenance support personnel is included in these three levels (see Tables 1, 2, and 3).

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

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

2. Normative References¹

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

1. For Informative (nonmandatory) References, see Annex B.

(1) AWS A3.0, *Standard Welding Terms and Definitions*²

(2) AWS QC19, *Standard for the AWS Certification of Robotic Arc Welding Personnel*³

3. Definitions

Standard welding terms are defined in the current edition of AWS A3.0, *Standard Welding Terms and Definitions*. Terms unique to this standard are defined herein.

inspection. Examination or measurement to verify whether an item or activity conforms to specified requirements.

inspector. A person who performs an inspection or exam function to verify conformance to specific requirements.

qualification. Verification by testing of the characteristics or abilities gained through training, experience, or both that enables individuals to perform certain functions.

robotic arc welding personnel. Individuals who may be operators, technicians, or maintenance support personnel for robotic arc welding applications.

robotic arc welding personnel qualification. The verification of robotic arc welding personnel's ability to meet prescribed standards for performance qualification.

verification. The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specified requirements.

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

3. A free copy may be obtained from AWS at <http://www.aws.org/certification/>.

4. Specifications for Qualification of Robotic Arc Welding Personnel

Tables 1 through 3 provide the specifications for the qualification of robotic arc welding personnel at the three levels designated by this standard. Table 1 lists skill requirements, experience and educational requirements, and training recommendations for a Level 1 (CRAW-L1) applicant. Table 2 lists skill requirements, experience and educational requirements, and training recommendations for a Level 2 (CRAW-O) applicant. Table 3 lists skill requirements, experience and educational requirements, and training recommendations for a Level 3 (CRAW-T) applicant.

To qualify at a specific Level, one must demonstrate the ability to complete the required performance objectives for that Level. Table 4 summarizes the requirements and at which level(s) they apply. AWS QC19, *Standard for the AWS Certification of Robotic Arc Welding Personnel*, details how personnel are certified and the procedures for maintaining certification.

The components for the specimen used to conduct the performance welding test (per AWS QC19) shall be of the dimensions and layout shown in Figure 1. Assembly of the components of the test specimen shall be as shown in Figure 2. Test welds shall be performed to the specifications shown in Figure 3 and shall comply with the requirements of AWS QC19.

Table 1
Performance Qualifications for Robotic Arc Welding Personnel—Level 1 (CRAW-L1)

To qualify as a Level 1 Certified Robotic Arc Welding Operator (CRAW-L1), one shall meet the requirements in Sections A and B of Table 1. Section C lists training recommendations.

A. SKILLS AND ABILITY REQUIREMENTS

1. Have the ability to power up the robot and peripheral equipment such as all power sources, coolant pumps, and torch cleaners.
 2. Be capable of servicing the robotic welding torch and wire feeding system. This includes servicing the torch, contact tips, gas diffusers, insulators, nozzles, and drive rolls, and changing welding wire.
 3. Have a basic understanding of the robot as it is outlined in the company's routine maintenance procedures.
 4. Have a basic understanding of the robot control panel so that the robot can be brought back to operation after work has been performed inside the work cell. This includes resetting any safety circuits and making sure that the robot is in the home position.
 5. Have knowledge of general safety requirements.
 6. Have a working knowledge of all of the robotic peripheral equipment. Have the ability to perform routine and preventative maintenance on such items as the torch cleaner, wire feeder, torch mount, and torch cable support hardware.
-

B. EXPERIENCE AND EDUCATION REQUIREMENTS

1. Have minimum of 1000 hours manual or semiautomatic arc welding experience.
Note: Hours consist of time on the job employed as a welder, and not actual arc time (i.e., time under hood).
 2. Have a high school diploma or equivalent.
 3. Have good mechanical aptitude.
 4. Have good written and oral communication skills.
-

C. TRAINING RECOMMENDATIONS

1. Obtain basic instruction in the operation of all robotic peripheral equipment.
 2. Obtain basic instruction covering the safe and proper operation of the robot's mechanical arm and control circuitry.
 3. Take a visual inspection course for the applicable product.
-

Table 2
Performance Qualifications for Robotic Arc Welding Personnel—Level 2 (CRAW-O)

To qualify as a Level 2 Certified Robotic Arc Welding Operator (CRAW-O), one shall meet the requirements for Level 1, and shall meet the following additional requirements in Sections A and B of Table 2. Section C lists training recommendations.

A. SKILLS AND ABILITY REQUIREMENTS

1. Have the ability to visually inspect the welds on the component to the applicable standard and make changes as allowed by the welding procedure to bring the welds within specifications. The individual should have a strong welding background and should have a thorough understanding of the robotic program and its function.
 2. Have the ability to document information on any robot related problems and communicate them to the welding engineer or technician. Have good written and oral communication skills.
 3. Be capable of evaluating weld cross sections.
-

B. EXPERIENCE AND EDUCATION REQUIREMENTS

1. Have minimum of 2000 hours or two years of arc welding experience, 1000 hours of which shall be manual or semiautomatic arc welding.

Note: This requirement does not imply actual arc hours but instead time working with the welding process in general.

2. Have any combination of post-secondary education and/or work experience totaling 3 years, with a minimum of 1 year work experience being required.
-

C. TRAINING RECOMMENDATIONS

1. Obtain training to understand the use of the teach pendant.
 2. Obtain training to acquire the ability to evaluate weld quality when presented with a properly prepared cross-section sample.
 3. Continue education in robotic arc welding related disciplines.
 4. Complete robot operation courses provided by original equipment manufacturers or equivalent robot operation courses.
-

Table 3
Performance Qualifications for Robotic Arc Welding Personnel—Level 3 (CRAW-T)

The person who qualifies as a Level 3 Certified Robotic Arc Welding Technician (CRAW-T) is ultimately responsible for the weld quality in their plant or department. To qualify as a Level 3, one shall meet the requirements for Levels 1 and 2 and shall meet the following additional requirements in Sections A and B of Table 3. Section C lists training recommendations.

A. SKILLS AND ABILITY REQUIREMENTS

1. Have the ability to make changes to the weld data, torch angles, electrode stickout, starting techniques, and other welding variables. Have an extensive welding background and a thorough understanding of the robotic interfacing system.
 2. Demonstrate a thorough understanding of all aspects of the robotic work cell. Demonstrate programming, robotic arc welding, seam tracking, fixturing, and any other welding or robotic related functions. Have the capability to enter the work cell and make changes to the weld program, main program, torch clean program, or any other related programs. Capable of fixture changes to improve part fit up and part locating.
 3. Be capable of performing file management tasks, such as saving, copying, and deleting program files.
 4. Demonstrate expertise in the welding operations including all of the arc welding robots, automated welding equipment, and all manual welding operations.
 5. Be responsible for the initial weld inspection and be familiar with the tools that measure the weldment quality.
 6. Have the ability to perform weld cross sectioning by cutting, polishing, and etching appropriate samples when necessary.
 7. Keep accurate and up to date records, including issuing revised weld procedures as needed.
-

B. EXPERIENCE AND EDUCATION REQUIREMENTS

1. Meet all of the experience and education requirements from previous levels.
 2. Have a minimum of 3000 hours or 3 years arc welding experience.
 3. Have a two year Associates Degree in Welding/Robotics/Electrical or equivalent combination of appropriate education and experience.
 4. Hold current CWI certification (Certified Welding Inspector).
-

C. TRAINING RECOMMENDATIONS

1. Obtain training in the proper operation of cross sectioning tools and related hardware such as plasma cutting and band saws.
 2. Obtain instruction in the applicable destructive testing methods used, such as macroetch or bend testing.
 3. Receive instruction in the operation of quality measuring tools, including applicable computer software for measuring weld cross sections.
 4. Complete programming courses offered by original equipment manufacturers or equivalent robotic programming courses.
 5. Become familiar with personal computers and relevant software.
-

Table 4
Summary of Specifications for Robotic Arc Welding Personnel

A. ABILITY TO PERFORM OR DEMONSTRATE:	LEVEL
1. Have the ability to power up the robot and peripheral equipment such as all power sources, coolant pumps, and torch cleaners.	1 2 3
2. Be capable of servicing the robotic welding torch and wire feeding system. This includes servicing the torch, contact tips, gas diffusers, insulators, nozzles, and drive rolls, and changing welding wire.	1 2 3
3. Have a basic understanding of the robot as it is outlined in the company's routine maintenance procedures.	1 2 3
4. Have a basic understanding of the robot control panel so that the robot can be brought back up onto the line after work has been performed inside the work cell. This includes resetting any safety circuits and making sure that the robot is in home position.	1 2 3
5. Have knowledge of general safety requirements.	1 2 3
6. Have a working knowledge of all of the robotic peripheral equipment. Have the ability to perform routine and preventative maintenance on such items as the torch cleaner, wire feeder, torch mount, and torch cable support hardware.	1 2 3
7. Have the ability to visually inspect the welds on the component to the applicable standard and make changes as allowed by the welding procedure to bring the welds within specifications. The individual should have a strong welding background and should have a thorough understanding of the robotic program and its function.	2 3
8. Have the ability to document information on all the robot related problems and communicate them to the welding engineer or technician. Have good written and oral communication skills.	2 3
9. Be capable of evaluating weld cross sections.	2 3
10. Have the ability to make changes to the weld data, torch angles, electrode stickout, starting techniques, and other welding variables. Have an extensive welding background and a thorough understanding of the robotic interfacing system.	3
11. Demonstrate a thorough understanding of all aspects of the robotic work cell. Demonstrate programming, robotic arc welding, seam tracking, fixturing, and any other welding or robotic related functions. Have the capability to enter the work cell and make changes to the weld program, main program, torch clean program, or any other related programs. Capable of fixture changes to improve part fit up and part locating.	3
12. Be capable of performing file management tasks, such as saving, copying, and deleting program files.	3
13. Demonstrate expertise in the welding operations including all of the arc welding robots, automated welding equipment, and all manual welding operations.	3
14. Be responsible for the initial weld inspection and be familiar with the tools that measure the weldment quality.	3
15. Have the ability to perform weld cross sectioning by cutting, polishing, and etching appropriate samples when necessary.	3
16. Keep accurate and up to date records including issuing revised weld procedures as needed.	3
B. EXPERIENCE AND EDUCATION REQUIREMENTS	LEVEL
1. Have minimum of 1000 hours manual or semiautomatic arc welding experience. <i>Note: Hours consist of time on the job employed as a welder, and not actual arc time (i.e., time under hood).</i>	1 2 3
2. Have high school diploma or equivalent.	1 2 3
3. Have good mechanical aptitude.	1 2 3
4. Have good written and oral communication skills.	1 2 3
5. Have minimum of 2000 hours or two years arc welding experience, 1000 hours of which shall be manual or semiautomatic arc welding. <i>Note: This does not mean actual arc hours but instead time working with the welding process in general.</i>	2 3
6. Have any combination of post-secondary education and/or work experience totaling 3 years, with a minimum of 1 year work experience being required.	2 3

(continued)

Table 4 (Continued)
Summary of Specifications for Robotic Arc Welding Personnel

7. Have minimum of 3000 hours or 3 years arc welding experience.	3
8. Have a two year Associates Degree in Welding/Robotics/Electrical or equivalent combination of appropriate education and experience.	3
9. Hold current CWI certification (Certified Welding Inspector).	3
C. TRAINING RECOMMENDATIONS	
	LEVEL
1. Obtain basic instruction in the operation of all robotic peripheral equipment.	1 2 3
2. Obtain basic instruction covering the safe and proper operation of the robot's mechanical arm and control circuitry.	1 2 3
3. Take a visual inspection course for the applicable product.	1 2 3
4. Obtain training to understand the use of the teach pendant.	2 3
5. Obtain training to acquire the ability to evaluate weld quality when presented with a properly prepared cross-section sample.	2 3
6. Continue education in robotic arc welding related disciplines.	2 3
7. Complete robot operation courses provided by original equipment manufacturers or equivalent robot operation courses.	2 3
8. Obtain training in the proper operation of cross sectioning tools and related hardware such as plasma cutting and band saws.	3
9. Obtain instruction in the applicable destructive testing methods used, such as macroetch or bend testing.	3
10. Receive instruction in the operation of quality measuring tools, including applicable computer software for measuring weld cross sections.	3
11. Complete programming courses offered by original equipment manufacturers or equivalent robotic programming courses.	3
12. Become familiar with personal computers and relevant software.	3

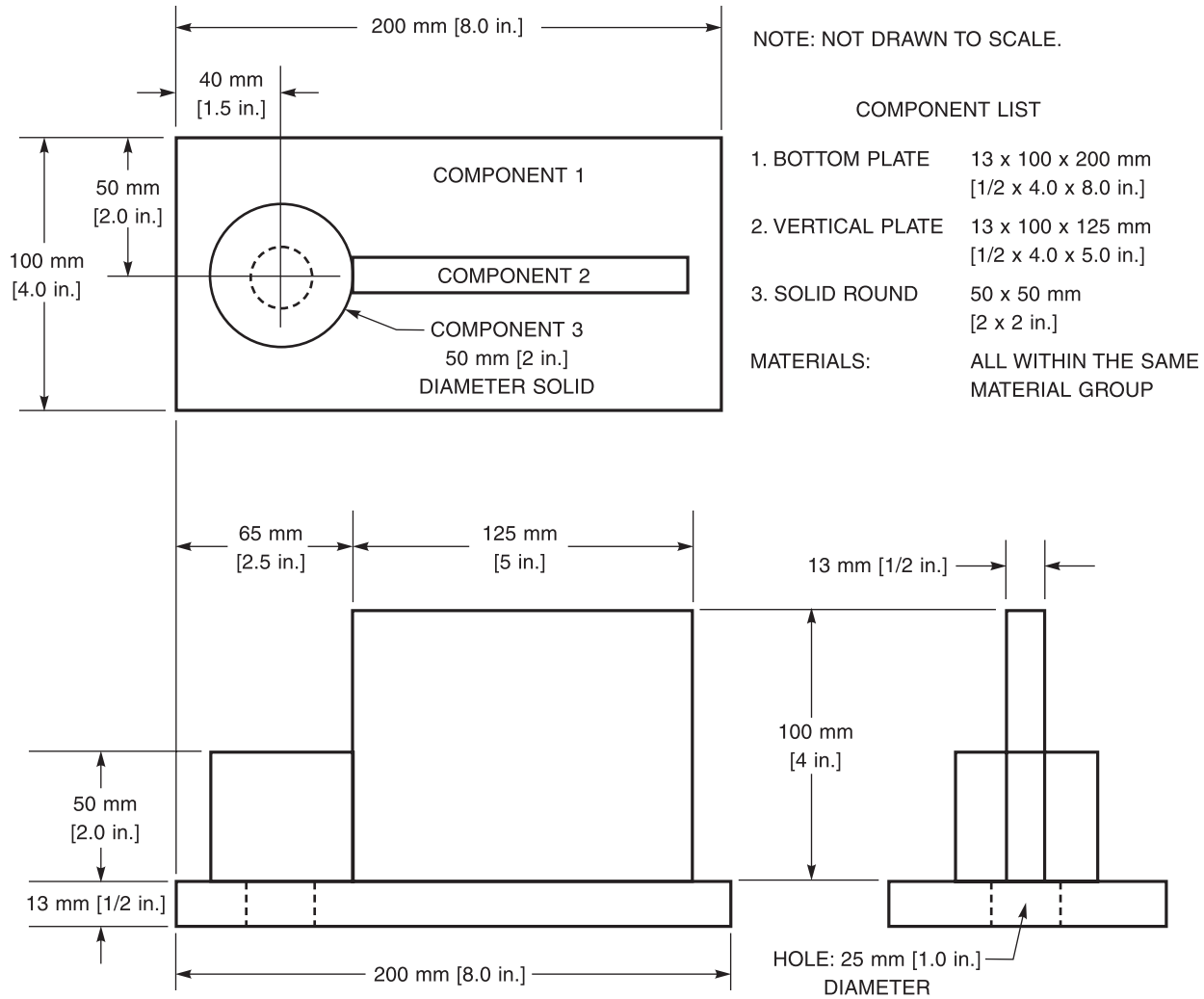


Figure 1—Test Specimen Components, Dimensions, and Layout

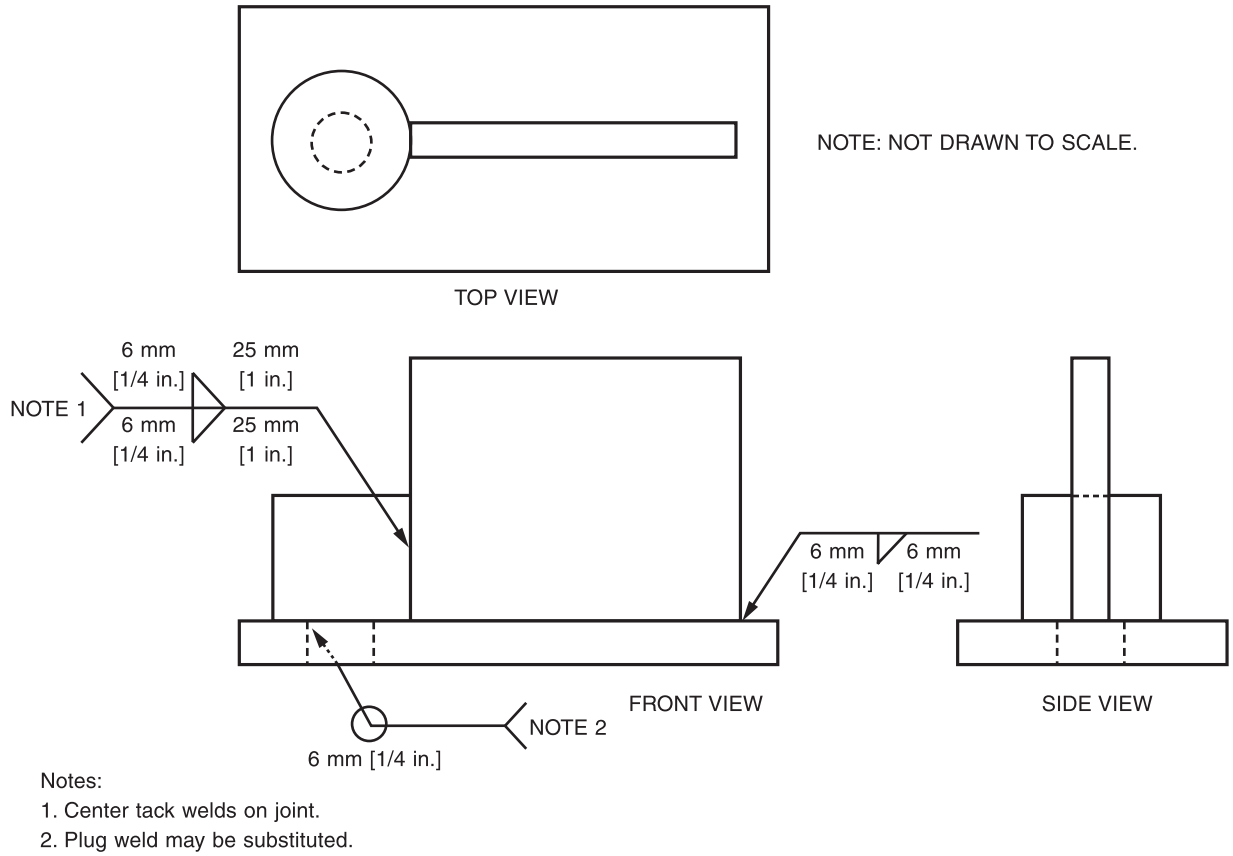
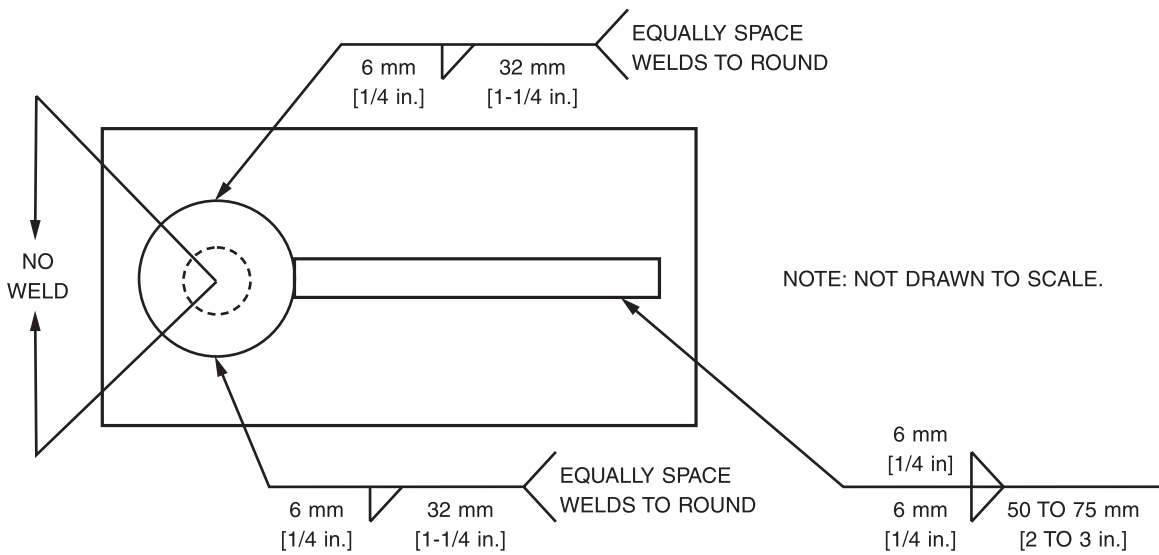


Figure 2—Assembly Specifications for Test Specimens



General Note: Intermittent welds shall have at least two increments.

Figure 3—Specifications for Test Welds

Nonmandatory Annexes

Annex A

Guidelines for Preparation of Technical Inquiries for AWS Technical Committees

(This Annex is not a part of AWS D16.4M/D16.4:2005, *Specification for the Qualification of Robotic Arc Welding Personnel*, but is included for informational purposes only.)

A1. Introduction

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

A2. Procedure

All inquiries must be directed to:

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

All inquiries must contain the name, address, and affiliation of the inquirer, and they must provide enough information for the committee to fully understand the point of concern in the inquiry. Where that point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and should also be in the format used here.

A2.1 Scope. Each inquiry must address one single provision of the standard, unless the point of the inquiry involves two or more interrelated provisions. That provision must be identified in the scope of the inquiry, along

with the edition of the standard that contains the provisions or that the inquirer is addressing.

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

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

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

A3. Interpretation of Provisions of the Standard

Interpretations of provisions of the standard are made by the relevant AWS Technical Committee. The secretary of the committee refers all inquiries to the Chair of the particular subcommittee that has jurisdiction over the portion of the standard addressed by the inquiry. The subcommittee reviews the inquiry and the proposed reply to determine what the response to the inquiry should be. Following the subcommittee's development of the response, the inquiry and the response are presented to the entire committee for review and approval. Upon

approval by the committee, the interpretation will be an official interpretation of the Society, and the secretary will transmit the response to the inquirer and to the *Welding Journal* for publication.

A4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal*.

A5. Telephone Inquiries

Telephone inquiries to AWS Headquarters concerning AWS standards should be limited to questions of a general nature or to matters directly related to the use of the standard. The Board of Directors' policy requires that all AWS staff members respond to a telephone request for an official interpretation of any AWS standard with the information that such an interpretation can be

obtained only through a written request. The Headquarters staff cannot provide consulting services. The staff can, however, refer a caller to any of those consultants whose names are on file at AWS Headquarters.

A6. The AWS Technical Committee

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

Annex B

Bibliography

(This Annex is not a part of AWS D16.4M/D16.4:2005, *Specification for the Qualification of Robotic Arc Welding Personnel*, but is included for informational purposes only.)

- (1) AWS D16.1, *Specification for Robotic Arc Welding Safety*
- (2) AWS/NEMA D16.2, *Standard for Components of Robotic and Automatic Welding Installation*
- (3) AWS D16.3, *Risk Assessment Guide for Robotic Arc Welding*
- (4) AWS AWR, *Arc Welding With Robots: Do's and Don'ts*
- (5) AWS *Safety and Health Fact Sheets*
- (6) ANSI B11.1, *Safety Requirements for Construction, Care, and Use of Mechanical Power Presses*
- (7) ANSI B15.1, *Safety Standard for Mechanical Power Transmission Apparatus* (with ASME)
- (8) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes* (published by the American Welding Society)
- (9) NFPA 79-1994, *Electrical Standard for Industrial Machinery*
- (10) RIA 15.06, *American National Standard for Industrial Robot and Robot Systems*
- (11) UL 1740-95, *Safety Standard for Industrial Robots and Robotic Equipment*

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List of AWS Documents on Robotics and Automatic Welding

Designation	Title
D16.1	<i>Specification for Robotic Arc Welding Safety</i>
D16.2	<i>Guide for Components of Robotic and Automatic Welding Installations</i>
D16.3	<i>Risk Assessment Guide for Robotic Arc Welding</i>
D16.4	<i>Specification for the Qualification of Robotic Arc Welding Personnel</i>
AWR	<i>Arc Welding with Robots: Do's and Don'ts</i>

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