AWS D16.4M/D16.4:2015
An American National Standard

Specification for the Qualification of Robotic Arc Welding Personnel

American Welding Society®

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AWS D16.4M/D16.4:2015
An American National Standard

Approved by the
American National Standards Institute
December 12, 2014

Specification for the Qualification of Robotic Arc Welding Personnel

3rd Edition

Supersedes AWS D16.4M/D16.4:2005

Prepared by the
American Welding Society (AWS) D16 Committee on Robotic and Automatic Welding

Under the Direction of the
AWS Technical Activities Committee

Approved by the
AWS Board of Directors

Abstract

This specification provides requirements for the qualification of robotic arc welding personnel at three different classifications—Operator (O), Technician (T), and Engineer (E).

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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 appropriate technical committee. Such requests should be addressed to the American Welding Society, Attention: Managing Director, Technical Services Division, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex B). With regard to technical inquiries made concerning AWS standards, oral opinions on AWS standards may be rendered. These opinions are offered solely as a convenience to users of this standard, and they do not constitute professional advice. 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 It must be reviewed every five years and if not revised, it must be either reaffirmed or withdrawn.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, 8669 NW 36 St, # 130, Miami, FL 33166.

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Foreword

This foreword is not part of AWS D16.4M/D16.4:2015, *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. The second edition (AWS D16.4M/D16.4:2005) included revisions based on the experience of the certification program for robotic arc welding personnel. This edition reduced the levels of qualification from four to three and aligned education and experience requirements more realistically with those in industry.

This third edition changes the levels of qualification to Level 1—Certified Robotic and Automated Welding Operator (CRAW-O), Level 2—Certified Robotic and Automated Welding Technician (CRAW-T), and Level 3—Certified Robotic and Automated Welding Engineer (CRAW-E) from the second edition's qualification designations of Level 1—CRAW-L1, Level 2—CRAW-O, and Level 3—CRAW-T. Those certified under the second edition certification level designations shall be grandfathered into the corresponding third edition level designation.

This third edition also includes changes to the figures from the second edition. Figures 1 and 2 have been revised and Figure 3 removed. Additional changes that have been made from the 2005 edition are represented by a vertical line in the margin.

The requirements for certification of Robotic Arc Welders are located in the QC19 document.

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, 8669 NW 36 St, # 130, Miami, FL 33166.

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Specification for the Qualification of Robotic Arc Welding Personnel

1. General Requirements

1.1 Scope. This standard provides requirements 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 three levels acronyms are Level 1—Certified Robotic and Automated Welding Operator (CRAW-O), Level 2—Certified Robotic and Automated Welding Technician (CRAW-T), and Level 3—Certified Robotic and Automated Welding Engineer (CRAW-E).

1.2 Units of Measurement. 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.

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard; some safety and health information is provided, but such issues are not fully addressed herein.

Safety and health information is available from the following sources:

American Welding Society:

(1) ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*

(2) AWS Safety and Health Fact Sheets

(3) Other safety and health information on the AWS website

Material or Equipment Manufacturers:

(1) Safety Data Sheets supplied by materials manufacturers

(2) Operating Manuals supplied by equipment manufacturers

Applicable Regulatory Agencies

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

2. Normative References[1]

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

American Welding Society (AWS) standards:[2]

AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination;* and

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*.

3. Terms and Definitions

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying*, provides the basis for terms and definitions used herein. However, the following terms and definitions are included below to accommodate usage specific to this document.

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 operator. The person designated to start, monitor, and stop the intended productive operation of a robot or robot system. An operator may also interface with a robot for productive purposes.

robotic arc welding personnel. Individuals who may be robotic operators, technicians, engineers 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.

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 the skill requirements, experience and educational requirements, and training recommendations for a Robotic Arc Welding Operator—Level 1 applicant. Table 2 lists skill requirements, experience and educational requirements, and training recommendations for a Robotic Arc Welding Technician—Level 2 applicant. Table 3 lists skill requirements, experience and educational requirements, and training recommendations for a Robotic Arc Welding Engineer—Level 3 applicant.

To qualify at a specific Level, one shall demonstrate the ability to complete the required performance objectives for that Level. Table 4 summarizes the requirements and at which level(s) they apply.

The components for the specimen used to conduct the performance welding test 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.

This third edition changes the levels of qualification to Level 1—Certified Robotic and Automated Welding Operator (CRAW-O), Level 2—Certified Robotic and Automated Welding Technician (CRAW-T), and Level 3—Certified Robotic and Automated Welding Engineer (CRAW-E) from the second edition's qualification designations of Level 1—CRAW-L1, Level 2—CRAW-O, and Level 3—CRAW-T. Those certified under the second edition certification level designations shall be grandfathered into the corresponding third edition level designation.

[1] For Informative (non-mandatory) References, see Annex A.
[2] AWS standards are published by the American Welding Society, 8669 NW 36 St, #130, Miami, FL 33166.

Table 1
Performance Qualifications for Robotic Arc Welding Operator—Level 1

To qualify as a Robotic Arc Welding Operator (O), the applicant shall meet the requirements in Sections A and B of Table 1. Section C lists training recommendations.

	A. Skill and Ability Requirements
1.	Identify sources of input power and demonstrate a working knowledge of how to power up the robot and robot ancillary equipment along with peripheral devices such as wire feeders, coolant pumps, and torch cleaner, etc.
2.	Demonstrate routine maintenance of the robotic welding torch including but not limited to demonstrating changing the contact tips, welding electrode feeding equipment, gas diffusers, insulators, and nozzles.
3.	Demonstrate a familiarity with and demonstrate working knowledge of the robot teaching pendant and any robot ancillary control device that is required for the startup, operation, maintenance, and supervision of the robot system.
4.	Identify all safeguarding devices consistent with D16.2 that are incorporated into the robot system. Identification of the safeguards also includes an explanation of their purpose, activation, and recovery.
5.	Demonstrate a working knowledge of the robot system and welding process equipment and a familiarity with the operating instructions.
6.	Demonstrate good mechanical aptitude through the use of tools to maintain the robot system and tooling.
7.	Demonstrate good verbal and written communication skills.
8.	Exhibit knowledge required to create, adjust, and modify robot system programs.
	B. Experience and Education Requirements
1.	Have a minimum of 1000 hours arc welding. Note: hours consist of time on the job employed as a welder, student, engineer and not actual arc on time while under the hood.
2.	High school diploma or equivalent.
	C. Training Recommendations
1.	Receive instruction in the safe use of an arc welding robot system.
2.	Receive instruction in visual weld inspection.
3.	Receive training to include information and knowledge required to create, adjust, and modify robot system programs.

Table 2
Performance Qualifications for Robotic Arc Welding Technician—Level 2

To qualify as a Robotic Arc Welding Technician (T), the applicant shall meet the requirements in Sections A and B of Table 2. Section C lists training recommendations.

A. Skill and Ability Requirements

1.	Satisfy the Robotic Arc Welding Operator skill and ability requirements in Table 1.
2.	Demonstrate the ability to visually inspect welds consistent with the requirements of the applicable welding quality standard.
3.	Perform basic welding inspection using the cross-section, cut, etch, and polish methodology.
4.	Create a robot program from initial requirement to finished welded product using an approved welding procedure.
5.	Modify robot program and parameters using the teach pendant.

B. Experience and Education Requirements

1.	Have a minimum of 1500 hours arc welding experience. The experience includes manufacturing engineering experience that is related to the robot arc welding experience.
2.	An associate's degree or equivalent in a technical field of study or experience.

C. Training Recommendations

1.	Receive instruction in robotic arc welding, inspection and testing, advanced performance functions and related disciplines including but not limited to the science of robot programming and the design and fabrication of welding fixtures and related disciplines.
2.	Receive training to include basic maintenance tasks and knowledge of preventative maintenance requirements.
3.	Receive appropriate robot training.
4.	Receive training to include information and knowledge emphasizing the science of arc welding based upon the AWS D16 suite of standards and the references in Annex A of this standard.

Table 3
Performance Qualifications for Robotic Arc Welding Engineer—Level 3

To qualify as a Robotic Arc Welding Engineer (E), the applicant shall meet the requirements in Sections A and B of Table 3. Section C lists training recommendations.

A. Skill and Ability Requirements

1.	Satisfy the Robotic Arc Welding Technician skill and ability requirements in Table 2.
2.	Demonstrate the ability to be responsible for the overall design and implementation of a robotic or automated welding process.
3.	Demonstrate proficiency to work from technical drawings and create welding process specifications to produce a manufacturing process that includes one or more automated welding processes.
4.	Demonstrate familiarity with physical properties, attributes and features that are critical to producing finished weldments and engineering concepts related to materials, NDE, and destructive testing.

B. Experience and Education Requirements

1.	A four year bachelor's degree or equivalent in engineering or other related science course of study.
2.	AWS CWI certification or equivalent.

C. Training Recommendations

1.	Receive training to include more extensive information and knowledge emphasizing the science of arc welding based upon the AWS D16 suite of standards and the references in Annex A of this standard.
2.	The candidate should be conversant with robot software, programming, and should be able to demonstrate the ability to troubleshoot system errors.

Table 4
Summary of Specifications for Robotic Arc Welding Personnel

	A. Skill and Ability Requirements	Classification
a.	Identify all sources of input power and demonstrate a working knowledge of how to power up all robot and robot ancillary equipment along with peripheral devices such as wire feeders, coolant pumps, and torch cleaners, etc.	O T E
b.	Provide for routine maintenance of the robotic welding torch including but not limited to demonstrating changing the contact tips, gas diffusers, insulators, and nozzles.	O T E
c.	Demonstrate a familiarity with and demonstrate working knowledge of the robot teaching pendant and any robot ancillary control device is required for the startup, operation, maintenance and supervision of the robot system.	O T E
d.	Identify all safeguarding devices, E-stops, systems, and procedures that are incorporated into the robot system production environment. Identification of the safeguards also includes an explanation of their purpose, activation, and recovery.	O T E
e.	Demonstrate a working knowledge of the robot and welding process equipment and a familiarity with the manufacturer's operating instructions.	O T E
f.	Demonstrate the proper procedures for changing the wire feed roll used on robot systems that utilize a wire feeding mechanism. Must demonstrate good mechanical aptitude through the use of tools to maintain the robot or robot tooling.	O T E
g.	Demonstrate good communication skills	O T E

(Continued)

Table 4
Summary of Specifications for Robotic Arc Welding Personnel

	A. Skill and Ability Requirements	Classification
h.	Demonstrate the ability to visually inspect welds consistent with the requirements of the applicable welding quality standard.	T E
i.	Perform basic welding inspection using the cross-section, cut, etch, and polish methodology.	T E
j.	Create a robot program from initial requirement to finished welded product using an approved welding procedure.	T E
k.	Adjust robot program and parameters using the teach pendant.	T E
l.	Demonstrate the ability to be responsible for the overall design and implementation of a robotic or automated welding process.	E
m.	Able to work from technical drawings and create welding process specifications to produce a manufacturing process that includes one or more automated welding processes.	E
n.	Must be familiar with physical properties, attributes and features that are critical to producing finished weldments and engineering concepts related to materials, NDE, and destructive testing.	E
	B. Experience and Education Requirements	
a.	Have minimum of 1000 hours arc welding. Note: hours consist of time on the job employed as a welder, student, engineer and not actual arc on time while under the hood.	O T E
b.	High school diploma or equivalent.	O T E
c.	Have minimum of 1500 hours arc welding experience. The experience includes manufacturing engineering experience that is related to the robot arc welding experience.	T E
d.	An associate's degree or equivalent in a technical field of study or experience.	T E
e.	A four year bachelor's degree or equivalent in engineering or other related science course of study.	E
f.	AWS CWI certification or equivalent.	E
	C. Training Recommendations	
a.	Receive instruction in the safe use of arc welding robots and welding power source equipment.	O T E
b.	Receive instruction in visual weld inspection.	O T E
c.	Receive information and knowledge required to create, adjust, and modify robot system programs.	O T E
d.	Receive training to include basic maintenance tasks and knowledge of preventative maintenance requirements.	O T E
e.	Receive training to include information and knowledge emphasizing the science of arc welding based upon the AWS D16 suite of standards and the references in Annex A of this standard.	T
f.	Receive appropriate robot training.	T E
g.	Receive instruction in robotic arc welding, inspection and testing, advanced performance functions and related disciplines including but not limited to the science of robot programming and the design and fabrication of welding fixtures and related disciplines.	T E
h.	Receive training to include more extensive information and knowledge emphasizing the science of arc welding based upon the AWS D16 suite of standards and the references in Annex A of this standard.	E
i.	The candidate should be conversant with robot software, programming, and should be able to demonstrate the ability to troubleshoot system errors.	E

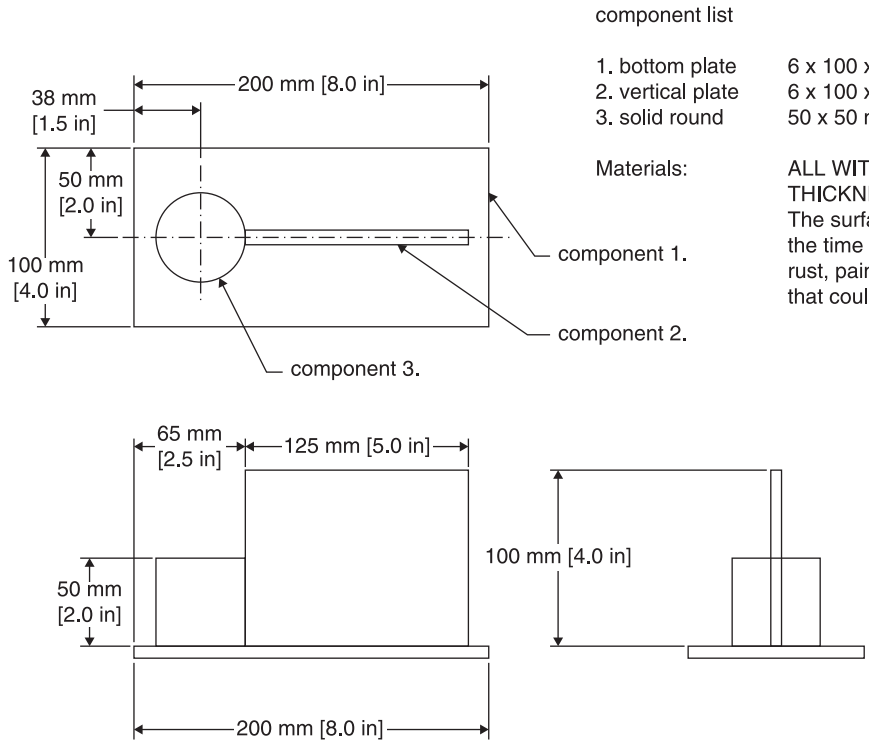

Figure 1—Test Specimen Components, Dimensions, and Layout

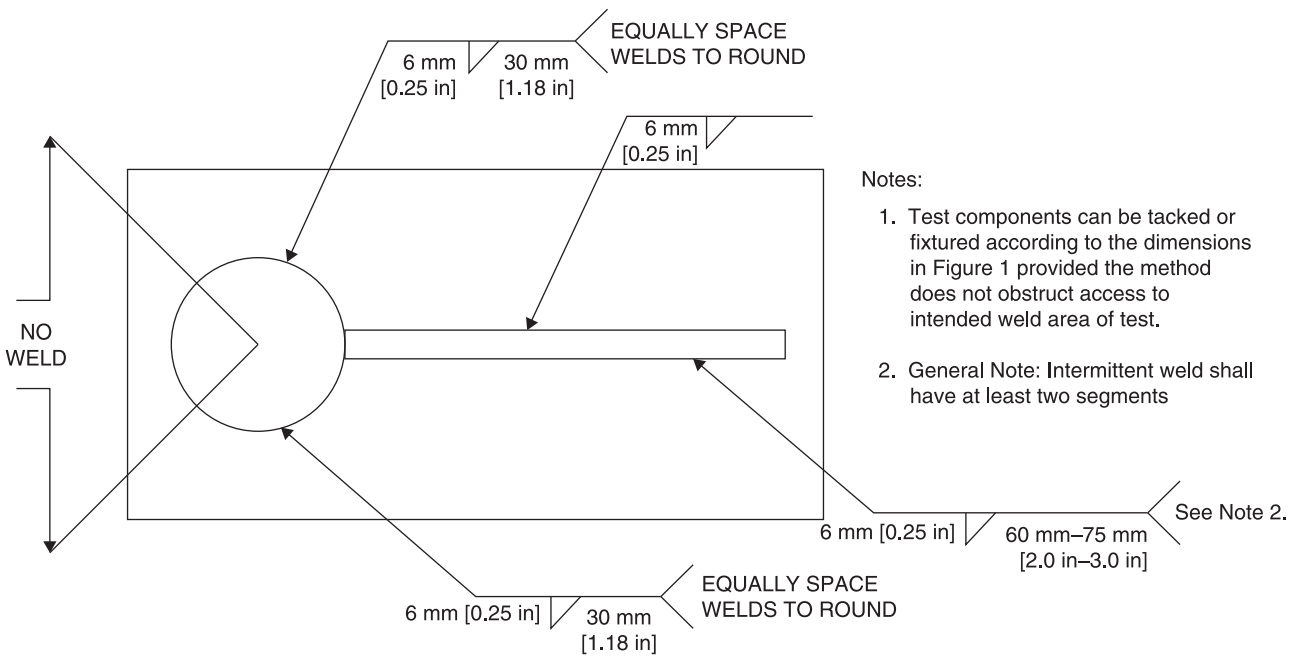

Figure 2—Assembly Specifications for Test Specimens

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Annex A (Informative)
Bibliography

This annex is not part of AWS D16.4M/D16.4:2015, *Specification for the Qualification of Robotic Arc Welding Personnel*, but is included for informational purposes only.

AWS D16.1, *Specification for Robotic Arc Welding Safety*

AWS/NEMA D16.2, *Standard for Components of Robotic and Automatic Welding Installation*

AWS D16.3, *Risk Assessment Guide for Robotic Arc Welding*

AWS AWR, *Arc Welding With Robots: Do's and Don'ts*

AWS *Safety and Health Fact Sheets*

ANSI B11.0, *Safety of Machinery: General Requirements and Risk Assessment*

ANSI B11.18, *Machine Tools—Safety Requirements for Machines Processing or Slitting Coiled or Non-Coiled Metal*

ANSI B11.19, *Performance Requirements for Safeguarding*

ANSI/RIA 15.06, *Robot Safety Standards*

ANSI Z49.1, *Safety in Welding, Cutting and Allied Processes (*published by the American Welding Society)

NFPA 51B, *Standard for Fire Prevention during Welding, Cutting, and other Hot Work*

NFPA 70, *National Electrical Code*

NFPA 79, *Electrical Standard for Industrial Machinery*

UL 1740, *Safety Standard for Industrial Robots and Robotic Equipment*

US Code of Federal Regulations, *29 CFR 1910 Occupational Safety and Health Standards*

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.

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Annex B (Informative)
Guidelines for the Preparation of Technical Inquiries

This annex is not part of AWS D16.4M/D16.4:2015, *Specification for the Qualification of Robotic Arc Welding Personnel*, but is included for informational purposes only.

B1. Introduction

The American Welding Society (AWS) Board of Directors has adopted a policy whereby all official interpretations of AWS standards are handled in a formal manner. Under this policy, all interpretations are made by the committee that is responsible for the standard. Official communication concerning an interpretation is directed 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.

B2. Procedure

All inquiries shall be directed to:

Managing Director
Technical Services Division
American Welding Society
8669 NW 36 St, # 130
Miami, FL 33166

All inquiries shall contain the name, address, and affiliation of the inquirer, and they shall provide enough information for the committee to understand the point of concern in the inquiry. When the point is not clearly defined, the inquiry will be returned for clarification. For efficient handling, all inquiries should be typewritten and in the format specified below.

B2.1 Scope. Each inquiry shall address one single provision of the standard unless the point of the inquiry involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the inquiry along with the edition of the standard that contains the provision(s) the inquirer is addressing.

B2.2 Purpose of the Inquiry. The purpose of the inquiry shall be stated in this portion of the inquiry. The purpose can be to obtain an interpretation of a standard's requirement or to request the revision of a particular provision in the standard.

B2.3 Content of the Inquiry. The inquiry should be concise, yet complete, to enable the committee to understand the point of the inquiry. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annex) that bear on the inquiry shall be cited. If the point of the inquiry is to obtain a revision of the standard, the inquiry shall provide technical justification for that revision.

B2.4 Proposed Reply. The inquirer should, as a proposed reply, state an interpretation of the provision that is the point of the inquiry or provide the wording for a proposed revision, if this is what the inquirer seeks.

B3. 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 is an official interpretation of the Society, and the secretary transmits the response to the inquirer and to the *Welding Journal* for publication.

B4. Publication of Interpretations

All official interpretations will appear in the *Welding Journal* and will be posted on the AWS web site.

B5. 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 AWS *Board Policy Manual* 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. Headquarters staff cannot provide consulting services. However, the staff can refer a caller to any of those consultants whose names are on file at AWS Headquarters.

B6. AWS Technical Committee

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees or to consideration of revisions to existing provisions on the basis of new data or technology. Neither AWS staff nor the committees are in a position to offer interpretive or consulting services on (1) specific engineering problems, (2) requirements of standards applied to fabrications outside the scope of the document, or (3) 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.

List of AWS Documents on Robotics and Automatic Welding

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

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