AWS B5.16:2025
An American National Standard

Specification for the Qualification of Welding Engineering Personnel

American Welding Society®

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An American National Standard

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American National Standards Institute
June 28, 2024

Specification for the Qualification of Welding Engineering Personnel

3rd Edition

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Prepared by the
American Welding Society (AWS) Qualification and Certification Committee

Under the Direction of the
AWS Technical Activities Committee

Approved by
AWS Board of Directors

Abstract

This specification establishes the requirements for qualification of Welding Engineering Technologists and Welding Engineers employed in the welding industry. The minimum experience, examination, application, qualification, and requalification requirements and methods are defined herein. This specification is a method for engineering personnel to establish a record of their qualification and abilities in welding industry work such as development of procedures, processes controls, quality standards, problem solving, etc.

American Welding Society®

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Personnel

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Foreword

This foreword is not part of this standard but is included for informational purposes only.

The Qualification and Certification Committee of the American Welding Society was formed in 1973. In 1996, it was divided into two committees. The Personnel and Facilities Qualification Committee (PFQC) was assigned responsibility for creating American National Standards for welding personnel and welding facility qualification requirements. The AWS Certification Committee was assigned responsibility for creating certification programs from these and other recognized Standards. The PFQC was formed and assigned the task of creating an American National Standard for the qualification of welding engineers. This new subcommittee was comprised of welding industry professionals that included AWS Past Presidents; representatives of academic institutions with welding engineering/technology programs; petrochemical, power generation, automotive, aerospace, and ship building industry representatives and consultants; and AWS staff members. The first edition of AWS B5.16, *Specification for the Qualification of Welding Engineers*, was published in 2001. The second edition was published in 2006 after completing an extensive review process under the AWS Technical Activities Committee Rules of Operation.

In 2016, the PFQC and Certification subcommittees were again joined and identified as the Qualification and Certification Committee.

This is the third edition of this specification and changes have been made to implement a competency taxonomy between welding engineering technologists and welding engineering roles and align these competencies to job tasks of experienced graduates from Accreditation Board for Engineering and Technology (ABET) accredited engineering colleges. The changes are widespread enough that clear markup of the changes is difficult and therefore not shown. The taxonomy provides a qualification structure to clearly differentiate the competencies between Welding Engineering Technologist and Welding Engineer. This standard for the qualification of welding engineering personnel was developed to provide a qualification basis which defines minimum requirements for welding engineering technologists and welding engineers to demonstrate competence through a combination of education, experience, and examination.

Bloom's taxonomy is used to differentiate the cognitive levels and competencies between the following roles:

Welding Engineering Technologist	Remember, Understand, Apply, Analyze
Welding Engineer	Remember, Understand, Apply, Analyze, Evaluate, Create

Action verbs associated with Bloom's taxonomy are used to differentiate job duties, bodies of knowledge, and exam structures.

The Welding Engineering Technologist (WET) is able to understand, apply, and analyze welding and allied technologies including design, materials, processes, quality, and economic considerations for defined welding applications. For advanced welding applications that require engineering analysis to evaluate, design, and develop the application, the WET coordinates requirements between engineering and production or fabrication. The WET shall be familiar with various codes, standards, specifications, base materials, filler materials, heat treatment, mechanical properties, welding processes and procedures, welding equipment, quality assurance systems, inspection methods, acceptance standards, various test methods, welder and welding operator qualification, welding procedure qualification requirements, fabrication tolerances, and other aspects of fabrication and assembly with which the welding technologist may be involved. The WET prepares and reviews written instructions to produce weldments. The WET shall also prepare and produce reports which reflect professional judgments. For the WET to be effective, the activities performed shall be consistent with specified requirements, technical and ethical principles. The WET must be able to work with the engineer, technician, inspector, welder, and others involved in the project; and appreciate the role of each in the development of weldments.

The Welding Engineer (WE) is a person who understands, applies, analyzes, and evaluates weld requirements which may be governed under a specific code, contract, drawing, specification, purchase order, or other documents. The WE either prepares or reviews written instructions for the production of welded joints. The WE must be familiar with various codes, specifications, other standards, base materials, filler materials, heat treatment, mechanical properties, welding and joining processes, procedures, weld joint design, welding equipment, thermal cutting, inspection methods, acceptance criteria, tests, welding qualification requirements, fabrication tolerances, and other aspects of fabrication and assembly. The WE shall also prepare and produce reports which accurately reflect professional judgment. For the welding engineer to be effective, activities shall be performed in a manner consistent with specified requirements and technical and ethical principles. The WE must be able to work with management representatives, engineers of various disciplines, engineering technologists, welding coordinators, technicians, inspectors, welding, and trade personnel and should be able to understand the role of each in the development of weldments.

Errata. It is the Qualification and Certification Committee's Policy that all errata should be made available to users of this document. Therefore, any significant errata will be published in the Society News Section of the *Welding Journal* and posted on the AWS web site at: http://www.aws.org/standards/page/errata.

Suggestions. Your comments for improving AWS B5.16, *Specification for Qualification of Welding Engineering Personnel* are welcome. Submit comments to the Secretary of the Qualification and Certification Committee, American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

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Specification for Qualification of Welding Engineering Personnel

1. General Requirements

1.1 Scope. This specification establishes qualification requirements for Welding Engineering Technologists (WET) and Welding Engineers (WE). It describes how qualifications are determined, and the manner by which qualification may be attained and maintained.

1.1.1 This specification establishes the qualification requirements for these individuals and specifies the bodies of knowledge for examinations that will test their comprehension of engineering fundamentals and their ability to apply the principles of welding engineering.

1.1.2 This specification is intended to supplement the minimum requirements of employers, codes, other standards, or documents and shall not be construed as a preemption of the employer's responsibility for the work or for the performance of the work.

1.1.3 Employers shall be responsible for determining that their employees, having qualified as WETs or WEs, are capable of performing the specific duties involved in their work assignments.

1.2 Units of Measurement. This standard does not require units of measure. Therefore, no equivalents or conversions are contained except when they are cited in examples.

1.3 Safety. Safety and health issues and concerns are beyond the scope of this standard and therefore are not 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.

1.4 As used in this specification, the word ***shall*** denotes a requirement, the word ***should*** denotes a guideline, and the word ***may*** denotes a choice.

2. Normative References

The documents listed below are referenced within this publication and are mandatory to the extent specified herein. For undated references, the latest edition of the referenced standard shall apply. For dated references, subsequent amendments or revisions of the publications may not apply since the relevant requirements may have changed.

American Welding Society (AWS) documents:

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*

AWS D1.1/D1.1M, *Structural Welding Code—Steel*

AWS D14.0/D14.0M, *Machinery and Equipment Welding Specification*

AWS QC1, *Specification for AWS Certification of Welding Inspectors*

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

American Society of Mechanical Engineers (ASME) documents:

ASME *Boiler and Pressure Vessel Code, Section VIII, Division 1*

ASME BPVC B31.3, *Process Piping*

3. Terms and Definitions

AWS A3.0M/A3.0, *Standard Welding Terms and Definitions*, 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.

certification. A credential attesting to a type or level of qualification.

contact hour. A measure representing a minimum fifty (50) minute period of scheduled instruction.

continuing education unit (CEU). A measure used in continuing education programs to assist a WET or WE to maintain certification. A CEU is equivalent to ten (10) contact hours.

qualification. Process of demonstrating whether an entity or individual is capable of fulfilling specified requirements.

4. Qualification

This standard defines the qualification requirements for two (2) levels of welding engineering personnel as follows:

4.1 Welding Engineering Technologist (WET). An individual with the required education, experience, and knowledge specified in Part A—Clauses 6 and 7, and who successfully passes the required examinations described in Part A—Clause 8, shall be considered qualified as a WET.

4.2 Welding Engineer (WE). An individual with the demonstrated education, experience, and knowledge specified in Part B—Clauses 11 and 12, and who successfully passes the required examinations described in Part B—Clause 13, shall be considered qualified as a WE.

4.2.1 Qualification as a WE in accordance with this specification alone may not legally qualify these personnel for provision of technical services to the public when contract documents, building, or jurisdiction laws require such services be performed under the direction and responsibility of a registered and licensed Professional Engineer (PE). As such, designation as a Welding Engineer **DOES NOT** imply the status of a registered PE under the laws of any state or other governmental entity.

Part A
Requirements for Welding Engineering Technologists (WET)

5. Functions

The WET shall be capable of selecting, implementing, reviewing, coordinating and ensuring those operations associated with the production of weldments are completed in accordance with the applicable codes, standards, and other documents to produce a satisfactory product. The WET's duties may begin before production work, continue through the production process, and may not end until after the production process is completed. Each employer is responsible for defining the specific duties of a WET in the place of employment. The WET shall be able to demonstrate their ability to perform the activities of this standard. The capabilities of a WET include the following:

5.1 Welding Engineering Technologist Responsibilities. The WET shall be considered competent to perform assigned job functions at a cognitive level that includes the ability to effectively *remember*, *understand*, *apply*, and *analyze* (per Bloom's taxonomy) technical principles and requirements in the topical areas below. Demonstration of the required knowledge related to each of these responsibilities is addressed in Clause 8.

5.1.1 Welding and Cutting Safety. The WET shall be knowledgeable of safety practices as they pertain to welding, cutting, and joining processes. This individual shall be capable of identifying issues related to unsafe processes and practices and facilitating corrective measures to alleviate identified concerns.

5.1.2 Welding, Joining, and Allied Processes. The WET shall demonstrate a working knowledge of fusion welding, brazing, and soldering and have a general understanding of high energy beam welding and solid-state welding. The WET shall have knowledge of the competencies below related to welding, joining, and allied processes and be capable of effectively communicating with others regarding their application. While the ability to utilize these processes is desirable, it is not considered a requirement if the WET is capable of determining whether the processes are being applied correctly in accordance with documented procedures.

The WET shall have knowledge of the following competencies:

(1) Possessing a detailed understanding of the fundamental principles of commonly used welding and cutting processes;

(2) Possessing a working knowledge of each process to determine if a given process is suited for a given application and capable of operating effectively to produce sound welds;

(3) Evaluating and adjusting welding and cutting apparatus and consumables;

(~~4~~) Understanding the various types of welding and cutting power sources and how they are adjusted to comply with applicable welding procedure specifications;

(5) Understanding the AWS filler metal classification systems and being capable of reviewing material test records for compliance with applicable specifications;

(6) Reviewing qualification requirements and determining what test coupons, welding variables, materials, etc., are required for effective procedure or performance qualification;

(7) Conducting welding procedure and performance qualification tests and fully documenting in accordance with applicable welding standards;

(8) Understanding safety requirements and hazards associated with welding and cutting process, being prepared to enforce those requirements, and determining what precautions are required for safe operation and protection of personnel;

(9) Selecting welding equipment, fixtures, and apparatus based on application and procedure requirements;

(10) Ensuring welding procedure specifications and performance qualification records exist and are appropriate for application and code requirements;

(11) Using measurement and data acquisition devices for equipment calibration and process monitoring;

(12) Selecting preferred welding or joining processes based on material, thickness, joint design, and position based on production and welding standards requirements;

(13) Understanding various base material preparation processes and their proper application for different alloy systems and job specifications;

(14) Calculating welding costs based on materials, process performance, schedules, and labor rates;

(15) Analyzing welding process performance for conformance with applicable procedures to ensure soundness and reproducibility;

(16) Comparing economics of different welding processes to minimize cost and/or achieve productivity while maintaining quality requirements;

(17) Understanding fundamentals of various destructive and nondestructive methods for evaluation of the effectiveness of welding procedures for compliance with applicable standards;

(18) Analyzing effects of welding consumables, process parameters, and resulting properties to meet or exceed application requirements;

(19) Determining the cause(s) of discrepant welds (e.g., welding technique, equipment, consumables); and

(20) Selecting mechanized, automated, or robotic systems and ancillary equipment based on process production requirements; and setting up, programming, and operating these systems.

The WET shall be capable of effectively communicating with others regarding the above requirements, their interpretation, application, and analysis.

5.1.3 Material Properties and Welding Metallurgy. The WET shall have an understanding of ferrous and nonferrous materials. The WET shall have an understanding of the effects of welding on these materials in terms of the resulting properties and dimensions of weldments. The WET shall have knowledge in the following competencies related to materials and welding metallurgy:

(1) Understanding physical metallurgy and changes occurring as a result of the welding operation;

(2) Understanding corrosion and changes in corrosion properties resulting from the welding operation;

(3) Understanding the principles of heat treatment of materials, including review of heat treatment procedures and heat treatment records in terms of compliance with applicable standards;

(4) Understanding the effects on material properties of forming, cutting, and other preparation processes;

(5) Classifying alloys in terms of chemical composition and mechanical properties and resulting effects on weldability;

(6) Reviewing chemical composition and mechanical property data for compliance with applicable standards;

(7) Using metallographic examinations to measure and analyze weld macrostructures;

(8) Understanding the principles of mechanical tests used for procedure and performance qualification and interpretation of test results for compliance with applicable standards;

(9) Understanding heat flow in metals during welding and resulting effects on weldment dimensions and microstructures of weld metal and heat-affected zones (HAZs); and

(10) Identifying distortion and understanding measures for reducing distortion by analyzing causative effects of heat input, material properties, joint design, and weld sequencing.

The WET shall be capable of effectively communicating with others regarding the above requirements, as well as their interpretation, application, and analysis.

5.1.4 Welding Design and Joint Configurations. The WET shall be capable of applying generally accepted engineering technology principles related to the design of welded structures or weldments manufactured using processes in accordance with applicable requirements or standards. This understanding shall include knowledge of design requirements of applicable fabrication standards, how those designs, including joint designs, are communicated on drawings, and how those requirements are interpreted and applied.

The WET shall possess knowledge in the following competencies related to welding design:

(1) Using and interpreting welding symbols;

(2) Applying principles of drawing interpretation, with basic knowledge of computer-aided design (CAD) an added benefit;

(3) Applying basic principles of static and cyclic structural loads and how these are addressed in welding standards, especially in terms of the types of welds specified and resulting acceptance criteria;

(4) Understanding types of weld joints, groove preparations, and the practical aspects of executing specified designs in terms of accessibility, sequencing, welding processes being applied, and applicable standards;

(5) Analyzing the effectiveness of joint designs in terms of cost of preparation and welding;

(6) Using welding standards for selection and implementation of joint designs for structures, machinery, and equipment;

(7) Selecting materials and processes meeting design requirements;

(8) Classifying common joint connections in structures, machinery, and equipment;

(9) Assessing material properties in terms of strength, ductility, toughness, hardness, etc., for conformance with design requirements; and

(10) Analyzing welded joints using mechanical testing.

The WET shall be capable of effectively communicating with others regarding the above requirements, as well as their interpretation, application, and analysis.

5.1.5 Quality Assurance, Quality Control, and Nondestructive Examination (NDE). The WET shall understand the principles and practices related to quality assurance systems and quality control activities and be capable of actively participating in the implementation of these practices. The WET shall be knowledgeable in all aspects of quality control and understand requirements for welding procedure qualification, and welder and operator performance qualification, including destructive and nondestructive testing. The WET shall understand visual inspection of welds and related acceptance criteria. The WET shall understand the advantages and limitations of NDE and be capable of recommending the appropriate NDE methods for a particular weldment.

The WET shall have knowledge of the following competencies related to quality assurance, quality control, and NDE:

(1) Understanding general concepts and principles of quality assurance (QA) and quality control (QC) and their interrelationships;

(2) Understanding the roles and qualifications of various QA and QC personnel and their interaction to ensure conformance with applicable standards;

(3) Reviewing documentation defining these activities, including quality manuals, quality control procedures, NDE procedures, nonconformance reports, and understanding requirements for compliance;

(4) Understanding weld quality systems, including processes for correction of identified nonconformances;

(5) Using and interpreting symbols for welding and NDE;

(6) Understanding various inspection personnel qualifications defined by AWS, the American Society for Nondestructive Testing (ASNT), and others;

(7) Reviewing job specifications to determine inspection requirements and acceptance criteria;

(8) Interpreting requirements for NDE, including magnetic particle, penetrant, radiographic, ultrasonic, and visual methods;

(9) Understanding basic principles of magnetic particle and penetrant methods for surface examination;

(10) Understanding basic principles of radiographic and ultrasonic methods for volumetric examination;

(11) Understanding which NDE methods are appropriate and preferred for various welding applications based on materials, types of discontinuities to be detected, and standard requirements;

(12) Understanding the comparative economics of various inspection methods considering materials, process capabilities, and personnel training and qualification requirements;

(13) Conducting visual inspection of all elements of the welding operation, before, during, and after welding. The WET is encouraged to achieve qualification as an AWS Certified Welding Inspector;

(14) Understanding the types, characteristics, and causes of weld and base metal discontinuities;

(15) Understanding common causes of weld discontinuities resulting from improper application of welding processes;

(16) Interpreting and applying acceptance criteria for these discontinuities in accordance with applicable standards;

(17) Reviewing NDE reports for conformance with applicable standards; and

(18) Reviewing and completing applicable production control documents to ensure adequate identification and traceability of materials and successful completion of processing steps.

The WET shall be capable of effectively communicating with others regarding these requirements, as well as their interpretation, application, and analysis.

6. Education, Experience, and Credential Requirements for Examination Eligibility

While achievement of the WET credential shall be determined by successfully passing the required examinations as specified in 8.1, it is recognized that eligibility for these examinations may be attained using various combinations of education and experience, as well as possessing recognized credentials. Table 6.1 summarizes the various paths for eligibility based on level of education and relevant experience, or credential and relevant experience. Clause 6.1 specifies what is relevant experience for examination eligibility.

6.1 Relevant Experience. Experience shall be defined as activities in one or more of the areas listed below. This experience may be gained concurrently with education and shall include that time working at the respective education level shown in Table 6.1 and Figure 6.1.

Table 6.1
Minimum Education, Experience, and Credential Requirements for Examination Eligibility (see 6.1)

Education[a]	Experience, yr.	Credential	Experience, yr.	Examination Eligibility
BSc Welding Engineering Technology	1	-	—	8.1.1, 8.1.2, 8.1.3
BSc Welding Engineering Technology	1	+ CWI	—	8.1.3
BSc Engineering (other than Welding)	2	-	—	8.1.1, 8.1.2, 8.1.3
BSc Engineering (other than Welding)	2	+ CWI	—	8.1.3
BSc Engineering Technology (other than Welding)	3	-	—	8.1.1, 8.1.2, 8.1.3
BSc Engineering Technology (other than Welding)	3	+ CWI	—	8.1.3
Associate degree in Welding Technology	4	—	—	8.1.1, 8.1.2, 8.1.3
Associate degree in Welding Technology	4	+ CWI	—	8.1.3
Associate degree in Technology (other than Welding)	5	—	—	8.1.1, 8.1.2, 8.1.3
Associate degree in Technology (other than Welding)	5	+ CWI	—	8.1.3
AWS Senior Certified Welding Inspector (SCWI)	—	—	2	8.1.3
IIW International Welding Technologist (IIW IWT)	—	—	1	8.1.2, 8.1.3

[a] Engineering diplomas from accredited universities, technical colleges, and polytechnics are considered equivalent for each of the listed categories.

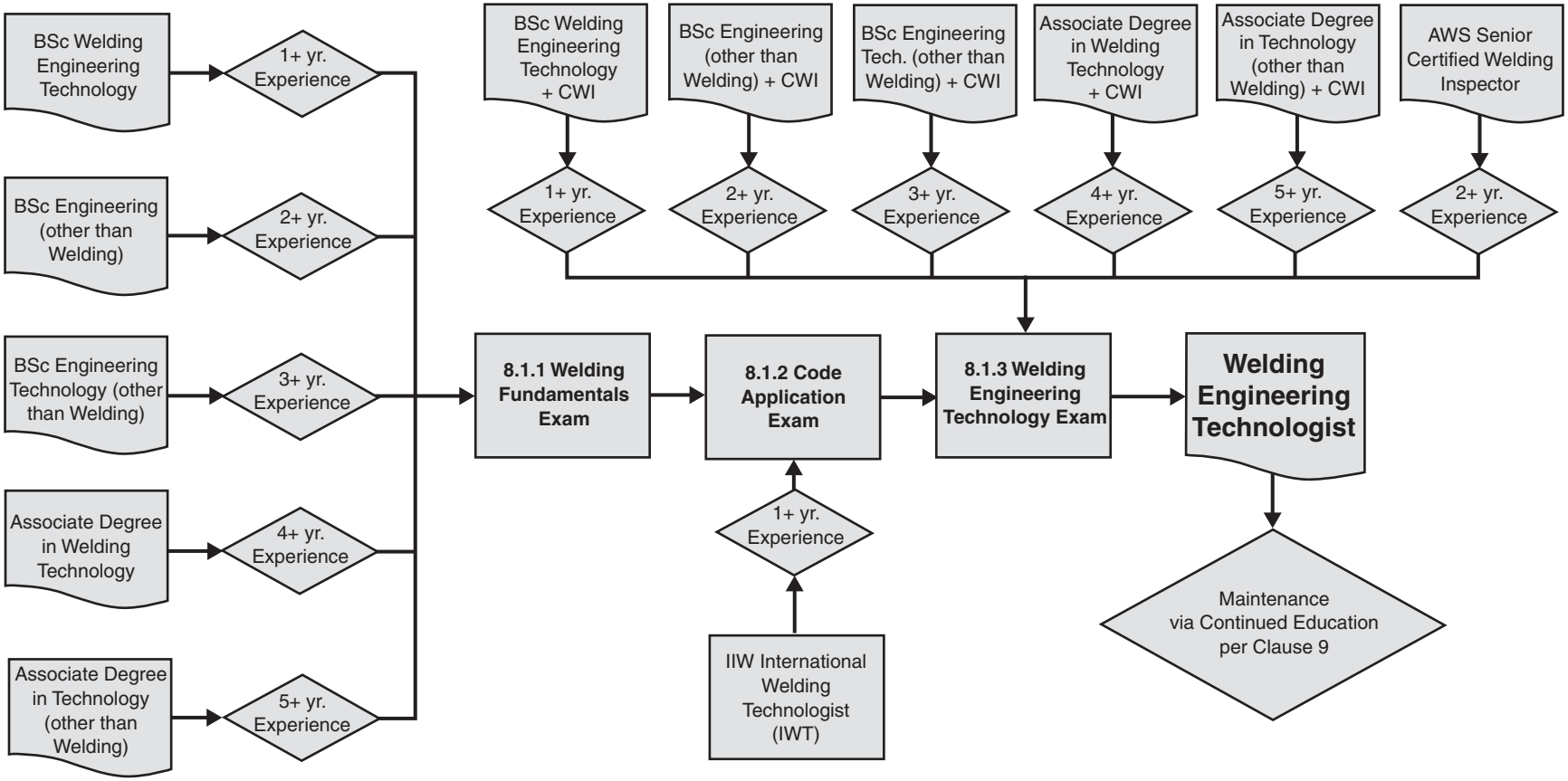

Figure 6.1—Flowchart Showing Paths To Qualification As Welding Engineering Technologist (see 6.1)

6.1.1 Manufacturing. Experience shall consist of overseeing, applying, or operating welding process lines or cells for the manufacture of welded products such as automobiles, appliances, welded pipe, or other welded products.

6.1.2 Fabrication. Experience shall consist of overseeing, applying, or operating welding processes and systems used to fabricate welded products. Fabricated products may be covered by national, customer, or internal standards or specifications.

6.1.3 Construction. Experience shall consist of overseeing, applying, and implementing welding and quality requirements on welding construction projects such as buildings, pipelines, ships, refineries, offshore oil rigs, and power generation facilities being constructed in accordance with national, customer, or internal standards or specifications.

6.1.4 Research and Development. Experience shall consist of research and development to enhance welded products or processes, welding materials, manufacturing methods, fabrication techniques, field erection of welded products, or the selection and optimization of welding manufacturing systems.

6.1.5 Training. Experience shall consist of instructing courses in various welding topics or related technologies. This training shall be at an associate or baccalaureate level.

7. Body of Knowledge

Welding Engineering Technologists (WETs) focus on the application and implementation of welding using technical and applied engineering principles. Welding Engineering Technologists typically require knowledge of algebra, geometry, trigonometry, and other analytical approaches, all of which are more practical than theoretical in nature. With that as a basis, they are capable of understanding and applying technical aspects of welding and allied processes, materials, and basic design principles so that applicable quality requirements are achieved in the most effective and efficient manner possible. The body of knowledge items for each examination defined in Clause 8 are defined in Annex A.

8. Examination Requirements

Figure 6.1 shows paths to achieving qualification as a WET based on various initial technical levels. Individuals seeking qualification as a WET shall successfully complete examinations on Welding Fundamentals, Welding Engineering Technology, and Code Application. These examinations are independent of each other and may be taken in any order. The examination questions shall be drawn from the body of knowledge in Clause 7 and Annex A.

The Welding Fundamentals examination evaluates the candidate's ability to remember and understand welding terms and definitions, the components of welding processes, application of welding and allied processes, and application of NDE processes. This is a closed book examination. Completion and passage of the AWS Certified Welding Inspector (CWI) Fundamentals examination is considered as satisfaction of this requirement. The Welding Engineering Technology examination evaluates the candidate's ability to understand, apply, and analyze the following core areas: welding, joining, and allied processes; materials and welding/joining metallurgy; welding design and joint configurations; and quality assurance, quality control, and NDE. This exam requires knowledge of engineering units and qualitative relationships for each core area. Calculations require knowledge of algebra, geometry, and trigonometry. Knowledge of common equations is required for common physical, mechanical, and electrical relationships used in welding. The Code Application examination evaluates the candidate's abilities to apply and analyze the requirements of an internationally or nationally recognized welding code or standard (e.g., AWS D1.1, *Structural Welding Code—Steel*, AWS D14.0, *Machinery and Equipment Welding Specification,* ASME BPVC B31.1, *Pressure Piping* ASME BPVC B31.3, *Process Piping,* ASME BPVC Section VIII Division 1). Completion of a CWI Code Application or Endorsement examination applicable to one of these standards is considered as satisfaction of this requirement.

8.1 Examination Structure. Individuals seeking qualification as a WET shall successfully complete the following examinations described in 8.1.1, 8.1.2, and 8.1.3, with content summarized in Tables 8.1, 8.2, and 8.3, respectively. Those required examinations may be completed in any order. Tables 8.1 through 8.3 list percentages of questions from each of the listed Domains and Subdomains. References forming the technical basis for questions on the Welding Engineering Technology (Table 8.3) examination are specified in Annex B.

8.1.1 Welding Fundamentals Examination. The individual shall pass an examination covering various topics related to the fundamentals of applying, controlling, and inspecting welding. Those topics contained in the examination and the number of questions from each Domain are listed in Table 8.1.

8.1.2 Welding Code Application Examination. The individual shall pass an examination covering various topics related to the use, interpretation, and application of the requirements of a selected code or standard. Those topics contained in the examination and the numbers of questions from each Domain are listed in Table 8.2.

8.1.3 Welding Engineering Technology Examination. The individual shall pass an examination covering various topics considered to be essential for a WET to function effectively in that position. Those topics contained in the examination and the number of questions from each Domain/Subdomain are listed in Table 8.3.

8.2 Examination Eligibility for AWS Senior Certified Welding Inspector (SCWI). The Welding Fundamentals portion of the examination requirements described in Table 8.1 is fulfilled without examination by completion and passage of AWS Senior Certified Welding Inspector (SCWI) examinations. Completion of the CWI Code Application examination or a Code Endorsement examination are considered as satisfaction of the Code Application requirement described in Table 8.2. All these examinations are governed by the requirements of AWS QC1, *Specification for AWS Certification of Welding Inspectors.*

Table 8.1
Welding Fundamentals Examination

Domain	Minimum Percentages of Total Questions
Definitions and terminology	12
Welding and cutting processes	12
Symbols-welding and NDE	10
Visual examination	10
Welding application and control	9
NDE fundamentals	8
Base metals, heat treatments, and ferrous metallurgy	6
Welding-related calculations	6
Duties and responsibilities	4
Destructive testing fundamentals	3

Table 8.2
Welding Code Application Examination

Domain	Minimum Percentages of Total Questions
Qualification	25
Fabrication	25
Inspection	25
Reports and records	5
Material properties and joint design	5

Table 8.3
Welding Engineering Technology Examination

Domain/Subdomain	Minimum Percentages of Total Questions
Welding, Joining, and Allied Processes	**35**
Arc welding processes	8
Electrical circuits & measurements	5
Arc welding power sources	5
Arc physics, arc energy, and heat input	3
Arc welding procedure and performance qualification	3
Resistance welding processes	3
High energy beam welding processes	2
Solid-state welding	1
Thermal cutting processes	1
Welding and cutting safety	1
Materials and Welding/Joining Metallurgy	**30**
Welding metallurgy of steels and stainless steels	8
Welding metallurgy of nonferrous alloys	4
Mechanical and physical properties of materials	4
Regions of a weld in fusion welding and expected properties	4
Effect of carbon equivalent of carbon and low alloy steels on preheat and interpass temperatures	2
Effects of welding procedure variables on chemical and mechanical properties	2
Metal processing methods (casting, forming, forging, etc.)	2
Heat treatment of steels	1
Welding Design and Joint Configurations	**15**
Structural welding design	4
Joint configurations and their effect on soundness and productivity	3
Heat flow behavior in welding	2
Thermal stresses, residual stresses, weld sequencing, and distortion	3
Design drawings and welding symbols	3
Quality Assurance, Quality Control, and NDE	**10**
Classification of defects and discontinuities	4
Fundamentals of common NDE methods	2
Application of AWS codes and standards	1
Elements of fabrication quality control systems	1

8.3 Examination Eligibility for International Institute of Welding (IIW) International Welding Technologist (IIW-IWT). The Welding Fundamentals portion of the examination requirements described in Table 8.1 is fulfilled without examination by individuals possessing a diploma indicating successful completion of the requirements for the IIW-IWT. This individual shall be eligible for the Code Application examination per Table 8.2 and the Welding Engineering Technology examination per Table 8.3.

9. Qualification Maintenance

The WET shall maintain the qualification through continued education (which may include the teaching of these subjects). This education shall be restricted to the subjects listed in Clause 7. The WET shall demonstrate successful completion of continued education every five (5) years to maintain the qualification. Continued education shall relate to the subjects as defined in Clause 7 and shall be equivalent to 75 contact hours in the five-year period or a combination of contact hours plus continuing education units totaling 75 contact hours.

Part B
Requirements for Welding Engineers (WE)

10. Functions

Welding Engineers shall be capable of directing those operations associated with the production of weldments in accordance with appropriate contract documents, codes, and other standards to produce a satisfactory product. Their responsibilities begin before production welding and continue through the entire life cycle. Each employer shall be responsible for defining the specific duties of WEs. For the purposes of this standard, the following are the functions and capabilities of WEs.

10.1 Welding Engineer Responsibilities. The WE shall be competent to perform assigned job functions at a cognitive level that includes the ability to effectively *remember*, *understand*, *apply*, *analyze*, *evaluate*, and *create* (per Bloom's taxonomy) technical principles and requirements in the following topical areas. The WE shall have competence in all the same areas as the WET and be capable of performing job functions at the same cognitive levels as the WET, as well as possess the ability to *evaluate* and *create* applicable information. Demonstration of the required knowledge related to each of these activities is determined by successful completion of the examinations described in Clause 13.

10.1.1 Safety. The WE shall be knowledgeable of safety practices as they pertain to welding, cutting, and joining processes. This individual shall be capable of both identifying issues related to unsafe processes and practices and facilitating corrective measures to alleviate identified concerns.

10.1.2 Design. The WE shall be capable of applying accepted engineering principles related to the design of welded structures or weldments manufactured using processes in accordance with applicable requirements or standards. This understanding shall include knowledge of design requirements of applicable fabrication standards and how those designs, including joint designs, are communicated on drawings and how those requirements are interpreted and applied. The WE shall have knowledge in the following competencies related to welding design:

(1) Using and interpreting welding symbols;

(2) Interpreting dimensional and configurational information presented on drawings and creating fabrication or manufacturing plans for executing the design;

(3) Understanding basic principles of static and cyclic loading and how these are addressed in welding standards, especially in terms of the types of welds specified and resulting acceptance criteria;

(4) Understanding different weld joints and groove preparations, and the practical aspects of executing specified designs in terms of accessibility, sequencing, and welding process application;

(5) Evaluating joint designs in terms of cost of preparation and welding application efficiency;

(6) Creating design specifications for welds and welding details meeting or exceeding product requirements;

(7) Using welding standards for selection and implementation of joint designs for structures, machinery, equipment, pressure vessels, and piping;

(8) Selecting base and filler metals for structures, machinery, equipment, pressure vessels, and piping;

(9) Evaluating and creating design criteria for welded connections in structures and machinery subject to a variety of loading conditions, including fatigue, fracture toughness, and stress-induced corrosion;

(10) Evaluating and creating design criteria of welded joints for piping and pressure vessels, including calculations for wall thickness and nozzle reinforcement, for vessels subject to a variety of loading and environmental conditions;

(11) Understanding classifications of joint designs in structures, machinery, equipment, pressure vessels, and piping;

(12) Assessing material requirements in terms of strength, ductility, toughness, and hardness for conformance with design and code requirements;

(13) Evaluating welded joints using mechanical or proof testing;

(14) Establishing design criteria for new materials and welding processes using appropriate test methods;

(15) Performing basic welding design calculations per applicable design standards:

(16) Applying design for manufacturability principles considering loading, processes, accessibility, weld sequencing, distortion, weld volume, and applicable standards;

(17) Evaluating joints and joint designs for fatigue performance considering fatigue design requirements, weld profiles, and surface stress concentrations per applicable standards;

(18) Specifying weld profile modification methods for improved fatigue performance;

(19) Evaluating material properties and loading conditions for the development of fitness-for-service acceptance criteria per applicable relevant standards; and

(20) Evaluating and selecting base and filler metals for fracture toughness performance per applicable requirements.

The WE shall be capable of effectively communicating with others regarding the above requirements, as well as their interpretation, application, analysis, evaluation, and creation.

10.1.3 Material Properties and Welding Metallurgy. The WE shall have practical knowledge of ferrous and nonferrous materials including carbon, low-alloy, and stainless steels; nickel and nickel alloys; aluminum and aluminum alloys; copper and copper alloys; and titanium and titanium alloys. The WE shall understand the effects of welding on these materials in terms of the resulting properties and dimensions of weldments. The WE shall have knowledge in the following competencies related to materials and welding metallurgy:

(1) Understanding physical and mechanical metallurgy and changes occurring as a result of the welding operation;

(2) Understanding corrosion mechanisms and changes in corrosion properties resulting from the welding operation;

(3) Understanding heat treatment of materials, including specification of postweld heat treatment (PWHT) requirements for weldments and review of heat treatment procedures and heat treatment records in terms of compliance with applicable standards;

(4) Understanding the effects of forming, cutting, and other preparation processes on material properties;

(5) Evaluating the chemical composition of alloys for specification of preheat requirements and the resulting effects on weldability;

(6) Selecting and specifying welding consumables for advanced welding applications considering loading conditions and service environment;

(7) Specifying methods for improvement of mechanical properties of weldments through process enhancement, such as the use of temper bead techniques;

(8) Specifying tests and criteria for characterization and selection of materials in terms of weldability, fabricability, and fitness-for-service;

(9) Eliminating weld-related cracking through investigation of processing, material properties, residual stresses, applied loading, and corrosive service conditions;

(10) Interpreting and analyzing chemical composition and mechanical property data for compliance with applicable standards;

(11) Using metallographic examinations to measure and analyze weld macrostructures and microstructures;

(12) Specifying mechanical testing requirements for procedure and performance qualification and interpretation of test results for compliance with applicable standards;

(13) Understanding heat flow in metals during welding and the resulting effects on weldment dimensions and microstructures of weld metal and HAZs;

(14) Understanding principles of distortion resulting from welding heat input conditions, material properties, and joint geometry so that welding and fabrication techniques can be adjusted to minimize detrimental effects;

(15) Interpreting mechanical property data for conformance with applicable standards;

(16) Evaluating fatigue or fracture toughness properties of welded joints using advanced testing methods;

(17) Conducting failure analysis for determination of defect morphology and cause, and specification of corrective measures to prevent future occurrence;

(18) Specifying plans and techniques for the repair of critical components damaged because of normal service or extreme loading conditions;

(19) Evaluating material property data for selection of base and filler metals meeting applicable design requirements;

(20) Developing relationships among welding parameters, metallurgical characteristics, and mechanical properties to establish effective welding procedures;

(21) Developing welding procedures for specified process conditions or applications; and

(22) Using and interpreting various testing techniques and advanced metallurgical analyses for characterization of weld metal and HAZ microstructures for assessment of variations of chemical composition, hardness, etc., and potential effects on corrosion-resistance and mechanical properties.

The WE shall be capable of effectively communicating with others regarding the above requirements, as well as their interpretation, application, analysis, evaluation, and creation.

10.1.4 Welding, Joining, and Allied Processes. The WE shall demonstrate a working knowledge of fusion welding, high-energy beam welding, solid-state welding, brazing, and soldering. The WE shall demonstrate a working knowledge of oxyfuel gas cutting and gouging, arc cutting and gouging, thermal spraying, and high-energy beam cutting. While the ability to utilize these processes is desirable, it is not considered a requirement as long as the WE is deemed capable of determining if the processes are being applied correctly in accordance with documented procedures. The WE shall possess knowledge in the following competencies related to welding, joining, and allied processes:

(1) Possessing a detailed understanding of the fundamental principles of commonly used welding and cutting processes;

(2) Possessing a working knowledge of each process to determine if a given process is suited for a given application and capable of operating effectively to produce sound welds;

(3) Evaluating and comparing different types of welding and cutting apparatus for selection of best equipment for specific applications;

(4) Understanding the various types of welding and cutting power sources and how they are adjusted to comply with applicable procedures;

(5) Understanding AWS filler metal classification systems and being capable of reviewing material test reports for compliance with applicable filler metal specifications;

(6) Reviewing qualification requirements found in applicable welding standards to determine what test coupons, welding variables, materials, etc., are required for effective procedure or performance qualification;

(7) Conducting welding procedure and performance qualification tests and fully documenting in accordance with applicable welding standards;

(8) Understanding safety requirements and hazards associated with welding and cutting processes, being prepared to enforce those requirements, and determining what precautions are required for safe operation and protection of personnel;

(9) Selecting welding equipment, fixtures, and apparatus based on application, production, productivity, and procedure requirements;

(10) Ensuring that welding procedure specifications and performance qualification records exist and are appropriate for application requirements;

(11) Using measurement and data acquisition devices for equipment calibration and process monitoring;

(12) Selecting preferred welding or joining processes based on the material, thickness, joint design, position, productivity expectations, and applicable welding standards;

(13) Understanding various base material preparation processes and their proper application for different alloys and job specifications;

(14) Calculating welding costs, including consideration of materials, process performance, and labor;

(15) Using statistical methods for analysis of welding process performance in terms of productivity, quality, and reproducibility;

(16) Comparing the economics of different welding processes to minimize cost and/or improve productivity;

(17) Creating welding process variants or their application mode as a means of production enhancement, while assuring quality requirements are met;

(18) Understanding the fundamentals of various destructive and nondestructive methods for evaluation of the effectiveness of welding procedures for compliance with applicable standards;

(19) Analyzing effects of welding consumables, process parameters, and resulting properties to meet or exceed application requirements;

(20) Conducting and documenting welding procedures and welding personnel qualification in accordance with applicable standards;

(21) Developing repair/rework plans and specifying processes and consumables to be used;

(22) Evaluating processes and production conditions to establish optimized parameters for satisfaction of productivity and quality requirements;

(23) Selecting mechanized, automated, or robotic application methods for enhancement of process productivity while assuring that quality requirements will be achieved;

(24) Using sensors for feedback control of critical parameters or welding characteristics;

(25) Creating welding automation solutions for complex weld joint designs or weldment geometries as a means of enhancing both quality and productivity;

(26) Developing and qualifying new processes or materials for critical applications;

(27) Specifying and qualifying production, fabrication and/or assembly processes and techniques employing welding, joining, and allied processes;

(28) Developing and implementing welding personnel qualification management systems.

(29) Developing and qualifying procedures for advanced welding processes based on application requirements;

(30) Selecting welding and allied processes, establishing fabrication methods, allocating personnel, and specifying postweld treatments for welding applications meeting requirements of applicable standards; and

(31) Developing and implementing a Welding Program, including its technical aspects and the means for its implementation and enforcement.

The WE shall be capable of effectively communicating with others regarding the above requirements, as well as their interpretation, application, analysis, evaluation, and creation.

10.1.5 Quality Assurance, Quality Control, and NDE. The WE shall understand the principles and practices related to quality assurance systems and quality control activities and be capable of actively participating in the implementation of these practices. The WE shall be knowledgeable in all aspects of quality control and understand requirements for welding procedure qualification, and welder and operator performance qualification, including destructive testing and nondestructive examination. The WE shall be capable of performing visual inspection of welds and recommending the appropriate nondestructive examination (NDE) methods for a particular weldment. The WE shall understand the advantages and limitations of NDE.

The WE shall have knowledge in the following competencies related to quality assurance, quality control and NDE:

(1) Understanding general concepts and principles of quality assurance (QA) and quality control (QC) and their interrelationships;

(2 Understanding the roles of various QA, QC, and production personnel and their interaction to ensure conformance with applicable standards;

(3) Reviewing and complying with documentation defining these activities including, but not limited to, quality manuals, quality control procedures, NDE procedures, and nonconformance reports;

(4) Understanding weld quality systems, including processes for correction of identified nonconformances;

(5) Applying and interpreting symbols for welding and NDE;

(6) Understanding the qualifications and responsibilities associated with common certified inspector designations (e.g., AWS CWI, ASNT NDT Level II, ASNT NDT Level III);

(7) Reviewing and interpreting NDE personnel qualification documentation to determine whether individuals are considered qualified to perform NDE in accordance with applicable standards;

(8) Reviewing job specifications for determination of inspection requirements for visual examination and other NDE methods;

(9) Understanding the effective use of NDE methods in welded fabrications and materials joining applications;

(10) Understanding basic principles of magnetic and penetrant methods for surface examination;

(11) Understanding basic principles of radiographic and ultrasonic methods for volumetric examination;

(12) Understanding which NDE methods are appropriate and preferred for various welding applications based on materials, types of discontinuities to be detected, and standards requirements;

(13) Understanding the comparative costs associated with various inspection methods considering materials, process performance, and personnel qualifications and the associated labor rates;

(14) Conducting visual inspection of all elements of the welding operation, before, during, and after welding. The WE is encouraged to achieve qualification as an AWS Certified Welding Inspector;

(15) Evaluating types, characteristics, and causes of weld and base metal discontinuities;

(16) Understanding common causes of weld discontinuities resulting from improper use of welding processes;

(17) Interpreting and applying acceptance criteria for these discontinuities in accordance with applicable standards;

(18) Reviewing NDE reports for conformance to applicable standards;

(19) Creating applicable production control documents to specify production steps before, during, and after welding and reviewing documentation to ensure successful completion of processing steps;

(20) Reviewing and auditing quality control systems and personnel qualifications;

(21) Specifying NDE methods and acceptance criteria for fitness-for-service evaluations;

(22) Reviewing and approving specifications and procedures for advanced NDE methods such as phased-array UT and digital RT;

(23) Interpreting automated NDE and data acquisition results;

(24) Specifying inspection plans and procedures meeting applicable industry and customer requirements;

(25) Using statistical process control techniques for establishment of inspection frequency for production applications;

(26) Understanding and applying quality control or quality management systems conforming with ISO 9001 or others, as applicable;

(27) Reviewing and approving NDE techniques for examination of complex weldments;

(28) Reviewing and approving minimum flaw size process capabilities using probability of detection principles; and

(29) Specifying repair process plans and related inspection procedures for verification of successful correction of non-conformities.

The WE shall be capable of effectively communicating with others regarding the application of the above principles, as well as their interpretation, application, analysis, evaluation, and creation.

11. Education, Experience, and Credential Requirements for Examination Eligibility

While achievement of the Welding Engineer credential shall be determined by successfully passing the required examinations as specified in 13.1, it is recognized that eligibility for these examinations may be attained using various combinations of education and experience, as well as possession of recognized credentials. Table 11.1 summarizes the various paths for eligibility based on level of education and relevant experience, or credential and relevant experience. Subclause 11.1 specifies what is relevant experience for examination eligibility.

11.1 Relevant Experience. Experience shall be defined as activities in one or more of the following areas. This experience may be gained concurrently with education. This experience shall include that time working at the respective education level shown in Table 11.1 and Figure 11.1.

Table 11.1
Minimum Education, Experience, and Credential Requirements for Examination Eligibility (see 11.1)

Education	Experience, yr.	Credential	Examination Eligibility
BSc Welding Engineering	1		13.1.1, 13.1.2, 13.1.3
BSc Welding Engineering—International	1		13.1.1.1
BSc Engineering (other than Welding)	3		13.1.1, 13.1.2, 13.1.3
BSc Engineering (other than Welding)—International	3		13.1.1.1
BSc Welding Engineering Technology	5		13.1.1, 13.1.2, 13.1.3
PE—Welding Engineering Emphasis	0		Qualified without examination
BSc Engineering + PE – Other than Welding Engineering Emphasis	3		13.1.2, 13.1.3
IIW International (or European) Welding Engineer (IIW IWE or EWE)	2	IWE or EWE	13.1.2, 13.1.3

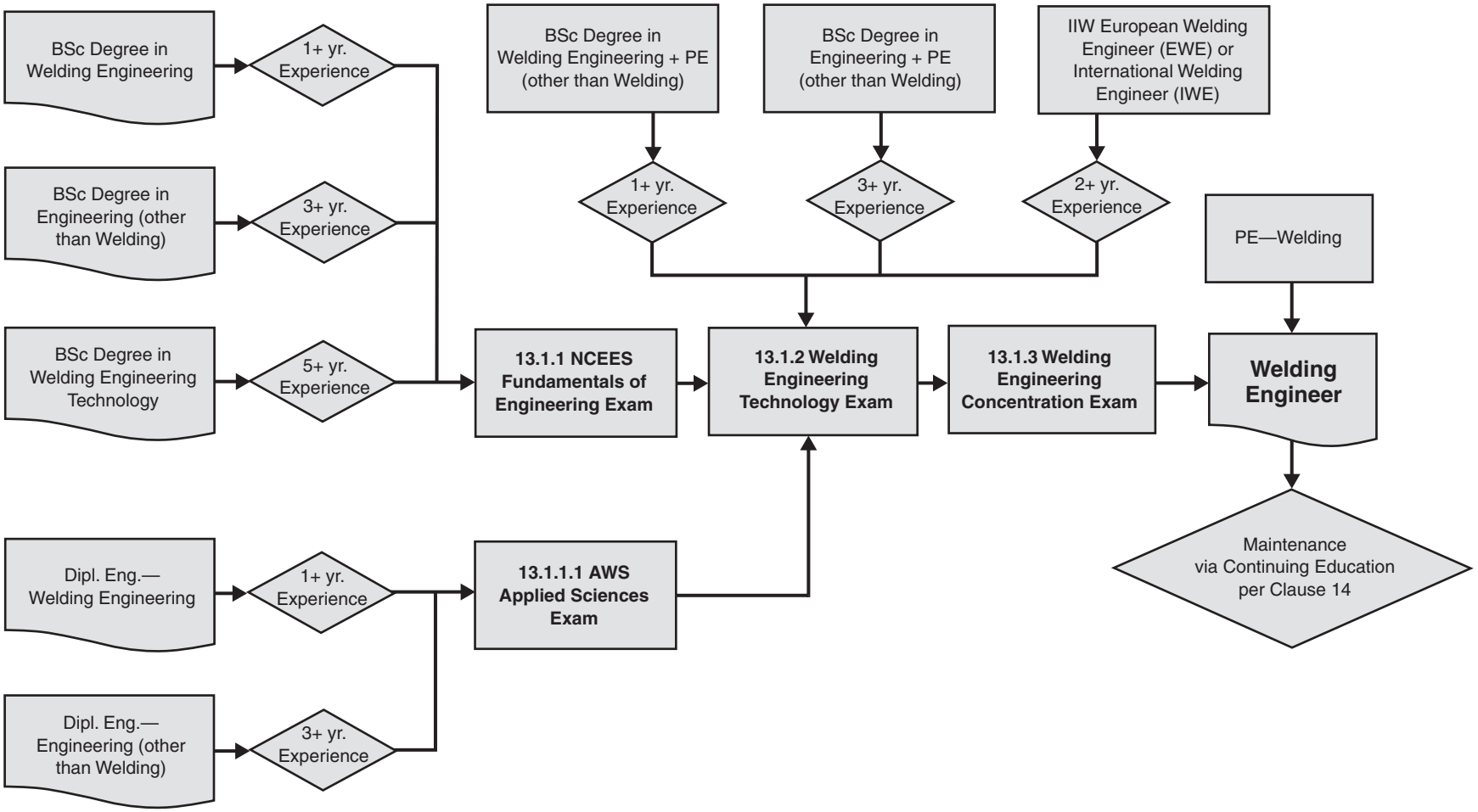

Figure 11.1—Flowchart Showing Paths to Qualification as Welding Engineer (see 11.1)

11.1.1 Manufacturing. Experience shall consist of the design, specification, application, or oversight of welding process lines or cells for the manufacture of welded products such as automobiles, appliances, welded pipe, or other welded standard products.

11.1.2 Fabrication. Experience shall consist of the design, specification, application, or oversight of welding processes and systems used to fabricate welded products. Fabricated products may be covered by national, customer, or internal standards or specifications.

11.1.3 Construction. Experience shall consist of design, specification, application, and implementation of welding and quality requirements on welding construction projects such as buildings, pipelines, ships, refineries, offshore oil rigs, and power generation facilities being constructed in accordance with national, customer, or internal standards or specifications.

11.1.4 Research and Development. Experience shall consist of research and development leading to the enhancement of welded products or processes, welding materials, manufacturing, fabrication, field erection of welded products, or the design and specification of welding manufacturing systems.

11.1.5 Training. Experience shall consist of instructing college-level courses in various welding topics or related technologies.

12. Body of Knowledge

A WE shall be capable of applying engineering theory and principles to specify the way welding and allied processes are applied to effectively execute welding designs. Additionally, a WE shall be capable of both specifying the materials to be used as well as having a clear understanding of the effects on those materials when the welding is being accomplished. A WE shall have these competencies at both an engineering and engineering technology level. To achieve this, a WE shall be able to apply these principles with an understanding of higher-level mathematics, including competencies in calculus and calculus-based theoretical science.

The key benefit of a WE is that this individual is capable of specifying the processes and materials to be used and how they are applied so that resulting welds meet both design and quality requirements. The body of knowledge items for each examination defined in Clause 13 for WEs are defined in Annex C.

13. Examination Requirements

Figure 11.1 is a flowchart illustrating paths to achieving qualification for a WE. An individual meeting the education and experience requirements of Clause 12 and who successfully passes the examinations specified in 13.1 shall be qualified as WE.

Examinations for WE are independent of each other and may be taken in any order.

Individuals seeking qualification as a WE shall successfully complete the Fundamentals of Engineering (FE) examination per 13.1.1, Welding Engineering Technology examination per 13.1.2, and shall select and successfully pass two (2) of four (4) Welding Engineering Concentration examinations per 13.1.3.

13.1 Examination Structure. Individuals seeking qualification as a WE shall successfully complete the examinations listed in 13.1.1 through 13.1.3 in any order. References forming the technical basis for questions on the Welding Engineering Technology (13.1.2 and Table 13.1) and Welding Engineering Concentration examination per 13.1.3 are specified in Annex D.

13.1.1 Fundamentals of Engineering Examination. The Fundamentals of Engineering (FE) examination evaluates the candidate's understanding of basic and applied sciences, providing the foundation for applying and evaluating welding engineering-related disciplines. The FE portion of the examination shall be satisfied by successful completion of any National Council for Examination of Engineers and Surveyors (NCEES) FE examination (formerly Engineer-in-Training (EIT) examination). These FE examinations are offered in seven (7) technical categories.

13.1.1.1 Applied Sciences Examination—International. For candidates without access to the National Council for Examination of Engineers and Surveyors (NCEES) Examination (formerly Engineer-in-Training (EIT) examination), an AWS-developed Applied Sciences examination shall serve as a replacement for the FE portion of the examination.

13.1.2 Welding Engineering Technology Examination. The Welding Engineering Technology examination evaluates the candidate's understanding, application knowledge, and analysis skills for all the technical core areas:

(1) Welding, joining, and allied processes;

(2) Material properties and welding metallurgy;

(3) Welding design and joint configurations; and

(4) Quality assurance, quality control, and NDE.

This examination requires knowledge of engineering units and qualitative relationships for each core area.

Table 13.1 lists the applicable domains and subdomains for each of the four (4) technical core areas listed above and lists the associated minimum percentages of questions for each technical core area, domain, and subdomain.

Table 13.1
Welding Engineering Technology Examination

Domain/Subdomain	Minimum Percentages of Total Questions
Welding, Joining, and Allied Processes	**45**
Fundamentals and application of arc welding processes	15
Fundamentals and application of high energy beam welding processes	10
Fundamentals and application of resistance welding processes	5
Fundamentals and application of solid-state welding processes	3
Analysis of arc welding circuits	3
Arc physics, arc energy, and heat input	3
Arc welding power sources	3
Fundamentals and application of brazing and soldering	2
Welding and cutting safety	1
Material Properties and Welding/Joining Metallurgy	**30**
Welding metallurgy of carbon and low alloy steels	7
Welding metallurgy of stainless steels, including dissimilar metal joints	4
Welding metallurgy of nonferrous alloys	4
Procedure qualification for control of HAZ properties	3
Procedure qualification of corrosion-resistant overlays for prevention of stress corrosion cracking and other environmental damage	3
Weld metal and HAZ microstructures and their evolution	2
Weld metal and HAZ cracking mechanisms	2

(Continued)

Table 13.1 (Continued)
Welding Engineering Technology Examination

Domain/Subdomain	Minimum Percentages of Total Questions
Weld solidification	1
Weldability testing	1
Failure analysis	1
Welding Design and Joint Configurations	**10**
Economics of weld joint design	1
Design of structural connections and fatigue of welded joints	1
Prediction and reduction of residual stress and distortion	1
Mechanical properties and selection of base and filler metals	1
Weld design for improved fatigue performance	1
Material selection and process control for enhanced toughness	1
Fracture mechanics of welded joints	1
Mechanical metallurgy	1
Quality Assurance, Quality Control and NDE	**10**
Visual examination of welds and welding discontinuities	2
Welding procedure and performance qualification requirements	2
Fundamentals of common NDE methods and their application	2
Interpretation of codes and standards	1
Quality schemes for welding fabricators	1

13.1.3 Welding Engineering Concentration Examination. To become qualified as a WE, an individual shall successfully complete a Welding Engineering Concentration (WEC) examination. This examination shall consist of situations requiring the individual to apply welding engineering principles to practical applications per the requirements of a specified welding standard. The applicable standard will be AWS D14.0, *Machinery and Equipment Welding Specification* which uses AWS B2.1, *Specification for Welding Procedure and Performance Qualification* for rules governing the qualification of welding procedures and personnel.

13.2 Exemption from NCEES Fundamentals of Engineering (FE) Examination. Individuals with the following credentials and experience are considered to have satisfied the requirements of the FE Examination. Individuals with documented evidence of these credentials and experience shall be eligible for the Welding Engineering Technology Examination per 13.1.2:

(1) Bachelor of Science (BSc) degree in Engineering and registered Professional Engineer (PE), in a discipline other than Welding, with three (3) years of relevant experience

(2) Either an International Institute of Welding—International Welding Engineer (IIW-IWE) or European Welding Federation—European Welding Engineer (EWF-EWE) Diploma, with two (2) years of relevant experience.

13.3 Exemption from Welding Engineering Examinations. Individuals registered as a Professional Engineer (PE)—Welding shall be considered as meeting the knowledge and experience requirements for AWS Welding Engineer. As such, this individual shall be exempt from AWS Welding Engineering examinations, and the AWS Welding Engineer credential shall be granted upon submission of the required application and evidence of the PE—Welding license. The Professional Engineer—Welding credential was formerly issued by the State of Ohio, but this no longer exists.

14. Qualification Maintenance

Welding engineering personnel shall maintain qualification through continued education (which may include teaching of these subjects). This education shall be restricted to the functions as defined in Clause 11. Welding engineering personnel shall demonstrate successful completion of continued education every five (5) years to maintain the qualification. Continued education shall relate to the functions in Clause 11 and shall be equivalent to 75 contact hours in the five-year period or a combination of contact hours plus continuing education units totaling 75 contact hours.

PRECAUTION: Qualification as a WE in accordance with this specification alone may not legally qualify these personnel for the provision of technical services to the public when contract documents, building, or jurisdiction laws require such services be performed under the direction and responsibility of a registered and licensed PE. As such, designation as a Welding Engineer **DOES NOT** imply the status of a registered PE under the laws of any state or other governmental entity.

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Annex A (Normative)

Body of Knowledge for Welding Engineering Technologists

This annex is part of this standard and includes mandatory elements for use with this standard.

The following information should be used to create the course outline to prepare for Welding Engineering Technologist examinations:

(1) Welding Fundamentals

(2) Welding Engineering Technology

(3) Welding Code Applications

A1. Welding Fundamentals

The body of knowledge for welding fundamentals is based on understanding the principles of key technologies that are used in welding fabrication. There is significant emphasis on understanding the breadth of welding and allied processes, and knowledge of terms, definitions, abbreviations, and symbols. There is also an emphasis on key documents and quality processes used to manage, qualify, and control the fabrication materials and processes. Finally, knowledge of welding discontinuities and types of inspection processes used to ensure soundness is required. The body of knowledge for welding fundamentals is based on the following topics:

(1) Definitions and terminology;

(2) Welding and cutting processes;

(3) Symbols—welding and NDE;

(4) Visual examination;

(5) Welding application and control;

(6) NDE fundamentals;

(7) Base materials, heat treatments, and metallurgy (ferrous materials);

(8) Welding-related calculations;

(9) Duties and responsibilities; and

(10) Destructive testing fundamentals.

NOTE: The body of knowledge defined in Clause A1 is the same body of knowledge required for Welding Inspectors per AWS B5.1, Specification for the Qualification of Welding Inspectors.

A2. Welding Code Application

This examination evaluates the candidate's ability to analyze and apply the requirements of an internationally or nationally recognized code or standards. The body of knowledge for code application is based on the following topics:

(1) Qualification,

(2) Fabrication,

(3) Inspection,

(4) Material and weld joint application, and

(5) Reports and records.

NOTE: The body of knowledge defined in Clause A1 is the same body of knowledge required for Welding Inspectors per AWS B5.1, Specification for the Qualification of Welding Inspectors.

A3. Welding Engineering Technology

The body of knowledge for Welding Engineering Technology is based on understanding, applying, and analyzing the core areas:

(1) Safety;

(2) Welding, Joining, and Allied Processes;

(3) Materials and Welding/Joining Metallurgy;

(4) Welding Design; and

(5) Quality Assurance, Quality Control, and Nondestructive Examination (NDE) at the ABET engineering technology level.

A3.1 Welding and Cutting Safety

(1) Recognize health hazards relating to welding and cutting

(2) Recognize safety hazards relating to welding and cutting

(3) Recognize precautions to avoid injury and possess a working knowledge of applicable health, safety and fire standards

A3.2 Welding, Joining, and Allied Processes

(1) Arc welding processes

(2) Arc welding power sources: selection, adjustment, and measurement of electrical output

(3) Arc physics, arc energy, and heat input

(4) Arc welding procedure and performance qualifications

(5) Resistance welding processes

(6) High energy beam and solid-state welding processes

(7) Thermal cutting processes

A3.3 Materials and Welding/Joining Metallurgy

(1) Welding metallurgy of carbon, low alloy, and stainless steels

(2) Metal processing methods (casting, forming, forging, etc.)

(3) Regions of a weld in fusion welding and properties

(4) Mechanical and physical properties of materials

(5) Carbon equivalent and its effect on weld properties and need for preheat

(6) Welding procedure variables and their effects on weld properties

(7) Welding metallurgy of nonferrous alloys

(8) Heat treatment of steels

A3.4 Welding Design and Joint Configurations

(1) Interpretation of drawings and welding symbols

(2) Joint configurations and their effect on weld soundness, productivity, and weld economics

(3) Heat flow behavior in welding

(4) Thermal stresses, residual stresses, and distortion

(5) Structural welding design fundamentals

A3.5 Quality Assurance, Quality Control, and NDE

(1) Classification and identification of welding defects and discontinuities

(2) Application of AWS codes and standards

(3) Elements of fabricator quality assurance systems

(4) Fundamentals of common NDE methods

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Annex B (Normative)

Normative References for Welding Engineering Technologists

This annex is part of this standard and includes mandatory elements for use with this standard.

B1. Reference Documents

The following documents provide the technical basis for questions and answers on the examinations listed below. The latest editions of the reference documents shall be used unless otherwise noted.

B1.1 Welding Fundamentals Documents

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Products*, American Welding Society.

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

AWS A3.0, *Standard Welding Terms and Definitions*, American Welding Society.

AWS, *Fundamentals of Welding Inspection*, American Welding Society.

AWS, *Welding Handbook, Volume 1: Welding Science & Technology*, American Welding Society.

B1.2 Welding Engineering Technology Documents

B1.2.1 Welding, Joining, and Allied Processes

AWS, *Welding Handbook, Volume 2: Welding Processes, Part 1*, American Welding Society.

AWS, *Welding Handbook, Volume 3: Welding Processes, Part 2*, American Welding Society.

B1.2.2 Material Properties and Welding Metallurgy

AWS, *Introductory Welding Metallurgy*, American Welding Society.

AWS, *Welding Handbook, Volume 4: Materials and Applications, Part 1*, American Welding Society.

AWS UGFM, *AWS User's Guide to Filler Metals*, American Welding Society.

B1.2.3 Welding Design and Joint Configurations

AWS B4.0, *Standard Methods for Mechanical Testing of Welds*, American Welding Society.

AWS, *Welding Handbook, Volume 1: Welding Science & Technology*, American Welding Society.

Blodgett, O. W., 1966, *Design of Welded Structures*, Cleveland Ohio: James F. Lincoln Arc Welding Foundation.

B1.2.4 Quality Assurance, Quality Control, and NDE

AWS B1.10M/B1.10, *Guide for the Nondestructive Examination of Welds*, American Welding Society.

AWS B1.11M/B1.11, *Guide for the Visual Inspection of Welds*, American Welding Society.

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, American Welding Society.

AWS B5.1, *Specification for the Qualification of Welding Inspectors*, American Welding Society.

AWS B5.17, *Specification for Qualification of Welding Fabricators*, American Welding Society.

AWS D1.1/D1.1M, *Structural Welding Code—Steel*, American Welding Society.

AWS D14.0/D14.0M, *Machinery and Equipment Welding Specification*, American Welding Society.

AWS QC1, *Specification for AWS Certification of Welding Inspectors*, American Welding Society.

AWS WI, *Welding Inspection Handbook*, American Welding Society.

AWS, *Welding Handbook, Volume 1: Welding Science & Technology*, American Welding Society.

ISO 3834-2, *Quality requirements for fusion welding of metallic materials—Part 2: Comprehensive quality requirements*, International Organization for Standardization.

NOTE: Other internationally or nationally recognized welding codes may be used if approved by the certifying body.

Annex C (Normative)
Body of Knowledge for Welding Engineers

This annex is part of this standard and includes mandatory elements for use with this standard.

The following information should be used to create the course outline to prepare for Welding Engineer examinations:

(1) Fundamentals of Engineering

(2) Welding Engineering Technology

(3) Welding Engineering Concentration

C1. Fundamentals of Engineering

The Fundamentals of Engineering portion of the examination shall be satisfied by successful completion of any National Council for Examination of Engineers and Surveyors (NCEES) Fundamentals of Engineering (FE) examination (formerly Engineer-in-Training (EIT) examination). These FE examinations are offered in seven (7) technical categories. Please refer to NCEES (https://ncees.org) for information related to the Body of Knowledge for these FE examinations.

C1.1 Applied Sciences—International. For candidates without access to the NCEES FE examination (formerly Engineer-in-Training (EIT) examination), an AWS-developed Applied Sciences examination shall serve as a replacement for the Fundamentals of Engineering portion of the examination.

C2. Welding Engineering Technology

The body of knowledge for the Welding Engineering Technology Examination is based on understanding, applying, and analyzing the core areas:

(1) Safety;

(2) Welding, Joining, and Allied Processes;

(3) Materials and Welding/Joining Metallurgy;

(4) Welding Design and Joint Configurations; and

(5) Quality Assurance, Quality Control, and Nondestructive Examination (NDE).

C2.1 Welding and Cutting Safety

(1) Recognize health hazards relating to welding and cutting.

(2) Recognize safety hazards relating to welding and cutting.

(3) Recognize precautions to avoid injury and possess a working knowledge of applicable health, safety, and fire standards.

C2.2 Welding, Joining, and Allied Processes

(1) Analysis of arc welding circuits

(2) Arc physics, arc energy, and heat input

(3) Arc welding power sources

(4) Qualification of welding procedures and personnel

(5) Fundamentals and application of arc welding processes

(6) Fundamentals and application of resistance welding processes

(7) Fundamentals and application of solid-state welding processes

(8) Fundamentals and application of high energy beam welding processes

(9) Fundamentals and application of brazing and soldering

C2.3 Material Properties and Welding Metallurgy

(1) Weld solidification

(2) Fusion zone and HAZ microstructures and their evolution

(3) Weldability testing

(4) Procedure qualification for control of HAZ properties

(5) Procedure qualification of corrosion-resistant overlays for prevention of stress corrosion cracking and other environmental damage

(6) Fusion zone and HAZ cracking mechanisms

(7) Welding metallurgy of carbon and low alloy steels

(8) Welding metallurgy of stainless steels, including dissimilar metal joints

(9) Welding metallurgy of nonferrous alloys

C2.4 Welding Design and Joint Configurations

(1) Economics of weld joint design

(2) Analysis of residual stresses and distortion and residual stress measurement

(3) Material selection and process control for enhanced toughness

(4) Design for fatigue enhancement of welded structures

(5) Welded joint analysis and design

(6) Mechanics of materials including section properties, stress and strain, torsion, bending, and buckling

(7) Weld sizing and weld requirements for built-up members

(8) Design of structural connections and fatigue of welded joints using AWS D14.0/D14.0M

(9) Mechanical metallurgy

(10) Fracture mechanics of welded joints

C2.5 Quality Assurance, Quality Control, and NDE

(1) Visual examination of welds and welding discontinuities

(2) Quality schemes for welding fabricators

(3) Interpretation of codes and standards

(4) Welding procedure and performance qualification requirements

(5) Fundamentals of common NDE methods and their application

C3. Welding Engineering Concentration

The body of knowledge for welding engineering concentrations is based on understanding, analyzing, and evaluating the core areas:

(1) Welding, Joining, and Allied Processes;

(2) Materials and Welding/Joining Metallurgy;

(3) Welding Design; and

(4) Quality Assurance, Quality Control, and NDE at the ABET engineering level.

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Annex D (Normative)
Normative References for Welding Engineers

This annex is part of this standard and includes mandatory elements for use with this standard.

D1. Reference Documents

The following documents provide the technical basis for questions and answers on the examinations listed below. The latest editions of the reference documents shall be used unless otherwise noted.

D1.1 Fundamentals of Engineering and AWS Applied Sciences Documents

(1) National Council of Examiners for Engineering and Surveying (NCEES) (https://ncees.org).

(2) Applicable references:

(a) *NCEES FE Reference Handbook*

(b) *NCEES FE Practice Exam (one of seven engineering disciplines)*.

D1.2 Welding Engineering Technology Documents

D1.2.1 Welding, Joining, and Allied Processes

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, American Welding Society.

AWS, *Welding Handbook, Volume 1: Welding Science and Technology*, American Welding Society.

AWS, *Welding Handbook, Volume 2: Welding Processes, Part 1*, American Welding Society.

AWS, *Welding Handbook, Volume 3: Welding Processes, Part 2*, American Welding Society.

D1.2.2 Material Properties and Welding Metallurgy

AWS, *Welding Handbook, Volume 4: Materials and Application, Part 1*, American Welding Society.

AWS, *Welding Handbook, Volume 5: Materials and Application, Part 2*, American Welding Society.

AWS, UGFM *User's Guide to Filler Metals*, American Welding Society.

Kotecki, D. J. and J. C. Lippold, Wiley, *Welding Metallurgy and Weldability of Stainless Steels*, Hoboken, New Jersey, 2005: John Wiley & Sons, Inc.

Linnert, G. E., *Welding Metallurgy: Fundamentals, Volume 1*, Miami, Florida, 1995: American Welding Society.

Stout, R. D., *Weldability of Steels*, 1987, New York, New York: The Welding Research Council.

D1.2.3 Welding Design and Joint Configurations

AWS D1.1/D1.1M, *Structural Welding Code—Steel*, American Welding Society.

AWS D14.0/D14.0M, *Machinery and Equipment Welding Code*, American Welding Society.

AWS, *Welding Handbook, Volume 1: Welding Science and Technology*, American Welding Society.

ASME, *Boiler and Pressure Vessel Code, Section VIII, Division 1*, American Society of Mechanical Engineers.

ASME BPVC B31.1, *Pressure Piping*, American Society of Mechanical Engineers.

ASME BPVC B31.3, *Process Piping*, American Society of Mechanical Engineers.

Blodgett, O. W., *Design of Welded Structures*, Cleveland Ohio, 1966: James F. Lincoln Arc Welding Foundation.

Dieter, G., *Mechanical Metallurgy*, 1986: McGraw-Hill.

D1.2.4 Quality Assurance, Quality Control, and NDE

AWS B1.10M/B1.10, *Guide for the Nondestructive Examination of Welds*, American Welding Society.

AWS B1.11M/B1.11, *Guide for the Visual Inspection of Welds*, American Welding Society.

AWS B5.1, *Specification for the Qualification of Welding Inspectors*, American Welding Society.

AWS B5.17, *Specification for Qualification of Welding Fabricators*, American Welding Society.

AWS, *Welding Inspection Handbook*, American Welding Society.

AWS, *Welding Handbook, Volume 1: Welding Science and Technology*, American Welding Society.

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*, International Organization for Standardization.

ISO 14731, *Welding coordination — Tasks and responsibilities*, International Organization for Standardization.

D1.3 Welding Engineering Concentration Documents

AWS D14.0/D14.0M, *Machinery and Equipment Welding Code*, American Welding Society.

AWS B2.1/B2.1M, *Specification for Welding Procedure and Performance Qualification*, American Welding Society.

Annex E (Informative)

Requesting an Official Interpretation on an AWS Standard

This annex is not part of this standard but is included for informational purposes only.

E1. Introduction

The following procedures are here to assist standard users in submitting successful requests for official interpretations to AWS standards. Requests from the general public submitted to AWS staff or committee members that do not follow these rules may be returned to the sender unanswered. AWS reserves the right to decline answering specific requests; if AWS declines a request, AWS will provide the reason to the individual why the request was declined.

E2. Limitations

The activities of AWS technical committees regarding interpretations are limited strictly to the interpretation of provisions of standards prepared by the committees. 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.

E3. General Procedure for all Requests

E3.1 Submission. All requests shall be sent to the Managing Director, AWS Certification. For efficient handling, it is preferred that all requests should be submitted electronically through certification@aws.org. Alternatively, requests may be mailed to:

Managing Director
Certification
American Welding Society
NW 36 St, # 130
Miami, FL 33166

E3.2 Contact Information. All inquiries shall contain the name, address, email, phone number, and employer of the inquirer.

E3.3 Scope. Each inquiry shall address one single provision of the standard unless the issue in question involves two or more interrelated provisions. The provision(s) shall be identified in the scope of the request along with the edition of the standard (e.g., D1.1/D1.1M:2020) that contains the provision(s) the inquirer is addressing.

E3.4 Question(s). All requests shall be stated in the form of a question that can be answered ‘yes’ or ‘no’. The request shall be concise, yet complete enough to enable the committee to understand the point of the issue in question. When the point is not clearly defined, the request will be returned for clarification. Sketches should be used whenever appropriate, and all paragraphs, figures, and tables (or annexes) that bear on the issue in question shall be cited.

E3.5 Proposed Answer(s). The inquirer shall provide proposed answer(s) to their own question(s).

E3.6 Background. Additional information on the topic may be provided but is not necessary. The question(s) and proposed answer(s) above shall stand on their own without the need for additional background information.

E4. AWS Policy on Interpretations

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 official interpretations are approved by the technical committee that is responsible for the standard. Communication concerning an official interpretation is directed through the AWS staff member who works with that technical committee. The policy requires that all requests for an official interpretation be submitted in writing. Such requests will be handled as expeditiously as possible, but due to the procedures that must be followed, some requests for an official interpretation may take considerable time to complete.

E5. AWS Response to Requests

Upon approval by the committee, the interpretation is an official interpretation of the Society, and AWS shall transmit the response to the inquirer, publish it in the *Welding Journal*, and post it on the AWS website.

E6. 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.

Annex F (Informative)

List of AWS Documents on Qualification and Certification

This annex is not part of this standard but is included for informational purposes only.

Qualification Designation	Title
B5.1	*Specification for the Qualification of Welding Inspectors*
B5.2	*Specification for the Training, Qualification, and Company Certification of Welding Inspector Specialists and Welding Inspector Assistants*
B5.4	*Specification for the Qualification of Welder Test Facilities*
B5.5	*Specification for the Qualification of Welding Educators*
B5.9	*Specification for the Qualification of Welding Supervisors*
B5.14	*Specification for the Qualification of Welding Sales Representatives*
B5.15	*Specification for the Qualification of Radiographic Interpreters*
B5.16	*Specification for the Qualification of Welding Engineers*
B5.17	*Specification for the Qualification of Welding Fabricators*

Certification Designation	Title
QC1	*Specification for AWS Certification of Welding Inspectors*
QC5	*AWS Standard for Certification of Welding Educators*
QC9	*Administrative Procedures for Alleged Violations of AWS Certification Programs*
QC13	*Specification for the Certification of Welding Supervisors*
QC14	*Specification for the Certification of Welding Sales Representatives*
QC15	*Specification for AWS Certification of Radiographic Interpreters*
QC17	*Specification for AWS Accreditation of Certified Welding Fabricators*
QC19	*Specification for AWS Certification of Robotic Arc Welding Personnel*
QC20	*Specification for AWS Certification of Resistance Welding Technicians*
QC47	*Specification for AWS Certification of Welders and Accreditation of Test Facilities*

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