

Guide for the Training of Welding Personnel: SENSE Level II— Advanced Welders



Documents

Document Sharing Hub

Guide for the Training of Welding Personnel: SENSE Level II—Advanced Welders

**Supersedes EG3.0-96
Revision 0**

Prepared by the
American Welding Society (AWS) Education Committee—Task Group on SENSE Standards

Under the Direction of the
AWS Education Committee

Approved by the
AWS Board of Directors

Abstract

This guide contains information to assist training organizations in the development and administration of a modular, competency-based training program that leads to the training certificate of trainees in accordance with the requirements of AWS QC11, *Specification for Qualification and Certification of SENSE Level II—Advanced Welders*.



ISBN: Print: 978-0-87171-973-7
ISBN PDF: 978-0-87171-974-4
© 2017 by American Welding Society
All rights reserved
Printed in the United States of America

Photocopy Rights. No portion of this standard may be reproduced, stored in a retrieval system, or transmitted in any form, including mechanical, photocopying, recording, or otherwise, without the prior written permission of the copyright owner.

Authorization to photocopy items for internal, personal, or educational classroom use only or the internal, personal, or educational classroom use only of specific clients is granted by the American Welding Society provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, tel: (978) 750-8400; Internet: <www.copyright.com>.

Statement on the Use of American Welding Society Standards

All standards (codes, specifications, recommended practices, methods, classifications, and guides) of the American Welding Society (AWS) are voluntary consensus standards that are developed through a consensus standards development process that brings together volunteers representing varied viewpoints and interests to achieve consensus. While the American Welding Society administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in its standards. Further, given the rapid changes in the field, AWS cannot warrant that the standard will at all times reflect the most current knowledge.

AWS disclaims liability for any injury to persons or to property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this standard. AWS also makes no guarantee or warranty as to the accuracy or completeness of any information published herein.

In issuing and making this standard available, AWS is neither undertaking to render professional or other services for or on behalf of any person or entity, nor is AWS undertaking to perform any duty owed by any person or entity to someone else. Anyone using these documents should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. It is assumed that the use of this standard and its provisions is entrusted to appropriately qualified and competent personnel.

This standard may be superseded by new editions. This standard may also be corrected through publication of amendments or errata, or supplemented by publication of addenda. Information on the latest editions of AWS standards including amendments, errata, and addenda is posted on the AWS web page (www.aws.org). Users should ensure that they have the latest edition, amendments, errata, and addenda.

Publication of this standard does not authorize infringement of any patent or trade name. Users of this standard accept any and all liabilities for infringement of any patent or trade name items. AWS disclaims liability for the infringement of any patent or product trade name resulting from the use of this standard.

AWS does not monitor, police, or enforce compliance with this standard, nor does it have the power to do so.

Official interpretations of any of the technical requirements of this standard may only be obtained by sending a request, in writing, to the appropriate education committee. Such requests should be addressed to the American Welding Society, Attention: Director, Education Services Department, 8669 NW 36 St, # 130, Miami, FL 33166 (see Annex H). 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 Education Committee. 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 Education Committee 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 Education Committee 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 Education Committee. A copy of these Rules can be obtained from the American Welding Society, 8669 NW 36 St, # 130, Miami, FL 33166.

This page is intentionally blank.

Personnel

AWS Education Committee

E. Norman, Chair	<i>EDCO Industries, LLC</i>
T. Lienert, Vice Chair	<i>Los Alamos National Laboratory</i>
P. Henry, Secretary	<i>American Welding Society</i>
Y. Adonyi	<i>LeTourneau University</i>
M. Anderson	<i>New Castle Area Career Programs</i>
A. Ash	<i>U.S. Army</i>
T. Baber	<i>College of the Canyons</i>
J. Carney	<i>Ferris State University</i>
J. Colton	<i>Pennsylvania College of Technology</i>
G. Donovan	<i>International Training Institute of the SMWIA</i>
T. T. Gilligan	<i>United Association</i>
J. Greer	<i>Moraine Valley Community College</i>
D. Haas	<i>Ingalls Shipbuilding</i>
M. Hayden	<i>Cedartown Comprehensive High School</i>
S. V. Houston	<i>American Technical Publishers</i>
J. Jones	<i>The Lincoln Electric Company</i>
P. Mendez	<i>University of Alberta</i>
B. Muehlbrandt	<i>The Lincoln Electric Company</i>
D. L. Myers	<i>ESAB Welding & Cutting Products</i>
N. Peterson	<i>Miller Electric Manufacturing Company</i>
D. Phillips	<i>The Ohio State University</i>
R. Polanin	<i>Illinois Central College</i>
M. Relyin	<i>International Association of Iron Workers</i>
J. Schmidt	<i>The Lincoln Electric Company</i>
D. Turner	<i>Yuba Community College</i>
R. Vanscoy	<i>International Brotherhood of Boilermakers</i>
Z. Yu	<i>Colorado School of Mines</i>
W. Zhang	<i>The Ohio State University</i>

Advisors to the AWS Education Committee

D. Klingman	<i>Welding Consultant</i>
A. Godley	<i>Welding Consultant</i>

AWS Task Group on SENSE Standards

S. Houston, Chair	<i>American Technical Publishers</i>
I. Santa Cruz, Secretary	<i>American Welding Society</i>
M. Anderson	<i>New Castle Area Career Programs</i>
T. T. Gilligan	<i>United Association</i>
D. P. Hamilton	<i>Stringer Bead Welding</i>
D. Klingman	<i>Welding Consultant</i>
J. Knapp	<i>Northeast Community College</i>
E. Norman	<i>EDCO Industries</i>
R. Richwine	<i>Ivy Tech Community College</i>
J. Schmidt	<i>The Lincoln Electric Company</i>
M. Sloan	<i>International Training Institute of the SMWIA</i>
R. Vanscoy	<i>International Brotherhood of Boilermakers</i>

This page is intentionally blank.

Foreword

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

The AWS Schools Excelling through National Skill Standards Education (SENSE) program began in 1993 with the award of a grant by the U.S. Department of Education to develop a series of voluntary standards to promote consistency and quality in welding education on a national basis. The development of these National Skill Standards involved a survey of the welding industry, skilled trades, and the welding education community, to arrive at a consensus on welder skills and competencies required by industry. The result of this survey was an occupational task analysis. This task analysis formed the basis for the development of the SENSE specifications and guidelines.

Currently, there are two levels of SENSE: Level I—Entry Welder and Level II—Advanced Welder. Both levels are designed to facilitate the implementation of a modular welder training program based on best practices.

The specifications and guidelines for SENSE Level I—Entry Welder were revised in 2016 and SENSE Level II—Advanced Welder was modularized to facilitate implementation in a variety of welder training programs. Supplements were also developed to provide technique sheets and AWS standard welding procedure specifications (SWPSs) for SENSE workmanship and performance qualification tests. The supplements are based on AWS B2.0, *Standard Welding Procedure Specifications (SWPSs)*. In addition, AWS QC21, *Specification for AWS Accreditation of SENSE Welder Training Programs*, was added. The specifications, guidelines, and supplements for SENSE welder training and welder training program accreditation are:

AWS QC10, *Specification for Qualification and Certification of SENSE Level I—Entry Welders*

AWS EG2.0, *Guide for the Training of Welding Personnel: SENSE Level I—Entry Welders*

AWS EG2.0 Supplement, *Supplement SENSE Level I—Entry Welder Training Performance Testing Procedures*

AWS QC11, *Specification for Qualification and Certification of SENSE Level II—Advanced Welders*

AWS EG3.0, *Guide for the Training of Welding Personnel: SENSE Level II—Advanced Welders*

AWS EG3.0 Supplement, *Supplement SENSE Level II—Advanced Welder Training Performance Testing Procedures*

AWS QC21, *Specification for AWS Accreditation of SENSE Welder Training Programs*

AWS EG21, *Specification for the Qualification of SENSE Welder Training Programs*

This latest revision of AWS EG3.0, *Guide for the Training of Welding Personnel: Level II—Advanced Welders*, represents the AWS Education Committee's consensus on the requirements for trainees of SENSE training organizations to receive an AWS SENSE Advanced Welder credential, and to be registered in the AWS SENSE Certificate Database.

This page is intentionally blank.

Table of Contents

Personnel	v
Foreword.....	vii
List of Tables	x
1. General Provisions.....	1
1.1 Scope.....	1
1.2 Objectives.....	1
1.3 Implementation	1
2. Industrial Awareness.....	1
2.1 Scope.....	1
2.2 Advanced Welder Definition.....	2
2.3 Advanced Welder Occupational Description	2
2.4 Advanced Welder Occupational Conditions	3
3. SENSE Guidelines	4
3.1 General Guidelines.....	4
3.2 Modular Competency Based Program Outline	7
3.3 Modular Guidelines for SENSE Level II—Advanced Welder.....	15
Annex A (Normative)—Recommendations for Support Personnel and Systems	141
Annex B (Normative)—Recommendations for the Trainee Population	145
Annex C (Normative)—Recommendations for Facility Planning	147
Annex D (Normative)—Recommendations for Personal and Shop Materials, Equipment, and Tools.....	151
Annex E (Normative)—Training Achievement Record	159
Annex F (Normative)—Reference Materials	167
Annex G (Normative)—Standard Welding Procedure Specifications for Level II Welding Performance Qualification Tests.....	169
Annex H (Informative)—Guidelines for the Preparation of Technical Inquiries for the AWS Education Committees	171

List of Tables

Table	Page No.
3.1 AWS SENSE Level II—Advanced Welder Compulsory Modules	4
3.2 AWS SENSE Level II—Advanced Welder Optional Plate Modules	5
3.3 AWS SENSE Level II—Advanced Welder Optional Pipe Modules.....	5
3.4 AWS SENSE Level II—Advanced Welder Optional Welding Fabrication Module.....	6

Guide for the Training of Welding Personnel: SENSE Level II—Advanced Welders

1. General Provisions

1.1 Scope. AWS EG3.0, *Guide for the Training of Welding Personnel: SENSE Level II—Advanced Welders*, defines the recommended minimum welder training requirements for a SENSE Level II—Advanced Welder in accordance with AWS QC11, *Specification for Qualification and Certification of SENSE Level II—Advanced Welders*.

This guide is intended to specify a credible path for training organizations to implement new welding programs or to enhance existing programs to administer SENSE Level II—Advanced Welder training.

This guide establishes the minimum requirements for trainees to receive an AWS SENSE credential for the SENSE Level II—Advanced Welder program. SENSE training organizations are free to exceed these minimum requirements.

1.2 Objectives

1.2.1 Provide training organizations with an awareness of the occupational analysis, conditions, tasks, and profile that encompass the advanced welder job classification.

1.2.2 Establish national consensus guidelines, based on an industry-wide survey of the minimum acceptable skill requirements for the training of a SENSE Level II—Advanced Welder.

1.2.3 Provide training organizations with a list of *Key Indicators* (desired outcomes), *Objectives*, and *Recommended Instructional Activities* necessary to accomplish SENSE Level II—Advanced Welder training.

1.2.4 Provide training organizations with a national consensus guideline with which to compare their own curriculum, evaluate third party curricula, or develop a new curriculum that is aligned with this national consensus modular SENSE Level II—Advanced Welder guideline.

1.2.5 Provide training organizations with AWS documents and standards for the evaluation or development training materials.

1.2.6 Provide training organizations participating in SENSE with information related to the administration of SENSE Level II—Advanced Welder testing necessary to meet the requirements of AWS QC11.

1.3 Implementation

1.3.1 Completion Status. AWS QC11 defines the requirements to receive an AWS SENSE credential as an AWS *SENSE Advanced Welder*. In order to list a trainee in the AWS SENSE Certificate Database, the training organization must submit the trainee's scores to the AWS Education Services Department.

1.3.2 Continuation of Trainees in the AWS SENSE Certificate Database. Trainee records shall be listed in the AWS SENSE Certificate Database for three (3) years, after which time a permanent record shall be archived.

2. Industrial Awareness

2.1 Scope. Training organizations should understand the needs of industry and provide welder training programs that prepare students to fill these needs. This is difficult because of the diverse nature of the welding function, along with the fact that it varies from industry-to-industry and from company-to-company.

Recognizing this diversity, AWS conducted an industry-wide survey, covering a broad base of businesses, job classifications, and educational institutions, to gather and analyze data concerning the skills and knowledge that an advanced

welder should possess. A profile of an advanced welder was developed from this analysis. This profile identifies skill and knowledge areas common to all advanced welders, regardless of their unique situation in industry.

The second step used to understand the function of a welder in industry, was to prepare a task analysis based on the advanced welder profile. The results of this analysis included a definition (see 2.2), an occupational description (see 2.3), and a description of occupational conditions (see 2.4).

Upon completion of the task analysis, technical information topics, materials, equipment, and tools were identified. This information was then converted from occupational data to a guide with the key indicators (desired outcomes), objectives, evaluation criteria, and recommended instructional activities.

2.2 Advanced Welder Definition. An individual employed in this capacity is considered to possess a prerequisite amount of theoretical knowledge, welding skills, attitude, and habits required to perform proceduralized tasks under general supervision, and more complex tasks under close supervision.

2.3 Advanced Welder Occupational Description. The position of advanced welder is comprised of the following areas:

2.3.1 Layout and Fitup Practices. The individual demonstrates a working knowledge of layout and fit up principles; exhibits the ability to operate shop equipment safely and use layout tools for geometric construction; has a working knowledge of measurement practices, design for welding, and the use of fixtures and positioners; works from drawings or sketches to prepare, form, or cut multiple parts, and assemble weldments; and interprets welded joint and welding requirements based on welding symbol information and on Welding Procedure Specifications (WPSs).

2.3.2 Trade Math. Possesses the ability to add, subtract, multiply, and divide whole numbers, fractions, mixed numbers, and decimals; round-off decimals to one or more places; use measuring devices to determine size, length, angle, and distance; convert mixed number fractions to decimals and vice versa; convert between Metric and U.S. Customary units; identify geometric shapes; understand the functions of angles and parts of a circle; prepare parts using the principles of geometry; and read and use measuring tapes, rules, and squares calibrated in both metric and U.S. Customary units.

2.3.3 Arc Welding. The individual has a working knowledge of welding metallurgy, including mechanical and chemical properties of metals, weld zone metallurgy, residual stress, and distortion control; demonstrates a working knowledge of joint design and preparation, selection of materials, arc welding applications, weld quality, weld repairs (corrective actions), and performs minor maintenance on welding equipment; and demonstrates ability in one or more of the following areas:

2.3.3.1 Shielded Metal Arc Welding (SMAW) Plate. Sets up and performs all position fillet and groove welding on an unlimited thickness range of carbon steel and stainless steel plate with carbon steel and stainless steel filler metals.

2.3.3.2 Shielded Metal Arc Welding (SMAW) Pipe. Sets up and performs all position fillet and groove welding on carbon steel pipe.

2.3.3.3 Gas Metal Arc Welding (GMAW) Plate. Sets up for GMAW spray transfer and performs groove welds on unlimited thickness carbon steel in the flat position, limited thickness aluminum groove welds on aluminum in the flat position, as well as horizontal position fillet welds on carbon steel and aluminum. Sets up for GMAW-P and performs all position fillet and groove welding on unlimited thickness carbon steel, and limited thickness stainless steel.

2.3.3.4 Gas Metal Arc Welding (GMAW) Pipe. Sets up for GMAW-S and performs all position fillet and groove welds on carbon steel pipe. Sets up for GMAW spray transfer and performs flat position groove welds on carbon steel pipe. Sets up for GMAW-P and performs all position fillet and groove welds on carbon steel pipe.

2.3.3.5 Flux Cored Arc Welding (FCAW) Plate. Sets up for FCAW-G and performs all position fillet and groove welds on unlimited thickness carbon steel plate. Sets up for FCAW-S and performs all position fillet and groove welds on unlimited thickness carbon steel plate.

2.3.3.6 Flux Core Arc Welding (FCAW) Pipe. Sets up for FCAW-G and performs fillet and groove welding on carbon steel pipe.

2.3.3.7 Gas Tungsten Arc Welding (GTAW) Plate. Sets up for GTAW and performs all position fillet and groove welds within a limited thickness range of carbon steel, stainless steel, and aluminum plate.

2.3.3.8 Gas Tungsten Arc Welding (GTAW) Pipe. Sets up for GTAW and performs all position fillet and groove welds on carbon steel pipe with carbon steel and stainless steel filler metals.

2.3.4 Oxyfuel Gas Cutting (OFC). Possesses the prerequisite OFC skills of an entry level welder. Sets up and performs manual OFC operations that include straight and shape cutting, beveling and weld removal (weld washing) on various product forms including plate and pipe. Sets up and operates machine OFC equipment (track burner and pipe beveller) to perform straight cutting and beveling operations. Demonstrates knowledge of preparation and selection of materials, cutting applications, cut quality and cut surface repairs (corrective actions). Performs minor maintenance on OFC equipment.

2.3.5 Arc Cutting and Gouging. Possesses the prerequisite arc cutting skills of an entry level welder. Sets up air carbon arc cutting (CAC-A) equipment and performs manual operations that include gouging, beveling, and weld removal on various product forms including plate and pipe. Sets up manual plasma arc cutting (PAC) equipment and performs cutting operations that include straight cutting, shape cutting, and beveling on various product forms including plate and pipe. Sets up machine plasma arc cutting equipment (track burner and pipe beveller) and performs straight cutting and beveling operations. Demonstrates knowledge of preparation and selection of materials, arc cutting applications, cut quality and cut surface repairs (corrective actions). Performs minor maintenance on arc cutting equipment.

2.3.6 Welding Codes and Standards. Possesses a working knowledge of welding code and standards interpretation.

2.3.7 Qualification and Certification. Possesses a working knowledge of the functions of welding procedure specifications, welding procedure qualifications, and welder performance qualification.

2.3.8 Inspection and Testing. Possesses the prerequisite inspection skills of an entry level welder. Visually examines all personal welding and cutting assignments for unfavorable weld and cut edge surface discontinuities. Takes corrective actions to repair unfavorable weld and cut edge surface discontinuities before final inspection by a supervisor. Has a working knowledge of destructive testing and non-destructive examination principles, as well as weld test interpretation.

2.4 Advanced Welder Occupational Conditions

2.4.1 Work Environment. Advanced welders are employed in a wide range of manufacturing, fabrication, and construction industries that use welding and welding-related tasks. Industries include a mix of small, medium, and large union and non-union facilities.

2.4.2 Occupational Hazards. As is the case in most metalworking industries, the potential for injury and hazardous situations exists. High electrical currents and voltages are used to operate machinery and welding equipment. Machinery for shearing, forming, and punching is used on various thicknesses of materials. Flammable and other compressed gases are used during flame cutting and welding operations. The welder may be in direct contact with heavy sections of material during lifting and positioning operations. The welder may also work in enclosed or restricted spaces, or at high elevations and in awkward positions. Excessive noise levels are sometimes generated during the production process. The welder must take safety precautions, and be safety conscious at all times.

2.4.3 Advanced Welder Profile. This position of advanced welder involves concentration, decision making, and physical tasks.

2.4.3.1 Physical Requirements. Advanced welders must meet the physical requirements established by the employer.

2.4.3.2 Employability. Advanced welders should exhibit good job-related written, oral, and listening skills, in addition to competency in problem solving, decision making, and trade-related math. These individuals should display dependability, good judgment, and interact well with others.

2.4.3.3 Education. Advance welder training may be accomplished through secondary and postsecondary institutions, apprenticeships, military training, and employer-based welder training programs. Sufficient workplace skills (i.e., foundation skills such as: reading, writing, math, science, communication skills, adaptability skills, and employability skills) are required to complete requisite welding related knowledge and skill training.

3. SENSE Guidelines

3.1 General Guidelines. It is the sole intent of this document to provide guidelines for a modular, competency-based welder training program. It is the responsibility of the training organization to sequence instruction to suit the specific application, and to develop or acquire suitable training materials. Training activities should consistently reinforce the use of previously acquired entry-level welder skills, as well as basic skills (i.e., trade-related reading, writing, math, and communications).

3.1.1 Pre-assessment. The welding industry wants advanced welders with strong employability skills such as trade-related reading, writing, mathematics, listening, and oral communication skills that are closely related to successful job performance. SENSE Level II—Advanced Welder training also requires sufficient basic skills to comprehend technical material, read prints, and complete assignments. Therefore, it is strongly recommended that prospective trainees undergo a pre-placement assessment of basic skill competency as defined by federal or state guidelines prior to entry into the welding program.

3.1.2 Review. Training organizations should review 3.2, *Modular Competency-Based Program Outline for SENSE Level II—Advanced Welder*, and 3.3, *Modular Guidelines for Level II—Advanced Welder*, prior to the introduction of the SENSE Level II—Advanced Welder into the training cycle.

3.1.3 Implementation—Modular Design. AWS SENSE Level II—Advanced Welder is designed to facilitate the implementation of a modular welder training program based on best practices. In order to receive a SENSE credential as a SENSE Advanced Welder, trainees must successfully complete the compulsory modules in Table 3.1, including the practical knowledge exam and the performance test for all four units in Module 5: Thermal Cutting Processes, as well as a minimum of one optional plate module per Table 3.2. Trainees may also receive a SENSE Advanced Welder credential in one or more of the optional pipe welding modules per Table 3.3, provided they complete the corresponding welding process plate module(s) (SMAW, GMAW, FCAW, or GTAW), and pass the SENSE Level II Pipe Welding written exam. The training organizations offering welding fabrication training in conjunction with their welding programs should use the optional Welding Fabrication module in Table 3.4.

Table 3.1
AWS SENSE Level II—Advanced Welder Compulsory Modules

Module	Prerequisite	Practical Knowledge Exam	NDE	Destructive	Competency Achieved by
1. Trade Math	None	Yes	NA	NA	Practical knowledge exam score 75%
2. Welding Metallurgy	None	Yes	NA	NA	Practical knowledge exam score 75%
3. Welding Inspection & Testing Methods	Level I Welding Inspection & Testing	Yes	Yes (Visual, Liquid Penetrant)	Yes (Fillet Break, Macroetch ^a)	Practical knowledge exam score 75% Fillet break, liquid penetrant tests, and visual examination completed
4. Documents Governing Welding & Welding Inspection	None	Yes	NA	NA	Practical knowledge exam score 75%
5. Thermal Cutting Processes	Level I Thermal Cutting Processes	Yes	Yes (Visual)	NA	Practical knowledge exam score 75% Visual examination passed

^a Macroetch is optional.

Table 3.2
AWS SENSE Level II—Advanced Welder Optional Plate Modules

Module	Prerequisite	Practical Knowledge Exam	NDE	Destructive	Competency Achieved by
6. SMAW Plate	SMAW Level I	Yes	Yes (Visual)	Yes ^a	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^a (QC7 Cert optional)
8. GMAW Plate	GMAW Level I	Yes	Yes (Visual)	Yes ^a	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^a (QC7 Cert optional)
10. FCAW Plate	FCAW Level I	Yes	Yes (Visual)	Yes ^a	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^a (QC7 Cert optional)
12. GTAW Plate	GTAW Level I	Yes	Yes (Visual)	Yes ^a	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^a (QC7 Cert optional)

^a Radiographic examination (RT) accepted in lieu of destructive testing.

Table 3.3
AWS SENSE Level II—Advanced Welder Optional Pipe Modules

Module	Prerequisite	Written	NDE	Destructive	Competency Achieved by
7. SMAW Pipe	SMAW Level I SMAW Level II Plate	Yes ^a	Yes (Visual)	Yes ^b	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^b (QC7 Cert optional)
9. GMAW Pipe	GMAW Level I GMAW Level II Plate	Yes ^a	Yes (Visual)	Yes ^b	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^b (QC7 Cert optional)
11. FCAW Pipe	FCAW Level I FCAW Level II Plate	Yes ^a	Yes (Visual)	Yes ^b	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^b (QC7 Cert optional)
13. GTAW Pipe	GTAW Level I GTAW Level II Plate	Yes ^a	Yes (Visual)	Yes ^b	Practical knowledge exam score 75% Visual inspection passed Destructive test passed ^b (QC7 Cert optional)

^a The pipe practical knowledge exam is generic to all pipe welding processes.

^b Radiographic Examination (RT) accepted in lieu of destructive testing.

Table 3.4
AWS SENSE Level II—Advanced Welder Optional Welding Fabrication Module

Module	Prerequisite	Written	NDE	Destructive	Competency Achieved by
14. Welding Fabrication	— Compulsory Level II Modules — Level II SMAW, GMAW, FCAW, & GTAW Plate Modules — Minimum of one Level II pipe module if attempting pipe component	No	Yes (Visual)	NA	Visual inspection passed

3.1.4 Curriculum Comparison. Each training organization's curriculum and training materials should be based on 3.3, *Modular Guidelines for SENSE Level II—Advanced Welder*.

3.1.5 Lesson Plan Development. The training organization's lesson plans should address the key indicators (learning outcomes), objectives, and recommended learning activities associated with each module or units within a module. (Refer to 3.3, *Modular Guidelines for SENSE Level II—Advanced Welder*.)

3.1.6 Teaching Sequence. The program sequence as outlined in 3.2, *Modular Competency Based Program Outline* and detailed in 3.3, *Recommended Modular Guidelines for SENSE Level II—Advanced Welder Training* is not mandatory. The teaching sequence should be determined by the instructor, the training organization, and the state educational authority, based on the needs of industry and the trainee population.

3.1.7 Practical Exercises. Practical exercises for plate modules consist of multiple pass 2F, 3F, and 4F position fillet welds, as well as 3G and 4G position groove welds, with the exception of GMAW spray transfer which does not lend itself to out of position welding. Practical exercises for pipe consist of multiple pass 2F, 4F, and 5F position pipe to plate fillet welds, and multiple pass 2G, 5G, and 6G position groove welds. GMAW spray transfer pipe exercises are limited to the 2F and 1G positions.

Practical exercises for stainless steel plate and pipe use carbon steel base metal with stainless steel filler in order to reduce costs. Training organizations may substitute stainless steel base metal for carbon steel if desired.

The practical exercises listed above, are considered the minimum required for trainees to successfully complete the SENSE Level II—Advanced Welder performance qualification tests. However, the training organization is free to provide trainees with additional practical exercises as necessary. For example, the training organization may wish to have trainees practice 1G and 2G position multiple pass groove welds in addition to the 3G and 4G position welds recommended in this guide.

3.1.8 Practical Knowledge Exams. Trainees must achieve a minimum score of 75% on AWS SENSE Level II—Advanced Welder practical knowledge exams administered at the completion of each compulsory and optional module, with the exception of Welding Fabrication. There is no Welding Fabrication practical knowledge exam. In addition to the AWS SENSE Level II—Advanced Welder practical knowledge exams, it is recommended that the instructors develop and administer frequent and appropriate tests during and after the completion of classroom instruction to measure mastery of key concepts. Tests may be written, or administered over a Learning Management System (LMS).

3.1.9 Welder Performance Qualification Testing. Unlike AWS SENSE Level I—Entry Welder which focuses on workmanship qualification tests, AWS SENSE Level II—Advanced Welder concentrates on multiple pass plate and pipe welder performance qualification tests. These welder performance qualification tests are representative of the tests that trainees are typically required to pass on the job. For example, SMAW plate welder performance qualification tests are 3G and 4G unlimited thickness tests.

3.1.9.1 EG 3.0 Supplement, SENSE Level II Advanced Welder Performance Testing Procedures. The EG3.0 supplement contains Welder Performance Qualification Technique Sheets (WPQTS) for all welder performance qualifi-

cation tests. It also includes Standard Welding Procedure Specifications (SWPSs) from AWS B2.0, where available. These SWPSs are made available to SENSE training organizations for educational use only.

3.1.9.2 Radiographic Examination. Radiographic examination (RT) may be substituted in lieu of AWS standard guided bend and side bend tests.

3.1.9.3 Optional QC7 Certified Welder Testing. Trainees electing to use the AWS QC7 Certified Welder option for welder performance qualification tests must use an AWS Accredited Test Facility (ATF). Test results must be sent to the AWS Certification Department for processing. A copy of the AWS Certified Welder card must be sent to the AWS Education Department as specified in AWS QC11, *Specification for Qualification and Certification of SENSE Level II—Advanced Welders*.

3.1.10 Workmanship Qualification Testing. The only workmanship qualification test in AWS SENSE Level II—Advanced Welder is associated with the optional Welding Fabrication module. However, training organizations may implement additional workmanship qualification tests as desired.

3.1.11 Endorsements. A trainee can receive endorsements for successfully completing welder performance qualification tests previously covered under SENSE Level III—Expert Welder, as well as a variety of other test positions, materials, and welding processes. See AWS QC11, *Specification for Qualification and Certification of SENSE Level II—Advanced Welders*, for more details on endorsements.

3.1.12 Record Keeping. It is recommended that training organizations develop appropriate records to track each trainee's achievements. In addition, appropriate records should be developed so that the trainees may keep a record of achievement.

3.1.13 New Technology. AWS recognizes that many training organizations may not have the latest welding technology available for training. Nevertheless, training organizations should ensure that instructors have access to information about advances in the welding technology, and that the welding curriculum be updated regularly to reflect these advances.

3.1.14 Participation in AWS. Trainees should be encouraged to participate in AWS student chapters or in AWS sections as student members in order to develop their industry awareness, and to network with welding professionals. Likewise, training organizations can promote their welding training facilities and develop credibility with the local welding industry by hosting AWS student nights, by hosting local and regional welding skills competitions, and by organizing student chapters.

3.1.15 Field Trips and Industry Involvement. If time and policies permit, training organizations are encouraged to arrange field trips to local manufacturers, union training centers, and metal fabricators involved with welding. The opportunity to experience welding applications used in real-world settings can be extremely motivational and enlightening for the trainees. Field trips and industry involvement also build important relationships between training organizations and potential employers.

3.1.16 Guest Speakers and Job Fairs. Training organizations are also encouraged to invite industry and trade union representatives to discuss career opportunities and employment requirements with trainees. Job fairs also provide excellent networking opportunities between trainees and potential employers.

3.1.17 Budget. Adequate financial resources should be provided to maintain and enhance the welding program. Primary funding is for all necessary equipment (e.g., power sources, filler metals, gases, power equipment, hand tools). Additional monies should be available to provide the materials necessary for adequate welding instruction. Budget resources should also be available for staff and faculty technical and professional development.

3.2 Modular Competency Based Program Outline

Sense Level II—Advanced Welder

Prerequisites

Occupational Orientation (SENSE Level I—Entry Welder)

Safety and Health of Welders (SENSE Level I—Entry Welder)

3.2.1 Module 1: Trade Math

Prerequisites

None.

Key Indicators

1. Performs basic mathematical functions with fractions and mixed numbers.
2. Converts fractions to decimals and performs basic mathematical functions with decimals.
3. Reads a rule in U.S. Customary and Metric units, performs linear measurements, and calculates the area of shapes.
4. Calculates volume and weight associated with different shapes.
5. Converts U.S. Customary units to Metric units, and vice versa.

3.2.2 Module 2: Welding Metallurgy

Prerequisites

None.

Key Indicators

1. Exhibits a working knowledge of the metallurgy and weldability of carbon steel.
2. Exhibits a working knowledge of the metallurgy and weldability of stainless steel.
3. Exhibits a working knowledge of the metallurgy and weldability of aluminum.
4. Exhibits a working knowledge of the principles related to residual stress and distortion control.

3.2.3 Module 3: Documents Governing Welding and Welding Inspection

Prerequisites

None.

Key Indicators

1. Possesses a working knowledge of the major welding codes.
2. Possesses a working knowledge of documents related to welding specifications and qualifications.
3. Possesses a working knowledge of documents related to standard symbols for welding and nondestructive examination, nondestructive inspection of welds, visual inspection of welds, and mechanical testing of welds.
4. Possesses a working knowledge of the major base metal designation systems, filler metal specifications, and a material test report.

3.2.4 Module 4: Welding Inspection and Testing Methods

Prerequisites

Module 9: Welding Inspection and Testing (SENSE Level I—Entry Welder)

Key Indicators

1. Possesses a working knowledge of commonly used destructive testing methods.
2. Possesses a working knowledge of commonly used nondestructive examination methods.
3. Performs a dye penetrant test.
4. Performs a macroetch test (optional).
5. Performs a fillet break test.
6. Performs a visual examination of cut surfaces and edges of prepared base metal parts according to applicable fitup and preparation tolerances.
7. Performs a visual examination of tack welds, root pass, intermediate layers, and completed welds according to applicable acceptance criteria.

3.2.5 Module 5: Thermal Cutting Processes

Prerequisites

Module 8: Thermal Cutting Processes (SENSE Level I—Entry Welder)

Unit 1: Manual Oxyfuel Gas Cutting (OFC)

Key Indicators

1. Performs safety inspection, operator maintenance, sets up, and operates manual OFC equipment on carbon steel.
2. Performs straight, square edge cutting operations in the horizontal and vertical positions on carbon steel plate.
3. Performs straight, bevel edge cutting operations in the horizontal and vertical positions on carbon steel plate.
4. Performs straight, structural shape cutting operations on angle, channel, and square or rectangular carbon steel tubing, in the horizontal and vertical positions.
5. Performs straight, square edge cutting operations on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.
6. Performs straight, bevel edge cutting operations on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.

Unit 2: Mechanized Oxyfuel Gas Cutting (OFC) [Pipe Beveller]

Key Indicators

1. Performs mechanized OFC equipment safety inspection, operator maintenance, sets up, and operates mechanized OFC equipment on carbon steel pipe.
2. Performs straight, square edge cutting operations in the flat position on carbon steel pipe using a pipe beveller.
3. Performs straight, bevel edge cutting operations in the flat position on carbon steel pipe using a pipe beveller.

Unit 3: Plasma Arc Cutting (PAC)

Key Indicators

1. Performs PAC equipment safety inspection, operator maintenance, sets up, and operates manual PAC equipment on carbon steel, stainless steel, and aluminum.
2. Performs straight, square edge cutting operations in the horizontal and vertical positions on carbon steel, stainless steel, and aluminum.
3. Performs straight, bevel edge cutting operations in the horizontal and vertical positions on carbon steel, stainless steel, and aluminum.
4. Performs straight, structural shape cutting operations on angle, channel, and square or rectangular tubing in the horizontal and vertical positions, on carbon steel, stainless steel, and aluminum.
5. Performs straight, square edge cutting operations on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.
6. Performs straight, bevel edge cutting operations on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.

NOTE: Stainless steel and aluminum pipe optional.

Unit 4: Air Carbon Arc Cutting (CAC-A)

Key Indicators

1. Performs CAC-A equipment safety inspection, operator maintenance, sets up, and operates manual CAC-A equipment on carbon steel plate.
2. Performs straight, square edge cutting operations in the horizontal and vertical positions on carbon steel plate.
3. Performs straight, bevel edge cutting operations in the flat, horizontal, and vertical positions on carbon steel plate.
4. Performs gouging operations to remove base and weld metal in the vertical position on carbon steel plate.
5. Performs straight, structural shape cutting operations on carbon steel angle, channel, and square or rectangular tubing in the flat, horizontal, and vertical positions.
6. Performs straight, square edge cutting operations on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.
7. Performs straight, bevel edge cutting operations on carbon steel pipe with the pipe axis in the horizontal and vertical positions.

3.2.6 Module 6: Shielded Metal Arc Welding (SMAW)—Plate

Prerequisites

Module 4: Shielded Metal Arc Welding (SMAW) (SENSE Level I—Entry Welder)

Key Indicators

1. Performs safety inspection, operator maintenance, sets up, and operates SMAW equipment.
2. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate using stainless steel electrodes.
3. Makes multiple pass groove welds in the 3G and 4G positions on carbon steel plate using stainless steel electrodes, with and without backing.
4. Passes 3G and 4G position unlimited thickness welder performance qualification tests on carbon steel plate with stainless steel electrodes, with or without backing.

3.2.7 Module 7: Shielded Metal Arc Welding (SMAW)—Pipe**Prerequisites**

Module 4: Shielded Metal Arc Welding (SMAW) (SENSE Level I—Entry Welder)

Module 6: Shielded Metal Arc Welding (SMAW)—Plate (SENSE Level II—Advanced Welder)

Key Indicators

1. Performs safety inspection, operator maintenance, sets up, and operates SMAW equipment.
2. Makes multiple pass fillet welds in the 2F, 4F, and 5F positions on carbon steel pipe to plate.
3. Makes multiple pass groove welds in the 2G, 5G, and 6G positions on carbon steel pipe, with and without backing ring.
4. Passes a 6G welder performance qualification test on carbon steel pipe with or without backing ring.

3.2.8 Module 8: Gas Metal Arc Welding (GMAW)—Plate**Prerequisites**

Module 5: Gas Metal Arc Welding (GMAW) (SENSE Level I—Entry Welder)

Key Indicators**Spray Transfer (carbon steel)**

1. Performs GMAW equipment safety inspection, operator maintenance, sets up, and operates GMAW equipment in spray transfer mode on carbon steel plate.
2. Makes multiple pass groove welds in the 1G position on carbon steel plate with backing, using GMAW spray transfer.
3. Passes a 1G position unlimited thickness welder performance qualification test on carbon steel plate with backing, using GMAW spray transfer.

Pulsed Spray Transfer (carbon steel)

4. Sets up for GMAW-P and operates GMAW equipment on carbon steel plate in pulsed spray transfer mode.
5. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate using GMAW-P.
6. Makes multiple pass groove welds in the 3G and 4G position on carbon steel plate with and without backing, using GMAW-P.
7. Passes 3G and 4G position unlimited thickness welder performance qualification tests on carbon steel plate with or without backing, using GMAW-P.

Pulsed Spray Transfer (stainless steel)

8. Sets up for GMAW-P and operates GMAW equipment on carbon steel plate with stainless steel electrode in pulsed spray transfer mode.
9. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate with stainless steel electrode, using GMAW-P.
10. Makes multiple pass groove welds in the 3G and 4G position on carbon steel plate with stainless steel electrode, with and without backing, using GMAW-P.

Spray Transfer (aluminum)

11. Sets up for GMAW spray transfer and operates GMAW equipment in spray transfer mode on aluminum plate.
12. Makes multiple pass fillet welds in the 1F and 2F positions on aluminum plate using GMAW spray transfer.
13. Makes multiple pass groove welds in the 1G position on aluminum plate with backing using GMAW spray transfer.
14. Passes a 1G position welder performance qualification test on aluminum plate with backing, using GMAW spray transfer.

3.2.9 Module 9: Gas Metal Arc Welding (GMAW)—Pipe**Prerequisites**

Module 5: Gas Metal Arc Welding (GMAW) (SENSE Level I—Entry Welder)

Module 8: Gas Metal Arc Welding (GMAW)—Plate (SENSE Level II—Advanced Welder)

Key Indicators**Short Circuiting Transfer**

1. Performs a GMAW equipment safety inspection, operator maintenance, sets up, and operates GMAW equipment in short circuiting transfer mode on carbon steel pipe.
2. Makes multiple pass fillet welds in the 2F, 4F, and 5F positions on carbon steel pipe to plate using GMAW-S.
3. Makes multiple pass groove welds in the 2G, 5G, and 6G positions on carbon steel pipe with and without backing ring, using GMAW-S.
4. Passes a 6G position welder performance qualification test on carbon steel pipe, with or without backing ring, using GMAW-S.

Spray Transfer

5. Sets up for GMAW spray transfer and operates GMAW equipment in spray transfer mode on carbon steel pipe.
6. Makes multiple pass fillet welds in the 2F position on carbon steel pipe to plate using GMAW spray transfer.
7. Makes multiple pass groove welds in the 1G position on carbon steel pipe with GMAW-S root and remainder with GMAW spray transfer.
8. Passes a 1G position welder performance qualification test on carbon steel pipe with GMAW-S root and remainder with GMAW spray transfer.

Pulsed Spray Transfer

9. Sets up for GMAW-P and operates GMAW equipment in pulsed spray transfer mode on carbon steel pipe.
10. Makes multiple pass fillet welds in the 2F, 4F, and 5F positions on carbon steel pipe to plate using GMAW-P.
11. Makes multiple pass groove welds in the 2G, 5G, and 6G positions on carbon steel pipe, with and without backing ring, using GMAW-P.
12. Passes a 6G position welder performance qualification test on carbon steel pipe, with or without backing ring, using GMAW-P.

3.2.10 Module 10: Flux Cored Arc Welding (FCAW)—Plate**Prerequisites**

Module 6: Flux Cored Arc Welding (FCAW) (SENSE Level I—Entry Welder)

Key Indicators**FCAW-G**

1. Performs FCAW equipment safety inspection, operator maintenance, sets up, and operates FCAW equipment with shielding gas (FCAW-G) on carbon steel plate.
2. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate using FCAW-G.
3. Makes multiple pass groove welds in the 3G and 4G positions on carbon steel plate using FCAW-G with and without backing.
4. Passes 3G and 4G position, unlimited thickness FCAW-G welder performance qualification test on carbon steel plate with or without backing.

FCAW-S

1. Sets up for FCAW-S and performs FCAW-S operations on carbon steel plate.
2. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate using FCAW-S.
3. Makes multiple pass groove welds in the 3G & 4G positions on carbon steel using FCAW-S with and without backing.
4. Passes 3G & 4G position unlimited thickness FCAW-S welder performance qualification tests on carbon steel plate with or without backing.

3.2.11 Module 11: Flux Cored Arc Welding (FCAW)—Pipe**Prerequisites**

Module 6: Flux Cored Arc Welding (FCAW) (SENSE Level I—Entry Welder)

Module 10: Flux Cored Arc Welding (FCAW)—Plate (SENSE Level II—Advanced Welder)

Key Indicators

1. Performs FCAW equipment safety inspection, operator maintenance, sets up, and operates FCAW equipment with shielding gas (FCAW-G) on carbon steel pipe.
2. Makes multiple pass fillet welds in the 2F, 4F, and 5F positions on carbon steel pipe to plate using FCAW-G.
3. Makes multiple pass groove welds in the 2G, 5G, and 6G positions on carbon steel pipe with and without backing ring, using FCAW-G.
4. Passes a 6G welder performance qualification test on carbon steel pipe with GMAW-S or GTAW root with or without backing ring and remainder using FCAW-G.

3.2.12 Module 12: Gas Tungsten Arc Welding (GTAW)—Plate**Prerequisites**

Module 7: Gas Tungsten Arc Welding (GTAW) (SENSE Level I—Entry Welder)

Key Indicators**Carbon Steel**

1. Performs GTAW equipment safety inspection, operator maintenance, sets up, and operates GTAW equipment on carbon steel plate.
2. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate.
3. Makes multiple pass groove welds in the 3G and 4G positions on carbon steel plate with and without backing.
4. Passes 3G and 4G position welder performance qualification tests on carbon steel plate with or without backing.

Stainless Steel

5. Sets up and operates GTAW equipment on carbon steel plate using stainless steel filler metal.
6. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on carbon steel plate using stainless steel filler metal.
7. Makes multiple pass groove welds in the 3G and 4G positions on carbon steel plate using stainless steel filler metal, with and without backing.
8. Passes 3G and 4G position welder performance qualification tests on carbon steel plate using stainless steel filler metal, with or without backing.

Aluminum

9. Sets up and operates GTAW equipment on aluminum plate.
10. Makes multiple pass fillet welds in the 2F, 3F, and 4F positions on aluminum plate.
11. Makes multiple pass groove welds in the 3G and 4G positions on aluminum plate, with and without backing.
12. Passes 3G and 4G position welder performance qualification tests on aluminum plate, with or without backing.

3.2.13 Module 13: Gas Tungsten Arc Welding (GTAW)—Pipe**Prerequisites**

Module 7: Gas Tungsten Arc Welding (GTAW) (SENSE Level I—Entry Welder)

Module 12: Gas Tungsten Arc Welding (GTAW)—Plate (SENSE Level II—Advanced Welder)
 Module 7: Shielded Metal Arc Welding (SMAW)—Pipe (SENSE Level II—Advanced Welder)¹

Key Indicators

Carbon Steel

1. Performs GTAW equipment safety inspection, operator maintenance, sets up, and operates GTAW equipment on carbon steel pipe.
2. Makes multiple pass fillet welds in the 2F, 4F, and 5F positions on carbon steel pipe to plate.
3. Makes multiple pass groove welds in the 2G, 5G, and 6G position on carbon steel pipe, with and without backing ring.
4. Passes a 6G position multiple pass welder performance qualification test on carbon steel pipe, with or without backing ring.

Stainless Steel

5. Sets up and operates GTAW equipment on carbon steel pipe using stainless steel filler metal.
6. Makes multiple fillet welds in the 2F, 4F, and 5F position on carbon steel pipe to plate, with stainless steel filler metal.
7. Makes multiple pass groove welds 2G, 5G, and 6G positions on carbon steel pipe using stainless steel filler, with and without backing ring.
8. Passes a 6G position welder performance qualification test on carbon steel pipe using stainless steel filler metal, with or without backing ring.

Optional Welder Performance Qualification

9. Passes a 6G welder performance qualification test on 2.75 in diameter schedule 180 carbon steel pipe with GTAW root and optional first intermediate pass, and SMAW intermediate and cover passes.

3.2.14 Module 14: Welding Fabrication

Prerequisites

Module 1: Trade Math (SENSE Level II—Advanced Welder)
 Module 6: Shielded Metal Arc Welding (SMAW)—Plate (SENSE Level II—Advanced Welder)
 Module 8: Gas Metal Arc Welding (GMAW)—Plate (SENSE Level II—Advanced Welder)
 Module 10: Flux Cored Arc Welding (FCAW)—Plate (SENSE Level II—Advanced Welder)
 Module 12: Gas Tungsten Arc Welding (GTAW)—Plate (SENSE Level II—Advanced Welder)

NOTE: For trainees attempting the fabrication performance qualification test for both plate and pipe, they must complete at least one pipe module (SMAW, GMAW, FCAW, or GTAW), and use that process for the pipe welding component of the workmanship qualification test.

Unit 1: Introduction to Shop Equipment

Key Indicators

1. Follows safe operating procedures.
2. Selects shop equipment.
3. Sets up shop equipment.
4. Selects layout tools.
5. Operates shop equipment.
6. Operates lifting equipment.

Unit 2: Layout Principles and Practice

Key Indicators

1. Performs calculations related to parts preparation and component assembly.

¹ Required for optional 2.75 in schedule 180 carbon steel pipe welder performance qualification test only.

2. Possesses a working knowledge of fixtures and positioners used in welding fabrication.
3. Prepares material lists.
4. Selects materials.
5. Lays out materials.

Unit 3: Preparation, Fitup and Fabrication

Key Indicators

1. Performs bending or forming operations.
2. Performs drilling, punching, or boring operations.
3. Performs shearing and cutting operations.
4. Fits up parts or accessories.
5. Passes a welding fabrication workmanship performance qualification test on carbon steel with or without pipe.

3.3 Modular Guidelines for SENSE Level II—Advanced Welder

3.3.1 Module 1: Trade Math

Prerequisites

None required.

Key Indicator 1: Performs basic mathematical functions with whole numbers, fractions, and mixed numbers.

Objective: Provided with a period of instruction and demonstration, the trainee adds, subtracts, multiplies, and divides whole numbers, proper fractions, improper fractions, and mixed numbers.

Evaluation Criteria: The trainee performs addition, subtraction, multiplication, and division of proper fractions, improper fractions, and mixed numbers.

Recommended Instructional Activities

1. Introduce terms and definitions related to mathematical functions with whole numbers, fractions, and mixed numbers.
2. Provide instruction, demonstration, and exercises related to reducing fractions to their lowest common denominator.
3. Provide instruction, demonstration, and exercises related to converting between mixed numbers and improper fractions.
4. Provide instruction, demonstration, and exercises related to adding, subtracting, multiplying, and dividing whole number, fractions, and mixed numbers.
5. Develop and administer a test related to performing basic mathematical functions with whole numbers, fractions, and mixed number.
6. Keep training records reflecting results of performing basic mathematical functions with whole numbers, fractions, and mixed numbers.

3.3.1 Module 1: Trade Math

Key Indicator 2: Converts fractions to decimals and performs basic mathematical functions with decimals.

Objective: Provided with a period of instruction and demonstration, the trainee converts decimals to fractions and vice versa, performs rounding of decimals, and adds, subtracts, multiplies, and divides decimals.

Evaluation Criteria: The trainee converts decimals to fractions and vice versa, performs rounding of decimals, and successfully adds, subtracts, multiplies, and divides decimals.

Recommended Instructional Activities

1. Introduce terms and definitions related to converting fractions and decimals, and performing mathematical functions.
2. Provide instruction, demonstration, and exercises related to converting decimals to fractions, and vice versa, including rounding of decimals.
3. Provide instruction, demonstration, and exercises related to adding, subtracting, multiplying, and dividing decimals.
4. Develop and administer a test related to converting fractions to decimals and vice versa, and performing basic mathematical functions with decimals.
5. Keep training records reflecting results of converting decimals to fractions, fractions to decimals, rounding, and performing basic mathematical functions with decimals.

3.3.1 Module 1: Trade Math

Key Indicator 3: Reads a rule in U.S. Customary and Metric units, performs linear measurements, and calculates the area of shapes.

Objective: Provided with a period of instruction and demonstration, the trainee can read a rule in U.S. Customary and Metric units, and performs linear, angular, area, triangular, and circular measurements.

Evaluation Criteria: The trainee correctly reads a rule and in U.S. Customary and Metric units, and performs accurate linear, angular, area, triangular, and circular measurements.

Recommended Instructional Activities

1. Introduce terms and definitions related shapes and U.S. Customary and Metric measurements.
2. Provide instruction, demonstration, and exercises related to using a rule to perform linear measurements in U.S. Customary and Metric units.
3. Provide instruction, demonstration, and exercises related to performing angular measurements.
4. Provide instruction, demonstration, and exercises related to performing perimeter and area measurements of four-sided shapes.
5. Provide instruction, demonstration, and exercises related to performing perimeter and area measurements of triangular shapes.
6. Provide instruction, demonstration, and exercises related to performing circumferential and area measurements of circular shapes.
7. Develop and administer a test related to reading a rule in U.S. Customary and Metric units, performing linear measurements, and calculating the area of shapes.
8. Keep training records reflecting results of reading a rule in U.S. Customary and Metric measurements, and calculating the area of shapes.

3.3.1 Module 1: Trade Math

Key Indicator 4: Calculates volume and weight associated with different shapes.

Objective: Provided with a period of instruction and demonstration, the trainee calculates volume and weight of objects with different shapes and lengths.

Evaluation Criteria: The trainee accurately calculates volume and weight according to shapes and lengths.

Recommended Instructional Activities

1. Introduce terms and definitions related to shapes, volume, and weight.
2. Provide instruction, demonstration, and exercises related to performing volume calculations of regular and irregular shapes.
3. Provide instruction, demonstration, and exercises related to performing calculations of weight based on volume.
4. Provide instruction, demonstration, and exercises related to performing calculations of weight based on length.
5. Develop and administer a test to measure mastery of key concepts related to calculating volume and weight associated with different shapes.
6. Keep training records reflecting results of calculating volume and weight of objects with different shapes and lengths.

3.3.1 Module 1: Trade Math

Key Indicator 5: Converts U.S. Customary units to Metric units, and vice versa.

Objective: Provided with a period of instruction and demonstration, the trainee converts U.S. Customary units of length, weight, volume, and temperature to Metric units, and vice versa.

Evaluation Criteria: The trainee accurately converts U.S. Customary units of length, weight, volume, and temperature to Metric units, and vice versa.

Recommended Instructional Activities

1. Introduce terms and definitions related to U.S. Customary and Metric units.
2. Provide instruction, demonstration, and exercises related to converting U.S. Customary units to Metric units of length, and vice versa.
3. Provide instruction, demonstration, and exercises related to converting U.S. Customary units of weight to Metric units of mass, and vice versa.
4. Provide instruction, demonstration, and exercises related to converting temperature from Fahrenheit to Celsius, and vice versa.
5. Develop and administer a test related to converting U.S. Customary units to Metric units, and vice versa.
6. Prepare trainees for the Trade Math practical knowledge exam.
7. Keep training records reflecting results of converting U.S. Customary units of length, weight and temperature to Metric units, and vice versa.

3.3.2 Module 2: Welding Metallurgy

Prerequisites

None.

Key Indicator 1: Exhibits a working knowledge of the metallurgy and weldability of carbon steel.

Objective: Provided with a period of instruction and demonstration, the trainee exhibits a fundamental understanding of the metallurgy and weldability of carbon steels.

Evaluation Criteria: The trainee relates basic concepts of welding metallurgy to welding situations, and exhibits an understanding of the weldability of carbon steel, as well as the changes that occur in the heat-affected zone (HAZ) due to welding.

Recommended Instructional Activities

1. Provide instruction related to carbon steel as an alloy of iron and carbon, including the role of carbon in the hardness and strength of steel.
2. Provide instruction related to the types of carbon steel—low carbon, medium carbon, high carbon, and low alloy.
3. Define the terms *allotropy*, *transformation temperature*, *body-centered cubic*, *face-centered cubic*, *ferrite*, *pearlite*, *austenite*, *martensite*, and *bainite*.
4. Provide instruction related to the allotropic transformation of iron atoms from a body-centered cubic to face-centered cubic microstructure (austenite) as temperature increases above the transformation temperature.
5. Provide instruction related to the solubility of carbon in iron, and how the transformation from body-centered cubic to face-centered cubic affects the solubility of carbon.
6. Provide instruction related to the importance of controlling the cooling rate of certain carbon steels through heat treatment to prevent the formation of martensite.
7. Define the terms *tensile strength*, *toughness*, *hardness*, and *ductility* and provide instruction on the common alloying elements in carbon steels that affect these characteristics.
8. Define the term *heat-affected zone* (HAZ), and provide instruction on the metallurgical changes that occur in the HAZ.
9. Provide instruction related to how welding affects mechanical properties such as *yield strength*, *tensile strength*, *toughness*, *hardness*, and *ductility*.
10. Provide instruction related to the methods of metal identification—materials test report (MTR), appearance, color, markings, manufacturers specifications and color-coding, magnetic response test, chisel test, torch test, file test, and spark test.
11. Provide a demonstration of the spark test noting the different spark streams produced by different metals.
12. Keep training records reflecting results of the metallurgy and weldability of carbon steel training.

3.3.2 Module 2: Welding Metallurgy

Key Indicator 2: Exhibits a working knowledge of the metallurgy and weldability of stainless steels.

Objective: Provided with a period of instruction and demonstration, the trainee exhibits a fundamental understanding of the metallurgy and weldability of stainless steels.

Evaluation Criteria: The trainee relates basic concepts of welding metallurgy to welding situations, and exhibits an understanding of the weldability of stainless steels, as well as the changes that occur in the HAZ due to welding.

Recommended Instructional Activities

1. Provide instruction related to the difference between carbon steel and stainless steel and explain the importance of chromium in corrosion resistance.
2. Provide instruction related to the five types of stainless steel—austenitic, ferritic, martensitic, duplex, and precipitation hardening.
3. Provide instruction related the role of nickel in austenitic stainless steel.
4. Provide instruction related to the three-digit classification system for stainless steels.
5. Provide instruction related to the importance of cleaning stainless steel prior to welding to prevent problems such as cracking and porosity that may be caused by contamination.
6. Define the term *carbide precipitation* (sensitization) in relation to austenitic stainless steels.
7. Provide instruction related to the major causes of carbide precipitation and the temperature ranges at which carbide precipitation occurs.
8. Provide instruction related to the need for backing gas and the benefits of using gas lenses when welding stainless steels.
9. Provided instruction related to the metallurgical changes that occur in the HAZ of stainless steel.
10. Provide instruction related to the coloration of stainless steel welds and HAZs as a diagnostic tool to identify problems such as overheating and lack of shielding.
11. Keep training records reflecting results of the metallurgy and weldability of stainless steel training.

3.3.2 Module 2: Welding Metallurgy

Key Indicator 3: Exhibits a working knowledge of the metallurgy and weldability of aluminum.

Objective: Provided with a period of instruction and demonstration, the trainee exhibits a fundamental understanding of the metallurgy and weldability of aluminum.

Evaluation Criteria: The trainee relates basic concepts of welding metallurgy to welding situations, and exhibits an understanding of the weldability of aluminum, as well as the mechanical changes that occur in the HAZ due to welding.

Recommended Instructional Activities

1. Provide instruction related to the seven major series of aluminum, their major alloying elements, and the effects of each major alloying element on chemical and mechanical properties.
2. Define the terms *heat treatable* and *non-heat treatable* in relation to the weldability of aluminum, and provide instruction on the three heat treatable and four non-heat treatable series of aluminum.
3. Provide instruction related to the characteristics of the oxide coating on aluminum and the need to remove it during welding to ensure fusion.
4. Provide instruction related to the effects of welding aluminum on the mechanical properties of the HAZ.
5. Keep training records reflecting results of the metallurgy and weldability of aluminum training.

3.3.2 Module 2: Welding Metallurgy

Key Indicator 4: Exhibits a working knowledge of the principles related to residual stress and distortion control.

Objective: Provided with a period of instruction and demonstration, the trainee exhibits a fundamental understanding of residual stress and distortion control.

Evaluation Criteria: The trainee relates the effects of residual stress to welding situations, exhibits an understanding of the causes of residual stresses and distortion, and can take action to minimize residual stresses and prevent distortion.

Recommended Instructional Activities

1. Define the terms *residual stress* and *distortion*.
2. Provide instruction related to how residual stress contributes to distortion, fatigue, and other mechanical problems.
3. Provide instruction related to the effects of joint constraint on residual stresses.
4. Provide demonstrations related to the effects of residual stress and distortion in welding.
5. Define the terms *thermal conductivity* and *thermal expansion*.
6. Provide instruction related to the differences in thermal conductivity and thermal expansion between carbon steel, stainless steel, aluminum, and copper.
7. Provide instruction related to how thermal conductivity and thermal expansion contribute to residual stresses and distortion in metals.
8. Provide instruction and demonstrations related to methods of stress relief.
9. Provide instruction related to the major types of heat treatment.
10. Provide instruction and demonstrations related to the different methods of minimizing distortion including joint fitup and edge preparation, fixturing, presetting parts, using strongbacks and backing bars, controlling heat input, reducing the number of passes, back stepping, intermittent welding, and heat treatment.
11. Provide instruction, demonstrations, and exercises related to the control of distortion in welding.
12. Provide instruction, demonstrations, and exercises related to the correction of distortion in welding.
13. Prepare trainees for the Welding Metallurgy practical knowledge exam.
14. Keep training records reflecting results of residual stress and distortion control training.

3.3.3 Module 3: Documents Governing Welding and Welding Inspection

Prerequisites

None.

Key Indicator 1: Possesses a working knowledge of the major welding codes.

Objective: Provided with a period of instruction and demonstration, trainees possess a working knowledge of the major welding codes related to structural, pressure vessel, and pipeline welding.

Evaluation Criteria: The trainee demonstrates an understanding of the role of welding codes such as AWS D1.1, *Structural Welding Code—Carbon Steel*, AWS D1.2, *Structural Welding Code—Aluminum*, AWS D1.3, *Structural Welding Code—Sheet Steel*, AWS D1.6, *Structural Welding Code—Stainless Steel*, ASME Section IX, *Boiler and Pressure Vessel Code*, and API 1104 for the *Welding of Pipelines and Related Facilities*.

Recommended Instructional Activities

1. Provide instruction on the difference between a code and a specification.
2. Provide instruction on the purpose of the AWS D1.1, *Structural Welding Code* and the organization of the document into nine clauses that are subdivided into parts and annexes.
3. Provide instruction on the purpose of the Commentary (C.1 through C.8).
4. Provide instruction and demonstration on how a code would be used in a typical application.
5. Provide instruction on the purpose and scope of the AWS D1.2, *Structural Welding Code—Aluminum*.
6. Provide instruction on the purpose and scope of the AWS D1.3, *Structural Welding Code—Sheet Steel*.
7. Provide instruction on the purpose and scope of the AWS D1.6, *Structural Welding Code—Stainless Steel*.
8. Provide instruction on the purpose and scope of the ASME Section IX, *Boiler and Pressure Vessel Code*.
9. Provide instruction on the purpose and scope of API 1104 for the *Welding of Pipelines and Related Facilities*.
10. Provide instruction on the difference between ASME Section IX, *Boiler and Pressure Vessel Code* and API 1104 for the *Welding of Pipelines and Related Facilities*.
11. Keep training records regarding results of training related to the AWS structural codes, API 1104 and ASME Section IX.

3.3.3 Module 3: Documents Governing Welding and Welding Inspection

Key Indicator 2: Possesses a working knowledge of documents related to welding specifications and qualifications.

Objective: Provided with a period of instruction and demonstration, the trainee has a working knowledge of a Welding Procedure Specification (WPS), Welding Procedure Qualification Record (WPQR), Prequalified Welding Procedure Specification, Standard Welding Procedure Specification (SWPS), and a Performance Qualification Test Record (PQTR).

Evaluation Criteria: The trainee exhibits the ability to produce a weld as specified in a WPS, and exhibits a working knowledge of the relationship between a WPS and WPQR. The trainee also exhibits a working knowledge of Prequalified WPS, SWPS, and PQTR.

Recommended Instructional Activities:

1. Define the terms *Welding Procedure Specification*, *Welding Procedure Qualification Record*, *welder Performance Qualification Test Record*, *Prequalified Welding Procedure Specification*, and *Standard Welding Procedure Specification*.
2. Distribute a sample completed WPS and provide instruction on the purpose of each section of the document.
3. Provide instruction on the changes in essential variables that make it necessary to requalify a WPS.
4. Distribute a sample completed WPQR and provide instruction on the purpose of each section of the document.
5. Distribute a sample PQTR and provide instruction on the purpose of each section of the document.
6. Provide instruction on the rationale behind a Prequalified WPS and SWPS, and the conditions under which a Prequalified WPS and a SWPS can be used.
7. Provide instruction on the purpose and scope of the AWS B2.1, *Specification for Welding Procedure and Performance Qualification*.
8. Keep training records regarding results of training related to welding specifications and qualifications.

3.3.3 Module 3: Documents Governing Welding and Welding Inspection

Key Indicator 3: Possesses a working knowledge of documents related to standard symbols for welding and nondestructive examination, nondestructive inspection of welds, visual inspection of welds, and mechanical testing of welds.

Objective: Provided with a period of instruction and demonstration, the trainee has a working knowledge of AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*; AWS B1.10, *Guide for Nondestructive Inspection of Welds*; AWS B1.11, *Guide for the Visual Inspection of Welds*; and AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

Evaluation Criteria: The trainee exhibits a working knowledge of the purpose and contents of AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*; AWS B1.10, *Guide for Nondestructive Inspection of Welds*; AWS B1.11, *Guide for the Visual Inspection of Welds*; and AWS B4.0, *Standard Methods for Mechanical Testing of Welds*.

Recommended Instructional Activities

1. Provide instruction on the use of AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination* and indicate where a copy can be found for reference purposes.
2. Provide instruction on the use of AWS B1.10, *Guide for Nondestructive Inspection of Welds* and indicate where a copy can be found for reference purposes.
3. Provide instruction on the use of AWS B1.11, *Guide for the Visual Inspection of Welds* and indicate where a copy can be found for reference purposes.
4. Provide instruction on the use of AWS B4.0, *Standard Methods for Mechanical Testing of Welds* and indicate where a copy can be found for reference purposes.
5. Keep training records on the results of training regarding documents related to standard symbols for welding and nondestructive examination, nondestructive inspection of welds, visual inspection of welds, and mechanical testing of welds.

3.3.3 Module 3: Documents Governing Welding and Welding Inspection

Key Indicator 4: Possesses a working knowledge of the major base metal designation systems, filler metal specifications, and a Material Test Report.

Objective: Provided with a period of instruction and demonstration, trainees possess a working knowledge of the major base metal designation systems, filler metal specifications, and a Material Test Report.

Evaluation Criteria: The trainee exhibits a working knowledge of the SAE-AISI, Unified Numbering System (UNS), and ASTM designation systems for base metals, as well as a working knowledge of the AWS A5.XX filler metal specifications, and a Materials Test Report (MTR).

Recommended Instructional Activities

1. Provide instruction on the SAE-AISI numbering system for base metals.
2. Provide instruction on the UNS for base metals.
3. Provide instruction on the ASTM designation system for base metals.
4. Provide instruction on the use of the AWS A5.XX filler metal specifications to formulate and select filler metals.
5. Provide instruction on the difference between Typical Certification and Actual Certification with respect to filler metals.
6. Show a sample of a MTR and provide instruction on its purpose.
7. Prepare trainees for the Documents Governing Welding and Welding Inspection practical knowledge exam.
8. Keep training records regarding results of training related to the major base metal designation systems, filler metal specifications, and a MTR.

3.3.4 Module 4: Welding Inspection and Testing Methods

Prerequisites

Module 9: Welding Inspection and Testing (SENSE Level I—Entry Welder).

Key Indicator 1: Possesses a working knowledge of commonly used destructive testing methods.

Objective: Provided with a period of instruction and demonstration and personal protective equipment, the trainee exhibits a working knowledge of common destructive testing methods.

Evaluation Criteria: The trainee has a working knowledge of commonly used destructive testing methods including Tensile test, Standard Guided Bend test, Side Bend test, Rockwell B and Rockwell C Hardness tests, Charpy-V-Notch test, Nick-Break test, Fillet Weld Break test, and Macroetch test.

Recommended Instructional Activities

1. Provide a general definition of destructive testing and an overview of destructive testing to evaluate weld and base metal characteristics.
2. Define the terms *Tensile test*, *Standard Guided Bend test*, *Side Bend test*, *Rockwell B and Rockwell C Hardness tests* and other hardness tests, *Charpy-V-Notch test*, *Nick-Break test*, *Fillet Weld Break test*, and *Macroetch test*.
3. Provide instruction and demonstrations (where possible) related to Tensile tests, Rockwell B and Rockwell C Hardness tests, and Charpy-V-Notch tests.
4. Provide instruction, demonstration, and exercises related to types of defects and discontinuities that destructive testing reveals (incomplete fusion, inclusions, porosity, incomplete penetration).
5. Provide instruction, demonstration, and exercises related to Standard Guided Bend and Side Bend Testing.
6. Provide instruction, demonstration, and exercises related to Fillet Weld Break testing.
7. Provide instruction, demonstration, and exercises related to Macroetch testing.
8. Keep training records reflection results of training in destructive testing methods.

3.3.4 Module 4: Welding Inspection and Testing Methods

Key Indicator 2: Possesses a working knowledge of commonly used nondestructive examination methods.

Objective: Provided with a period of instruction and demonstration and personal protective equipment, the trainee exhibits a working knowledge of common nondestructive examination techniques.

Evaluation Criteria: The trainee exhibits a working knowledge of commonly used nondestructive examination methods including Visual examination (VT), Liquid Penetrant examination (PT), Magnetic Particle examination (MT), Ultrasonic examination (UT), Radiographic examination (RT), Electromagnetic examination (ET).

Recommended Instructional Activities

1. Provide a general definition of nondestructive examination and an overview of nondestructive examination to evaluate the integrity of welds.
2. Define the terms *Visual examination (VT)*, *Liquid Penetrant examination (PT)*, *Magnetic Particle examination (MT)*, *Ultrasonic examination (UT)*, *Radiographic examination (RT)*, *Electromagnetic examination (ET)*.
3. Provide instruction, demonstrations, and exercises related to Visual examination (VT).
4. Provide instruction, demonstrations, and exercises related to Liquid Penetrant examination (PT).
5. Provide instruction, demonstrations, and exercises (where possible) related to Magnetic Particle examination (MT).
6. Provide instruction and demonstrations (where possible) related to Ultrasonic examination (UT), Radiographic examination (RT), and Electromagnetic examination (ET).
7. Keep training records reflecting results of training in nondestructive examination methods.

3.3.4 Module 4: Welding Inspection and Testing Methods

Key Indicator 3: Performs a dye penetrant test.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, penetrant, and developer, the trainee performs a dye penetrant test.

Evaluation Criteria: The instructor observes the trainee preparing a specimen and performing a dye penetrant test. The trainee correctly identifies any weld discontinuities or defects.

Recommended Instructional Activities

1. Review procedures for preparing a specimen and performing a dye penetrant test.
2. Review the different discontinuities and defects commonly revealed by dye penetrant tests, and show examples as necessary.
3. Provide trainees with a welded joint, or have them weld a joint, and observe trainee preparing the specimen and performing a dye penetrant test.
4. Have trainees evaluate the weld with the aid of a checklist and identify any desirable weld characteristics, as well as any discontinuities or defects.
5. Keep training records reflecting results of each trainee's dye penetrant test.

3.3.4 Module 4: Welding Inspection and Testing Methods

Key Indicator 4: Performs a macroetch test (Optional).

Objective: Provided with a period of instruction and demonstration, personal protective equipment, and etchants, the trainee performs a macroetch test.

Evaluation Criteria: The instructor observes the trainee preparing a specimen and performing a macroetch test. The trainee correctly identifies the penetration characteristics of the weld, along with any discontinuities or defects.

Recommended Instructional Activities

1. Review procedures for preparing a specimen and performing a macroetch test.
2. Review the desired penetration characteristics revealed by macroetch tests, and show examples as necessary.
3. Review safety precautions related to the use of macroetchants.
3. Prepare a specimen and demonstrate a macroetch.
4. Have trainees evaluate the weld with the aid of a checklist and identify any desirable weld characteristics, as well as any discontinuities or defects.
5. Keep training records reflecting results of each trainee's macroetch test.

NOTE: The macroetch test and fillet break test can be combined if desired.

3.3.4 Module 4: Welding Inspection and Testing Methods

Key Indicator 5: Performs a fillet break test.

Objective: Provided with a period of instruction and demonstration and personal protective equipment, the trainee performs a fillet break test (2F position minimum).

Evaluation Criteria: The instructor observes the trainee performing a fillet break test (2F position minimum) and evaluating the weld. The trainee correctly identifies desirable weld characteristics, as well as any weld discontinuities or defects.

Recommended Instructional Activities

1. Review fillet break test procedures as necessary.
2. Review common discontinuities and defects associated with fillet break tests and show examples as necessary.
3. Provide trainees with a fillet weld in a T-joint, or have them weld a fillet weld in a T-joint, and observe trainees perform a fillet break test.
4. Have trainees evaluate the weld with the aid of a checklist and identify any desirable weld characteristics, as well as any discontinuities or defects.
5. Keep training records reflecting results of each trainee's fillet break test.

NOTE: The macroetch test and fillet break test can be combined if desired.

3.3.4 Module 4: Welding Inspection and Testing Methods

Key Indicator 6: Performs a visual examination of cut surfaces and edges of prepared base metal parts according to applicable fitup and preparation tolerances.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, a specification showing fitup and preparation tolerances, a specimen, and a measuring device, the trainee performs a visual examination of cut surfaces and edges of prepared base metal parts according to applicable fitup and preparation tolerances.

Evaluation Criteria: The instructor observes the trainee visually examining cut surfaces and edges of prepared base metal parts to ensure they comply with applicable fitup and preparation tolerances.

Recommended Instructional Activities

1. Review visual examination procedures as necessary.
2. Review the different discontinuities and defects commonly revealed by visual examination, and show examples as necessary.
3. Provide trainees with prepared base metal parts, and observe trainee performing a visual examination with the aid of a drawing or specification and measuring devices to determine if parts comply with applicable fitup and preparation tolerances.
4. Keep training records reflecting results of each trainee's visual examination of prepared base metal parts.

3.3.4 Module 4: Welding Inspection and Testing Methods

Key Indicator 7: Performs a visual examination of tack welds, root pass, intermediate layers and completed welds according to applicable acceptance criteria.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, and a job assignment, the trainee performs visual examination of tack welds, root pass, intermediate layers, and completed welds according to applicable acceptance criteria.

Evaluation Criteria: The instructor observes the trainee visually examining tack welds, root pass, intermediate layers, and completed welds according to applicable acceptance criteria.

Recommended Instructional Activities

1. Review visual examination procedures as necessary.
2. Review visual examination acceptance criteria and show examples of discontinuities and defects as necessary.
3. Provide trainees with plates that have been tack welded to form a joint, or have trainees prepare a joint, tack weld the plates, and visually examine the tack welds to ensure that they meet acceptance criteria.
4. Provide trainees with a root pass in a joint, or have them deposit a root pass, and visually examine it to ensure that it meets acceptance criteria.
5. Provide trainees with an intermediate passes or layers, or have them deposit intermediate passes or layers, and visually examine them to ensure that they meet acceptance criteria.
6. Provide trainees with a completed weld, or have them deposit a cover layer, and visually examine it to ensure that it meets acceptance criteria.
7. Prepare trainees for the Welding Inspection and Testing Methods practical knowledge exam.
8. Keep training records reflecting results of each trainee's visual examination of tack welds, root passes, intermediate layers, and completed welds.

3.3.5 Module 5: Thermal Cutting Processes

Prerequisites

Module 8: Thermal Cutting Processes (SENSE Level I—Entry Welder).

Unit 1: Manual Oxyfuel Gas Cutting (OFC)

Key Indicator 1: Performs safety inspection, operator maintenance, sets up, and operates manual OFC equipment on carbon steel.

Objective: Provided with a period of instruction and demonstration, safety inspection and maintenance guidelines, personal protective equipment, hand tools, manual OFC equipment, manual OFC gas, carbon steel base metal, and a cutting assignment, the trainee performs a safety inspection, operator maintenance, sets up, and operates manual OFC on carbon steel.

Evaluation Criteria

1. The trainee's personal protective equipment, work area, cutting equipment, and hand tools meet safety requirements. Hazard warnings are communicated to others in the immediate area prior to the start of OFC operations. In the course of daily operations, the trainee is observed following safe practices.
2. Maintenance on OFC and gas equipment is made in accordance with the manufacturer's recommendations and the institution's maintenance policy. Operator maintenance is performed correctly, and in a timely manner on a regular basis.
3. The trainee is prepared to cut. OFC equipment is set up and adjusted to the proper gas mixture and operating pressures on a routine basis.
4. The trainee's cutting is completed as required by the cutting assignment. During and after the operation, cuts are visually examined by the trainee and accepted by the instructor on a routine basis.

Recommended Instructional Activities

1. Review ANSI Z49.1, Section 10, Oxyfuel Gas Welding and Cutting Safety as necessary.
2. Review routine safety inspections of personal protective equipment, hand tools, manual OFC equipment, gas supply system, and work area as necessary.
3. Review manual OFC principles of operation and essential process variables as necessary.
4. Review manual OFC cutting tip identification and selection for carbon steel as necessary.
5. Review relevant terms and definitions as necessary.
6. Provide instruction, demonstration, and exercises related to operator maintenance of manual OFC equipment and gas supply system, as necessary.
7. Provide trainee with practice setting up manual OFC equipment, and gas supply.
8. Observe trainee setting up manual OFC equipment, and gas supply.
9. Provide training exercises on lighting and adjusting the manual OFC torch as necessary.
10. Provide training exercises on manual OFC equipment operations on carbon steel.
11. Observe trainee following safe manual OFC inspection, maintenance, set up, and operating procedures.
12. Visually inspect trainee's manual OFC cut edges and surfaces, and provide feedback.
13. Keep training records reflecting each trainee's successful completion of training in manual OFC safety inspection, operator maintenance, set up, and performance exercises on carbon steel.

3.3.5 Module 5: Thermal Cutting Processes

Unit 1: Manual Oxyfuel Gas Cutting (OFC)

Key Indicator 2: Performs straight, square edge cutting operations in the horizontal and vertical positions on carbon steel plate.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, hand tools, manual OFC equipment, gas supply, accessories, and a cutting assignment, the trainee makes manual OFC straight, square edge cuts in the horizontal and vertical positions on carbon steel plate.

Evaluation Criteria: The trainee produces acceptable manual OFC straight, square edge cuts in the horizontal and vertical positions on carbon steel plate. After each operation, cut edges and surfaces are visually examined by the trainee, and accepted by the instructor on a routine basis.

Recommended Instructional Activities

1. Provide instruction related to visual examination of manual OFC cut edges and surfaces.
2. Provide instruction and demonstration related to cutting procedures and workmanship for manual OFC straight, square edge cuts in the horizontal and vertical positions on carbon steel plate.
3. Provide training exercises related to making horizontal and vertical position straight, square edge manual OFC cuts on carbon steel plate.
4. Observe trainee operating manual OFC equipment and following safe OFC practices.
5. Visually inspect trainee's manual OFC cut edges and surfaces and provide feedback.
6. Keep training records reflecting each trainee's successful completion of making straight, square edge cuts on carbon steel plate.

3.3.5 Module 5: Thermal Cutting Processes

Unit 1: Manual Oxyfuel Gas Cutting (OFC)

Key Indicator 3: Performs straight, bevel edge cutting operations in the horizontal and vertical positions on carbon steel plate.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, hand tools, manual OFC equipment, gas supply, accessories, and a cutting assignment, the trainee makes manual OFC straight, bevel edge cuts in the horizontal and vertical positions on carbon steel plate.

Evaluation Criteria: The trainee produces acceptable manual OFC straight, bevel edge cuts in the horizontal and vertical position on carbon steel plate. After each operation, cut edges and surfaces are visually examined by the trainee, and accepted by the instructor on a routine basis.

Recommended Instructional Activities

1. Provide instruction and demonstration related to cutting procedures and workmanship for manual OFC straight, bevel edge cuts on carbon steel plate.
2. Provide training exercises related to making horizontal and vertical position straight, bevel edge manual OFC cuts on carbon steel plate.
3. Observe trainee operating manual OFC equipment and following safe OFC practices.
4. Visually inspect trainee's manual OFC cut edges and surfaces and provide feedback.
5. Keep training records reflecting each trainee's successful completion of making straight, bevel edge cuts on carbon steel plate.

3.3.5 Module 5: Thermal Cutting Processes

Unit 1: Manual Oxyfuel Gas Cutting (OFC)

Key Indicator 4: Performs straight, structural shape cutting operations on angle, channel, and square or rectangular carbon steel tubing, in the horizontal and vertical positions.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, hand tools, manual OFC equipment, gas supply, accessories, and a cutting assignment, the trainee makes manual OFC straight, structural shape cuts in the horizontal and vertical positions on angle, channel, and square or rectangular tube carbon steel.

Evaluation Criteria: The trainee produces acceptable manual OFC straight, structural shape cuts in the horizontal and vertical positions, on carbon steel angle, channel, and square or rectangular tube. After each operation, cut edges and surfaces are visually examined by the trainee and accepted by the instructor on a routine basis.

Recommended Instructional Activities

1. Provide instruction and demonstration related to cutting procedures and workmanship for manual OFC straight, structural shape cuts, in the horizontal and vertical positions, on carbon steel angle, channel, and square or rectangular tube.
2. Provide training exercises related to making horizontal and vertical position straight, structural shape manual OFC cuts on carbon steel angle, channel, and square or rectangle tube.
3. Observe trainee operating manual OFC equipment and following safe OFC practices.
4. Visually inspect trainee's manual OFC cut edges and surfaces and provide feedback.
5. Keep training records reflecting each trainee's successful completion of making straight, structural shape cuts on carbon steel angle, channel, and square or rectangular tube in the horizontal and vertical positions.

3.3.5 Module 5: Thermal Cutting Processes

Unit 1: Manual Oxyfuel Gas Cutting (OFC)

Key Indicator 5: Performs straight, square edge cutting operations on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.

Objective: Provided with a period of instruction and demonstration, personal protective equipment, hand tools, manual OFC equipment, gas supply systems, and a cutting assignment, the trainee will make manual OFC straight, square edge cuts on carbon steel pipe, with the pipe axis in the horizontal and vertical positions.

Evaluation Criteria: The trainee produces acceptable manual OFC straight, square edge cuts on carbon steel pipe, with the pipe axis in the horizontal and vertical positions. After each operation, cut edges and surfaces are visually examined by the trainee, and accepted by the instructor on a routine basis.

Recommended Instructional Activities

1. Provide instruction related to visual examination of manual OFC cut edges and surfaces.
2. Provide instruction and demonstration related to cutting procedures and workmanship for manual OFC straight, square edge cuts with the pipe axis in the horizontal position, and the pipe rolled.
3. Provide instruction and demonstration related to cutting procedures and workmanship for manual OFC straight, square edge cuts with the pipe axis in the horizontal position, and the pipe fixed.
4. Provide instruction and demonstration related to cutting procedures and workmanship for manual OFC straight, square edge, horizontal cuts, with the pipe axis in the vertical fixed position.
5. Provide training exercises related to making straight, square edge manual OFC cuts on carbon steel pipe, with the pipe axis in the horizontal position and the pipe rolled, the pipe axis in the horizontal position and the pipe fixed, and the pipe axis in the vertical position and the pipe fixed.
6. Observe trainee operating manual OFC equipment and following safe practices.
7. Visually inspect trainee's cut edges and surfaces and provide feedback.
8. Keep training records reflecting each trainee's successful completion of training in straight, square edge cuts on carbon steel pipe, with the pipe axis in the horizontal and the pipe rolled, the pipe axis in the horizontal and the pipe fixed, and the pipe axis in the vertical and the pipe fixed.