TN Department of Education | College, Career and Technical Education

May 2024

Welding I

Primary Career Cluster:	Advanced Manufacturing
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C13H12
Pre-requisite(s):	*Principles of Manufacturing* (C13H05) Recommended: *Algebra* (G02X02, G02H00), *Geometry* (G02X03, G02H11), and *Physical Science* (G03H00)
Credit:	1
Grade Level:	10
Elective Focus - Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other Advanced Manufacturing courses.
POS Concentrator:	This course satisfies one out of two required courses that meet the Perkins V concentrator definition, when taken in sequence in the approved program of study.
Programs of Study and Sequence:	This is the second course in the *Welding* program of study.
Aligned Student Organization(s):	Skills USA: http://www.skillsusatn.org/
Coordinating Work-Based Learning:	Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit https://www.tn.gov/education/educators/career-and-technical-education/work-based-learning.html.
Promoted Tennessee Student Industry Credentials:	Credentials are aligned with postsecondary and employment opportunities and with the competencies and skills that students acquire through their selected program of study. For a listing of promoted student industry credentials, visit https://www.tn.gov/education/educators/career-and-technical-education/student-industry-certification.html.
Teacher Endorsement(s):	551, 552, 553, 554, 555, 556, 557, 584, 705, OR any other Occupational License endorsement with AWS Industry Certification, BAT, or Certified Welding Educator Certification
Required Teacher Certifications/Training:	In addition, the teacher must hold one of the following current/valid industry certifications: American Welding Society (AWS), Certified Welding Inspector (CWI), Certified Welding Educator (CWE), Certified Radiographic Interpreters, Certified Welding Engineer (CWEng), Certified Robotic Arc Welder (CRAW), Certified Welding Fabricator, Certified Welder OR Bureau of Apprenticeship Training certification (BAT), or NOCTI Welding.
Teacher Resources:	https://www.tn.gov/education/educators/career-and-technical-education/career-clusters/cte-cluster-advanced-manufacturing.html Best for All Central: https://bestforall.tnedu.gov/

Course at a Glance

CTE courses provide students with an opportunity to develop specific academic, technical, and 21st century skills necessary to be successful in career and in life. In pursuit of ensuring every student in Tennessee achieves this level of success, we begin with rigorous course standards which feed into intentionally designed programs of study.

Students engage in industry relevant content through general education integration and experiences such as career and technical student organizations (CTSO) and work-based learning (WBL). Through these experiences, students are immersed with industry standard content and technology, solve industry-based problems, meaningfully interact with industry professionals and use/produce industry specific, informational texts.

Using a Career and Technical Student Organization (CTSO) in Your Classroom

CTSOs are a great resource to put classroom learning into real-life experiences for your students through classroom, regional, state, and national competitions, and leadership opportunities. Below are CTSO connections for this course, note this is not an exhaustive list.

- Participate in CTSO Fall Leadership Conference to engage with peers by demonstrating logical thought processes and developing industry specific skills that involve teamwork and project management.
- Participate in contests that highlight job skill demonstration. These include Career Pathways Showcase, Job Interview, Automated Manufacturing Technology, Additive Manufacturing, and Welding.

Using a Work-Based Learning (WBL) in Your Classroom

Sustained and coordinated activities that relate to the course content are the key to successful work-based learning. Possible activities for this course include the following. This is not an exhaustive list.

- **Standards 1.1-1.2** | Include a safety briefing in a visit to an industry partner/job site.
- **Standard 2.1** | Visit a local company and discuss with those employees the various career options.
- **Standard 3.2** | Ask an industry rep to discuss how often welders use drawings on the job.
- **Standard 5.1** | Ask an industry rep to discuss how often the different types of welds are used on the job.
- **Standard 6.2** | Ask an industry rep to discuss the impact of different materials to a welder on the job.
- **Standards 7.1-7.2** | Ask an industry rep to discuss the importance of quality control.
- **Standard 8.4** | Do a project that is used by a local industry or evaluated by local industry managers.

Course Description

Welding I is designed to provide students with the skills and knowledge to effectively perform cutting and welding applications used in the advanced manufacturing industry. Proficient students will develop proficiency in fundamental safety practices in welding, interpreting drawings, creating computer aided drawings, identifying and using joint designs, efficiently laying out parts for fabrication, basic shielded metal arc welding (SMAW), mechanical and thermal properties of metals, and quality control. Upon completion of this course, proficient students will be able to sit for the AWS SENSE Entry Level Welder certification and will be prepared to undertake more advanced welding coursework.

Course Standards

1. Safety

1.1 Safety: Accurately read, interpret, and **demonstrate adherence to safety rules**, including rules published by the (1) National Science Teachers Association (NSTA); (2) rules pertaining to electrical safety; (3) Occupational Safety and Health Administration (OSHA) guidelines; (4) American Society for Testing Materials, ANSI Z49.1: Safety and Welding, Cutting, and Allied Processes; and (5) state and national code requirements. Be able to distinguish between rules and explain why certain rules apply. Complete safety test with 100 percent accuracy.

1.2 Safety Equipment: Identify and explain the intended use of **safety equipment** available in the classroom. For example, demonstrate how to properly inspect, use, store, and maintain safe operating procedures with tools and equipment.

2. Career Exploration

2.1 Welder Qualifications: Locate and assess the American Welding Society website and analyze its structure, policies, and requirements for the **AWS Entry Welder qualification and certification.** Explain a welder certification document, what steps are required to obtain the certification, and how to prepare for the examination.

3. Interpreting and Creating Drawings

3.1 Interpret Drawings: Interpret drawings to weld. Compare and contrast the architectural scale versus the engineering scale used in mechanical drawings. Describe their distinguishing characteristics. Define a scale and perform conversion calculations of various distances.

3.2 Create Drawings: Building on the knowledge of a two-dimensional drawing, **create simple isometric (3-D pictorial) drawings,** properly using lines (e.g., object, hidden, center), labels, and dimensioning techniques.

4. Welding Design and Layout

4.1 Basic Weld Joints: Identify, sketch, and explain the **five basic weld joint designs** (e.g., butt, lap, tee, outside corner, and edge). Find examples of various joint designs applied to structures on or around campus and take pictures to present to classmates.

5. Shielded Metal Arc Welding (SMAW)

5.1 Set Up for SMAW: Safely **set up equipment for shielded metal arc welding (SMAW).** Identify and explain the equipment, equipment setup, and the electrical current used in the welding process. Compare and contrast SMAW with other welding and cutting processes such as oxyfuel gas welding (OFW), gas metal arc welding (GMAW), flux-cored arc welding (FCAW), and gas tungsten arc welding (GTAW).

5.2 SMAW Welding: Demonstrate how to **make single-pass and multiple-pass fillet welds and groove welds** with backing on plain carbon steel in the following positions.

a. flat
b. horizontal
c. vertical
d. overhead

Prior to welding, sketch a cross section, including the dimensions of each weld demonstration.

5.3 Metal Classification and SMAW: Explain the American Welding Society (AWS) filler **metal classification system**. Summarize the multiple factors that affect electrode selection for shielded metal arc welding (SMAW). Using various electrodes, **demonstrate how to make pad beads on plain carbon steel** in the following positions.

a. flat
b. horizontal
c. vertical
d. overhead

Summarize the demonstration results of using various electrodes and explain the findings using supporting evidence from the AWS metal classification system.

6. Properties of Metals

6.1 Mechanical Properties of Metals: Summarize the following **mechanical properties of metals** and their importance in the welding process.

a. tensile
b. strength
c. hardness
d. elasticity
e. ductility
f. toughness
g. brittleness

Explain the changes in the mechanical properties of weldments that occur during the welding process.

6.2 Thermal Properties of Metals: Investigate the **thermal properties of metals** and their effects on welding processes. Describe and demonstrate techniques to mitigate the effects of thermal expansion and contraction that occur during the welding process. During the demonstrations, observe and record the changes that occur in the mechanical properties of weld and parent metals caused by heating and cooling.

6.3 Heat Effect of Metals: Demonstrate the **effects of heat on different metals** such as steel and aluminum. Explain the differences. Explain the effect of thermal conductivity on the heating and cooling rates observed during the welding process, as well as the effect of specific heat on heat rates required for welding.

7. Quality Control

7.1 Discontinuities and Defects: Explain the relationship between **discontinuities and defects.** Describe various examples of defects found in welded products. Also identify and explain both destructive and nondestructive tests used as quality control techniques to prevent manufacturing defects in welding. Compare and contrast these techniques and provide specific examples when they are most appropriately used. Cite evidence to justify the examples.

7.2 Inspection: Measure and visually inspect welded products for acceptability to American Welding Society QC-10 standards. Record discontinuities and defects and compare data to given project specifications using class-defined analysis methods. Interpret and communicate results. If necessary, recommend changes that will reduce the number of product defects during the manufacturing process.

8. Welding Procedure Specification Development

8.1 Welding Elements: **Identify various welding elements**. Define the following elements and locate them in American Welding Society (AWS) Specification for Welding Procedure and Performance Qualification (AWS B2.1/B2.1M):

a. joint design,
b. base metal,
c. filler metal,
d. position,
e. preheat and interpass,
f. heat treatment,
g. shielding gas, and
h. electrical.

8.2 Elements Effects on Welding: Summarize the variables associated with the above elements and their **effects on welding processes**. Describe techniques to mitigate the effects of these variables that can occur during the welding process.

8.3 Welding Procedure Specification: Read and interpret an example of a **welding procedure specification** and observe demonstrations of qualified welders to understand the proper procedures involved in conducting a welding procedure test. Explain how to properly use the welding procedure specification impacts a welding procedure test. Include the following:
   a. code requirements,
   b. materials,
   c. documentation,
   d. destructive testing, and
   e. inspection and evaluation.

8.4 Welding Procedure Test: Explain how to conduct a welding procedure specification and a **welding procedure test**. Steps must include:
   a. properly setting up welding equipment for the process being tested;
   b. properly select base material and filler metal (gas shielding if required);
   c. gathering equipment needed to capture welding variables;
   d. properly set up test coupon (per code, or as performed in production);
   e. properly document data as coupon is being welded;
   f. performing visual inspection;
   g. performing destructive testing; and
   h. completing the Welding Procedure Specification document.

Standards Alignment Notes

*References to other standards include:

- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.