TN Department of Education | College, Career and Technical Education

May 2024

Welding II

Primary Career Cluster:	Advanced Manufacturing
Course Contact:	CTE.Standards@tn.gov
Course Code(s):	C13H10
Pre-requisite(s):	*Welding I* (C13H12) Recommended: *Algebra* (G02X02, G02H00), *Geometry* (G02X03, G02H11), *Physical Science* (G03H00)
Credit:	1-2 credits
Grade Level:	11-12
Elective Focus - Graduation Requirement:	This course satisfies two 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 third 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 & 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.
- **Standards 2.3, 3.3, 4.3** | Have the students do a project that is useful to a local employer. The employer can critique the student work.
- **Standards 5.1-5.3** | Have an industry person visit the class to discuss and demonstrate the importance of quality control.
- **Standard 6.1** | Ask an industry rep to discuss welding efficiency on the job.

Course Description

Welding II is designed to provide students with opportunities to effectively perform cutting and welding applications of increasingly complexity used in the advanced manufacturing industry. Proficient students will build on the knowledge and skills of the *Welding I* course and apply them in novel environments, while learning additional welding techniques not covered in previous courses. Specifically, students will be proficient in (1) fundamental safety practices in welding, (2) gas metal arc welding (GMAW), (3) flux cored arc welding (FCAW), (4) gas tungsten arc welding (GTAW), and (5) quality control methods. Upon completion of the *Welding II* course, proficient students will be eligible to complete the American Welding Society (AWS) Entry Welder or the AWS SENSE Advanced Welders qualifications and certifications.

Course Standards

1. Safety

1.1 Safety Rules: 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. Gas Metal Welding (GMAW)

2.1 GMAW Equipment: Safely set up **equipment for gas metal arc welding (GMAW).** Identify and explain the equipment, equipment setup, power sources, and the electrical current used in the welding process. Explain the characteristics and advantages of using GMAW over conventional electrode-type arc (stick) welding. For example, explain why it is easier to control the small molten weld pool using the GMAW process.

2.2 Metal Classification for GMAW: Explain the American Welding Society (AWS) **filler metal classification system**. Explain the multiple factors that affect electrode selection for gas metal arc welding (GMAW). For example, the 80 in ER80S-D2 designates the minimum tensile strength of the deposited weld metal in thousands.

2.3 Weld with GMAW: Using the gas metal arc welding (GMAW) process and various metal transfer methods (e.g., short-circuit, pulse-arc, globular, and spray transfer), **demonstrate how to pad beads and make fillet welds on plain carbon steel in all feasible positions** (e.g., horizontal, flat, vertical, overhead). Summarize the demonstration results, distinguishing between the metal transfer methods used, and explain the equipment adjustments made to change between metal transfer methods as if narrating a technical process to an audience.

3. Flux Cored Arc Welding (FCAW)

3.1 FCAW Equipment: Safely set up **equipment for flux cored arc welding (FCAW).** Identify and explain the equipment, equipment setup, power sources, and the electrical current used in the welding process. Drawing on multiple resources, research the advantages and limitations of FCAW. Write a brief informative paper distinguishing these characteristics. For example, determine which types of metals and alloys are most applicable for the use of FCAW.

3.2 Metal Classification for FCAW: Refer to previous research conducted on the **filler metal classification system** by the American Welding Society (AWS). Using proper domain-specific terminology, explain the multiple factors that affect electrode and shielded gas selection for flux cored arc welding (FCAW). For example, manufacturers sometimes consider the exact composition of fluxes a trade secret and do not provide enough details to classify electrodes. As a result, AWS uses G for electrodes that have not been classified.

3.3 Weld with FCAW: Using various electrodes and the flux cored arc welding (FCAW) process, **demonstrate how to pad beads and make fillet welds on plain carbon steel in all feasible positions** (e.g., horizontal, flat, vertical, overhead). Document observations such as the effects of metal surface conditions, voltage drop, welding position, and wire feed speed. Summarize the demonstration results of using various electrodes and explain the findings using supporting evidence from the AWS metal classification system and other resources.

3.4 Distinctives of FCAW: Identify and explain the following **distinctive features about flux cored arc welding (FCAW)**: arc-control, oxidation-prevention, self-shielded FCAW, and gas-shielded FCAW. Describe and demonstrate specific examples of how metal transfer is affected by arc-control, self-shielded, and gas-shielded FCAW. Explain the importance of using recommended gas mixtures.

4. Gas Tungsten Arc Welding (GTAW)

4.1 GTAW Equipment: Safely set up **equipment for gas tungsten arc welding (GTAW).** Identify and explain the equipment, equipment setup, power sources, and the electrical current used in the welding process. Compare and contrast water-cooled welding torches versus air-cooled welding torches used in GTAW. Explain the characteristics and the appropriate applications of each torch type. For example, determine which torch is preferred in production welding contexts and explain why.

4.2 Metal Classification for GTAW: Refer to previous research conducted on the **filler metal classification system** by the American Welding Society (AWS). Discuss the multiple factors that affect electrode selection for gas tungsten arc welding (GTAW). For example, pure tungsten (EWP) is not typically used with alternating current (AC) welding of materials because it has poor heat resistance and electron emission.

4.3 Weld with GTAW: Using various electrodes and the gas tungsten arc welding (GTAW) process, **demonstrate how to pad beads and make fillet welds on plain carbon steel, stainless steel, and aluminum in all feasible positions** (e.g., horizontal, flat, vertical, overhead).

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

4.4 Distinctives of GTAW: Identify and explain the following **distinctive features about gas tungsten arc welding (GTAW)**: arc-control, oxidation-prevention, and gas-shielded GTAW. Describe and demonstrate specific examples of how metal transfer is affected by various shielded gas GTAW (e.g., argon, helium, hydrogen, nitrogen). Identify which gases are noble inert gases and explain why this is a distinguishing characteristic.

5. Quality Control

5.1 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 both written and verbally. If necessary, recommend changes that will reduce the number of product defects during the manufacturing process.

5.2 Testing: Explain **nondestructive testing** beyond visual inspection, such as penetrant inspection, magnetic particle inspection, radiographic inspection, and ultrasonic inspection. Describe how these tests are applied as quality control techniques to prevent manufacturing defects in welding. Compare and contrast these techniques and provide specific examples for when they are most appropriately used. Cite evidence to justify the examples. **Demonstrate the proper use of the magnetic particle and penetrant inspection tests** on weldment samples of gas metal arc welding (GMAW), flux cored arc welding (FCAW), and gas tungsten arc welding (GTAW) processes.

5.3 Bend Tests: Describe and distinguish between the **guided-bend test and the free-bend test**. Explain when it is most appropriate to apply each test. Demonstrate the use of each test and properly document results on a mock qualification test record form conforming to the American Welding Society (AWS) requirements. For example, perform root- and face-guided bend tests on a butt joint weld coupon.

6. Welding Efficiency

6.1 Efficiency: **Analyze and differentiate among various types of elements that can directly impact welding efficiency**. Explain the following types of elements and details how their purposes and characteristics can directly affect efficiency:

a. arc time,
b. operating factor,
c. deposition rate (wire feed speed),
d. electrode efficiency,
e. travel speed,
f. weld size,
g. poor fit, and
h. defects/repairs.

6.2 Wire Feed Speed and Weld Size: **Explain how wire feed speed and weld size influences efficiency.** Demonstrate the consequences of using different variables in relation to wire feed speed and weld size. Upon completion of the work, explain and justify observations identifying different methods used and their final impact on efficiency.

6.3 Fillet and Groove Welds: Explain the differences between **Fillet and Groove Welds**. Summarize their purposes and characteristics, the costs associated with each weld, and a calculation of how long it would take a welder to successfully create each type.

7. Industry Certification and Portfolio

7.1 Industry Certification: **Pursue the industry certification exam** (e.g., American Welding Society SMAW module) using the shielded metal arc welding (SMAW) process. Demonstrate how to make multiple-pass open-butt groove welds on plain carbon steel in all feasible positions (e.g., horizontal, flat, vertical, overhead) conforming to American Welding Society quality standards.

7.2 Project: Complete assigned team projects that **incorporate the following welding processes in order to design, fabricate, evaluate, and test products** made in this course. For each project, produce a technical report documenting illustrations, findings, and justifications for project solutions. Compile photographs of each project, along with technical documentation, into a **portfolio of work**.

a. Using the gas metal arc welding (GMAW) process and various metal transfer methods (e.g., short-circuit, pulse-arc, and spray transfer), demonstrate how to make a complete joint penetration weld on plain carbon steel in all feasible positions (e.g., horizontal, flat, vertical, overhead) conforming to American Welding Society quality standards.
b. Using the flux cored arc welding (FCAW) process, demonstrate how to make a complete joint penetration weld on plain carbon steel in all feasible positions (e.g., horizontal, flat, vertical, overhead) conforming to American Welding Society quality standards.
c. Using electrodes and the gas tungsten arc welding (GTAW) process, demonstrate how to complete joint penetration welds on plain carbon steel, stainless steel, and aluminum in all feasible positions (e.g., horizontal, flat, vertical, overhead) conforming to American Welding Society quality standards.

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.