**Course Description**

Students will use the Gas Metal Arc Welding process (GMAW) to safely join various types of metal. They will cut metals using oxy-fuel processes and perform multiple types of welds and joints in all positions, up to and including overhead. They will select the appropriate type of electrode wire and shielding gas, and they will adjust welding equipment based on the physical characteristics and metal properties. Students will apply quality control factors to evaluate weld quality.

**Strand 1. Business Operations/21st Century Skills**

Learners apply principles of economics, business management, marketing and employability in an entrepreneur, manager and employee role to the leadership, planning, developing and analyzing of business enterprises related to the career field.

**Outcome 1.1. Employability Skills:** Develop career awareness and employability skills (e.g. face-to-face, online) needed for gaining and maintaining employment in diverse business settings.

**Competencies**

1.1.1. Identify the knowledge, skills and abilities necessary to succeed in careers.

1.1.2. Identify the scope of career opportunities and the requirements for education, training, certification, licensure and experience.

1.1.5. Develop strategies for self-promotion in the hiring process (e.g. filling out job applications, résumé writing, interviewing skills, portfolio development).

1.1.6. Explain the importance of work ethic, accountability and responsibility and demonstrate associated behaviors in fulfilling personal, community and workplace roles.

1.1.7. Apply problem-solving and critical-thinking skills to work-related issues when making decisions and formulating solutions.

1.1.8. Identify the correlation between emotions, behavior and appearance and manage those to establish and maintain professionalism.

1.1.9. Give and receive constructive feedback to improve work habits.

1.1.10. Adapt personal coping skills to adjust to taxing workplace demands.

1.1.11. Recognize different cultural beliefs and practices in the workplace and demonstrate respect for them.

1.1.12. Identify healthy lifestyles that reduce the risk of chronic disease, unsafe habits and abusive behavior.

**Strand 4. Materials Joining**

Learners apply principles of physics and metallurgy to join materials and test joints. Knowledge and skills may be applied to arc welding processes, non‐arc welding processes, testing and inspection and thermal cutting.

**Outcome 4.1. Physics of Welding:** Apply the physics of arc welding to the process of joining metal.

**Competencies**

4.1.1. Explain how the welding arc produces a weld.

4.1.2. Identify the factors that affect heat transfer.

4.1.3. Identify the factors that affect melting.

4.1.4. Describe the effects of arc length and shielding gases on the arc.

4.1.5. Identify key variables that determine the type of metal transfers.

4.1.6. Identify how metal transfers in different welding processes (i.e. short circuit, globular, spray transfer, pulsed spray transfer).

4.1.7. Explain the characteristics of different transfer modes (i.e. short circuit, globular, spray transfer, pulsed spray transfer).

4.1.8. Describe the relationship between wire feed speed and welding current.

4.1.9. Describe pulsed arc transfer mode.

4.1.10. Describe the effects of wire size on deposition rate and current ranges.

4.1.11. Identify the characteristics of a stable arc, arc voltage and arc length.

4.1.12. Describe the relationship of current and voltage as it applies to constant voltage power sources.

4.1.13. Explain conditions when arc blow occurs and how to reduce arc blow.

4.1.14. Describe how polarity affects the arc welding process.

4.1.16. Compare transformers, rectifiers and inverters in relation to the arc welding process.

**Outcome 4.2. Metallurgy of Welding:** Apply the metallurgy of welding to the processes of joining metal.

**Competencies**

4.2.1. Explain phases of matter and phase changes during solidification.

4.2.2. Explain how the common crystal structure in metallic materials affects welds.

4.2.3. Explain point, line and surface imperfection in metal crystal structure.

4.2.4. Explain the types of weld imperfections and indicate their effects on material properties.

4.2.5. Explain grain boundaries.

4.2.6. Explain allotropic phase changes as a function of temperature.

4.2.7. Explain the production of ferrous and nonferrous alloys.

4.2.9. Explain how the constituent structure of eutectoid steel changes when it is slowly cooled from austenite to pearlite and when it is rapidly cooled from austenite to martensite.

4.2.11. Identify the phases present in the two‐phase pro‐eutectoid ferrite region.

4.2.12. Explain transformation strengthening, deformation strengthening and precipitation strengthening.

**Outcome 4.3. Arc Welding Processes:** Perform types of welds in the six positions using arc welding processes.

**Competencies**

4.3.1. Identify types of ferrous and nonferrous materials to be joined.

4.3.2. Select the types of weld required for product specifications.

4.3.3. Explain electrode and filler metal classification systems and procedures for handling and storing.

4.3.4. Select an arc welding process based on product specifications.

4.3.6. Join materials using the gas metal arc welding (GMAW) process.

4.3.7. Join materials using the flux core arc welding (FCAW) process.

**Outcome 4.5. Testing and Inspection:** Test and inspect joints and weld structures.

**Competencies**

4.5.1. Identify the factors considered in weld quality.

4.5.2. Conduct a visual defect examination.

4.5.3. Conduct destructive weldment testing.

4.5.4. Conduct dye penetrant examination.

4.5.5. Conduct radiographic examination.

4.5.6. Conduct eddy current examination.

4.5.7. Analyze weld structure test results to determine weld quality.

4.5.8. Describe emerging non-destructive examination process related to quality testing.

**Outcome 4.6. Cutting Processes:** Cut materials using cutting processes.

**Competencies**

4.6.1. Identify types of materials to be cut.

4.6.2. Identify the characteristics of the cut (e.g. bevels, miters, angles) and finish (e.g. machined, grind, rolled).

4.6.3. Select a cutting process based on product specifications.

4.6.4. Cut metals using the plasma arc cutting (PAC) process.

4.6.5. Cut and gouge metals using the air carbon arc (CAC‐A) process.

4.6.6. Cut metals using manual and machine‐guided oxy‐fuel processes.

4.6.7. Cut metals using advanced cutting systems (e.g. plasma computer‐aided controls, computer numeric controls [CNC], laser).

**Strand 5. Pre‐Engineering: Design and Development**

Learners apply principles of design and development related to the design process, sketching and visualization, modeling, drafting, materials and production and process design.

**Outcome 5.2. Sketching, Drawing, and Visualization:** Conceptualize, sketch and draw design projects and components.

**Competencies**

5.2.1. Compare technical sketching and drawing.

5.2.2. Sketch possible solutions to an existing design problem.

5.2.3. Apply tolerancing techniques when dimensioning.

5.2.4. Apply annotations on sketches and drawings.

5.2.5. Create sketches using integration sketching techniques and styles.

5.2.6. Apply coordinate systems (e.g. absolute, relative, user, cylindrical, Cartesian).

5.2.7. Sketch geometric forms and shapes.

5.2.8. Describe geometric constraints (e.g. geometric dimension and tolerancing [GD&T], run out, location, and form).

5.2.9. Select a view to graphically communicate a design solution.

**Strand 6. Precision and Advanced Machining**

Learners apply principles of precision machining to measuring work pieces, drawing interpretation, inspection, bench work and layout, power saws, drilling machines, lathes and turning machines, milling machines and grinding machines.

**Outcome 6.1. Measurement and Interpretation:** Interpret drawings and documentation and perform measurements.

**Competencies**

6.1.1. Identify measuring tools and gradations used in precision machining and their purposes.

6.1.2. Identify typical measurements in precision machining (e.g. angles, diameter, hardness).

6.1.3. Identify measuring systems and convert between systems.

6.1.4. Identify information and symbols provided in drawings and specifications.

6.1.5. Measure and inspect work pieces according to product specifications.

**Strand 7.** **Industrial Maintenance and Safety**

Learners apply principles of protection, prevention and mitigation to create and maintain safe working conditions at manufacturing sites. Knowledge and skills may be applied in all aspects of personal and site safety, including handling materials, using tools and equipment, working with and around electricity and using personal protective equipment.

**Outcome 7.1. Site Safety:** Handle materials, prevent accidents and mitigate hazards.

**Competencies**

7.1.1. Use Occupational Safety and Health Administration (OSHA)‐defined procedures for identifying employer and employee responsibilities, working in confined spaces, managing worker safety programs, using ground fault circuit interrupters (GFCIs), maintaining clearance and boundaries and labeling.

7.1.2. Identify and rectify or mitigate hazards associated with walking surfaces, working surfaces and lighting.

7.1.6. Identify source of electrical and mechanical hazards and use shut‐down and established lock out/tag‐out procedures.

7.1.7. Identify and eliminate worksite clutter in accordance with standards for cleanliness and safety.

7.1.8. Identify procedures for the handling, storage and disposal of hazardous materials.

7.1.9. Identify the location of emergency flush showers, eyewash fountains, Safety Data Sheets (SDSs), fire alarms and exits.

7.1.10. Select and operate fire extinguishers based on the class of fire.

7.1.11. Identify the components of a hazardous materials safety plan.

7.1.12. Create a hazardous materials safety plan.

7.1.13. Set up for ergonomic workflow.

7.1.14. Describe the interactions of incompatible substances when measuring and mixing chemicals.

**Outcome 7.2. Personal Safety:** Practice personal safety.

**Competencies**

7.2.1. Interpret personal safety rights according to the employee Right to Know plan.

7.2.2. Describe how working under the influence of drugs and alcohol increases the risk of accident, lowers productivity, raises insurance costs and reduces profits.

7.2.3. Select, use, store, maintain and dispose of personal protective equipment (PPE) appropriate to job tasks, conditions and materials.

7.2.4. Identify workplace risk factors associated with lifting, operating and moving heavy objects and establish an ergonomics process.

7.2.5. Identify, inspect and use safety equipment appropriate for a task.

7.2.6. Use safe practices when working with electrical, mechanical or other equipment.

7.2.8. Safely operate manual, electrical‐powered and pneumatic tools.