Metal Fabrication and Joining Technologies Standards and Skills



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Health & Safety Standards

## Standard 1: Safety and Health in a Metal Fabrication Environment

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| Students will be able to demonstrate health and safety in a shop environment, including the management of tools and equipment, use of personal protective equipment, and workspace ergonomics. | OSHA10 – General Industry |

**Skills:**

1. Describe and demonstrate the appropriate use of Personal Protective Equipment (PPE) for general shop practices (e.g., safety glasses, ear protection, foot protection, etc.).
2. Identify and explain the importance of ventilation and respiratory protection.
3. Describe and demonstrate appropriate material handling and storing techniques: lifting, hoisting, hauling, and storing.
4. Describe and demonstrate proper operation of metal fabrication equipment.
5. Discuss and implement machine guarding to comply with industry standards.
6. Identify and comply with Occupational Safety and Health Administration (OSHA) cylinder handling and storage regulations.
7. Identify and comply with regulations for working in confined spaces.
8. Identify and comply with fire protection regulations, local permit requirements, and state/federal regulations (i.e., OSHA, Hot Work, National Fire Protection Association (NFPA), 527CMR.100).
9. Describe and demonstrate ladder safety procedures.
10. Describe and demonstrate lock out/ tag out procedures.
11. Safely use and store hand tools, power tools, and ladders according to OSHA standards.
12. Appropriately document and communicate safety risks and equipment maintenance needs.
13. Describe OSHA 10 General Industry standards related to its fifteen domains, including powered platforms, hazardous materials, PPE, first aid, and machine guarding.
14. Demonstrate compliance with each of the standards in Subpart Q of OSHA 10 General Industry Standards (1910.252-1910.255) related to welding, cutting, and brazing.

Technical & Integrated Academic Standards

## Standard 2: Metallurgy and Metal Fabrication in Society

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| --- | --- |
| Students will be able to explain the importance of metallurgy and the history and impact of metal fabrication on society.  |  |

**Skills:**

1. Identify and describe all aspects of the metal fabrication and welding industry.
2. Explain the evolution of the metal fabrication industry and its importance to modern society.
3. Identify and describe the regulatory codes, standards, and licensing/certification requirements for the metal fabrication industry.
4. Identify and describe career opportunities in the field of metal fabrication and joining.
5. Describe the concept of apprenticeship models and the professional and licensure requirements of the metal fabrication industry (i.e., pipefitter, sheet metal worker, iron worker, laborer).

## Standard 3: Fabrication Materials and Practices

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| Students will be able to evaluate and prepare a variety of materials, describe, and demonstrate appropriate joining methods, and identify and describe basic types of weld joints. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Skills:**

1. Describe and demonstrate appropriate methods of joining fabricated materials.
2. Identify and explain the appropriate use of fasteners (i.e., bolts, screws, rivets, and/or adhesives).
3. Identify and explain common materials and structural shapes used in the metal fabrication industry.
4. Describe and demonstrate how to assemble and fit up parts for welding.
5. Identify and describe the five common types of weld joints (butt, lap, tee, outside corner, and edge).
6. Identify and explain classifications and weldability of ferrous and nonferrous metals.
7. Identify and explain the mechanical and physical properties of ferrous and nonferrous metals.
8. Identify and explain heat treatment applications for ferrous and nonferrous metals (i.e., annealing, tempering, and hardening).
9. Identify and demonstrate proper use of measurement devices for specific applications.
10. Define attributes, tolerances, bend allowances, units, and systems of measurement used in the metal fabrication industry.
11. Determine measurement from a decimal equivalent chart.
12. Determine measurement from common shop hand tools such as: combination squares, tape measures, weld gauges, sheet metal gauges, trammel points, dividers, protractors, Vernier calipers, micrometers, and centering heads.

## Standard 4: Sheet Metal

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| Students will be able to evaluate and prepare, describe, and demonstrate appropriate sheet metal techniques.  | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Skills:**

1. Describe and demonstrate fabrication techniques for ferrous, nonferrous, and galvanized sheet metal.
2. Demonstrate the layout of dimensions on sheet metal materials using scribes, awls, dividers, squares, protractors, trammel points, combination square, and steel ruler.
3. Demonstrate pattern development using parallel line, radial line, and triangulation techniques.
4. Demonstrate the fabrication of sheet metal hems, Pittsburg locks, slip and drives, standing seams, laps, elbow locks, beading, and crimping.
5. Demonstrate fabrication procedures using hand and mechanical seamers, hand, foot, and mechanical shears, hand and mechanical brakes, bar folders, cheek benders, and forming stakes.
6. Demonstrate safe and proper soldering operations.
7. Identify and explain appropriate equipment, procedures, and PPE for soldering operations.
8. Describe and demonstrate the safe and proper set up of soldering equipment and preparation of materials.
9. Identify and describe various types of solder and flux.
10. Describe and demonstrate soldering techniques.
11. Demonstrate safe and proper resistance welding operations, according to industry and OSHA standards.
12. Identify and explain appropriate equipment, procedures, and PPE for resistance welding.
13. Describe and demonstrate the safe and proper setup, operation, and maintenance of resistance welding equipment.
14. Describe and demonstrate resistance welds on a variety of thin gauge material.

## Standard 5: Print Reading

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| Students will be able to interpret and design detailed drawings and blueprints. | Massdot D1.1 SMAW 3G & 4G Welding Certification |

**Skills:**

1. Read and interpret technical drawings and prints.
2. Explain the purpose of technical drawings, pictorial drawings, and mechanical drawings.
3. Identify and describe the purpose of detail, assembly, and sub-assembly prints.
4. Identify and apply blueprint specifications, notes, and abbreviations.
5. Identify and describe the basic line types used in mechanical/architectural drawings.
6. Identify and describe various views used in technical drawings: (i.e., auxiliary, sectional, enlarged, revolved, and developed views).
7. Identify and apply various blueprint dimensioning techniques: linear, angular, radius, holes, tolerances, and scale.
8. Demonstrate the ability to sketch the following: oblique, isometric, and orthographic projections.
9. Develop a bill of materials.
10. Convert blueprint measurements to scale.
11. Identify and interpret common welding symbols and abbreviations.

## Standard 6: Hand and Pneumatic Tools

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| Students will be able to demonstrate safe and proper use and maintenance of hand, power, and pneumatic tools according to industry and OSHA standards. | Massdot D1.1 SMAW 3G & 4G Welding Certification |

**Skills:**

1. Demonstrate the safe and proper operation of hand tools, according to industry and OSHA standards.
2. Demonstrate the safe and proper use of wrenches, hammers, and screwdrivers.
3. Demonstrate the safe and proper use of clamping tools.
4. Demonstrate the safe and proper creation of holes using awls and punches.
5. Demonstrate proper techniques to determine square, level, and plumb.
6. Demonstrate the safe and proper use of a pop-rivet gun.
7. Demonstrate the safe and proper use of chisels and center punches of varied applications.
8. Demonstrate the safe and proper selection and use of taps and dies.
9. Demonstrate the safe and proper selection and use of hand files.
10. Demonstrate the safe and proper use of sheet metal shears.
11. Demonstrate the safe and proper use of a handheld hacksaw.
12. Demonstrate the safe and proper operation of power tools, according to industry and OSHA standards.
13. Demonstrate the safe and proper use of hand-held and stationary grinders and sanders.
14. Demonstrate the safe and proper use of electric hand shear.
15. Demonstrate the safe and proper use of a hand drill.
16. Demonstrate the safe and proper use of a handheld electric jig saw.
17. Demonstrate the safe and proper use a of reciprocating saw.
18. Demonstrate the safe and proper use of a portable bandsaw.
19. Demonstrate the safe and proper operation of pneumatic tools, according to industry and OSHA standards.
20. Demonstrate the safe and proper use of grinders and sanders.
21. Demonstrate the safe and proper use of an air hammer.
22. Demonstrate the safe and proper use of a die grinder.
23. Demonstrate the safe and proper use of a needle scaler.

## Standard 7: Welding and Joining Standard Techniques and Processes

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| Students will be able to safely perform welding and joining processes and operate mechanical cutting, thermal cutting, metal forming, automated, and pipe welding equipment. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Skills:**

1. Demonstrate safe and proper operation of mechanical cutting equipment according to industry and OSHA standards.
2. Demonstrate the safe and proper use of a power shear.
3. Demonstrate the safe and proper use of a foot operated shear.
4. Demonstrate the safe and proper use of a drill press.
5. Demonstrate the safe and proper use of a cold saw and/or abrasive saw.
6. Demonstrate the safe and proper use of a horizontal band saw and/or vertical band saw.
7. Demonstrate the safe and proper use of an Ironworker.
8. Demonstrate safe and proper operation of metal forming equipment according to industry and OSHA standards.
9. Identify and describe the appropriate metal forming tools and techniques for specific projects.
10. Demonstrate safe and proper use of hand operated brakes.
11. Demonstrate safe and proper use of slip rollers.
12. Demonstrate safe and proper use of power rollers.
13. Demonstrate safe and proper use of a power press brake.
14. Demonstrate safe and proper use of a universal bender.
15. Demonstrate safe and proper use of a lock former.
16. Demonstrate the safe and proper use of the oxy-fuel gas cutting process, according to industry and OSHA standards.
17. Identify and describe appropriate equipment, procedures, and PPE for oxyfuel cutting operations.
18. Describe and demonstrate safe and proper use of oxyfuel cutting equipment to include set up, start up, and shut down procedures.
19. Describe and demonstrate manual oxyfuel gas, straight/radius, and shape cutting operations on plain carbon steel.
20. Describe and demonstrate bevel cutting operations on plain carbon steel.
21. Describe and demonstrate straight cutting and beveling operations on structural shapes.
22. Describe and demonstrate straight cutting and beveling operations utilizing mechanized oxyfuel cutting equipment.
23. Demonstrate the safe and proper operation of the plasma arc cuttingprocess, according to industry and OSHA standards.
24. Identify and describe appropriate equipment, procedures, and PPE for plasma arc cutting operations.
25. Describe and demonstrate the safe and proper set up and operation of hand-held plasma arc cutting equipment.
26. Describe and demonstrate safe and proper set up and operation of Computerized Numerical Control (CNC) plasma arc cutting equipment.
27. Identify consumables necessary for cutting ferrous and non-ferrous metals.
28. Demonstrate the safe and proper operation of the Carbon Arc Cutting (CAC) process, according to industry and OSHA standards.
29. Identify and describe appropriate equipment, procedures, and PPE for CAC and gouging operations.
30. Describe and demonstrate the safe and proper set up and operation of manual CAC and gouging equipment on plain carbon steel.
31. Demonstrate the safe and proper operation of the oxy-acetylene welding process, according to industry and OSHA standards.
32. Identify and describe appropriate equipment, procedures, and PPE for oxy-fuel welding operations.
33. Describe and demonstrate safe and proper use of oxy-fuel welding equipment to include set up, start up, and shut down procedures.
34. Describe and demonstrate the safe and proper technique to form a weld bead on mild steel.
35. Describe and demonstrate the safe and proper technique to braze joints in a flat position.
36. Demonstrate the safe and proper operation of the Shielded Metal Arc Welding(SMAW) process, according to industry and OSHA standards.
37. Identify and explain appropriate equipment, procedures, and PPE for SMAW operations.
38. Describe and demonstrate safe and proper use of SMAW equipment to include set up and operational procedures.
39. Identify various types of electrodes by their diameters and characteristics.
40. Describe and demonstrate surface welding techniques in flat and horizontal positions.
41. Describe and demonstrate fillet welding techniques in the 1F and 2F positions on structural shapes and plate.
42. Describe and demonstrate fillet welding techniques in the 3F and 4F positions on structural shapes and plate.
43. Describe and demonstrate groove welding techniques in the 1G and 2G positions on structural shapes and plate.
44. Describe and demonstrate groove welding techniques in the 3G and 4G positions on structural shapes and plate.
45. Demonstrate safe and proper operation of the Gas Metal Arc Welding (GMAW) process, according to industry and OSHA standards.
46. Identify and describe appropriate equipment, procedures, and PPE for GMAW operations.
47. Describe and demonstrate safe and proper use of GMAW equipment to include set up and operational procedures.
48. Identify and describe the various metal transfer modes and shielding gases.
49. Identify sizes and application of common spool and filler wires.
50. Describe and demonstrate surface welding techniques in flat and horizontal positions.
51. Describe and demonstrate fillet welding techniques on structural shapes and plate in all positions.
52. Describe and demonstrate the safe and proper welding techniques for aluminum using spool and/or push-pull systems.
53. Demonstrate the safe and proper operation of the Flux Core Arc Welding (FCAW) process, according to industry and OSHA standards.
54. Identify and explain appropriate equipment, procedures, and PPE for FCAW operations.
55. Describe and demonstrate safe and proper use of FCAW equipment to include set up and operational procedures.
56. Identify and describe dual shield, self-shield, and metal core filler wires and their proper shielding gases.
57. Describe and demonstrate surface welding techniques in flat and horizontal positions.
58. Describe and demonstrate fillet welding techniques in the 1F and 2F positions on structural shapes and plate.
59. Describe and demonstrate fillet welding techniques in the 3F and 4F positions on structural shapes and plate.
60. Describe and demonstrate groove welding techniques in the 1G and 2G positions on structural shapes and plate.
61. Describe and demonstrate groove welding techniques in the 3G and 4G positions on structural shapes and plate.
62. Demonstrate the safe and proper operation of the Gas Tungsten Arc Welding (GTAW) process, according to industry and OSHA standards.
63. Identify and describe appropriate equipment, procedures, and PPE for GTAW operations.
64. Describe and demonstrate safe and proper use of GTAW equipment to include set up and operational procedures for ferrous and non-ferrous metals.
65. Describe and demonstrate proper welding techniques on carbon steel with and without filler.
66. Describe and demonstrate proper welding techniques on stainless steel and aluminum with and without filler.
67. Describe and demonstrate proper fillet welding techniques on ferrous and non-ferrous metals.
68. Describe and demonstrate proper groove welding techniques on ferrous and non-ferrous metals including structural shapes and plate.

## Standard 8: Pipe Welding Standard Techniques and Processes

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| --- | --- |
| Students will be able to safely perform welding and joining processes and operate automated and pipe welding equipment. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Skills:**

1. Identify and perform the fundamentals of pipe welding.
2. Identify and describe appropriate equipment, procedures, and PPE for pipe welding operations.
3. Describe and demonstrate proper base metal preparation techniques for ferrous and non-ferrous pipe and tubing.
4. Describe and demonstrate pipe beveling techniques with or without the use of a grinder, beveling machine, oxy-fuel manual, or mechanized equipment.
5. Describe and demonstrate proper joint alignment, root face preparation, and root opening with the use of tack welds and or pipe clamps/jigs.
6. Describe and demonstrate safe and proper SMAW techniques on pipe.
7. Describe and demonstrate safe and proper GTAW techniques on pipe.
8. Describe and demonstrate safe and proper GMAW techniques on pipe.
9. Describe and demonstrate safe and proper FCAW techniques on pipe.

**Standard 9: Automated Equipment**

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| Students will be able to identify and describe the fundamentals of special cutting, welding, and manufacturing processes. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Skills:**

1. Describe and/or demonstrate the setup and safe operation of waterjet cutting equipment.
2. Describe and/or demonstrate the setup and safe operation of a Computerized Numerical Control (CNC) Pressbrake.
3. Describe and/or demonstrate the setup and safe operation of welding automation and robotic welding equipment.
4. Describe and/or demonstrate the setup and safe operation of weld positioners.
5. Describe and/or demonstrate the setup and safe operation of weld simulators.
6. Describe and/or demonstrate the setup and safe operation of pipe and tube bending equipment and machinery.

## Standard 10: Preventative Maintenance and Equipment Inspection

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| Students will be able to conduct preventative safety procedures in a welding environment, including machinery maintenance and welding inspection and testing procedures. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Skills:**

1. Identify and describe the fundamentals of welding inspection procedures and testing methods.
2. Identify and describe quality control procedures in various work environments.
3. Explain the importance of a welding specification procedure sheet for weld inspection and testing procedures.
4. Describe and demonstrate visual weld inspection techniques.
5. Identify and describe other non-destructive testing methods.
6. Identify and describe destructive testing methods.
7. Identify and describe common inspection tools utilized for weld inspection.
8. Monitor basic equipment and perform machinery maintenance.
9. Monitor equipment indicators to ensure that equipment is operating correctly.
10. Develop a preventative maintenance schedule in accordance with the manufacturer's recommendations.
11. Identify and diagnose the source of the welding and metal forming equipment issue, then develop steps to resolve the problem.

**Employability Standards**

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## Standard 11: Employability Skills

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| Students will understand and demonstrate the roles of professional communication, critical thinking, problem solving, professionalism, teamwork, and collaboration within the context of within the context of metal fabrication and joining technologies. |  |

**Skills:**

1. Demonstrate the impact of communication skills on the project planning and project management processes.
2. Describe appropriate methods of communication for internal and external stakeholders.
3. Evaluate the communication skills used in a hypothetical needs analysis session vis-à-vis a general understanding of the goals of the project.
4. Troubleshoot a project plan to find mistargeted or extraneous work that does not contribute to the ultimate objectives of the project.
5. Build a team-based project plan that includes recruiting teammates and assigning roles for a project.
6. Examine the role of a Metal Fabrication professional in society, particularly in terms of its significance for employability and career opportunities.

# Entrepreneurship Standards

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## Standard 12: Entrepreneurship

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| Students will be able to describe opportunities for entrepreneurship and be able to evaluate the value proposition of business ownership in the metal fabrication and joining field. |  |

**Skills:**

1. Understand and be able to explain the needs for a startup metal fabrication company (including initial equipment and staffing needs, a marketing/business development plan, and a basic revenue management strategy).
2. Describe the concept of professional networking and demonstrate personal introductions and an “elevator speech” appropriate for other metal fabrication professionals, potential employers, and other potential business partners.
3. Evaluate the licensing, regulatory, and tax implications of self-employment and business ownership as a metal fabrication professional compared to W-2 employment.

# Digital Literacy Standards

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## Standard 13: Digital Literacy

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| Students will be able to demonstrate the use of common software and information technology in a modern shop environment.  |  |

**Skills:**

1. Describe the use of online resources in licensing and professional development as a certified welder.
2. Demonstrate the use of a common ticketing/case management system for construction services.
3. Demonstrate the use of common scheduling, resource management and customer relationship software systems.
4. Understand where to find online resources that support effective metal fabrication work and how to be a safe and ethical consumer and creator of digital content.
5. Apply strategies for using digital tools and technology to drive business and commerce.

# Sample Performance Tasks

## Standard 1: Safety and Health in a Metal Fabrication Environment

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| Students will be able to demonstrate health and safety in a shop environment, including the management of tools and equipment, use of personal protective equipment, and workspace ergonomics. | OSHA10 – General Industry |

**Sample Performance Tasks:**

* Students will obtain a 10-hour OSHA safety certification.
* After completing the Hot Work Certification Program, students will identify and comply with the necessary hot work permit procedures when welding or cutting outside of the welding facility**.**

## Standard 2: Metallurgy and Metal Fabrication in Society

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| --- | --- |
| Students will be able to explain the importance of metallurgy and the history and impact of metal fabrication on society.  |  |

**Sample Performance Tasks:**

* Students will conduct a research project on career pathways in the welding and metal fabrication industry that explores future employment opportunities.

## Standard 3: Fabrication Materials and Practices

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| --- | --- |
| Students will be able to evaluate and prepare a variety of materials, describe, and demonstrate appropriate joining methods, and identify and describe basic types of weld joints. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Sample Performance Tasks:**

* Students will be able to identify ferrous and non-ferrous metals using visual identification, spark test, file test, magnet test, and chip test.
* Students will demonstrate their understanding of proper assembly and alignment of parts by identifying the necessary steps that must take place prior to welding. These steps include metal preparation, joint preparation, clamping or the use of jigs for proper material alignment, joint spacing, and tack welding.
* Students will demonstrate the ability to determine metal thickness with the use of sheet metal gauges, micrometer, and Vernier caliper.
* Students will be able to layout and fabricate basic sheet metal fittings.
* Students will adjust the back gauge to accurately cut materials to size using the power shear.
* Students will be able to calculate bend allowances and accurately form materials using the power press brake.

## Standard 4: Sheet Metal

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| --- | --- |
| Students will be able to evaluate and prepare, describe, and demonstrate appropriate sheet metal techniques.  | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Sample Performance Tasks:**

* Students will demonstrate safe and proper soldering techniques on metal seams to prevent leaks.
* Students will perform a resistance weld on thin gage metals.

## Standard 5: Print Reading

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| Students will be able to interpret and design detailed drawings and blueprints. | Massdot D1.1 SMAW 3G & 4G Welding Certification |

**Sample Performance Tasks:**

* Students will identify title block, scale, bill of material, symbols and notes from a given print.

## Standard 6: Hand and Pneumatic Tools

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| Students will be able to safely operate and maintain hand, power, pneumatic tools according to industry and OSHA standards | Massdot D1.1 SMAW 3G & 4G Welding Certification |

**Sample Performance Tasks:**

* + - Using sheet metal shears, students will demonstrate the proper cutting techniques on thin gauge metal.
		- Students will use an electric sander to create a proper finish on fabricated materials according to industry standards.
		- Students will use a die grinder equipped with a cutting wheel to cut metal plate.

## Standard 7: Welding and Joining Standard Techniques and Processes

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| --- | --- |
| Students will be able to safely perform welding and joining processes and operate mechanical cutting, thermal cutting, metal forming, automated and pipe welding equipment. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Sample Performance Tasks:**

* Given a specific material, students will identify the proper consumable to use when plasma arc cutting.
* Students will describe the proper safety procedures to follow before performing Carbon Arc Gouging.
* Students will perform multiple outside corner joints with and without filler rod.
* Students will use Shielded Metal Arc Welding (SMAW) equipment to perform multiple fillet welds with E6011 in the 2F position.
* Students will use Gas Metal Arc Welding (GMAW) equipment to perform multiple fillet welds with ER70S-6 in the 3F position.
* Students will use Flux Core Arc Welding (FCAW) equipment to perform multiple groove welds with E71T-9 in the 1G position.
* Students will use Gas Tungsten Arc Welding (GTAW) equipment to perform multiple corner welds with and without the use of filler wire on low carbon steel.

## Standard 8: Pipe Welding Standard Techniques and Processes

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| Students will be able to safely perform welding and joining processes and operate automated and pipe welding equipment. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Sample Performance Tasks:**

* Students will use Shielded Metal Arc Welding (SMAW) welding equipment to perform a multiple pass groove weld on 6" carbon steel pipe with E6010 and E7018 in the 1G position.

## Standard 9: Automated Equipment

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| Students will be able to identify and describe the fundamentals of special cutting, welding, and manufacturing processes. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Sample Performance Tasks:**

* Students will use the CNC Press Brake to program a multiple step, bend sequence on light gauge sheet metal.

## Standard 10: Preventative Maintenance and Equipment Inspection

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| Students will be able to conduct preventative safety procedures in a welding environment, including machinery maintenance and welding inspection and testing procedures. | Massdot D1.1 SMAW 3G & 4G Welding CertificationAWS SENSE Level I Certification |

**Sample Performance Tasks:**

* Students will perform a visual welding inspection on multiple fillet welds by measuring the leg length and throat with a fillet weld gauge.
* Students will develop a preventative maintenance schedule in accordance with the manufacturer’s recommendations for the welding equipment.