Sheet Metalworking Standards and Skills

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## Health & Safety Standards

### Standard 1: Safety and Health in a Sheet Metalworking Environment

Students will be able to apply health and safety protocols in a shop or job site environment by managing tools and equipment, utilizing personal protective equipment, and implementing workspace ergonomics.

* Aligned Industry Recognized Credentials: OSHA10 – General Industry

#### Skills:

1. Identify, describe, and demonstrate the effective use of Safety Data Sheets (SDS) to meet documentation requirements, including identifying hazards related to chemicals and materials used in sheet metalworking.
2. Locate emergency response equipment, e.g., first aid kit, fire extinguisher, and review the emergency action and response plan, including labels and signage following OSHA’s Hazard Communication Standard (HAZCOM).
3. Describe and demonstrate the appropriate use of Personal Protective Equipment (PPE) for general shop practices e.g., safety glasses, ear protection, gloves, foot protection, etc.
4. Identify and explain the importance of ventilation and respiratory protection.
5. Describe and demonstrate appropriate material handling and storing techniques: lifting, hoisting, hauling, and storing.
6. Apply safety rules for hand and power-based tools by conducting demonstrations of proper usage according to industry and OSHA standards.
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.

## Technical & Integrated Academic Standards

### Standard 2: Role of Sheet Metalworking Professionals in Society

Students will be able to evaluate the significance of metallurgy, the historical evolution, and the impact of metal fabrication on society, emphasizing the role of sheet metalworking professionals.

#### Skills:

1. Assess the evolution of sheet metalworking, its impact on modern society, and how innovations, such as automated machinery, advanced welding technologies, and precision manufacturing, have shaped the industry.
2. **Identify and explain regulatory codes, industry standards, and licensing/certification requirements relevant to sheet metalworking and metal fabrication, including Massachusetts regulations, such as 271 CMR 2.00, 3.00, and 5.00, and their application to the practices of sheet metalworking.**
3. Evaluate apprenticeship models in the metal fabrication industry, including the progression and licensure requirements for trades, such as pipefitter, sheet metal worker, ironworker, and laborer.

### Standard 3: Sheet Metal Tools and Equipment Operation

Students will apply safety protocols to the operation of sheet metal tools and equipment, following OSHA guidelines and industry standards to ensure safety, efficiency, and quality in tool usage, storage, and handling.

#### Skills:

1. Execute a fabrication procedure utilizing hand and mechanical seamers, foot and mechanical shears, hand and mechanical brakes, bar folders, and cheek benders.
2. Operate material cutting shears, pipe crimpers, nibblers, squaring shears, hand turning machines, and blind rivet guns in accordance with safety protocols.
3. Demonstrate appropriate techniques to smooth surfaces using files, right angle grinders, and air die grinders, ensuring safety standards are met.
4. Demonstrate advanced use of drill bits, taps, and dies by performing precise operations under controlled conditions.
5. Demonstrate the proper application of a hand punch for hole-punching tasks while adhering to safety practices.
6. Utilize a turret free-standing punch to safely punch holes in various materials.
7. Demonstrate safe operation techniques with all sheet metal equipment.
8. Set up and operate hand and power brakes, ensuring safety and precision during operation.
9. Configure and operate foot and power shears, demonstrating safety protocols and efficiency during use.
10. Set up and operate a hand drill safely, demonstrating proper technique and equipment handling.
11. Set up and operate hand-turning machines, ensuring safe usage and optimal performance.
12. Set up and operate a drill press, ensuring precise and safe drilling operations.
13. Set up and operate an iron worker, applying safety standards for efficient operation.
14. Set up and operate a vertical band saw, demonstrating safe cutting techniques.
15. Set up and operate a horizontal band saw, ensuring precision in material handling and cutting.
16. Set up and operate a chop or cold saw, applying safety protocols for quality cuts.
17. Set up and operate a pedestal grinder, ensuring smooth grinding operations through safety measures.
18. Set up and operate lock forming machines, demonstrating safety procedures for accurate results.
19. Set up and operate a masonry rotary hammer drill, ensuring safety in heavy-duty drilling tasks.
20. Set up and operate a reciprocating saw, applying correct cutting techniques for safety.
21. Set up and operate a circle cutter, ensuring accuracy and safety during operation.
22. Set up and operate an angle grinder, adhering to safety standards for effective metalworking.
23. Set up and operate an air die grinder, ensuring safety and efficiency in precision grinding tasks.

### Standard 4: Print Reading and Blueprint Design

Students will be able to interpret, design, and produce technical drawings and blueprints, applying industry standards and codes to ensure accuracy, compliance, and efficiency in their work.

#### Skills:

1. Identify and explain the basic layouts and specifications of technical prints/drawings, demonstrating an understanding of the key features of a print.
2. Identify basic print terms, abbreviations, line types, symbols, and notes to interpret technical drawings effectively.
3. Apply an architect’s scale to convert measurements from a print, ensuring accuracy in the translation of dimensions.
4. Define and interpret floor plans, elevations, sections, details, ceiling plans, and finish schedules, and assess their relevance to the overall design.
5. Use estimating methods to analyze and price jobs from drawings/prints, considering materials and labor.
6. Prepare material quantity takeoff sheets from technical prints, ensuring that all quantities are accurate and aligned with project requirements.
7. Evaluate state and/or local code requirements that apply to prints, ensuring compliance with industry standards.
8. Define and interpret plan elevation sections, detail views, and schedules, ensuring accuracy in the translation of print information to fabrication plans.
9. Identify and explain the function of supply, return, fresh air supply, exhaust, and ventilation air duct systems and their corresponding symbols, ensuring correct interpretation in the context of building systems.
10. Sequence and describe methods of fabricating, assembling, and installing sheet metal products using blueprints, sketches, or product specifications, demonstrating a clear understanding of the workflow.
11. Draw a basic print of a layout of an air-duct system, demonstrating competency in technical drawing software or manual drafting techniques.
12. Inspect assemblies and installations for conformance to specifications, using standard measurement instruments, and evaluate compliance with project drawings.
13. Explain the importance of coordinating air duct systems with structural and architectural considerations, demonstrating an understanding of interdisciplinary collaboration in construction projects.
14. Use the appropriate industry terminology when producing drawings and technical writing, including the language used in project documentation.
15. Develop a basic drawing using line types, symbols, and notes to clearly communicate technical specifications in compliance with industry standards.

### Standard 5: Fundamentals of Sheet Metalworking

Students will be able to identify, evaluate, and fabricate sheet metal projects using various materials, techniques, and tools, applying foundational skills in the process.

#### Skills:

1. Conduct scratch, spark, and magnetic tests to identify materials, applying each method to differentiate between types of sheet metal.
2. Fabricate a project using non-ferrous sheet metal, demonstrating appropriate handling, techniques, and tools required for non-ferrous metals.
3. Fabricate a project using ferrous sheet metal, demonstrating proficiency in the processes and techniques unique to ferrous metals.
4. Fabricate a project using galvanized sheet metal, ensuring proper safety and fabrication methods for working with galvanized materials.
5. Fabricate a project using cold-rolled sheet metal, highlighting key properties and handling techniques specific to cold-rolled materials.
6. Fabricate a project using hot-rolled sheet metal, demonstrating the specific processes and safety protocols for hot-rolled materials.
7. Fabricate a project using structural-shaped metal, demonstrating an understanding of structural metal properties and fabrication techniques.
8. Fabricate a project using alloys and special materials, demonstrating knowledge of alloy properties and their use in sheet metal fabrication.
9. Demonstrate proper use of basic hand tools, e.g., aviation snips, bulldog snips, micrometers, dial calipers, hammers, mallets, punches, ensuring safe and effective tool application for various sheet metal tasks.
10. Calculate the weight of ferrous and non-ferrous sheet metal by gauge, applying appropriate formulas and charts to determine accurate weight.
11. Use various charts, e.g., fraction/decimal, tap and drill, circumference, power brake tonnage, hydraulic punch tonnage, circumference rule, to interpret data and apply it to the fabrication process, enhancing accuracy and efficiency.

### Standard 6: Fabrication and Pattern Layouts

Students will be able to apply layout, pattern development, and fabrication techniques to sheet metal projects, ensuring precision and accuracy with both manual and digital tools, while adhering to industry standards for design and fabrication.

#### Skills:

1. Determine the thickness of ferrous and non-ferrous sheet metal by using a sheet metal gauge and micrometer and analyze the measurements to ensure accuracy for specific applications.
2. Layout and mark dimensions on materials, using tools such as scribes, awls, dividers, squares, protractors, trammel points, combination squares, and steel rulers, ensuring precise and accurate measurements.
3. Design and cut templates accurately using drawing boards, tee squares, triangles, compasses, and dividers, demonstrating proficiency in creating physical patterns from technical drawings.
4. Apply parallel line development techniques to layout and fabricate sheet metal projects, ensuring precise dimensional accuracy and alignment.
5. Apply triangulation methods in the layout and fabrication of sheet metal parts, ensuring geometric accuracy and proper alignment.
6. Use radial line development techniques to layout and fabricate sheet metal components, demonstrating precision in circular and angled designs.
7. Demonstrate the use of computer-generated working drawings utilizing AutoCAD, Inventor, or other CAD software applications.
8. Create basic mechanical drawings with dimensions to manufacture templates and duct components, ensuring drawings are accurate, clear, and ready for production.
9. Convert and save drawings to DXF file format for use with CNC plasma cutting equipment, ensuring compatibility and precision in automated manufacturing processes.
10. Demonstrate the fabrication of sheet metal using seams, edges, notches, locks, and clips.
11. Identify and apply hand forming stakes to shape sheet metal fittings, demonstrating knowledge of how each stake contributes to forming processes.
12. Fabricate hems, Pittsburg and pipe locks, slips, and drives, standing seams, laps, elbow locks, beading, crimping, and other sheet metal forms, ensuring each technique is executed accurately and safely to meet project specifications.

### Standard 7: Welding and Plasma Arc Cutting

Students will apply proper setup, maintenance, and safety protocols to the operation of welding and plasma arc cutting equipment, ensuring safe and efficient use in accordance with industry standards to achieve high-quality welding and cutting results.

#### Skills:

1. Identify, operate, and maintain gas metal arc welding equipment, ensuring all components are functional and properly calibrated for optimal performance.
2. Identify and set up the gun, copper nozzle, cable, and wire spool, demonstrating correct assembly and preparation for welding tasks.
3. Determine and set the voltage and amperage for welding based on the gauge thickness and welding position, ensuring parameters align with material specifications.
4. Identify and select appropriate shielding gases for welding different metals, ensuring correct gas mixture for each welding application.
5. Analyze potential hazards such as fire, explosions, and electrical shock, and implement safety measures to mitigate risks during welding operations.
6. Identify and use personal protective equipment (PPE) for welding practices, ensuring safety standards are adhered to during all welding processes.
7. Demonstrate welding using filler in flat, horizontal, and vertical positions, demonstrating consistency and precision in bead placement.
8. Demonstrate preparing fittings, joints, and seams for welding, ensuring proper fit-up and surface preparation to optimize weld quality.
9. Identify, safely operate, and maintain gas tungsten arc welder (GTAW) welding equipment, ensuring all components are in proper working condition and ready for use.
10. Identify and set up the gun, tungsten, and ceramic nozzle, demonstrating correct assembly and preparation for specific welding tasks.
11. Demonstrate set up of welding controls for the specific material, gauge thickness, and welding position, ensuring the parameters are optimized for the task at hand.
12. Identify and select the correct shielding gases for welding different metals, ensuring proper gas flow and protection for optimal weld quality.
13. Identify and use appropriate PPE for welding, ensuring all necessary protective gear is properly worn and used to safeguard the welder from potential hazards.
14. Weld beads in flat, horizontal, and vertical positions, demonstrating accuracy and proficiency in TIG welding techniques.
15. Identify, set up, and maintain the resistance welder, adjusting heat and cycle time to fuse the appropriate metal type and thickness, ensuring optimal welding conditions.
16. Identify, set up, and safely operate a hand-held plasma cutter with correct settings for metal type and thickness, ensuring accurate and efficient cutting.
17. Identify and use appropriate PPE for metal cutting practices, ensuring the welder is fully protected from cutting hazards.
18. Identify and analyze potential hazards of fire, explosions, and electrical shock, implementing safety protocols to minimize risks when using plasma cutting equipment.
19. Identify and maintain cutting torch consumables, such as swirl rings, electrodes, and torch tips, ensuring they are clean, functional, and properly installed to maximize cutting efficiency.

### Standard 8: Soldering Metals

Students will apply fundamental soldering techniques, including the proper use of materials, tools, and safety protocols, to create high-quality, durable solder joints in metalworking projects.

#### Skills:

1. Identify and demonstrate the use of different types of soft and hard solders, analyzing their properties and selecting the appropriate solder for different applications.
2. Demonstrate the use of various types and shapes of soldering coppers, ensuring proper selection and usage based on the task and materials.
3. Demonstrate the application of different liquid, paste, and powder fluxes, ensuring proper use for effective soldering and preventing oxidation.
4. Compare the different compositions of soft solders, selecting the most suitable composition based on the metal being soldered.
5. Demonstrate the process of making cut, killed, or cured acid using zinc pieces and hydrochloric acid in a well-ventilated area, ensuring all safety measures are followed.
6. Demonstrate the preparation of metal surfaces for soldering, including cleaning, deoxidizing, and prepping the surfaces to ensure strong and durable solder joints.
7. Demonstrate soldering techniques, such as sweating, skimming, tinning, and tacking, ensuring each method is performed with precision and understanding of its application in various soldering tasks.
8. Demonstrate soldering copper and brass using an acetylene torch, ensuring correct heat application and appropriate safety protocols.
9. Demonstrate forging techniques using a soldering copper/soldering iron, ensuring proper technique and safety standards are maintained throughout the process.

### Standard 9: Design and Install Air Duct Systems and Accessories

Students will be able to design and install efficient forced-air duct systems, applying industry standards and best practices to ensure system performance, safety, and quality installation.

#### Skills:

1. Describe the role of static pressure in the sizing of air ducts, analyzing how pressure affects the selection and performance of ducts in HVAC systems.
2. Apply an air-duct calculator to ensure accurate sizing and design calculations for duct systems.
3. Design and install forced-air rectangular duct systems, ensuring proper alignment, sealing, and integration with HVAC components.
4. Design and install forced-air round duct systems, ensuring correct fitting, sealing, and support for optimal airflow and system performance.
5. Identify the physical and thermal properties of moist air using a psychrometric chart and psychrometer, interpreting the data to optimize moisture control and air handling in duct design.
6. Demonstrate the installation of air duct fasteners, ensuring secure connections and proper alignment to prevent leaks and ensure system integrity.
7. Demonstrate the installation of sheet metal hangers and supports, ensuring ducts are securely suspended and aligned according to industry standards.
8. Demonstrate the installation of sheet metal flex connections, ensuring flexibility and vibration absorption while maintaining airtight seals.
9. Apply different types of longitudinal standing seams, understanding their applications and limitations for duct installation.
10. Demonstrate sealing a duct run according to industry standards, ensuring all joints are properly sealed to prevent air leakage and optimize system efficiency.
11. Explain the importance of coordinating air duct systems with structural and architectural considerations, ensuring that ductwork integrates effectively into the overall building design.
12. Identify and install fire dampers, ensuring proper integration of safety features for fire protection in HVAC systems.
13. Demonstrate installing access doors, ensuring easy access for maintenance and troubleshooting of the duct system.
14. Identify and install turning vanes to optimize airflow and minimize air resistance in the duct system.
15. Identify and install smoke dampers to control smoke in HVAC systems, ensuring compliance with safety codes.
16. Identify and install flex connectors to maintain flexibility for expansion and contraction while ensuring secure seals.
17. Identify and install vibration eliminators to minimize HVAC system vibrations, improving performance and reducing noise.
18. Identify and install control dampers to regulate airflow for optimal comfort or energy efficiency.
19. Identify and install outside air louvers to ensure proper ventilation and airflow from the outside environment.
20. Identify and install diffusers, grilles, and registers to ensure effective air distribution for comfort control.
21. Identify and install variable air volume (VAV) boxes, ensuring proper setup to adjust airflow based on load conditions.
22. Demonstrate installing sound attenuation and sound traps to reduce noise and vibration, ensuring a quieter indoor environment.

### Standard 10: Architectural Sheet Metal

Students will be able to fabricate and install various architectural sheet metal components, including gutters, cladding, roofing, and louvers, applying industry standards for material selection, fabrication techniques, and installation practices to ensure functionality and durability.

#### Skills:

1. Identify various alloys and types of metal used in architectural sheet metal, analyzing their suitability for different applications based on their properties and environmental factors.
2. Demonstrate positioning soldering techniques in flat, 45-degree, and 90-degree angles, ensuring precision and strong joints for various sheet metal projects.
3. Demonstrate fabricating gutter profiles in square, half-round, and ogee shapes, ensuring accurate dimensions and seamless integration with architectural designs.
4. Demonstrate fabricating gutter hanging brackets, spacers, and continuous bars, ensuring proper alignment, strength, and durability to support gutter systems.
5. Demonstrate installation of copper line built-in gutters with expansion joints, ensuring proper sealing, alignment, and functionality for efficient water flow.
6. Demonstrate fabricating hanging gutters with expansion joints, ensuring flexibility in the system to accommodate thermal expansion and prevent damage.
7. Demonstrate fabricating a conductor head, ensuring proper size, shape, and functionality for directing water flow from the gutter system.
8. Identify types of architectural roofing, including standing, flat, and batten seams, and fabricate the corresponding metal roofing systems with attention to durability, water resistance, and aesthetic value.
9. Identify and fabricate wall cladding with flat and standing seams, ensuring a secure, durable, and aesthetically pleasing exterior cladding system for building structures.
10. Demonstrate fabricating a metal louver, ensuring proper sizing, functionality, and alignment for efficient airflow and visual appeal in architectural designs.

## Employability Standards

### Standard 11: Employability Skills

Students will be able to demonstrate professional communication, critical thinking, problem-solving, professionalism, teamwork, and collaboration within the context of sheet metal fabrication and installation processes.

#### Skills:

1. Demonstrate the impact of clear communication skills on the planning, fabrication, and installation of sheet metal components, ensuring that all team members are well informed of project goals and expectations.
2. Describe appropriate methods of communication for both internal and external stakeholders in the sheet metal industry, including clients, suppliers, and team members, using verbal, written, and digital tools effectively.
3. Troubleshoot a sheet metal project plan to identify inefficiencies, unnecessary steps, or misdirected efforts, ensuring that all work contributes directly to the final product's quality, safety, and efficiency.
4. Apply critical thinking and problem-solving skills to resolve fabrication or installation challenges, including material defects, design discrepancies, or tool malfunctions, while maintaining project deadlines and quality standards.
5. Demonstrate professionalism by adhering to industry safety standards, ethical practices, and proper conduct in the workplace during all phases of sheet metal work, from design to installation.
6. Collaborate effectively with a team to complete a sheet metal installation or fabrication task, respecting each team member's role and contributing to achieving high-quality results on time.
7. Integrate industry-standard practices for quality control and continuous improvement within team projects, ensuring that every fabricated piece of sheet metal meets or exceeds industry specifications and client requirements.

## Entrepreneurship Standards

### Standard 12: Entrepreneurship

Students will be able to describe opportunities for entrepreneurship in the sheet metalworking industry and evaluate the value proposition of business ownership in metal fabrication, focusing on starting and growing a successful sheet metal fabrication business.

#### Skills:

1. Evaluate the licensing, regulatory, and tax requirements for self-employment or business ownership in sheet metalworking, comparing them to the responsibilities of traditional W-2 employment.
2. Explain the needs for starting a sheet metal fabrication business, including initial equipment requirements, staffing needs, and the development of a marketing/business plan to target clients in construction, HVAC, and architectural industries.
3. Describe professional networking within the sheet metal industry, using trade shows, conferences, and local business events, and demonstrate how to deliver a compelling ‘elevator speech' to introduce yourself to potential clients, partners, or employers.
4. Analyze the market demand for sheet metal fabrication services in various industries, e.g., construction, manufacturing, HVAC, automotive, and identify strategies for gaining competitive advantage in the market, including differentiation through quality, reliability, or customer service.
5. Understand the basics of supply chain management within the sheet metal fabrication business, including sourcing raw materials, managing inventory, negotiating with suppliers, and ensuring timely delivery of products for projects.
6. Evaluate the operational challenges in running a sheet metal fabrication company, including managing workflows, project timelines, safety compliance, and quality control processes to ensure efficient operations and customer satisfaction.

## Digital Literacy Standards

### Standard 13: Digital Literacy

Students will demonstrate proficiency in using common software and information technology tools in modern sheet metalworking shops.

#### Skills:

1. Demonstrate effective electronic communication (written and oral) by collaborating with team members, customers, and suppliers using tools, such as email, instant messaging, video conferencing, e.g., Microsoft Teams, Zoom, and project management platforms, e.g., Slack, Asana, ensuring clear and professional exchanges of information.
2. Locate and utilize online resources that support metal fabrication work, including digital libraries, forums, instructional videos, CAD tutorials, and software updates, while also practicing ethical consumption and creation of digital content.
3. Demonstrate the use of scheduling, resource management, and customer relationship management (CRM) software to manage sheet metal projects, track timelines, allocate resources, and communicate effectively with clients.
4. Apply strategies for utilizing digital tools and technology to enhance business operations, such as using CAD/CAM software for design and CNC (Computer Numerical Control) programming to precisely cut, bend, and shape sheet metal, thereby improving productivity, reducing waste, and increasing overall business efficiency.