# **Advanced Manufacturing Standards and Skills**

**October 2023**

Table of Contents

[Advanced Manufacturing Standards and Skills 0](#_Toc198368228)

[Health & Safety Standards 2](#_Toc198368229)

[Standard 1: Safety and Health in an Advanced Manufacturing Environment 2](#_Toc198368230)

[Technical & Integrated Academic Standards 2](#_Toc198368231)

[Standard 2: Principles of Manufacturing and Production 2](#_Toc198368232)

[Standard 3: Fundamentals of Design and Blueprint Reading 3](#_Toc198368233)

[Standard 4: Quality Practices and Measurement 3](#_Toc198368234)

[Standard 5: Machining Operations 4](#_Toc198368235)

[Standard 6: Controlling Operations of Equipment 6](#_Toc198368236)

[Standard 7: Computer Aided Manufacturing and CNC Programming 6](#_Toc198368237)

[Standard 8: Robotics in the Manufacturing Process 7](#_Toc198368238)

[Employability Standards 8](#_Toc198368239)

[Standard 9: Employability Skills 8](#_Toc198368240)

[Entrepreneurship Standards 8](#_Toc198368241)

[Standard 10: Entrepreneurship 8](#_Toc198368242)

[Digital Literacy Standards 9](#_Toc198368243)

[Standard 11: Digital Literacy 9](#_Toc198368244)

[Sample Performance Tasks 10](#_Toc198368245)

[Standard 1: Safety and Health in an Advanced Manufacturing Facility 10](#_Toc198368246)

[Standard 2: Principles of Manufacturing and Production 10](#_Toc198368247)

[Standard 3: Fundamentals of Design and Blueprint Reading 10](#_Toc198368248)

[Standard 4: Quality Practices and Measurement 10](#_Toc198368249)

[Standard 5: Machining Operations 10](#_Toc198368250)

[Standard 6: Controlling Operations of Equipment 11](#_Toc198368251)

[Standard 7: Computer Aided Manufacturing and CNC Programming 11](#_Toc198368252)

[Standard 8: Robotics in the Manufacturing Process 11](#_Toc198368253)

[Credentials of Value 12](#_Toc198368254)

[SAFETY CREDENTIALS 12](#_Toc198368255)

[ESSENTIAL CREDENTIALS 12](#_Toc198368256)

[SUPPLEMENTAL CREDENTIALS 12](#_Toc198368257)

[SUPPLEMENTAL CREDENTIALS – Postsecondary 12](#_Toc198368258)

## Health & Safety Standards

### Standard 1: Safety and Health in an Advanced Manufacturing Environment

Students will demonstrate health and safety standard practices in a shop environment, including the management and maintenance of machines and tools, and use of personal protective equipment (PPE), and personal safety practices.

**Aligned Credentials:** OSHA, MACWIC Level 1, NIMS Machining Level 1

**Skills:**

1. Demonstrate safe use and management of hand tools, power tools, and ladders to meet OSHA requirements.
2. Select and use personal protective equipment in compliance with current industry and OSHA standards.
3. Manage and provide routine maintenance for equipment and machinery, keep a written log of service and recommendations for repair.
4. Identify and define hazard communications including emergency codes and symbols, classification and labeling of chemicals, safety data sheets (SDS), and other forms of warning.
5. Demonstrate safe storage, transfer, use, and disposal of hazardous materials (HAZMAT).
6. Apply all facility procedural concepts to prevent errors and injury through a safe work environment.
7. Describe disaster and fire evacuation plans used by various facilities and statewide alert codes.
8. Demonstrate machine tool safety.
9. Explain and implement machine guarding.

## Technical & Integrated Academic Standards

### Standard 2: Principles of Manufacturing and Production

Students will examine the manufacturing process, applying math, science, innovative technologies, and manufacturing standards to identify and design solutions to a variety of real problems.

**Aligned Credentials:** MACWIC Level 1

**Skills:**

1. Design a LEAN production plan needed to satisfy a project from start to finish.
2. Demonstrate logic and reasoning in the planning process to identify strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.
3. Develop testing protocols to drive decision-making and iterative design improvements.
4. Compare the relative costs and benefits of potential production choices or actions and choose the most appropriate one.
5. Examine ethical issues related to professional practice and product development.
6. Describe the importance of a cleanroom and climate-controlled environments in the Manufacturing Industry.
7. Demonstrate skills in problem solving.
8. Determine and select appropriate material, size and quantity needed to complete specified product(s).
9. Formulate an order of operations, proper tooling and work holding devices.

### Standard 3: Fundamentals of Design and Blueprint Reading

Students will be able to interpret and design detail drawings and blueprints to meet American National Standards Institute (ANSI) and International Organization for Standards (ISO) standards and demonstrate basic computer aided drafting and design (CAD) operations using current industry standard software.

**Aligned Credentials:** MACWIC Level 1, NIMS Machining Level 1

**Skills:**

1. Identify terms, abbreviations, symbols, and line types of technical drawings and blueprints.
2. Convert blueprint measurements to scale.
3. Design a basic workpiece including mathematical annotation in the technical drawing.
4. Demonstrate technical drawing and 3D solid modeling using CAD to create and analyze prototypes, record CAD data, and create output file.
5. Create solid three-dimensional and three-dimensional assembly models including specifications.
6. Assemble products according to detailed blueprints.
7. Measure dimensions of completed products or workpieces to verify conformance to specifications.
8. Read and interpret detail drawings to meet American National Standards Institute (ANSI) and International Organization for Standards (ISO) standards.
9. Read and interpret assembly drawings.
10. Create part level design or drawing specifications.
11. Create assembly level design and drawing specifications.
12. Convert files to generic formats i.e. (.pdf, .dxf, .igs, .stp, .stl, etc.).

### Standard 4: Quality Practices and Measurement

Students will be able to demonstrate precise measurement of workpieces and identify types of metal and advanced materials required for quality outcomes.

**Aligned Credentials:** MACWIC Level 1, NIMS Machining Level 1

**Skills:**

1. Quantify the precision and accuracy of measurements and of measuring tools.
2. Calculate dimensions of workpieces, products, or equipment.
3. Demonstrate use of Gage Blocks to assist with inspection of a workpiece.
4. Apply material sciences and properties to determine their effect on machinability.
5. Identify types of metals and advanced materials (carbon fiber, plastics, composites).
6. Describe heat treatment processes: harden, temper, anneal, normalize, and case harden.
7. Develop an inspection and sampling plan, conduct tests and inspections of products, services, or processes to evaluate quality or performance.
8. Monitor production data to identify when process changes/improvements are needed, apply Statistical Process Control (SPC).
9. Determine metal or plastic production methods and equipment.
10. Exchange information with team members, advise others on ways to improve processes or products.
11. Measure workpiece with a scale within a tolerance of +/- 1/64”.
12. Measure radius on a work piece.
13. Measure angle(s).
14. Measure workpiece with a precision caliper within a tolerance of +/- .005”.
15. Measure a workpieces outside diameter, inside diameter, depth, and location and size of a feature with the precision instrument to a tolerance of at least +/- .001”.
16. Identify a thread and measure outside and pitch diameter to design specifications.
17. Compare and/or measure surface finish quality of a part to print specification.
18. Describe cleanroom and climate-controlled environments and their purpose in the Manufacturing Industry.

### Standard 5: Machining Operations

Students will demonstrate machining operations and common equipment processes needed to manufacture specified products, including power saws, precision grinding, lathe processes, milling processes, additive manufacturing processes, and electrical discharge machining (EDM).

**Aligned Credentials:** MACWIC Level 1, NIMS Machining Level 1

**Skills:**

1. Demonstrate different techniques to manufacture a hole in given material, (drill, countersink, tap, counter bore and machine) to the depth and diameter specified by blueprint and/or standard including specified tolerance.
2. Drill a hole to the designated size and in the predetermined location.
3. Countersink a hole to depth and diameter specified by blueprint and/or standard.
4. Machine a hole to a specified tolerance of +/- .001”.
5. Tap a hole to specified depth and thread size.
6. Setup and bore a hole to size and location within a tolerance of +/- .001”.
7. Counter bore a hole to the specified diameter and depth according to the blueprint.
8. Calculate speeds and feeds for given tooling and material.
9. Cut material using power saws to specified length.
10. Identify the appropriate blade and speed to cut a given material.
11. Explain the selection and process of finishing techniques.
12. Deburr workpiece.
13. Demonstrate mounting of a grinding wheel according to industry standards.
14. Demonstrate precision grinding operations using the tools associated with the production of square and cylindrical finished products.
15. Demonstrate the operations of offhand grinding for the completion of a product and sharpening of tools associated with the trade.
16. Dress wheel, set tool rest and spark guard on pedestal grinder to proper height and clearance.
17. Explain and demonstrate the grinding of tools for specific application and use.
18. Operate precision turning equipment.
19. Identify and setup work-holding devices including universal and independent chucks and collets.
20. Demonstrate outside turning procedures, including facing, grooving, turning diameters to a shoulder, and tapering to a specified tolerance.
21. Demonstrate inside turning procedures, including boring, grooving, and tapering to a specified tolerance.
22. Demonstrate single-point threading to a specified tolerance.
23. Demonstrate cut-off techniques.
24. Machine a form into the workpiece.
25. Demonstrate knurling a piece to design specifications from a blueprint.
26. File and polish a workpiece.
27. Operate precision milling equipment.
28. Operate metal or plastic forming equipment.
29. Operate precision milling equipment to mill a variety of angles, a shoulder, slots, and pockets within a specified tolerance.
30. Indicate vise within a tolerance of .0005” over a 6" span.
31. Tram milling head within a tolerance of .001” over a 6" diameter sweep.
32. Locate a datum feature using an edge finder.
33. Locate and indicate holes and pins.
34. Mill a flat surface within a specified tolerance and finish using a variety of tooling.
35. Mill a variety of angles within a specified tolerance.
36. Square a workpiece within a specified tolerance.
37. Apply climb and conventional milling strategies.
38. Describe the operation of keys and keyways and mill each to specifications.
39. Identify the safest way to remove chips from a lathe or milling machine.
40. Demonstrate manufacturing a part using an electrical discharge machine (EDM).
41. Compare and contrast EDM process with conventional machining.
42. Explain the process of manufacturing a design using additive manufacturing equipment.

### Standard 6: Controlling Operations of Equipment

Students will demonstrate skills recommended by current industry to control operations of equipment and systems, including equipment setup for production, monitoring gauges, dials, and other indicators that machines are working properly, identifying equipment malfunctions and reporting such for required maintenance or repair.

**Aligned Credentials:** MACWIC Level 1, NIMS Machining Level 1

**Skills:**

1. Examine blueprints or other instructions to determine equipment setup requirements.
2. Program equipment, enter commands, instructions, or specifications to perform production tasks, install mechanical components, and mount attachments or tools.
3. Perform regular maintenance of equipment according to specifications, including lubrication, identification of worn components, and making simple repairs as needed.
4. Demonstrate calculated adjustment to equipment controls to regulate flow of production materials or products.
5. Determine causes of operating errors and decide what to do about it.
6. Prepare fabric or other materials for processing or production.
7. Identify appropriate person(s) for maintenance and repair of equipment.
8. Review and state equipment indicators to ensure that equipment is operating according to manufacturer's specifications.
9. Demonstrate ability to maintain equipment.
10. Report and maintain a written log for service and recommend process repair of equipment.

### Standard 7: Computer Aided Manufacturing and CNC Programming

Students will demonstrate the use of industry standard software to design and apply machining processes, Computer Aided Manufacturing (CAM), and demonstrate the process of posting and receiving of programs to a CNC machine to complete a specified workpiece for production.

**Aligned Credentials:** MACWIC Level 1

**Skills:**

1. Construct a safe and effective part program by defining G and M codes and using conversational programming strategies.
2. Define G and M codes.
3. Construct a safe and effective part program using G and M codes.
4. Construct a safe and effective part program using conversational programming strategies.
5. Transfer part program to and from a machine control.
6. Demonstrate basic programming strategies at the machine control.
7. Set up live tooling on a CNC mill/turn center and a workpiece on CNC milling 4th axis rotary table and 5th axis CNC milling machine.
8. Use computer aided manufacturing (CAM) software to apply machining processes to design (e.g., speeds, feeds, cutter compensation, etc.).
9. Post process program and transfer to and from CNC machine.
10. Use Manual Data Input (MDI) and control panel operations including simple programming, tool changes and spindle speeds.
11. Demonstrate sequential start-up and shut-down operations.
12. Set up datum point, tool length offsets and tool geometry offsets.
13. Set cutter compensation.
14. Load programs, dry run, edit, and execute program.
15. Set up live tooling on a CNC mill/turn center.
16. Set part origin on a CNC milling machine using a probing system.
17. Set tool length and diameter offsets on a CNC milling machine using a table mounted tool setter.
18. Set multi-axis offsets with a CNC lathe tool presetter.

### Standard 8: Robotics in the Manufacturing Process

Students will be able to identify uses of robotics in the manufacturing process and examine how automated systems engineering is used to reduce human effort and time and increase accuracy in production.

**Aligned Credentials:** MACWIC Level 1

**Skills:**

1. Describe a Computer Integrated Manufacturing (CIM) system utilizing appropriate safety precautions. (i.e., cages, light curtains).
2. Describe automated systems engineering introductory knowledge and skills.
3. Define an automated system and a robot.
4. Identify individual components used in CIM systems.
5. Describe the working relationship between the CNC equipment and the robot.
6. Describe and identify various grippers: standard, servo, non-servo, vacuum, and magnetic (end effector).
7. Define the following robot terms: degrees of freedom, position axes, orientation axes, work envelope, tool center point.
8. Define and give an example of the following specifications for industrial robots: payload, repeatability, memory capacity, and environmental requirements.
9. Describe open-loop and close-loop control systems.

## Employability Standards

### Standard 9: Employability Skills

Students will be able to demonstrate understanding of the roles of professional communication, critical thinking, problem solving, professionalism, teamwork, and collaboration to the field of work.

**Skills:**

1. Identify complex problems, review related information to develop and evaluate options and implement solutions for such problems.
2. Analyze implications of new information for both current and future problem-solving and decision-making.
3. Use effective methods of communication for internal and external stakeholders throughout the project planning and project management process.
4. Evaluate communication skills used in hypothetical needs analysis session vis-a-vis a general understanding of the goals of a project.
5. Troubleshoot a project plan to find mistargeted or extraneous work that do not contribute to the ultimate objectives of the project.
6. Build a team-based project plan that includes recruiting teammates, assigning roles, and delegating tasks for a project.
7. Examine the role of advanced manufacturing in society, particularly in terms of its significance for employability and career opportunities.

## Entrepreneurship Standards

### Standard 10: Entrepreneurship

Students will be able to explain various career pathways in the field, describe opportunities for entrepreneurship and be able to evaluate the value proposition of business ownership in this field.

**Skills:**

1. Name the possible career pathways in the manufacturing field.
2. Understand and explain the elements of a business plan (including initial equipment and staffing needs, a marketing/business plan, and a basic revenue management strategy) for a startup manufacturing company.
3. Describe the concept of professional networking and demonstrate personal introductions and an “elevator speech” in a professional setting.
4. Evaluate the licensing, regulatory, and tax implications of business ownership in this field.

## Digital Literacy Standards

### Standard 11: Digital Literacy

Students will be able to understand the role computer science, digital literacy and social media play in society and this field.

**Skills:**

1. Demonstrate safe practices and critical thinking when collaborating, researching, and utilizing online resources and platforms.
2. Understand how to be a safe and ethical consumer and creator of digital content.
3. Analyze the benefits, harmful effects, and overall impact of digital innovations on society.
4. Apply strategies for using digital tools and technology to drive business and commerce.
5. Discuss potential dangers and implications associated with cyberbullying, hacking, and privacy.

## Sample Performance Tasks

### Standard 1: Safety and Health in an Advanced Manufacturing Facility

**Sample Performance Tasks:**

* Students will demonstrate safe operation of equipment, following the rules of the shop. Personal Protective Equipment (PPE) rules will be strictly adhered to. Students will pass safety tests for all equipment before they are allowed to operate said equipment.

### Standard 2: Principles of Manufacturing and Production

**Sample Performance Tasks:**

* Using appropriate shop project designs, students will identify problems in the manufacturing process. Students will solve these problems using strategies in a group setting or alone.
* Students will research all materials and tooling needed to build a product from the curriculum. Students will design a LEAN production plan that will satisfy the steps needed to create the project from start to completion.

### Standard 3: Fundamentals of Design and Blueprint Reading

**Sample Performance Tasks:**

* Students will build and assemble products according to detailed drawings and annotated hand sketches. This will include the interpretation of prints with geometric dimensioning and tolerancing symbols, and fitment and weldment callouts that meet ANSI and ISO specifications.
* Modify or create model based on requirements, record CAD data and create output file.

### Standard 4: Quality Practices and Measurement

**Sample Performance Tasks:**

* + - Students will demonstrate the ability to distinguish among the appropriate precision measuring tools according to allowable tolerances on a given design. Using appropriate measuring tools and a print with specifications, the student will measure and document all dimensions to determine if a product passes inspection.
    - Through research and discovery, students will identify material properties that have a direct effect on its machinability.

### Standard 5: Machining Operations

**Sample Performance Tasks:**

* Students will demonstrate skills in the set up and milling of shapes and surfaces using cylindrical and square material through the completion of shop designed projects and tasks. Using industry standard locating tools, students will demonstrate a working knowledge of datums to set up and machine a finish product.
* Demonstrate manufacturing a part using an additive manufacturing machine.
* Students will demonstrate skills in the turning of cylindrical and square stock through the completion of shop designed projects and tasks. Through the selection of appropriate work holding devices, students will demonstrate a working knowledge set up and fixtures needed for the completion of machining processes.
* Students will produce an additive manufacturing part based on CAD model they have created.
* Students will produce a part utilizing EDM technology.
* Performance Example: Using shop developed projects and tasks, students will perform machining operations that are relevant to a multitude of machines.
* Performance Example: Students will demonstrate the use of power saw equipment and cut material for the creation of shop designed projects and tasks.
* Performance Example: Through classroom work and shop projects, students will demonstrate the operations of finishing processes for the completion of a product.
* Performance Example: Using industry standard equipment and classroom theory, students will demonstrate precision grinding operations using the tools associated with the production of square and cylindrical finished products.
* Through classroom work and shop projects, students will demonstrate the operations of offhand grinding for the completion of a product and sharpening of tools associated with the trade.

### Standard 6: Controlling Operations of Equipment

**Sample Performance Tasks:**

* Students will follow a preventative maintenance program developed by the instructors according to machine specifications.

### Standard 7: Computer Aided Manufacturing and CNC Programming

**Sample Performance Tasks:**

* Students will demonstrate the operation of the control panel to set up, run, and edit a program for a shop designed project.
* Using industry standard CNC equipment and classroom theory, students will demonstrate a working knowledge of a written program and the different codes that are associated within it.
* Using industry standard software, students will design and apply machining processes for the completion of shop projects and tasks. Students will demonstrate the process of posting and receiving of programs to a CNC machine to properly complete a project to shop specifications.
* Students will demonstrate the operation of the control panel to set up, run, and edit a program for a shop designed project using 4 axis, 5 axis milling as well as live tooling.

### Standard 8: Robotics in the Manufacturing Process

**Sample Performance Task:**

* Student will describe the integration of robotics into the manufacturing process.

## Credentials of Value

### SAFETY CREDENTIALS

* OSHA 10 General Industry, OSHA

### ESSENTIAL CREDENTIALS

* Level One Certification, Manufacturing Advancement Center Workforce Innovation Collaborative (MACWIC)
* Machining Level 1 (NIMS)
* Certified Production Technician (CPT), Manufacturing Skills Standard Council (MSSC)

### SUPPLEMENTAL CREDENTIALS

* MACWIC Level 2 Certification, Manufacturing Advancement Center Workforce Innovation Collaborative
* Certified Production Technician (CPT), Manufacturing Skills Standard Council (MSSC
* CAM Milling Programmer, National Institute for Metalworking Skills
* CAM Turning Programmer, National Institute for Metalworking Skills
* CNC 5-Axis Milling Operator, National Institute for Metalworking Skills
* CNC 5-Axis Milling Specialist, National Institute for Metalworking Skills
* Press Brake Operator, National Institute for Metalworking Skills
* Industrial Technology Maintenance Certifications, National Institute for Metalworking Skills
* Machining Certifications, National Institute for Metalworking Skills
* Metal forming Certifications, National Institute for Metalworking Skills
* Level 1 – Welding, National Center for Construction Education and Research
* Certified SolidWorks Associate, SolidWorks
* HAAS Certification Lathe, HAAS
* HAAS Certification Mill, HASS
* MASTERCAM Associate Certification, MASTERCAM
* Autodesk Inventor Certified Associate, AutoDesk

### SUPPLEMENTAL CREDENTIALS – Postsecondary

* Certified Metalworking Fluids Specialist, Society of Tribologists and Lubrication Engineers
* Oil Monitoring Analyst I, Society of Tribologists and Lubrication Engineers
* Level I Machine Lubricant Analyst, International Council for Machinery Lubrication
* Certified Oil Monitoring Analyst II, Society of Tribologists and Lubrication Engineers
* Certified Measurement and Verification Professional, Association of Energy Engineers
* Fluid Power Engineer, International Fluid Power Society