

COMPETENCY-BASED OCCUPATIONAL FRAMEWORK FOR REGISTERED APPRENTICESHIP

Additive Manufacturing Maintenance Technician

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Competency-Based Occupational Frameworks

The Urban Institute, under contract with the US Department of Labor, has worked with employers, subject matter experts, labor unions, trade associations, credentialing organizations, and academics to develop Competency-Based Occupational Frameworks (CBOFs) for Registered Apprenticeship programs. These frameworks define the **purpose** of an occupation, the **job functions** that are carried out to fulfill that purpose, the **competencies** that enable the apprentice to execute those job functions well, and the **performance criteria** that define the specific knowledge, skills, and personal attributes associated with high performance in the workplace. This organizational hierarchy—job purpose, job functions, competencies, performance criteria—is designed to illustrate that performing work well requires more than just acquiring discrete knowledge elements or developing a series of manual skills. To perform a job well, the employee must be able to assimilate knowledge and skills learned in various settings, recall and apply that information to the present situation, and carry out work activities using sound professional judgment, demonstrating an appropriate attitude or disposition and achieving a level of speed and accuracy necessary to meet the employer’s business need.

The table below compares the terminology of Functional Analysis with that of traditional Occupational Task Analysis to illustrate the important similarities and differences. While both identify the key technical elements of an occupation, functional analysis includes the identification of behaviors, attributes, and characteristics of workers necessary to meet an employer’s expectations.

Framework Terminology	Traditional Task Analysis Terminology
Job Function: the work activities that are carried out to fulfill the job purpose	Job Duties: roles and responsibilities associated with an occupation
Competency: the actions an individual takes and the attitudes he/she displays to complete those activities	Task: a unit of work or set of activities needed to produce some result
Performance Criteria: the specific knowledge, skills, dispositions, attributes, speed, and accuracy associated with meeting the employer’s expectations	Subtask: the independent actions taken to perform a unit of work or activity

Although designed for use in competency-based apprenticeship, these Competency-Based Occupational Frameworks also support time-based apprenticeship by defining more clearly and precisely what an apprentice is expected to learn and do during the allocated time period.

CBOFs are comprehensive to encompass the full range of jobs that may be performed by individuals in the same occupation. As employers or sponsors develop their individual apprenticeship programs, they can extract from or add to the framework to meet their unique organizational needs.

Components of the Competency-Based Occupational Framework

Occupational Overview: This section of the framework provides a description of the occupation including its purpose, the setting in which the job is performed, and unique features of the occupation.

Work Process Schedule: This section includes the job functions and competencies that would likely be included in an apprenticeship sponsor's application for registration. These frameworks provide a point of reference that has already been vetted by industry leaders so sponsors can develop new programs knowing that they will meet or exceed the consensus expectations of peers. Sponsors maintain the ability to customize their programs to meet their unique needs, but omission of a significant number of job functions or competencies should raise questions about whether or not the program has correctly identified the occupation of interest.

Cross-Cutting Competencies: These competencies are common among all workers and focus on the underlying knowledge, attitudes, personal attributes, and interpersonal skills that are important regardless of the occupation. That said, while these competencies are important to all occupations, the relative importance of some versus others may change from one occupation to the next. These relative differences are illustrated in this part of the CBOF and can be used to design pre-apprenticeship programs or design effective screening tools when recruiting apprentices to the program.

Detailed Job Function Analysis: This portion of the framework includes considerable detail and is designed to support curriculum designers and trainers in developing and administering the program. The detail in this section may be confusing to those seeking a more succinct, higher-level view of the program. For this reason, we recommend that the Work Process Schedule be the focus of program planning activities, leaving the detailed job function analysis sections to instructional designers as they engage in their development work.

- a. **Related Technical Instruction:** Under each job function appears a list of foundational knowledge, skills, tools, and technologies that would likely be taught in the classroom to enable the apprentice's on-the-job training safety and success.
- b. **Performance Criteria:** Under each competency, we provide recommended performance criteria that could be used to differentiate between minimally, moderately, and highly competent apprentices. These performance criteria are generally skills based rather than knowledge based, but may also include dispositional and behavioral competencies.

Using the Competency-Based Occupational Framework to Develop a Registered Apprenticeship Program

When developing a registered apprenticeship program, the Work Process Schedule included in this CBOF provides an overview of the job functions and competencies an expert peer group deemed to be important to this occupation. The Work Process Schedule in this document can be used directly, or modified and used to describe your program content and design as part of your registration application.

When designing the curriculum to support the apprenticeship program—including on-the-job training and related technical instruction—the information the Detailed Job Functions section could be helpful. These more detailed job function documents include recommendations for the key knowledge and skills that might be included in the classroom instruction designed to support a given job function, and the performance criteria provided under each competency could be helpful to trainers and mentors in evaluating apprentice performance and insuring inter-rater reliability when multiple mentors are involved.

Additive Manufacturing Maintenance Technician Occupational Overview

Occupational Purpose and Context

Additive manufacturing maintenance technicians work in the private and public sectors and are critical to ensuring the smooth and reliable operation of the industrial plants and equipment in their industry. They maintain and repair additive manufacturing and 3-D printing equipment, and through their work they maintain the additive manufacturing machinery and equipment at the highest possible level and ensure the productivity and safety of the entire production team.

Potential Job Titles

Additive Manufacturing Maintenance Technician; Production Technician; Automotive Technician; Electrical Repairer; Electronics Repairer; Commercial Equipment Mechanic; Industrial Equipment Mechanic; Industrial Machinery Mechanics; Maintenance Workers, Machinery; Maintenance and Repair Workers, General; and Installation, Maintenance, and Repair Workers

Attitudes and Behaviors

Additive Manufacturing Maintenance Technicians should have well-developed, autonomous critical-thinking skills to solve problems quickly; strong interpersonal skills including listening skills and cultural sensitivity; the ability to identify and focus on important details; the ability to understand the implications of new information; the capability to troubleshoot and make decisions; the ability to execute tasks in a specific order to obtain an outcome; intrinsic motivation to solve a problem; attention to details and specifics when documenting them; the ability to stay focused despite distractions; the ability to combine pieces of information to form general rules or conclusions; and the ability to arrange objects or actions in an order or pattern related to a specific rule or set of rules.

Apprenticeship Prerequisites

Some apprenticeship programs may require apprentices to pass drug testing before commencing their apprenticeships. Other apprenticeship programs may require a TABE test and some industry-specific assessments.

Occupational Pathways

Additive Manufacturing Maintenance Technicians can enter a variety of high-tech jobs that include maintaining, troubleshooting and improving complex machines and additive and 3-D systems, such as conveying systems, multi-axis machines, robotic welding arms, and hydraulic lifts. They can also enter the fields of engineering and design for additive manufacturing and 3-D equipment.

Certifications, Licensure, and Other Credential Requirements

Credential	Offered by	Before, During, or After Apprenticeship
Additive Manufacturing Technician	Society of Manufacturing Engineers	After

Job Functions

Job Functions	Core or Optional
1. Protects self and other workers from accidents and injuries	Core
2. Demonstrates workplace skills and plans and controls work processes	Core
3. Selects the proper materials, tools, and equipment for the job	Core
4. Prepares for installation	Core
5. Installs/assembles the machine	Core
6. Operates the machine	Core
7. Uses proper methods with electrical systems	Core
8. Problem solves, diagnoses, and troubleshoots effectively	Core
9. Engages in career management and employee relations	Optional

Stackable Programs

This occupational framework is designed to link to the following additional framework(s) as part of a career laddering pathway.

Stackable Programs	Base or Higher Level	Stacks on Top of
1. n/a		
2.		
3.		

Options and Specializations

The following options and specializations have been identified for this occupation. The Work Process Schedule and individual job function outlines indicate which job functions and competencies were deemed by industry advisors to be optional. Work Process Schedules for Specializations are included at the end of this document.

Options and Specializations	Option	Specialization
Additive manufacturing maintenance technician		
Production technician		
Automotive technician		
Electrical and Electronics Repairers		
General Installation, Maintenance, and Repair Workers		
Industrial Machinery Mechanics		
Maintenance and Repair Workers		
Machinery Maintenance Workers		
Commercial and Industrial Equipment Mechanics		

Levels

Industry advisors have indicated that individuals in this occupation may function at different levels, based on the nature of their work, the amount of time spent in an apprenticeship, the level of skills or knowledge mastery, and the degree of independence in performing the job or supervisory/management responsibilities.

Level	Distinguishing Features	Added Competencies	Added Time Requirements
n/a			

Work Process Schedule

WORK PROCESS SCHEDULE		ONET Code: 17-3029.09	
Additive Manufacturing Maintenance Technician		RAPIDS Code: 2078HY	
Job Title: Additive Manufacturing Maintenance Technician			
Level:		Specialization:	
Stackable Program: __Yes __No			
Base Occupation Name:			
Company Contact:			
Address:		Phone:	Email:
Apprenticeship Type: _X_ Competency Based __ Time Based __ Hybrid		Prerequisites:	

Job Function 1: Protects self and other workers from accidents and injuries			
Competencies	Core or Optional	RTI	OJT
A. Adheres to personal grooming requirements in the facility	Core		
B. Uses personal protective equipment	Core		
C. Follows fire safety procedures	Core		
D. Works around energy sources and performs lock-out/tag-out procedures	Core		
E. Handles and stores hazardous materials as assigned	Core		
F. Demonstrates both emergency and standard shutdown of all required equipment	Core		
G. Uses and locates eyewash sinks and first-aid kits	Core		
H. Demonstrates, reports, and responds promptly, safely, and appropriately to emergency or hazard situations and troubleshoots any issues that may arise	Core		

I. Handles dense material	Core		
J. Adheres to National Electric Code (NEC) safety procedures for tightening, disconnecting, or connecting electrical conductors and components	Core		
K. Adheres to hazard avoidance procedures when in contact with live electrical systems	Core		
L. Resets circuit breakers	Core		

Job Function 2: Demonstrates workplace skills and plans and controls work processes

Competencies	Core or Optional	RTI	OJT
A. Procures and evaluates information	Core		
B. Conducts discussions with line managers and colleagues and within the team in a situation-appropriate manner; presents facts and circumstances	Core		
C. Communicates in a timely manner using available modes of communication	Core		
D. Uses opportunities to resolve conflicts	Core		
E. Selects proper software	Core		
F. Handles technical computer systems and, in particular, deploys software and connects and uses peripheral devices	Core		
G. Prepares protocols and reports using standard software	Core		
H. Demonstrates proficiency in mathematical processes	Core		
I. Schedules time to run machine	Core		

Job Function 3: Selects the proper materials, tools, and equipment for the job

Competencies	Core or Optional	RTI	OJT
A. Chooses and applies a type of material to render parts	Core		
B. Compares the differing properties and characteristics of common materials used for additive manufacturing models	Core		
C. Ensures proper parts are in stock and orders parts, supplies, or equipment from catalogs or suppliers	Core		
D. Plans and lays out repair work	Core		
E. Demonstrates fluency in using technology to assess and troubleshoot issues	Core		
F. Initiates a formal bid process for materials	Core		
G. Evaluates supplier capabilities against a standard set of well-documented criteria	Core		
H. Demonstrates proper storage of additive materials (i.e., powders)	Core		

Job Function 4: Prepares for installation			
Competencies	Core or Optional	RTI	OJT
A. Builds or assembles additive manufacturing equipment devices or systems	Core		
B. Engages, as part of the engineer team, in the design, configuration, or application of additive manufacturing equipment systems	Core		
C. Fabricates housings, fittings, or fixtures, using metalworking machines	Core		
D. Develops three-dimensional simulations and models of automation systems	Core		
E. Evaluates the efficiency and reliability of industrial additive manufacturing equipment systems	Core		

Job Function 5: Installs and assembles machine			
Competencies	Core or Optional	RTI	OJT
A. Sets up and commissions a 3-D printer and supporting equipment	Core		
B. Installs, programs, or repairs programmable controllers, robot controllers, end-of-arm tools, or conveyors	Core		
C. Documents additive manufacturing equipment test procedures and results	Core		
D. Aligns, fits, or assembles component parts	Core		
E. Terminates wires between controllers	Core		
F. Assembles, installs, or repairs key components	Core		
G. Sets up and operates machine tools to repair or fabricate machine parts, fixtures, or tools	Core		
H. Aligns and calibrates new equipment after installation	Core		
I. Tests performance of additive manufacturing equipment assemblies	Core		

Job Function 6: Operates the machine			
Competencies	Core or Optional	RTI	OJT
A. Starts up and shuts down an operation in accordance with standard operating procedures	Core		
B. Fabricates a verification part or assembly using additive manufacturing equipment	Core		
C. Conducts quality assurance post-print	Core		

Job Function 7: Uses proper methods with electrical systems			
Competencies	Core or Optional	RTI	OJT
A. Uses a multimeter properly	Core		
B. Calculates power in an electrical circuit given current and voltage	Core		
C. Installs fuses and circuit breakers in circuits	Core		
D. Inspects circuit breakers to determine if they have been tripped	Core		
E. Recognizes all protective tags and lockout devices used to isolate equipment and components from hazardous energy sources	Core		

Job Function 8: Problem solves, diagnoses, and troubleshoots effectively			
Competencies	Core or Optional	RTI	OJT
A. Inspects, operates, or tests machinery or equipment to diagnose machine malfunctions	Core		
B. Dismantles machines, equipment, or devices	Core		
C. Diagnoses mechanical problems and determines the most efficient way to correct them	Core		
D. Uses proper standards and techniques to troubleshoot	Core		
E. Troubleshoots additive manufacturing equipment systems	Core		
F. Repairs machines, equipment, or systems	Core		

Job Function 9: Engages in career management and employee relations			
Competencies	Core or Optional	RTI	OJT
A. Develops and explains a short-term career plan and resumé	Optional		
B. Demonstrates appropriate interpersonal skills in job performance evaluations, group communication and decision-making, and conflict resolution	Optional		
C. Identifies and explains the major departments or functions in a company and how they affect production units	Optional		
D. Understands additive business or “use” case	Optional		

Related Technical Instruction Plan

COURSE NAME	Course Number
	Hours
LEARNING OBJECTIVES	

COURSE NAME	Course Number
	Hours
LEARNING OBJECTIVES	

COURSE NAME	Course Number
	Hours
LEARNING OBJECTIVES	

COURSE NAME	Course Number
	Hours
LEARNING OBJECTIVES	

Cross-Cutting Competencies

COMPETENCY**		0	1	2	3	4	5	6	7	8
Personal Effectiveness	Interpersonal Skills	0	1	2	3	4	5	6	7	8
	Integrity	0	1	2	3	4	5	6	7	8
	Professionalism	0	1	2	3	4	5	6	7	8
	Initiative	0	1	2	3	4	5	6	7	8
	Dependability and Reliability	0	1	2	3	4	5	6	7	8
	Adaptability and Flexibility	0	1	2	3	4	5	6	7	8
	Lifelong Learning	0	1	2	3	4	5	6	7	8
Academic	Reading	0	1	2	3	4	5	6	7	8
	Writing	0	1	2	3	4	5	6	7	8
	Mathematics	0	1	2	3	4	5	6	7	8
	Science and Technology	0	1	2	3	4	5	6	7	8
	Communication	0	1	2	3	4	5	6	7	8
	Critical and Analytical Thinking	0	1	2	3	4	5	6	7	8
	Basic Computer Skills	0	1	2	3	4	5	6	7	8
Workplace	Teamwork	0	1	2	3	4	5	6	7	8
	Customer Focus	0	1	2	3	4	5	6	7	8
	Planning and Organization	0	1	2	3	4	5	6	7	8
	Creative Thinking	0	1	2	3	4	5	6	7	8
	Problem Solving and Decision Making	0	1	2	3	4	5	6	7	8
	Working with Tools and Technology	0	1	2	3	4	5	6	7	8
	Checking, Examining, and Recording	0	1	2	3	4	5	6	7	8
	Business Fundamentals	0	1	2	3	4	5	6	7	8
	Sustainable	0	1	2	3	4	5	6	7	8
	Health and Safety	0	1	2	3	4	5	6	7	8

** The names of the cross-cutting competencies come from the US Department of Labor’s Competency Model Clearinghouse, and definitions for each can be viewed at <https://www.careeronestop.org/CompetencyModel/competency-models/building-blocks-model.aspx>.

Cross-cutting competencies identify transferable skills—sometimes called “soft skills” or “employability skills”—that are important for workplace success, regardless of a person’s occupation. Still, the relative

importance of specific cross-cutting competencies differs from occupation to occupation. The cross-cutting competencies table, above, provides information about which of these competencies is most important to be successful in a particular occupation. This information can be useful to employers or intermediaries in screening and selecting candidates for apprenticeship programs, or to pre-apprenticeship providers who seek to prepare individuals for successful entry into an apprenticeship program.

The scoring system utilized to evaluate competency levels required in each cross-cutting skill aligns with the recommendations of the Lumina Foundation's Connecting Credentials Framework. The framework can be found at <http://connectingcredentials.org/wp-content/uploads/2015/05/ConnectingCredentials-4-29-30.pdf>.

Detailed Job Functions

Job Function 1: Protects self and other workers from accidents and injuries

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> • OSHA requirements for personal and occupational safety • Methods for protecting against the transmission of blood-borne pathogens • First-aid procedures for cuts, burns, fainting, electrocution, heart attack, etc. • Principles of electricity, currents, and methods to protect against electrocution and electrical fire • Methods for working safely in confined spaces • Principles and techniques of first aid and emergency response • Principles of hazards identification and mitigation • Location, use, and interpretation of Material Safety Data Sheets • Risk-assessment techniques and protocols • Classification of fire extinguishers • Basic principles of electricity and conductivity 	<ul style="list-style-type: none"> • Lift and move materials properly • Perform lock-out/tag-out procedures • Inspect parts, equipment, safety devices, tools, and production products • Identify and reduce/eliminate potential hazards • Maintain situational awareness • Perform risk-assessment and risk-mitigation activities • Use fire extinguisher 	<ul style="list-style-type: none"> • Protective equipment— safety glasses, hard hat, hearing protection devices, safety footwear, fall-arrest equipment • Harnesses and lifts • Forklift • Hand tools • Fire extinguishers/blankets • Eyewash station • Emergency shower

Competency A: Adheres to personal grooming requirements in the facility	Core or Optional
PERFORMANCE CRITERIA	
1. Ensures attire and outerwear does not impede work	Core
2. Keeps body and hair protected to not interfere with machinery	Core

Competency B: Uses personal protective equipment	Core or Optional
PERFORMANCE CRITERIA	
1. Uses and explains the purpose for required personal protective equipment, including but not limited to head, hand, ear, eye, foot, and body protection	Core
2. Wears protective eyewear, footwear, hearing-protection devices, etc., as necessary	Core

Competency C: Follows fire safety procedures	Core or Optional
PERFORMANCE CRITERIA	
1. Prevents and responds to fires using appropriate fire extinguisher	Core
2. Uses or assists others with the fire blanket, emergency shower, or eyewash station when necessary	Core

Competency D: Works around energy sources and performs lock-out/tag-out procedures	Core or Optional
PERFORMANCE CRITERIA	
1. Properly shuts off equipment based on manufacturer's or employer's protocol	Core
2. Identifies and isolates hazardous energy sources and renders them inoperable before performing equipment maintenance	Core
3. Locks down and tags equipment to prevent accidental use	Core
4. Confirms that maintenance is complete before repowering equipment	Core
5. Repowers and starts equipment according to manufacturer's or employer's protocol	Core

Competency E: Handles and stores hazardous materials as assigned	Core or Optional
PERFORMANCE CRITERIA	
1. Maintains a safe and organized work area	Core
2. Reviews Material Safety Data Sheets (MSDS) before working with hazardous substances	Core
3. Follows employer-specific safety procedures for identifying and addressing potential hazards	Core
4. Stores raw and finished materials, as well as chemicals, lubricants, and other substances, properly	Core
5. Disposes of waste products properly and according to OSHA, EPA, and company policies	Core
6. Notifies appropriate individuals immediately in the event of a spill and reacts swiftly to deploy containment/protection strategies	Core
7. Operates safely in confined spaces, ensuring that proper ventilation is in place and that appropriate devices are in place to prevent collapse	Core

Competency F: Demonstrates both emergency and standard shut down of all required equipment	Core or Optional
PERFORMANCE CRITERIA	
1. Adheres to employer's emergency or hazard-response procedures	Core
2. Identifies location of first-aid materials	Core
3. Follows other applicable OSHA or employer-safety regulations	Core
4. Adheres to employer fire-extinguishing procedures	Core
5. Uses personal fall-arrest equipment when working from an elevated position	Core
6. Recommends corrective action(s)	Core

Competency G: Uses and locates eyewash sinks and first-aid kits	Core or Optional
PERFORMANCE CRITERIA	
1. Wears protective eyewear, footwear, hearing-protection devices, etc., as necessary	Core
2. Identifies location of first-aid equipment, including first-aid kits, safety showers, eyewash stations, fire blankets, defibrillators, and related equipment and uses promptly and appropriately when necessary	Core

Competency H: Demonstrates, reports, and responds promptly, safely, and appropriately to emergency or hazard situations and troubleshoots any issues that may arise	Core or Optional
PERFORMANCE CRITERIA	
1. Removes self and others from immediate area in the event of a chemical spill, accidental release, or other hazard situation	Core
2. Notifies appropriate individuals when a hazardous situation occurs	Core
3. Identifies sources of potential hazards and takes action to mitigate them in advance	Core
4. Uses appropriate containment and protective devices to stop spread of hazard	Core
5. Responds with appropriate emergency or first-aid equipment	Core
6. Prevents and responds to fires using appropriate fire extinguisher	Core
7. Uses or assists others with the fire blanket, emergency shower, or eyewash station when necessary	Core
8. Uses CPR or emergency first-aid procedures to sustain life while awaiting first responders	Core

Competency I: Handles dense material	Core or Optional
PERFORMANCE CRITERIA	
1. Selects correct material given manual specifications	Core
2. Handles and stores material correctly based on employer's specifications	Core

Competency J: Adheres to National Electric Code (NEC) safety procedures for tightening, disconnecting, or connecting electrical conductors and components	Core or Optional
PERFORMANCE CRITERIA	
1. Sizes fuses and circuit breakers in accordance with NEC requirements for a given power draw in an electrical circuit with consideration for ampacity of wiring in that circuit	Core

Competency K: Adheres to hazard avoidance procedures when in contact with live electrical systems	Core or Optional
PERFORMANCE CRITERIA	
1. Uses a multimeter to measure incoming voltage and current to an electrical circuit	Core
2. Uses a multimeter to measure voltage and current in an electrical circuit	Core
3. Uses a multimeter to measure resistance in an electrical circuit	Core
4. Uses a multimeter to perform a continuity check in an electrical circuit	Core
5. Uses an amp meter (clamp-on)	Core
6. Calculates power in an electrical circuit given current and voltage	Core

Competency L: Resets circuit breakers	Core or Optional
PERFORMANCE CRITERIA	
1. Sizes fuses and circuit breakers in accordance with NEC requirements for a given power draw in an electrical circuit with consideration for ampacity of wiring in that circuit	Core
2. Tests fuses	Core
3. Inspects circuit breakers to determine if tripped	Core
4. Resets circuit breakers	Core

Job Function 2: Demonstrates workplace skills and plans and controls work processes

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> • Additive manufacturing equipment • Function and use of mechanical and visual controls • Operational sequencing of production • Methods for identifying raw materials • Methods for identifying supply requirements, product transition, and inspection needs • Manufacturer and employer specifications • Production schedules • Principles of hazards identification and mitigation • Risk assessment techniques and protocols • Material suppliers and their roles and responsibilities • Production capacity of machines 	<ul style="list-style-type: none"> • Lift and move materials properly • Inspect parts, equipment, safety devices, tools, and production products • Identify and reduce/eliminate potential hazards • Maintain situational awareness • Perform risk-assessment and risk-mitigation activities • Logical thinking • Clear oral communication 	<ul style="list-style-type: none"> • Harnesses and lifts • Forklift • Hand tools • Production machinery

Competency A: Procures and evaluates information	Core or Optional
PERFORMANCE CRITERIA	
1. Follows operational sequence instructions and diagrams	Core
2. Follows material requirements when selecting and using raw materials	Core
3. Follows tooling requirements in preparing and processing materials	Core
4. Follows inspection requirements and guidelines	Core
5. Follows machine set-up instructions (such as programming)	Core

Competency B: Conducts discussions with line managers and colleagues and within the team in a situation-appropriate manner; presents facts and circumstances	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies key personnel in the production process	Core

2. Identifies key facts that should be imparted	Core
3. Clearly discusses production processes with key personnel	Core

Competency C: Communicates in a timely manner using available modes of communication	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies issues of discussion as soon as they arise	Core
2. Uses available modes of communication (phone, email) to discuss issues	Core

Competency D: Uses opportunities to resolve conflicts	Core or Optional
PERFORMANCE CRITERIA	
1. Determines cause of conflict	Core
2. Properly determines resolution methods	Core
3. Speaks to proper individuals about conflict	Core
4. Establishes plan to resolve conflict	Core

Competency E: Selects proper software	Core or Optional
PERFORMANCE CRITERIA	
1. Selects a computer that uses Microsoft Windows or Linux operating system software	Core
2. Uses software programs such as MS Word, Excel, Access, and other tools	Core

Competency F: Handles technical computer systems and, in particular, deploys software and connects and uses peripheral devices	Core or Optional
PERFORMANCE CRITERIA	
1. Connects power and digital input/output wiring to a machine	Core
2. Selects and appropriately connects sinking and sourcing inputs and outputs	Core
3. Configures and connects a laptop or other programming device to the proper machine to upload, download, and save a program	Core

Competency G: Prepares protocols and reports using standard software	Core or Optional
PERFORMANCE CRITERIA	
1. Chooses the proper software outlined by the employer	Core
2. Begins developing protocols with software used by the employer	Core

3. Delivers protocols to key staff	Core
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Competency H: Demonstrates proficiency in mathematical processes	Core or Optional
PERFORMANCE CRITERIA	
1. Shows proper understanding of algebra, geometry, and basic mathematical functions	Core
2. Applies mathematical understanding to machine processes	Core

Competency I: Schedules time to run machine	Core or Optional
PERFORMANCE CRITERIA	
1. Determines proper time to run machine during production run	Core
2. Ensures machine is available to run	Core

Job Function 3: Selects the proper materials, tools, and equipment for the job

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> • 3-D and CAD models • Polymers • Proper technological usage • Upstream and downstream product development • Production process, cost controls, production time, and product quality • Product business development • Proper storage techniques 	<ul style="list-style-type: none"> • Logical thinking • Clear oral communication • Critical analysis • Business acumen • Teamwork 	<ul style="list-style-type: none"> • Computer-processing systems

Competency A: Chooses and applies a type of material to render parts	Core or Optional
PERFORMANCE CRITERIA	
1. Demonstrates basic product-design principles of visual and spatial form	Core
2. Captures physical three-dimensional (3-D) objects, and reverse engineers accurate computer-aided design (CAD) models from three-dimensional (3-D) scans	Core
3. Describes the fundamentals of material selection for product and system design	Core
4. Measures and calculates part properties	Core
5. Applies orthographic projection principles to drawing's layouts	Core
6. Performs analyses on the sketch procedures and refines the sketch design	Core
7. Performs advanced mating using multiple parts or subassemblies	Core
8. Creates and inserts render parts in the sheet environment of a solid-modeling drawing	Core

Competency B: Compares the differing properties and characteristics of common materials used for additive manufacturing models	Core or Optional
PERFORMANCE CRITERIA	
1. Checks the grade level of the polymers	Core
2. Ensures the polymers work as intended	Core
3. Identifies eight common fused-deposition-model (FDM) materials and their chemical structures	Core
4. Compares relevant material properties that affect printing behavior	Core
5. Relates chemical structure to material properties and the variability of properties	Core

Competency C: Ensures proper parts are in stock and orders parts, supplies, or equipment from catalogs or suppliers	Core or Optional
PERFORMANCE CRITERIA	
1. Helps ensure raw material flow to completed product	Core
2. Checks to see if supplies are low	Core
3. Orders materials from appropriate supplier	Core
4. Documents the process of obtaining raw materials	Core
5. Obtains raw materials	Core

Competency D: Plans and lays out repair work	Core or Optional
PERFORMANCE CRITERIA	
1. Reads and interprets technical drawings of parts and assemblies	Core
2. Correctly interprets line types and basic symbology	Core
3. Identifies and interprets multiview drawings of cylindrical and prismatic-shaped parts	Core
4. Performs metric and English dimension conversions correctly	Core
5. Identifies and follows dimension lines for linear, circular, and angular dimensions	Core
6. Identifies and properly interprets title blocks	Core
7. Identifies feature sizes using a drawing scale and converts to actual measurements	Core
8. Identifies standard dimensional tolerance	Core
9. Follows assembly drawings to repair and assemble equipment	Core
10. Identifies assembly tolerances and interference-fit concepts	Core
11. Identifies and interprets maximum material condition symbols	Core

Competency E: Demonstrates fluency in using technology to assess and troubleshoot issues	Core or Optional
PERFORMANCE CRITERIA	
1. Using computer processing systems, identifies equipment malfunctions	Core
2. Informs proper maintenance personnel of equipment malfunctions	Core
3. Assists in the repair and replacement of any equipment	Core
4. Records equipment malfunctions in log book and computer	Core

Competency F: Initiates a formal bid process for materials	Core or Optional
PERFORMANCE CRITERIA	
1. Checks to see if supplies are low	Core
2. Checks on pricing of supplies from suppliers	Core

3. Documents the process of obtaining raw materials	Core
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Competency G: Evaluates supplier capabilities against a standard set of well-documented criteria	Core or Optional
PERFORMANCE CRITERIA	
1. Uses well-established company practices to view previous acquisition of materials	Core
2. Compares suppliers' abilities to provide materials	Core

Competency H: Demonstrates proper storage of additive materials (i.e., powders)	Core or Optional
PERFORMANCE CRITERIA	
1. Reviews material safety data sheets and follows appropriate use, storage, disposal, and accidental-exposure directions	Core
2. Handles and stores hazardous materials as assigned while adhering to safe practices in accordance with OSHA and EPA requirements and guidelines	Core
3. Ensures materials are properly stored and free from contamination	Core

Job Function 4: Prepares for installation

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> Identifying proper materials Developing 3-D models Risk-assessment techniques and protocols CAD technology 	<ul style="list-style-type: none"> Teamwork Logical thinking Clear oral communication Maintain situational awareness Perform risk-assessment and risk-mitigation activities 	<ul style="list-style-type: none"> Metalworking equipment Housings, fittings, and fixtures

Competency A: Builds or assembles additive manufacturing equipment devices or systems	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies and selects materials and tools to build additive manufacturing equipment devices or systems	Core
2. Lays out parts of the devices or systems	Core
3. Completes sawing parts to fit the layout	Core
4. Creates programs for manufacturing parts on the devices or systems	Core

Competency B: Engages, as part of the engineer team, in the design, configuration, or application of additive manufacturing equipment systems	Core or Optional
PERFORMANCE CRITERIA	
1. Collaborates with engineers, machinists, and management to achieve project objectives	Core
2. Follows a standardized workflow that maximizes quality in production	Core
3. Meets quality and scheduling expectations	Core

Competency C: Fabricates housings, fittings, or fixtures, using metalworking machines	Core or Optional
PERFORMANCE CRITERIA	
1. Uses metalworking machines to cut housings, fittings, or fixtures	Core
2. Uses metalworking machines to bend housings, fittings, or fixtures	Core
3. Uses metalworking machines to assemble housings, fittings, or fixtures	Core

Competency D: Develops three-dimensional simulations and models of automation systems	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies and selects from different types of modeling, such as polygonal modeling, curve modeling, and digital sculpting	Core
2. Uses 3-D graphics or CAD technology to create simulations of automation systems	Core
3. Uses simulations and models to craft physical automation systems	Core

Competency E: Evaluates the efficiency and reliability of industrial additive manufacturing equipment systems	Core or Optional
PERFORMANCE CRITERIA	
1. Tests equipment systems using quality-inspection equipment	Core
2. Performs capability assessment of equipment	Core
3. Reprograms defective materials, components, or devices	Core
4. Calibrates new equipment systems against known standards to ensure proper functioning	Core

Job Function 5: Installs and assembles machine

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> Employer’s standard operating procedures Programmable Logic Controllers (PLCS) and 3-D printers Dimensional, visual, and mechanical inspection Alignment of equipment Risk-assessment techniques and protocols Principles of hazards identification and mitigation 	<ul style="list-style-type: none"> Inspect parts, equipment, safety devices, tools, and production products Identify and reduce/eliminate potential hazards Maintain situational awareness Perform risk-assessment and risk-mitigation activities Logical thinking Clear oral communication 	<ul style="list-style-type: none"> 3-D printer Mechanical and visual controls Tooling, fixtures, and equipment Protective equipment—safety glasses, hard hat, hearing protection devices, safety footwear, fall-arrest equipment Various meters Wiring equipment

Competency A: Sets up and commissions a 3-D printer and supporting equipment	Core or Optional
PERFORMANCE CRITERIA	
1. Squares and levels the printer frame	Core
2. Checks that the print bed is flat and levels it using feeler gauges	Core
3. Lubricates leadscrews and any linear bearings	Core
4. Slowly prints initial layer to ensure a strong foundation	Core
5. Accurately sets up supporting equipment, such as filament holders and spatulas	Core

Competency B: Installs, programs, or repairs programmable controllers, robot controllers, end-of-arm tools, or conveyors	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies and selects appropriate programming languages for programming controllers, tools, and conveyers	Core
2. Installs and removes controllers, end-of-arm tools, and conveyers	Core
3. Routinely inspects controllers, tools, and conveyers for operation and deterioration	Core
4. Troubleshoots problems by inspecting equipment for faults, removing faulty equipment, and replacing it	Core

Competency C: Documents additive manufacturing equipment test procedures and results	Core or Optional
PERFORMANCE CRITERIA	
1. Practices general safety precautions for working with electrical circuits	Core

2. Correctly uses ammeters, voltmeters, ohmmeters, and multimeters to measure voltage, resistance, and current of a circuit	Core
3. Knows and uses destructive testing methods such as stress-strain testing and hardness testing	Core
4. Knows and uses nondestructive testing methods such as ultrasonic testing and magnetic particle inspection	Core
5. Diligently documents the results of equipment tests so that they are readable and replicable by other employees	Core

Competency D: Aligns, fits, or assembles component parts	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies, selects, and safely uses common hand tools such as measurement tools, general purpose tools, and cutting tools	Core
2. Identifies, selects, and accurately uses common power tools such as pneumatic tools and electric tools, taking proper extra safety precautions	Core
3. Reads, understands, and follows templates for aligning, fitting, or assembling component parts	Core
4. Follows proper torquing procedures	Core
5. Uses microscopes to align, fit, or assemble small component parts	Core
6. Properly cares for common assembly tools	Core

Competency E: Terminates wires between controllers	Core or Optional
PERFORMANCE CRITERIA	
1. Cuts wires to terminate them	Core
2. Uses wire strippers to terminate wires	Core
3. Uses manual or ratcheting wire-crimping tools to terminate wires	Core
4. Installs EOL resistors on the ends of network wires	Core

Competency F: Assembles, installs, or repairs key components	Core or Optional
PERFORMANCE CRITERIA	
1. Builds electrical harnesses using wiring diagrams and proper termination	Core
2. Installs wiring so that it is mechanically and electrically sound, properly supported, and neat in appearance	Core
3. Demonstrates knowledge of different types of additive manufacturing components and their uses	Core
4. Selects and assembles various pipe systems, plumbing, and other machinery	Core
5. Installs and removes pipe systems, plumbing, machinery, and other equipment	Core
6. Maintains equipment with proper care and routine inspection	Core
7. Determines type, size, and location of any damage, and removes and replaces damaged parts	Core

Competency G: Sets up and operates machine tools to repair or fabricate machine parts, fixtures, or tools		Core or Optional
PERFORMANCE CRITERIA		
1. Knows machine safety procedures and identifies of different machine parts and their functions		Core
2. Performs routine additive operations such as rapid prototyping, rapid tooling, and rapid manufacturing		Core
3. Produces new parts, fixtures, or tools		Core
4. Repairs damaged parts, fixtures, or tools		Core

Competency H: Aligns and calibrates new equipment after installation		Core or Optional
PERFORMANCE CRITERIA		
1. Aligns new equipment both horizontally and vertically		Core
2. Calibrates new equipment against a known and accurate standard		Core
3. Documents the results of alignment and calibration processes		Core

Competency I: Tests performance of additive manufacturing equipment assemblies		Core or Optional
PERFORMANCE CRITERIA		
1. Tests equipment assemblies using quality inspection equipment		Core
2. Performs capability assessment of equipment		Core
3. Removes or deactivates bugs or removes, replaces, and/or repairs the defective material, component, or device		Core
4. Restores normal operations		Core

Job Function 6: Operates the machine

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> Product cycle times, set-ups, and tooling Employer's standard operating procedures Knowledge of raw materials and their flow Dimensional, visual, and mechanical inspection Risk-assessment techniques and protocols CAD models 	<ul style="list-style-type: none"> Lift and move materials properly Perform lock-out/tag-out procedures Inspect parts, equipment, safety devices, tools, and production products Identify and reduce/eliminate potential hazards Maintain situational awareness Perform risk-assessment and risk-mitigation activities Logical thinking Clear oral communication 	<ul style="list-style-type: none"> Production equipment Mechanical and visual controls Tooling, fixtures, and equipment

Competency A: Starts up and shuts down an operation in accordance with standard operating procedures	Core or Optional
PERFORMANCE CRITERIA	
1. Reads and understands standard operating procedures	Core
2. Safely starts up equipment	Core
3. Performs operations after equipment is ready for use	Core
4. Safely shuts down equipment after use	Core

Competency B: Fabricates a verification part or assembly using additive manufacturing equipment	Core or Optional
PERFORMANCE CRITERIA	
1. Creates a CAD model for the part	Core
2. Converts CAD model into STL model	Core
3. Slices STL model into layers	Core
4. Builds part one layer at a time	Core
5. Cleans and processes part after printing	Core

Competency C: Conducts quality assurance post-print	Core or Optional
PERFORMANCE CRITERIA	
1. Removes part and supports from machine	Core

2. Cleans and finishes parts, such as sanding, coating, or painting	Core
3. Tests equipment assemblies using quality inspection equipment	Core

Job Function 7: Uses proper methods with electrical systems

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> Using a multimeter Ohm's and Power Law Circuit breakers Installation techniques 	<ul style="list-style-type: none"> Perform lock-out/tag-out procedures Inspect parts, equipment, safety devices, tools, and production products Maintain situational awareness Perform risk-assessment and risk-mitigation activities 	<ul style="list-style-type: none"> Meters

Competency A: Uses a multimeter properly	Core or Optional
PERFORMANCE CRITERIA	
1. Correctly identifies parts of the multimeter	Core
2. Reads and interprets voltage measurements	Core
3. Reads and interprets resistance measurements	Core
4. Reads and interprets current measurements	Core
5. Changes the fuse on a multimeter	Core

Competency B: Calculate power in an electrical circuit given current and voltage	Core or Optional
PERFORMANCE CRITERIA	
1. Knows and understands formulas such as Ohm's Law and the Power Law	Core
2. Performs basic arithmetic	Core
3. Uses measurements from multimeter in formulas to calculate power	Core

Competency C: Installs fuses and circuit breakers in circuits	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies different fuse and circuit-breaker types	Core
2. Determines and selects the correct fuse or circuit breaker type for a particular circuit	Core
3. Follows proper safety precautions when installing and replacing fuses and circuit breakers	Core

Competency D: Inspects circuit breakers to determine if they have been tripped	Core or Optional
PERFORMANCE CRITERIA	
1. Tests for open fuses using visual inspection, fuse indicators, and meters	Core
2. Tests for tripped circuit breakers using visual inspection, indicators, and meters	Core
3. Fixes or replaces faulty fuses and circuit breakers	Core

Competency E: Recognizes all protective tags and lockout devices used to isolate equipment and components from hazardous energy sources	Core or Optional
PERFORMANCE CRITERIA	
1. Follows OSHA and other standards for energy-control procedures	Core
2. Locks dangerous equipment after using it	Core
3. Tags less-dangerous equipment with warnings for other employees and users	Core
4. Recognizes and heeds tags left by other employees on equipment	Core

Job Function 8: Problem solves, diagnoses, and troubleshoots effectively

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> • Troubleshooting techniques • Machine schematics • Fault isolation • OEM standards 	<ul style="list-style-type: none"> • Use proper procedures when working • Maintain situational awareness • Logical thinking • Clear oral communication • Identify problems and correct them • Teamwork 	<ul style="list-style-type: none"> • PLCs • Meters and test equipment

Competency A: Inspects, operates, or tests machinery or equipment to diagnose machine malfunctions	Core or Optional
PERFORMANCE CRITERIA	
1. Visually inspects equipment for problems	Core
2. Runs the machine according to guidance	Core
3. Properly reads and interprets schematics, procedures, and other diagrams	Core
4. Correctly uses troubleshooting trees and other troubleshooting guides	Core

Competency B: Dismantles machines, equipment, or devices	Core or Optional
PERFORMANCE CRITERIA	
1. Deconstructs machines, equipment, and devices according to manufacturer's specifications	Core
2. Accesses and removes defective parts using hoists, cranes, hand tools, or power tools	Core

Competency C: Diagnoses mechanical problems and determines the most efficient way to correct them	Core or Optional
PERFORMANCE CRITERIA	
1. Applies methodologies to isolate problems in a particular subsystem; 5 why, fishbone, flow charts, half-split method, etc.	Core
2. Uses strong interpersonal communication skills to interact with production personnel, vendors, and colleagues	Core
3. Applies effective observation and interview strategies to validate errors or problems and determine the most effective troubleshooting strategy	Core
4. Analyzes production information, maintenance, and operation documents to assist in troubleshooting a malfunction	Core

Competency D: Uses proper standards and techniques to troubleshoot	Core or Optional
PERFORMANCE CRITERIA	
1. Uses the OEM standards to identify issues with machinery	Core
2. Observes machinery malfunctions	Core
3. Discusses with colleagues and supervisors the best troubleshooting methodology	Core

Competency E: Troubleshoots additive manufacturing equipment systems	Core or Optional
PERFORMANCE CRITERIA	
1. Uses knowledge of microprocessors to troubleshoot systems	Core
2. Uses programmable logic controllers (PLCs) to troubleshoot systems	Core
3. Uses electronics, circuit analysis, mechanics, sensor, or feedback systems to troubleshoot systems	Core
4. Uses knowledge of hydraulics to troubleshoot systems	Core
5. Uses knowledge of pneumatics to troubleshoot systems	Core

Competency F: Repairs machines, equipment, or systems	Core or Optional
PERFORMANCE CRITERIA	
1. Uses dimensional measurement tools properly to inspect dimensions of shafts and other components	Core
2. Lubricates equipment using correct lubricants, as recommended by the manufacturer's guidance	Core
3. Performs a preventive maintenance procedure for a given machine to extend machine life and minimize downtime	Core
4. Performs predictive maintenance on a given machine to extend machine life and minimize downtime	Core
5. Reads and interprets technical drawings of parts and assemblies with tolerances and basic Geometric Dimensioning and Tolerancing (GD&T)	Core
6. Uses hand tools to inspect, adjust or tighten, and assemble or disassemble equipment and supports preventive maintenance, inspection, and troubleshooting activities	Core
7. Uses hoists and other tools to safely handle and move parts and equipment	Core
8. Selects and uses troubleshooting methodologies to find malfunctions in machine systems to return the system to reliable, productive use in the shortest time possible	Core

Job Function 9: Engages in career management and employee relations

Related Technical Instruction		
KNOWLEDGE	SKILLS	TOOLS & TECHNOLOGIES
<ul style="list-style-type: none"> • Product life cycle • Cost-benefit analysis • SWOT analysis • Six-sigma goals • Upstream and downstream product development • Production process, cost controls, production time, and product quality • Product business development 	<ul style="list-style-type: none"> • Maintaining situational awareness • Performing risk-assessment and risk-mitigation activities • Logical thinking • Clear oral communication • Critical analysis • Business acumen • Teamwork 	<ul style="list-style-type: none"> • None

Competency A: Develops and explains a short-term career plan and resumé	Core or Optional
PERFORMANCE CRITERIA	
1. Establishes goals for career over a short timeline	Optional
2. Shares goals with coworkers and supervisors	Optional
3. Develops resume outlining key professional work accomplished	Optional

Competency B: Demonstrates appropriate interpersonal skills in job performance evaluations, group communication and decision-making, and conflict resolution	Core or Optional
PERFORMANCE CRITERIA	
1. Clearly explains findings from the business development and production design to other employees	Optional
2. Helps design manuals to impart knowledge to other employees	Optional
3. Participates in workshops and discussions to explain knowledge to others	Optional
4. Appropriately communicates findings to supervisor	Optional

Competency C: Identifies and explains the major departments or functions in a company and how they affect production units	Core or Optional
PERFORMANCE CRITERIA	
1. Identifies lean-manufacturing and six-sigma goals that can be used to improve the manufacturing process	Optional

2. Looks at the potential implications of using upstream versus downstream processes in acquiring materials	Optional
3. Helps to manage individual or team expectations	Optional
4. Applies appropriate corrections based on team input	Optional

Competency D: Understands additive business or “use” case	Core or Optional
PERFORMANCE CRITERIA	
1. Helps determine the production costs of product by calculating personnel, equipment, and raw-material usage	Optional
2. Works to determine marginal revenue of product to view how each product is profitable or unprofitable	Optional
3. Informs supervisor of findings	Optional

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