American Welding Society

Appendix A

WORK PROCESS SCHEDULE

AND

RELATED INSTRUCTION OUTLINE

Appendix A

WORK PROCESS SCHEDULE
Welding Automation Specialist (Existing Title: Welding Machine Operator, Arc)
O*NET-SOC CODE: 51-4122.00 RAPIDS CODE: 0945CB

This schedule is attached to and a part of these Standards for the above identified occupation.

1. APPRENTICESHIP APPROACH

☐ Time-based ☒ Competency-based ☐ Hybrid

2. TERM OF APPRENTICESHIP

The term of the apprenticeship is approximately 3 years (6000 hours), with an OJL attainment of all competencies listed, supplemented by the minimum recommended 465 hours of related instruction.

3. RATIO OF APPRENTICES TO JOURNEYWORKERS

The apprentice to journeyworker ratio is: 1 Apprentice to1 Journeyworker on the jobsite.

4. APPRENTICE WAGE SCHEDULE

Apprentices shall be paid a progressively increasing schedule of wages based on either a percentage or a dollar amount of the current hourly journeyworker wage rate, which is: $21.80*

*Median US Wage per O*NET. Wage rates and progression will be determined locally.

Sample Progression:
Year One: 70%
Year Two: 80%
Year Three: 90%
Exit Wage:100%

5. PROBATIONARY PERIOD

Every applicant selected for apprenticeship will serve a probationary period of *9 months.*

6. SELECTION PROCEDURES

Please see page A-10.

Appendix A

ON-THE-JOB LEARNING OUTLINE

Welding Automation Specialist (Existing Title: Welding Machine Operator, Arc)	
Job Description: Set up, operate, or tend welding, soldering, or brazing machines or robots that weld, braze, solder, or heat treat metal products, components, or assemblies. Includes workers who operate laser cutters or laser-beam machines.	
RAPIDS Code: 0945CB	**O*NET Code: 51-4122.00**
Estimated Program Length: 3 Years	
Apprenticeship Type: ☒ Competency-Based ☐ Time-Based ☐ Hybrid	

The work process schedule is intended as a guide. It is not to be followed in any particular sequence, and it is understood that some adjustments may be necessary in the apprentice's assignments allotted for different work experience. Overall, an apprentice shall receive sufficient experience to make him/her able to demonstrate a high level of expertise in the work processes which are part of this occupation. In addition, the apprentice shall be fully instructed in safety and OSHA requirements as may be applicable to maintain a safe and healthy work environment.

The following is the rating system that will be used to determine competency:

Rating System	Description	Points
Exceeds All Expectations	Consistently exceeds performance standard established for the time in position. Achieves results above and beyond what is required. Extends themselves in their roles to exceed personally and as a team to achieve exceptional results.	5
Meets & Exceeds Some Expectations	Apprentice not only meets all expectations in a fully satisfactory way but exceeds some of the objectives.	4
Meets Expectations	Consistently meets the performance standards established for time in position. Handles routine tasks & some unexpected situation with the usual amount of supervision. Can continue to develop with coaching, advanced training or more experience	3
Meets Some Expectations	Apprentice occasionally meets some of the objectives related to this goal but does not meet others in a fully satisfactory way. This performance level generally indicates the need for additional coaching, training, or other plan for performance improvements.	2
Does Not Meet / Meets Some Expectations	Does not consistently meet performance standards established for time in position. Requires basic training, coaching or experience to improve performance and become consistent. Additional follow-up will be necessary.	1
Does Not Meet Expectations	Clearly and repeatedly does not meet the performance standards established for time in position. Additional follow-up and specific suggestions for improvement mandatory.	0

Technical Competencies			
1	**Welding Fundamentals**	Rating	Completion Date/Initials
	Recognize Safe Work Practices & Welding Safety as per ANZI Z49.1		
	Utilize appropriate personal protective equipment.		
	Identify workplace hazards and take appropriate action.		
	Demonstrate adequate understanding and application of welding and joining processes		
	Outline proper metal preparation techniques for preparing common weld joints		
	Demonstrate proper setup and operation of manual and semi-automatic welding equipment.		
	Minimum comprehension and understanding with standard Weld Joints and Welding Positions		
	Operate and apply thermal cutting systems correctly.		
	Perform mathematical calculations and measurements related to weld dimensions, angles, and lengths.		
	Demonstrate adequate understanding and application of welding metallurgy, material chemistry, and alloys.		
	Demonstrate adequate understanding of essential weldability characteristics related to ferrous and nonferrous materials		
	Demonstrate adequate understanding of physical, chemical, and thermal properties of base metals and deposited weld metals		
	Demonstrate adequate understanding of various welding processes and their impact on metallurgy		
	Identify appropriate welding and cutting accessories, including torches, nozzles, and consumables, based on specific welding processes (e.g., MIG, TIG, plasma cutting) and material requirements.		
2	**Welding Automation Safety**		
	Review and apply safety standards for welding automation, including ANSI Z49.1, AWS D16.1 & D16.3, and other industry specific standards.		
	Describe and perform processes to safely halt robotic welding systems with emergency stop buttons and safety mechanisms		
	Demonstrate and apply safe practices for powering up and shutting down robotic welding systems to prevent accidental movements and electrical hazards.		
	Examine and apply concepts of safety zones around robotic welding systems-different types of safeguarding devices like barriers, pressure mats, and two-hand controls, and their application in robotic welding environments.		
	Proficiency with the functions of safety interlocks and their role in preventing accidental activation of robotic systems.		

	Examine and apply common safe protocols to ensure that robots are de-energized and immobilized before accessing work areas.		
	Outline electrical safety measures for power sources, cables, and grounding in robotic welding environments.		
	Demonstrate proper lockout/tagout procedures during maintenance and troubleshooting.		
	Identify, evaluate, and mitigate safety risks in welding automation systems through the application of industry safety standards, the implementation of control measures, and the performance of comprehensive risk assessments, in accordance with industry standards such as AWS D16.3 guidelines.		
3	**Robotic Welding Systems**		
	Demonstrate understanding and comprehension of robotic terminology, such as axes, degrees of freedom, teach pendant, and Cartesian coordinate systems.		
	Examine different types of welding robots, welding cells, and end-of-arm tooling, and their applications in automated welding.		
	Understand components and primary functions of a typical welding cell, including power supplies, wire feeders, positioners, and fixtures.		
	Understand the structure and function of robotic arms, peripheral devices, and calibration, comprehending how these components work together in a welding setup.		
	Identify common robotic welding techniques and showcase how automation improves weld consistency and accuracy.		
	Explain the methods by which robotic systems communicate over networks and outline basic troubleshooting steps for addressing communication issues.		
	Summarize the importance of sensors in welding process monitoring and demonstrate proficiency with sensor calibration.		
	Identify sources of input power and demonstrate working knowledge of powering up robot systems and peripherals.		
	Demonstrate and apply methods of calibrating robotic arms for high-precision tasks, ensuring repeatable accuracy in automated welding processes.		
4	**Tooling and Fixturing**		
	Work in conjunction with engineers to design and fabricate specialized welding jigs and fixtures.		
	Examine the application and use of NAAMS (North American Automotive Metric Standards) for fixtures and tooling.		
	Interpret technical drawings and specifications related to NAAMS tooling, including tooling models and features.		
	Identify and select appropriate NAAMS-style shim packs for specific adjustments, such as 2 fingers vs .3, 4, etc.		
	Conduct assessments for tooling and fixture setup to determine if shimming adjustments are needed. Perform thorough inspections		

	of existing tooling alignment using both visual methods and measurement-based checks.		
	Utilize precision instruments, including dial indicators, height gauges, laser alignment tools, and digital calipers, to measure critical dimensions and tolerances.		
	Identify fixture setup misalignment or gaps by analyzing root causes such as component wear, incorrect shimming, structural deformation, spatter buildup, grime, or improper use of materials like Elkonite (Copper Tungsten Alloy).		
	Interpret GD&T symbols, apply welding fixture tolerances, and verify compliance with measurement tools for alignment, fit, and function in automated welding.		
	Demonstrate skill to carefully reattach fixture components that are designed to prevent incorrect part placement and ensure appropriate torque settings on fasteners to maintain stability and precision.		
	Perform test cycles with the fixture in operation to confirm weld consistency, verify appropriate clamping and holding forces, and ensure alignment repeatability.		
	Document all adjustments, including shim types and quantities, measurements taken before and after, and any observations or recommendations. Communicate the results to relevant team members, such as welding engineers and maintenance personnel, to address and record alignment issues for future reference.		
5	**Programming and Operations**		
	Understand fundamental principles of robot functions, including coordinate systems, axes of movement, and basic robotic terminologies like payload, reach, and degrees of freedom.		
	Demonstrate proper set up and adjustment of tool center point, for accurate welding and robotic movement.		
	Apply simplified programming languages, and basic programming concepts, such as loops, conditional statements (if/else), input/output interactions, and variables.		
	Minimum understanding of program start and stop commands for welding to ensure proper sequence and avoiding defects.		
	Minimum understanding of adjusting programs for minor variances in workpiece positioning, improving accuracy without extensive reprogramming.		
	Perform and understand the safe restart of a robotic welding system after an error or emergency stop.		
	Create, adjust, and modify robot programs using a teach pendant.		
	Interface with control devices for troubleshooting and adjustments.		
	Develop adaptive welding programs that adjust based on sensor inputs.		
	Utilize offline programming software for robotic welding to perform reach studies and minimize downtime		
6	**Collaborative Applications**		

	Understand fundamental principles of cobot functions, including coordinate systems, axes of movement, and basic terminologies like payload, reach, and degrees of freedom.		
	Examine collaborative application equipment and their application in welding automation, including safety considerations and programming.		
	Outline and implement safety protocols unique to collaborative robotic environments, including force sensing and safety-rated monitored stops, etc.		
	Conduct specific risk assessments for collaborative welding tasks and implement risk reduction measures in accordance with industry standards, such as ISO and AWS.		
	Program collaborative equipment for welding tasks using both direct teaching and offline programming methods, and lead through teach or kinetic motion.		
	Conduct validation tests to ensure that cobots and associated equipment are correctly calibrated and consistently produce welds that meet quality standards		
	Perform thorough risk assessments and ensure synchronization of collaborative and ancillary equipment to maintain workflow accuracy, safety, and weld quality.		
	Adjust collaborative equipment programming on the production floor to accommodate real-time changes in workpiece dimensions, material variations, or unexpected interruptions.		
7	**Integration of Advanced Technology and Welding Techniques**		
	Understand the role of vision systems in welding automation, including real-time monitoring and vision guided weld seam tracking.		
	Utilize laser sensors and cameras for quality assurance and defect detection.		
	Program vision-guided robots to adjust welding parameters based on feedback from sensors.		
	Understand machine learning concepts and their applications in analyzing weld quality data, enabling predictive maintenance and defect detection in real time.		
	Differentiate between welding systems that automatically adjust parameters, such as current and voltage, based on changes in the welding environment or materials.		
	Understand fundamentals of using artificial intelligence to optimize robot motion paths, improving speed, efficiency, and energy consumption during welding operations.		
	Minimum understand of coordinating multiple robots to work together on complex welding tasks, such as synchronized movements and task-sharing for higher productivity.		
	Minimum understanding of 3D vision system applications for irregular or complex workpieces, adjusting welding paths dynamically based on object contours.		

	Competency in setting up and calibrating systems for accurate part detection and tracking		
	Implement welding procedures per AWS codes and standards for different materials (e.g., stainless steel, aluminum).		
	Understand the purpose and role of communication protocols like Ethernet/IP, PROFINET, Modbus, and DeviceNet in industrial robotics. Define key concepts such as IP addressing, basic subnetting, latency and its effect on robotic operations, and the differences between real-time and non-real-time communication.		
	Evaluate the capabilities and limitations of Through-Arc Seam Tracking (TAST) software and its applications, including its integration with automated welding systems, to enhance accuracy and performance across various welding scenarios.		
8	**Quality Control, Visual Inspection, and Documentation**		
	Minimum comprehension and understanding with identifying common types of discontinuities in butt, T-, corner, lap, and edge joints		
	Minimum comprehension and understanding with weld and base-metal discontinuities of common welding processes		
	Minimum comprehension and understanding with various examination tools and gauges commonly employed in visual welding examination including linear measurement devices, temperature-indicating materials, surface contact and non-contact thermometers, weld gauges, fiberscopes, borescopes, ferrite gauges, light sources, and ammeters/voltmeters.		
	Understand quality control programs and importance of visual examinations performed during all phases of fabrication		
	Maintain detailed records of welding activities and the results of inspections in accordance with AWS or industry relevant codes and standards.		
	Utilize visual acceptance criteria to assess weld quality according to industry codes and standards, showing an understanding of defect identification, measurement, and compliance requirements.		
9	**Maintenance and Troubleshooting**		
	Perform detailed preventive maintenance on robotic arms and associated systems (e.g., cleaning, replacing parts).		
	Diagnose and resolve common robot errors and alarms.		
	Execute basic adjustments to servo motors to ensure smoother operation of robotic arms.		
	Knowledge of using sensors to monitor the condition of robotic components and prevent unplanned downtimes.		
	Understand the use of PLCs in automating robotic welding systems, including basic programming and troubleshooting of PLCs.		
	Evaluate and maintain the tip-to-barrel system. Calibrate the wire feed mechanism for proper speed and alignment and		

	troubleshoot issues such as burn back or feeding irregularities to restore system functionality.		
	Diagnose and troubleshoot common accessory-related issues, such as overheating, wire feeding problems, shielding gas flow, or nozzle blockages in a robotic environment.		
10	**AWS Certification Preparation**		
	Investigate the requirements and process for taking the AWS Certified Robotic Arc Welding (CRAW) certification exam.		
	Prepare for AWS CRAW certification exam.		
	Prepare for the CRAW welding performance certification exam. Document welding processes and ensure compliance with AWS certification requirements.		
	Conduct a practical welding demonstration as part of the CRAW certification process.		
	Submit the required application and documentation to AWS for taking the CRAW exam.		

Appendix A

RELATED INSTRUCTION OUTLINE
Welding Automation Specialist (Existing Title: Welding Machine Operator)
O*NET-SOC CODE: 51-4122.00 RAPIDS CODE: 0945CB

Provider	
Name: American Welding Society	
Address: 8669 NW 36th Street#130; Miami, FL 33166-6672	
Email: customercare@aws.org	**Phone Number:** (800) 443-9353
Suggested Related Instruction Hours: 465	

Related Instruction Descriptions:	**Approximate Hours:**
Welding Automation Safety and Risk Assessment	8
Introduction to Thermal Cutting and Allied Cutting Processes	15
Introduction to Gas Metal Arc Welding and Gas Tungsten Arc Welding	80
Advanced to Gas Metal Arc Welding and Gas Tungsten Arc Welding	100
Introduction to Basic Weld Joint Design and Preparation	20
Fabrication Math I	18
Fabrication Math II	15
Safety for General Industry and Safety in Welding, Cutting and Allied Processes-Z49.1	15
Welding Metallurgy I	10
Print Reading and Welding Symbols	30
Welding Discontinuities and Defects	40
Introduction to Precision Measurement, Tools, and Metrology	8
Introduction to Welding Codes and Standards	20
Technical Report Writing	20
Introduction to Maintenance and Troubleshooting of Welding Equipment	15
Professional Workplace Skills	10
Robotic Manufacturer Training Courses	40
Industry certification and endorsements (AWS)	1
Total All Courses:	**465**

SELECTION PROCEDURES

The sponsor has adopted the following selection procedures, consistent with the requirements set forth in 29 CFR § 30.10(b):

The sponsor will recruit from (but not limited to) the following sources:

1. Incumbent workers
2. Colleges, Universities, Community Colleges, and Career and Technical Education Centers
3. One-Stop Centers, as established under the Workforce Investment Act, and reauthorized in the Workforce Innovation and Opportunities Act of 2014.