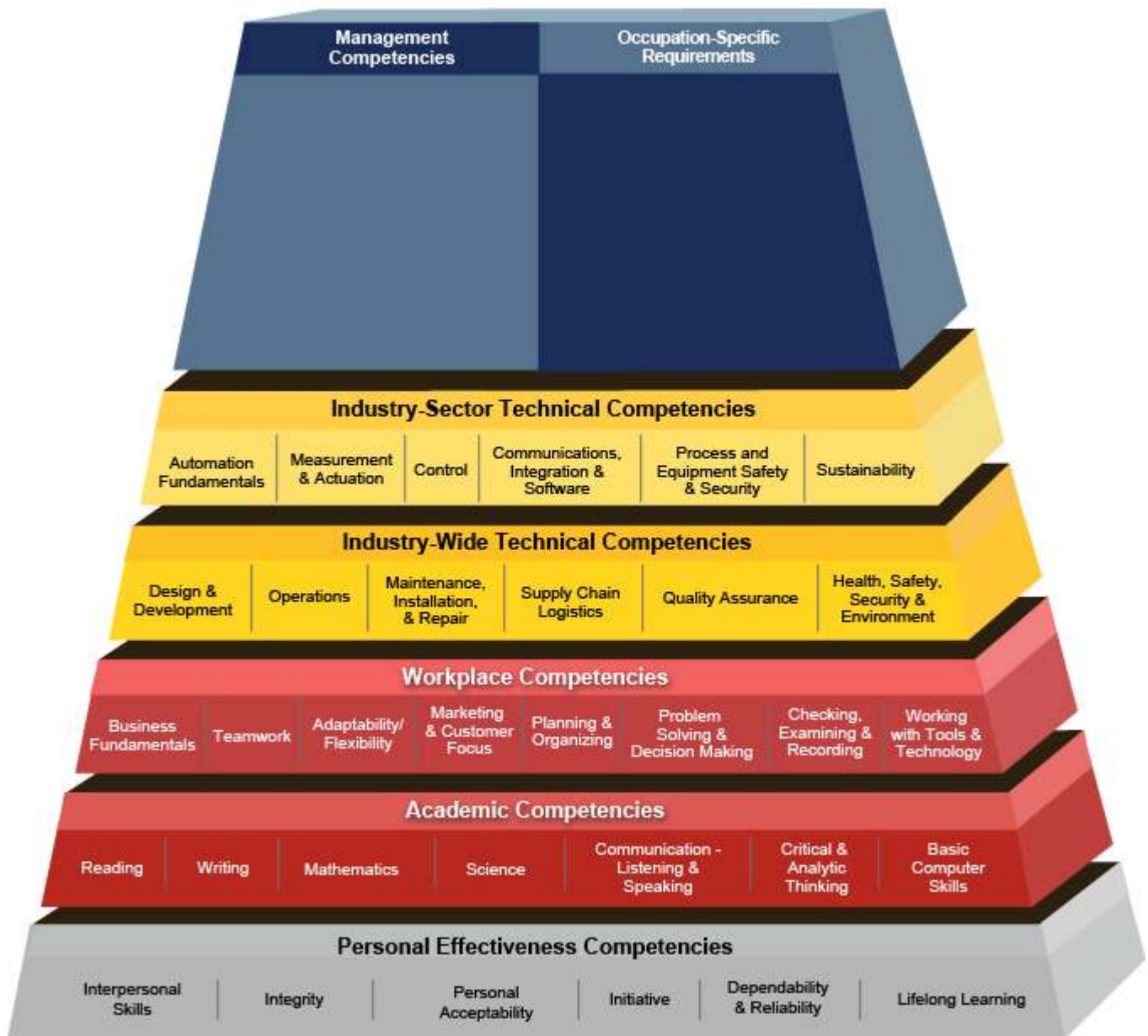


# Automation Competency Model

Updated October 2011



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## ABOUT THE MODEL

The Automation Competency Model is a resource that provides a comprehensive collection of the *competencies* or the knowledge, skills, and abilities required in the automation industry. The competencies are described using key behaviors, examples of the critical work functions, or the technical content common to an industry. A competency describes a behavior, but does not attempt to describe a level of performance, or competence. Not every worker in an industry needs the same level of performance in a competency area.

The model is depicted in a graphic consisting of several tiers on a pyramid. Each tier is comprised of blocks that group the skills, knowledge, and abilities essential for successful performance in the industry. At the base of the model, the competencies apply to a large number of occupations and industries. As a user moves up the model, the competencies become industry and occupation specific. The pyramid shape does not imply that competencies at the top are at a higher level of skill. The model's shape represents the increasing specialization and specificity in the application of skills as you move up the tiers. A table of the competency definitions and associated key behaviors follows the graphic.

Tiers 1 through 3, called Foundation Competencies, form the foundation needed to be ready to enter the workplace.

Tier 1 – Personal Effectiveness Competencies represent personal attributes or “soft skills”. Essential for all life roles, personal effectiveness competencies are generally learned in the home or community and reinforced at school and in the workplace.

Tier 2 – Academic Competencies are critical competencies primarily learned in a school setting. They include cognitive functions and thinking styles, and are likely to apply to most industries and occupations.

Tier 3 – Workplace Competencies represent motives and traits, as well as interpersonal and self-management styles honed in the workplace. They generally are applicable to a large number of occupations and industries.

Tiers 4 and 5 show the cross-cutting industry-wide technical competencies needed within an industry wherein a worker can move easily across industry sub-sectors. Rather than narrowly defining a single occupational career ladder, this model supports the development of an agile workforce.

Tier 4 – Industry-Wide Technical Competencies represent the knowledge and skills that are common across the sectors within a broader industry.

Tier 5 – Industry-Sector Technical Competencies represent technical competencies that are specific to Automation. Development of the technical competencies relied heavily on *A Guide to the Automation Body of Knowledge*, 2nd Edition, Vernon L. Trevathan, Editor. See - <http://www.isa.org/Template.cfm?Section=Books3&template=/Ecommerce/ProductDisplay.cfm&ProductID=8800>

The upper tiers represent the occupational specialization within the industry. Information on automation occupational competencies is available on the Automation Federation Web site at: [http://www.automationfederation.org/Content/NavigationMenu/General\\_Information/Alliances\\_and\\_Associations/The\\_Automation\\_Federation/Resources1/Resources.htm](http://www.automationfederation.org/Content/NavigationMenu/General_Information/Alliances_and_Associations/The_Automation_Federation/Resources1/Resources.htm)

## Tier 1—Personal Effectiveness Competencies

<b>1. <u>Interpersonal Skills</u>: Demonstrating the ability to work effectively with others.</b>
<ul style="list-style-type: none"><li>▪ Interact appropriately and respectfully with supervisors and coworkers</li><li>▪ Work effectively with people who have diverse personalities and backgrounds</li><li>▪ Respect the opinions, perspectives, customs, and individual differences of others</li><li>▪ Use appropriate strategies and solutions for dealing with conflicts and differences to maintain a smooth workflow</li><li>▪ Be flexible and open-minded when dealing with a wide range of people</li><li>▪ Listen to and consider others' viewpoints</li></ul>
<b>2. <u>Integrity</u>: Displaying accepted social and work behaviors.</b>
<ul style="list-style-type: none"><li>▪ Treat others with honesty, fairness, and respect</li><li>▪ Comply with ethical standards for your field</li><li>▪ Take responsibility for accomplishing work goals within accepted timeframes</li><li>▪ Accept responsibility for one's decisions and actions</li></ul>
<b>3. <u>Personal Acceptability</u>: Maintaining a socially acceptable demeanor.</b>
<ul style="list-style-type: none"><li>▪ Demonstrate self-control by maintaining composure and dealing with stressful situations</li><li>▪ Accept criticism and attempt to learn from mistakes</li><li>▪ Demonstrate a positive attitude towards work</li><li>▪ Follow rules and standards of dress</li><li>▪ Follow rules and standards of personal hygiene</li><li>▪ Refrain from substance abuse</li></ul>
<b>4. <u>Initiative</u>: Demonstrating a willingness to work.</b>
<ul style="list-style-type: none"><li>▪ Take initiative in seeking out new responsibilities and work challenges</li><li>▪ Pursue work with energy, drive, and effort to accomplish tasks</li><li>▪ Persist at a task despite interruptions, obstacles, or setbacks</li><li>▪ Establish and maintain personally challenging, but realistic work goals</li><li>▪ Strive to exceed standards and expectations</li></ul>
<b>5. <u>Dependability and Reliability</u>: Displaying responsible behaviors at work.</b>
<ul style="list-style-type: none"><li>▪ Behave consistently, predictably, and reliably</li><li>▪ Fulfill obligations, complete assignments, and meet deadlines</li><li>▪ Follow written and verbal directions</li><li>▪ Comply with organizational rules, policies, and procedures</li></ul>
<b>6. <u>Lifelong Learning</u>: Displaying a willingness to learn and apply new knowledge and skills.</b>
<ul style="list-style-type: none"><li>▪ Demonstrate an interest in personal and professional lifelong learning and development</li><li>▪ Treat unexpected circumstances as opportunities to learn and adopt new techniques</li><li>▪ Seek feedback, and modify behavior for improvement</li><li>▪ Broaden knowledge and skills through job shadowing and continuing education</li></ul>

- Use newly learned knowledge and skills to complete specific tasks
- Take charge of personal career development by identifying personal interests and career pathways
- Seek and maintain membership in professional associations
- Read technical publications to stay abreast of new developments in the industry
- Maintain certifications and continuing education credits

## Tier 2—Academic Competencies

### 1. **Reading:** Understanding written English sentences and paragraphs in work-related documents.

- Locate, understand, and interpret written technical and non-technical information in documents such as manuals, reports, memos, graphs, charts, tables, schedules, signs, and regulations
- Identify relevant details, facts, specifications, and main ideas
- Understand the essential message and purpose of written materials
- Infer or locate meaning of unknown or technical vocabulary

### 2. **Writing:** Using standard English to compile information and prepare written reports.

#### Organization and development

- Create documents such as letters, directions, manuals, reports, graphs, and flow charts
- Communicate thoughts, ideas, information, messages, and other written information, which may contain technical material, in a logical, organized, coherent, and persuasive manner
- Develop ideas with supporting information and examples

#### Mechanics

- Use standard syntax and sentence structure
- Use correct spelling, punctuation, and capitalization; use appropriate grammar (e.g., correct tense, subject-verb agreement, no missing words)
- Write in a manner appropriate for business; use language appropriate for the target audience; use appropriate tone and word choice (e.g., writing is professional and courteous)

### 3. **Mathematics:** Using principles of mathematics such as algebra, geometry, and trigonometry to solve problems.

Know and apply mathematical principles:

- Number Systems and Relationships - whole numbers, decimals, fractions, alternate base systems (e.g. binary, octal, and hexadecimal numbers)
- Arithmetic – arithmetic operations on numbers, percentages, square root, exponentiation, and logarithmic functions
- Plane and Solid Geometry – distance, perimeter, area, and volume, spatial coordinates, visualization, spatial reasoning, and geometric modeling
- Measurement – measurement of length, mass, time, systems of measurement, units, and conversion between systems (e.g. from English to metric)
- Mathematical Notation - the language of mathematics to express mathematical ideas
- Mathematical Reasoning and Problem Solving – inductive and deductive reasoning, conjectures, arguments, strategies, and interpretation of results
- Elementary Statistics and Laws of Probability – mean, median, and standard deviation
- Algebra and Functions – equations, patterns, and functions
- Elementary Trigonometry – triangles and trigonometric functions
- Elementary Calculus – exponential, logarithmic and trigonometric functions, vectors, complex numbers, conic sections, and analytic geometry

**4. Science: Knowing and applying scientific principles and methods to solve problems.**

- Know and apply scientific principles:
- Scientific Method – the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of a hypothesis
  - Chemistry – the composition, structure, properties, and reactions of matter, especially of atomic and molecular systems
  - Physics – matter and energy and physical interactions

**5. Communication—Listening and Speaking: Giving full attention to what others are saying and speaking in English well enough to be understood by others.**

- Listening**
- Receive, attend to, interpret, understand, and respond to verbal messages and other cues
  - Apply active listening skills using reflection, restatement, questioning, and clarification
  - Pick out important information in verbal messages
  - Understand complex instructions
- Speaking and Presenting**
- Speak clearly and confidently using common English conventions including proper grammar, tone, and pace
  - Express information to individuals or groups taking into account the audience and the nature of the information (e.g., explain technical concepts to non-technical audiences)
  - Present ideas in a persuasive manner

**6. Critical and Analytical Thinking: Using logic, reasoning, and analysis to address problems.**

- Use logic and reasoning to identify strengths and weaknesses of alternative solutions, conclusions, or approaches to problems
- Use inductive and deductive reasoning to analyze, synthesize, compare, and interpret information
- Draw conclusions from relevant or missing information
- Understand the underlying relationship among facts and connections between issues
- Organize problems into manageable parts

**7. Basic Computer Skills: Using a computer and related applications to input and retrieve information.**

- Navigation and File Management**
- Use scroll bars, a mouse, and dialog boxes to work within the computer's operating system
  - Access and switch between applications and files of interest
- Internet and E-mail**
- Navigate the Internet to find information
  - Open and configure standard browsers
  - Use searches, hypertext references, and transfer protocols
  - Send and retrieve electronic mail (e-mail)
  - Write e-mail with an appropriate tone

**Word Processing**

- Use a computer application to type text, insert pictures
- Format, edit, and print text
- Save and retrieve word processing documents

**Spreadsheets**

- Use a computer application to enter, manipulate, and format text and numerical data
- Insert, delete, and manipulate cells, rows, and columns
- Create and save worksheets, charts, and graphs

**Presentations**

- Use a computer application to create, manipulate, edit, and show virtual slide presentations

**Databases**

- Use a computer application to manage large amounts of information
- Create and edit simple databases
- Input data
- Retrieve detailed records
- Create reports to communicate the information

**Graphics**

- Work with pictures in graphics programs or other applications
- Create simple graphics
- Manipulate the appearance of graphics
- Insert graphics into other files/programs



## Tier 3—Workplace Competencies

### 1. **Business Fundamentals:** Knowledge of basic business principles, trends, and economics.

#### **Economic/Business/Financial Principles**

- Characteristics of Markets
- Cost and Pricing of Products
- Economic Terminology
- Fundamentals of Accounting
- Profit and Loss
- Supply/Demand

#### **Economic System as a Framework for Decision-making**

- Understand how one's performance can impact the success of the organization
- Consider the relative costs and benefits of potential actions to choose the most appropriate one

#### **Business Ethics** – Act in the best interests of the company, your co-workers, your community, other stakeholders, and the environment

- Legal/Financial
  - Comply with the letter and spirit of applicable laws as well as the letter
  - Use company property legitimately, minimizing loss and waste; report loss, waste, or theft of company property to appropriate personnel
  - Maintain privacy and confidentiality of company information, as well as that of customers and co-workers
  - Comply with intellectual property laws
  - Protect trade secrets
- Environmental/Health/Safety
  - Maintain a healthful and safe environment and report any violations/discrepancies
  - Ensure proper handling and disposal of toxic or hazardous materials
  - Ensure equipment and systems are designed to be environmentally friendly and strive to continually minimize the resulting carbon footprint
  - Practice sustainability by using processes that are non-polluting, conserving of energy and natural resources, economically efficient, and safe for workers, communities, and consumers
  - Safeguard the public interest
- Social
  - Emphasize quality, customer satisfaction and fair pricing
  - Deal with customers in good faith, no bribes, kickbacks, or excessive hospitality

## **Marketing**

- Demonstrate an understanding of market trends, company's position in the market place, and defined market segments
- Understand position of product/service in relation to market demand
- Uphold the company and product brand through building and maintaining customer relations
- Integrate internal and external customer demands and needs into manufacturing product and process development

## **2. Teamwork: Working cooperatively with others to complete work assignments.**

- Accept membership in and commit to the goals of a team
- Work effectively with multi-disciplinary teams
- Identify roles of team members and effectively communicate with all members of the team
- Recognize one's own effects on team performance
- Collaborate with others to formulate team objectives and develop consensus for best outcome
- Use teamwork skills to achieve goals, solve problems, and manage conflict
- Give and receive feedback constructively
- Express opinions openly and respect others' right to do so
- Be open to new ideas, new ways of doing things, and the merits of new approaches to work

## **3. Adaptability and Flexibility: Being open to change (positive or negative) and to considerable variety in the workplace.**

### **Entertain new ideas**

- Is open to considering new ways of doing things
- Actively seek out and carefully considers the merits of new approaches to work
- Willingly embrace new approaches when appropriate and discards approaches that are no longer working

### **Deal with ambiguity**

- Take effective action when necessary without having to have all the necessary facts in hand
- Change gears in response to unpredictable or unexpected events
- Effectively change plans, goals, actions, or priorities to deal with changing situations

## **4. Marketing and Customer Focus: Actively looking for ways to identify market demands and meet the customer, client, or stakeholder need.**

### **Understand customer needs**

- Identify internal and external customers
- Demonstrate a desire to understand customer needs
- Anticipate the future needs of the customer
- Ask questions as appropriate
- Demonstrate awareness of client goals
- Demonstrate awareness of the impact of the project's carbon footprint

**Provide personalized service**

- Provide prompt and efficient responses to meet the requirements, requests, and concerns of customers
- Provide thorough, accurate information to answer customers' questions and to meet commitment times or performance guarantees
- Actively look for ways to help customers by identifying and proposing appropriate solutions and/or services
- Establish boundaries as appropriate for unreasonable customer demands

**Act professionally**

- Be pleasant, courteous, and professional when dealing with internal or external customers
- Develop constructive and cooperative working relationships with customers
- Display a good-natured, cooperative attitude; is calm and empathetic when dealing with hostile customers
- Uphold the company and product brand in interactions with others

**Keep customers informed**

- Follow up with customers during projects and following project completion
- Keep clients up to date about decisions that affect them
- Seek the comments, criticisms, and involvement of customers
- Adjust services based on customer feedback
- Address customer comments, questions, concerns, and objections with direct accurate and timely responses

**5. Planning and Organizing: Planning and prioritizing work to manage time effectively and accomplish assigned tasks.****Plan**

- Approach work in a methodical manner
- Plan and schedule tasks so that work is completed on time
- Keep track of details to ensure work is performed accurately and completely

**Prioritize**

- Prioritize various competing tasks
- Perform tasks quickly and efficiently according to their urgency
- Find new ways of organizing work area or planning work to accomplish work more efficiently

**Allocate Resources**

- Estimate resources needed for project completion
- Allocate time and resources effectively
- Coordinate efforts with all affected parties
- Keep all parties informed of progress and all relevant changes to project timelines

**Anticipate Obstacles**

- Anticipate obstacles to project completion
- Develop contingency plans to address them
- Take necessary corrective action when projects go off track

**6. Problem Solving and Decision Making: Applying critical-thinking skills to solve problems by generating, evaluating, and implementing solutions.**

**Identify the problem**

- Anticipate or recognize the existence of a problem and define the problem
- Locate and obtain all information relevant to the problem
- Identify potential causes of the problem by analyzing its component parts
- Recall previously learned information that is relevant to the problem
- Communicate the problem to appropriate personnel

**Generate innovative solutions**

- Think creatively to generate a variety of approaches to the problem
- Integrate seemingly unrelated information to develop creative solutions
- Develop innovative methods of obtaining or using resources when insufficient resources are available
- Demonstrate innovative thinking by using new and existing technology in new ways
- Use logic and reasoning to evaluate the relative merits of the various solutions, conclusions, or approaches

**Choose a solution**

- Decisively choose the best solution after contemplating available approaches to the problem
- Make difficult decisions even in highly ambiguous or ill-defined situations
- Quickly choose an effective solution without assistance when appropriate

**Implement the solution**

- Commit to a solution in a timely manner
- Develop a realistic approach for implementing the chosen solution
- Use strategies, tools, resources, and equipment to implement the solution
- Observe and evaluate the outcomes of implementing the solution to assess the need for alternative approaches and to identify lessons learned

**7. Checking, Examining, and Recording: Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic format.**

- Record data in control system documentation
- Compile, code, categorize, calculate, inspect, or verify information or data
- Apply systematic techniques for observing and gathering data
- Detect and correct errors or inconsistencies, even under time pressure
- Organize records and files to maintain data

**8. Working with Tools and Technology: Selecting, using, and maintaining tools and technology to facilitate work activity.**

**Selection and Application**

- Identify, select, and apply appropriate and cost-effective tools or technological solutions
- Identify potential hazards related to the use of tools and equipment
- Operate tools and equipment in accordance with established operating procedures and safety standards
- Use information technology and computer applications as it supports the gathering, storage, manipulation, and transfer of data and information

**Keeping Current**

- Demonstrate an interest in learning about new and emerging tools and technologies
- Identify sources of information concerning state-of-the-art tools, equipment, materials, technologies and methodologies
- Seek out opportunities to improve knowledge of tools and technologies that may assist in streamlining work and improving productivity

**Maintenance and Troubleshooting**

- Perform routine maintenance on tools, technology, and equipment
- Determine causes of operating errors and decide what to do about it
- Troubleshoot maintenance problems in accordance with established procedures
- Perform work functions that require engaging in hands-on activity

## Tier 4—Industry-Wide Technical Competencies

### 1. **Design and Development:** Research and design for the application of technology to monitor and control the production of goods and services.

#### **Critical Work Functions:**

- Design automation-related production and production support systems.
- Create and apply technology to control production and process functions.
- Develop functional specifications for the design and development automated control systems.
- Communicate about and respond to requirements of internal and external customers.
- Interpret and clarify customer expectations and product specifications.

#### **Technical Content Areas:**

##### **Design Concepts**

- Design for Manufacturing and Design for Logistics
- Development of Prototype Processes and Products
- Support Systems Design and Development
- System Design, Development, Testing, and Costing

##### **Engineering Concepts**

- Chemical Engineering
- Computer Engineering
- Electrical Engineering
- Mechanical Engineering

##### **Research & Development Fundamentals**

- Intellectual Property Protection
- Human Subject Protection
- Market/Sales/Life Cycle Analysis
- Research and Design Procedures

##### **Technical Drawings and Schematics**

- CAD Drawing Fundamentals
- Geometric Dimensions and Tolerances
- Interpretation of Drawings and Schematics
- Print Reading

##### **Testing/Troubleshooting**

- Advanced Fault Finding Skills on Actual Equipment
- Data Analysis and Verification
- Data Interpretation and Corrective Action Implementation
- Statistical Process Control

##### **Workflow Assessment**

- Documentation Fault Finding Skills
- Ergonomic Simulation and Assessment of Tasks
- Manufacturing/Processing Concept Planning
- Mixed Model Line Balancing
- Plant Layout Planning and Analysis
  - Plant Design Optimization

- Walk-Path Assembly Planning
- Work Flow Simulation
- Procedure Analysis and Verification
- Process Simulation Tools e.g. Die Press Lines, Manufacturing Lines
- Resource Planning
- Workloads on Multiple Stations

**2. Operations: Set up, operate, monitor, control, and improve technology that supports production and process schedules to meet customer requirements.**

**Critical Work Functions:**

- Develop industrial production/process plans and documentation.
- Support the operation and control of production/process equipment.
- Monitor industrial processes and systems.
- Manage continuous improvement process.
- Manage raw materials/consumables/outputs.
- Perform industrial process applications and operations.

**Technical Content Areas:**

**Industrial Production and Process Basics** (including but not limited to a knowledge of)

- Industrial Process (continuous or batch) – processing, transporting or conveying liquids, gases, or goods in pipes or on conveyers.
  - Balancing
  - Continuous flow
  - Fermentation
  - Filtration
  - Mixing
  - Reaction
  - Recovery
  - Separation - Distillation etc.
- Discrete Manufacturing – the manufacture, assembly, or handling of individual parts.
  - Assembly
  - Fabrication
  - Finishing
- Hybrid Manufacturing – the packaging or bottling of manufactured goods.
  - Bottling
  - Finished goods handling and storage
  - Packaging

**Production/Process Monitoring**

- Calibration
- Process Troubleshooting
- Controlling Process Flow
- Documentation and Reporting
- Environmental Parameters
- Instrumentation
- Performance of Analytical Tests

- Time, Materials, and Costs

**Industry-wide Standards** (including but not limited to)

- Documentation of Measurement and Control Instruments and Systems (ISA 5)
- Enterprise/control Integration (ISA 95)
- Manufacturing and Control Systems Security (ISA 99)

**Project Management and Execution**

- Contracts
- Material and Resource Management
- Operator Training
- Personnel Management Methods
- Project Lifecycle
- Project Management Tools and Techniques

**3. Maintenance, Installation, and Repair: Maintain and optimize technology in support of process or manufacturing equipment and systems.**

**Critical Work Functions:**

- Support the installation, customization, or upgrading of equipment.
- Coordinate preventive maintenance to ensure production or industrial process runs smoothly.
- Identify, diagnose, and/or repair equipment problems.
- Communicate with others to ensure maintenance and repairs meet operational needs.
- Maintain hands-on knowledge of equipment operations.
- Maintain equipment, tools, and workstations.

**Technical Content Areas:**

**General Skills**

- Basic Disassembly/Assembly Skills
- Installation and Calibration of Instrumentation
- Equipment troubleshooting
- Installation of Parts for Industrial Equipment
- Schematic Drawings and Control Documents
- Use of Hand Tools

**Maintenance, Installation, and Repair Skills** (including but not limited to a basic knowledge of)

- Electrical/Electronic Systems
- Hydraulic/Pneumatic Systems
- Mechanical Power Transmission Systems
- Mechanical Systems
- Piping Operations

**Reliability and Maintainability**

- Analysis of Failure Data
- Basic Reliability Models
- Documentation Requirements
- Investigative Techniques



**4. Supply Chain Logistics: Plan and monitor the movement and storage of materials and products in coordination with suppliers, internal systems, and customers.**

**Critical Work Functions:**

- Ship and receive products and materials.
- Manage purchasing and just-in-time materials flow, shipping and receiving, packaging and transportation.
- Control inventory of materials and products.
- Develop and maintain production/delivery schedules and supplier networks.

**Technical Content Areas:**

**Automated Material Handling**

- Automated Material Handling and Distribution Systems
- Integrated Supply Chain Information Technology

**Awareness of Global Impacts**

- Customs and Export Control (Legal Aspects)
- Intellectual Property
- Shipping, Receiving, and Freight
- Taxes and Duties

**Detailed Scheduling and Planning**

- Detailed Material Planning
- Techniques of Inventory Management

**Executing Operations**

- Ergonomics
- Evaluating Performance
- Executing Plans and Implementing Controls
- Prioritizing and Sequencing Work
- Procurement and External Source of Supply
- Sharing and Collaboration Across the Supply Chain

**Managing Inventory**

- Expediting
- Inventory Forecasting
- Inventory Monitoring and Audits
- Ordering Materials and Supplies
- Stock Rotation Requirements

**Packaging and Distributing Product**

- Customs and Export Control (Basic Paperwork)
- Labeling Product- Inventory Tags and Bar Codes
- Packaging Product
- Transportation Methods
- Warehouse Management Systems

**Production Systems**

- Change Orders, Bills of Material, and Work Orders
- Lead and Cycle Time

**Resources Planning**

- Demand Management
- Master Scheduling
- Measuring Business Performance
- Sales and Operations Planning

**Supply-Chain Management**

- Centralized versus Decentralized Control
- Collaborative, Planning, Forecasting, and Replenishment
- Cost of Goods Sold (COGS) Real-Time
- E-Business and Direct Shipment
- Elements of the Supply Chain
- Just-in-Time/Lean Manufacturing
- Value Cost Analysis
- Manufacturing Resources Planning
- Vendor Managed Inventory Systems

**Work Flow**

- Lot Control
- Material Handling
- Plant Facility and Capacity
- Production Scheduling
- QA Release

**5. Quality Assurance: Ensure product and process meets quality system requirements as defined by customer specifications.****Critical Work Functions:**

- Understand and apply basic concepts associated with measuring quality.
- Implement controls to support quality management.
- Use process systems to ensure quality levels are maintained.
- Seek new approaches and techniques to improve quality levels.
- Employ audits and inspections to maintain the quality and continuous improvement process.
- Correct the product and process to meet quality standards.
- Support and maintain quality systems.

**Technical Content Areas****Corrective and Preventive Actions**

- Documentation Creation
- Eliminating Non-Conformities
- Verification and Documentation

**Improving Quality**

- Problem Solving Tools
- Sampling and Charting
- Statistical Process Control

**Quality Assurance**

- Industry Standards
- Meeting Customer Needs

- Quality Management Systems and Tools

**Quality Assurance Audits**

- Audit Procedures
- ISO 9000

**Statistical Process Control Methods**

- Acceptance Sampling
- Capability Analysis
- Factor Analysis
- Inspection/Test/Validation
- Reliability Analysis

**6. Health, Safety, Security, and Environment: Equipment, practices, and procedures which promote a healthy, safe, and secure work environment.**

**Critical Work Functions:**

- Understand and follow established personal safety, security, and environmental practices.
- Ensure that equipment is being used safely.
- Comply with local, federal and company health, safety, security, and environmental regulations.
- Identify unsafe or insecure conditions and take corrective action.
- Conduct health, safety, and/or environmental incident and hazard investigations.
- Conduct preventive health, safety, and/or environmental incident and hazard inspections.
- Implement continuous improvement in health, safety, security, and/or environmental practices.

**Technical Content Areas:**

**Continuous Improvement in Health, Safety, Security, and Environment**

- Analysis of Health/Safety/Security/Environmental Data
- Identification of Projects and Priorities
- Root Cause Analysis

**Environmental Protection/Waste Management**

- Chemical Hazard Assessment
- Design to Minimize Environmental Impact

**Investigations for Health, Safety, Security, or Environmental Incidences/Hazards**

- Developing Corrective Actions
- Documentation of Findings
- Follow-up Investigation
- Insurance (Property)
- Violations Reports to Proper Authorities
- Workers Compensation

**Personal Safety**

- Understanding and Following Established Safety Practices
- Safety Procedures for the Working Environment
- Use of Personal Protective Equipment and Clothing

**Preventive Health, Safety or Environmental Inspections**

- Audit of Records and Documentation
- Conducting Inspections

- Documentation of Inspection Findings
- Emergency Response Preparedness
- Fire Protection and Control

### **Regulations**

- Hazardous Material Communication (HAZCOM)
- Hazardous Material Handling and Disposal (HAZMAT)
- Hazardous Material Information System Labeling and Storage (HMIS)
- Office of Homeland Security System and Physical Security Regulations (US only)
- Regulations Governing Safe Use of Equipment
- Role of the Occupational Safety and Health Administration (OSHA), the Environmental Protection Administration (EPA) or Other Appropriate Regulatory Bodies in the Workplace (US only)
- Trade Compliance Department of Commerce (US only)

### **Standards**

- International Environmental Management Guidance (ISO14001)
- International Information Security Management Guidance (ISO27001)

### **Safety Procedures**

- Confined Spaces
- First Aid or First Response Procedures
- Assessing Material, Equipment and Fixtures for Hazards
- Lock /Tag Out Practices
- Material Safety Data Sheets (MSDS)
- Response to Shop Emergencies
- Safe Evacuation of Facility
- Safe Moving of Materials
- Safe, Prescribed Operation of Equipment and Tools
- Use, Maintenance and Inspection of Machine Safeguards
- Use of Safety Equipment

## Tier 5—Automation Technical Competencies

### 1. **Automation Fundamentals:** Systems, processes, applications, and standards supporting the design and application of automation.

#### **Critical Work Functions:**

- Understand the role of automation and control in industrial processes.
- Identify major application areas for automation technology and calculate the potential financial benefits of that automation.
- Integrate automation in various manufacturing, scientific, and technical applications.
- Abide by automation industry codes, standards, and regulations.
- Research and apply emerging and future automation technologies.

#### **Technical Content Areas:**

##### **Automation Types**

- Discrete (e.g. automotive, heavy equipment, aircraft, aerospace, consumer goods)
- Process (e.g. chemicals, refining, brewing, smelting, utilities, pharmaceutical manufacturing)
- Hybrid (e.g. food, beverage packaging, printing, consumer packaging, pharmaceutical packaging)
- Non-industrial applications (e.g. building automation, guidance systems, traffic control, test stands, and warehousing)

##### **Automation Project Phases**

- Conception
- Feasibility
- Definition
- System Design
- Project Planning
- Development
- Detail Design and Procurement
- Construction
- Start-up/Commissioning
- Testing and Validation
- Maintenance, Troubleshooting, and Repair

##### **Codes, Standards, and Regulations** (as applicable)

- American National Standards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
- International Society of Automation (ISA)
- International Electro-technical Commission (IEC)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Other Industry-specific Codes, Standards, and Regulations
- Other International Codes, Standards, and Regulations

## **2. Measurement and Actuation: The sensing, measurement, and actuation devices necessary for automation.**

### **Critical Work Functions:**

- Select, specify, and design the installation of devices to measure and analyze physical and chemical properties.
- Select, specify, and design the installation of devices to manipulate flows, energy, positions, speeds, and other variables.
- Design and install wired and/or wireless systems that reliably communicate information from these devices to and from control equipment.
- Calibrate, troubleshoot, test, repair, and improve sensing, measurement, and actuation devices.
- Document measurement and actuation devices and communications from these devices.

### **Technical Content Areas (including but not limited to):**

#### **Basic Process Instrumentation**

- Flow
- Level
- Pressure
- Temperature

#### **Specialized Process Instrumentation such as**

- Color
- Ion
- Moisture

#### **Analytical Instrumentation**

- Instrument Selection
- Sample Point Selection
- Sample Conditioning Systems
- Installation
- Maintenance

#### **High Performance Sensors such as**

- High Accuracy
- High Speed
- Specialized Technologies

#### **Other Measurements**

- Auto ID
- Discrete
- Position, speed, count
- Vision Systems
- Encoders

#### **Control Valves**

- Valve Types
- Valve Selection and Operation
- Standards and Codes
- Actuators and Accessories

**Actuation**

- Electric Actuation
- Hydraulic Actuation
- Pneumatic Actuation

**Electrical Installations**

- Electrical Installation Details
- Grounding
- Power
- Surge Suppressors
- Uninterruptible Power Systems (UPS)

**Motor and Drive Control**

- AC Motors
- DC Motors
- Speed and Torque Control
- Servos and Steppers

**3. Control: Ensuring predictable, stable, and consistent operation at target levels of performance with only normal variations.****Critical Work Functions:**

- Design, document, install, and maintain automation systems.
- Calibrate, troubleshoot, inspect, test, and repair automation systems.
- Efficiently supply reliable, quality power to automation systems.

**Technical Content Areas (including but not limited to):****Continuous and Process Control**

- Process Characteristics
- Feedback Control & Tuning
- Advanced Regulatory Control

**Discrete and Sequencing Control**

- Discrete/Sequential Control Concepts

**Batch Control**

- Control Activity Management
- Recipe Management
- Equipment Hierarchy Model

**Control Equipment**

- Distributed Control Systems: Hardware and Configuration
- Process Automation Controllers: Hardware, Architecture and Communications
- Programmable Logic Controllers: Hardware and Configuration
- SCADA Systems: Hardware, Architecture, and Communications

**Control System Documentation**

- Installation Details
- Instrument Lists
- Location Plans (Instrument Location Drawings)
- Logic Diagrams
- Loop Diagrams

- Operating Instructions
- Piping and Instrument Diagrams (P&ID)
- Process Flow Diagram (PFD)
- Specification Forms
- Standards and Regulations

#### **Advanced Control**

- Fuzzy Logic
- Multivariable Controls
- Model-based Control

#### **Virtual Plant**

- Actual Control System Configuration
- Advanced Control Tools
- Process Model

#### **Modeling and Simulation**

- Linear Dynamic Estimators
- Multivariate Statistical Process Control
- Artificial Neural Networks
- First Principle Models
- Techniques for Running Simulations

#### **Building Automation**

- Environmental Monitoring
- Heating Ventilation Air-Conditioning (HVAC)
- Security

#### **Motion Control**

- Controllers
- Motion Control System Design
- Performance

#### **Mechatronics**

- Computers and Logic Systems
- Physical System Modeling
- Product Classification
- Sensors and Actuators
- Signals and Systems
- Software and Data Acquisition

#### **Robotics**

##### **Robot Types**

- Articulated
- Delta
- Gantry
- Selective Compliant Assembly Robot Arm (SCARA)

##### **Programming Languages**

- C/C++
- G-Code (CNC)
- Visual Basic



- IEC – 61131
  - Instruction List
  - Ladder Diagram
  - Function block
  - Structured Text
  - Sequential Function Chart
- Electronic Device Description Language (EDDL)

**Visualization**

- Human Factors
- Machine Level Interfaces
- Mobile/Portable
- Operator Interface – Human Machine Interface (HMI)
- Enterprise Interfaces – Plant-wide Displays, Dashboards

**4. Communications, Integration, and Software: Databases, networks, and programming.**

**Critical Work Functions:**

- Design, document, install, and support the integration of automation systems with other systems.
- Design and operate databases for automation systems.
- Apply Manufacturing Operations Management Systems (MOM).

**Technical Content Areas:**

**Network Configuration**

- Cable (Wire and Fiber Optic) Networks
- Network Component Configuration
- Network Diagnostics
- Network Management
- Large Scale Sensor Wireless Networks
  - Mesh Network
  - Security Management
  - Network Access Points
  - Gateways
  - Wireless Device Setup

**Industrial Digital Field Protocols** (including but not limited to)

- AS-i
- DeviceNet
- Foundation Fieldbus
- HART
- INTERBUS
- Modbus
- PROFIBUS DP & PA

**Industrial Communication Protocols** (including but not limited to)

- BACnet
- Common Industrial Protocols

- ControlNet
- Ethernet-TCP/IP
- LonWorks
- Object-linked Embedding for Process Control (OPC)
- PROFINET

**Manufacturing Operations Management (MOM) and Business Integration**

- Manufacturing Execution Systems (MES)
- Detailed Production Scheduling
- Integration with Business Planning and Logistics
- Level 3 Equipment Hierarchy
- Level 3-4 Boundary
- Other Manufacturing Activities
- Production Operations Management
- Enterprise Asset Management

**Data Management**

- Data Documentation
- Data Contextualization (online / offline)
- Data Quality Issues
- Data Security
- Data Storage and Retrieval
- Database Operations and Maintenance
- Database Software
- Database Structure and Types
- Special Requirements of Real -Time Process Databases

**5. Process and Equipment Safety & Security: Automation system safety and reliability.**

**Critical Work Functions:**

- Analyze and determine the need for design changes or additional equipment to improve safety and security.
- Determine the appropriate tools and methods.
- Design, document, install, validate, periodically check, and maintain the safety equipment and systems.
- Design, document, install, validate, periodically check, and maintain the cybersecurity equipment and systems.
- Implement security of the automation systems.
- Apply instrumentation procedures in hazardous areas safely.

**Technical Content Areas:**

**Alarm Management**

- Alarm Management System
- HMI Design for Alarm Systems
- Key Components of an Alarm Philosophy
- Performance Metrics for Alarm Systems
- Products of Alarm Rationalization

**Reliability**

- Common Cause and Its Impact on Reliability

- Concepts of
  - Mean Time to Repair (MTTR)
  - Mean time to Failure (MTTF)
  - Mean Time Between Failures (MTBF)
- Safe and Dangerous Failure Modes
- Testing Intervals and Its Impact on Availability
- Types of Redundancy and How They Impact Dangerous and Safe Failure Modes

#### **Machine and Process Guarding**

- Concepts of Guarding
- Design Considerations
- Laws and Regulations
- Protection Levels
- Risk Analysis

#### **Manufacturing Safety: Process, Discrete, and Hybrid**

- Hazard and Risk Analysis including Hazard and Operability (HAZOP) Studies
- Safety Life Cycle
- Allocation of Safety Functions to Protective Layers
- Determination of Safety Integrity Levels
- Safety Requirements Specification
- Design and Engineering Issues and System Technologies
- Installation, Commissioning, and Validation
- Operations and Maintenance

#### **Safe Use and Application of Electrical Apparatus**

- Equipment for Use Where Explosive Concentrations of Gas, Vapor, or Dust Might be Present
- Installation Design for Hazardous Areas
- General Purpose Requirements

#### **Safety Controller Equipment**

- General Purpose Programmable Logic Controllers (PLCs)
- Safety PLCs
- Simplex, Duplex, and Quad Systems
- System Selection
- Diagnostic Annunciation
- Instrument Selection for Safety Systems
- Probabilistic Modeling of Sensors

#### **Cyber Security of the Automation System**

- Security Programs, Plans, and Policies
- System and Network Security Techniques
- User Support

**6. Sustainability:** Processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound. Sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs.

**Critical Work Functions:**

- Strive to minimize waste, improve efficiency, and reduce resource use.
- Operate with a triple bottom line, emphasizing financial profitability, environmental integrity, and corporate social responsibility.
- Understand life cycle analysis: the environmental and economic effects of a product at every stage of its existence, from extraction of materials through production to disposal and beyond.
- Suggest and/or implement continuous improvement actions.
- Abide by applicable federal, state, and local regulations and policies.
- Safeguard the public interest.
- Ensure equipment and systems are designed to minimize environmental impact.
- Seek to upgrade processes beyond pollution control to pollution prevention.
- Utilize advances in science and technology to upgrade levels of efficiency and environmental protection.
- Promote sustainable business practices consistent with ISO 14001 International Environmental Management Guidance.

**Technical Content Areas**

**Continuous Improvement**

- Benchmarking and Best Practice
- Business Process Reengineering
- Data Analysis
- Performance improvement strategies
- Systems Analysis

**Flexible Manufacturing**

- Product Grade and production
  - Automated Recipes
  - Automated Start-ups/Shutdowns
  - Automated Product Transitions
  - Plant-wide Feed-forward Control
- System Adaptation
  - Wireless
  - Modular
  - Plug and play

**Lean Manufacturing**

- Systems Approach/Engineering
- Virtualization of Automation Systems
- Model Based Manufacturing (Virtual Plant)

**Green Manufacturing**

- Resource Management
- Energy Management (WAGES – Water, Air, Gas, Electricity, Steam)

- Audit
  - Measure
  - Calculate
- Understand
  - Rate Structure
  - Time of Use
- Improve
  - Plant Utilities Control
- Co-Gen/Load Shedding
- Yield Optimization
  - Recovery Optimization
  - Process Reaction Optimization
  - Recycle Optimization
- Overall Equipment Effectiveness/Efficiency
- Advanced Process Control
  - Real Time Optimization
  - Model Predictive Control
  - Final Element Optimization (e.g. Valve Position Control)
  - Override Control
  - Supervisory Control
  - 4R's (Refuse, Reduce, Reuse, Recycle)
- Waste Treatment/Handling

#### **Expandable Manufacturing**

- Planning for the future

#### **Online Event Correlation**

- Yield Calculation
- Energy Efficiency
- Production Rate

## **Resources Reviewed**

- ***Automation Body of Knowledge***

ISA

<http://www.isa.org/Template.cfm?Section=Books3&template=/Ecommerce/ProductDisplay.cfm&ProductID=8800>

- ***Automation Control Systems Course Syllabus***

Chattanooga State Technical Community College

<http://river.chattanoogastate.edu/sacs/Syllabi/ET/mn226.pdf>

- ***Automation Engineering Technology Curriculum Standard***

North Carolina Community College System

[http://www.ncccs.cc.nc.us/Programs/docs/Curric\\_Standards/40/A40120%20Automation%20Eng%20Tech%20FA07.doc](http://www.ncccs.cc.nc.us/Programs/docs/Curric_Standards/40/A40120%20Automation%20Eng%20Tech%20FA07.doc)

- ***Automation Federation Workforce Development Policy***

Automation Federation

<http://www.automationfederation.org/automationfederation/2008-AF-Synopses.pdf>

- ***Automation, Robotics, and Controls/Instrumentation Austin Competency Analysis Profile***

Austin Community College

[http://irt.austincc.edu/ids/curriculum/PDFs/AutomationRoboticsControls\\_ACAP.pdf](http://irt.austincc.edu/ids/curriculum/PDFs/AutomationRoboticsControls_ACAP.pdf)

- ***Industrial Engineering Technicians Occupation Report***

O\*NET OnLine

<http://online.onetcenter.org/link/summary/17-3026.00>

- ***Industrial Instrumentation and Controls Technician Skill Standards***

Industrial Instrumentation and Controls Technology Alliance (IICTA)

<http://www.iicta.org/upload/IICTASkillStandardsBooklet.pdf>

- **Industrial Production Managers Occupation Report**  
O\*NET OnLine  
<http://online.onetcenter.org/link/details/11-3051.00>
  
- **The Influence of Manufacturing Facility Demographics on Manufacturing Competencies in North Carolina**  
Richard Temple, Western Carolina University  
<http://www.nait.org/jit/Articles/temple102903.pdf>
  
- **ISA Automation Engineering Degree Program**  
ISA  
[http://www.isa.org/Content/NavigationMenu/Products\\_and\\_Services/Certification3/CAP\\_Associate\\_Program/Model\\_Curriculum1/Model\\_Curriculum.htm](http://www.isa.org/Content/NavigationMenu/Products_and_Services/Certification3/CAP_Associate_Program/Model_Curriculum1/Model_Curriculum.htm)
  
- **ISA Career Library**  
ISA  
[http://www.isa.org/Content/NavigationMenu/General\\_Information/Careers/Career\\_Library1/Career\\_Library.htm](http://www.isa.org/Content/NavigationMenu/General_Information/Careers/Career_Library1/Career_Library.htm)
  
- **ISA Certified Automation Professional Body of Knowledge**  
ISA  
[http://www.isa.org/Content/NavigationMenu/Products\\_and\\_Services/Certification3/Certified\\_Automation\\_Professional1/Knowledge\\_and\\_Skills/Knowledge\\_and\\_Skills.htm](http://www.isa.org/Content/NavigationMenu/Products_and_Services/Certification3/Certified_Automation_Professional1/Knowledge_and_Skills/Knowledge_and_Skills.htm)
  
- **ISA Certified Control Systems Technician Body of Knowledge**  
ISA  
[http://www.isa.org/Template.cfm?Section=Certified\\_Control\\_Systems\\_Technician&Template=/Content/ContentGroups/MultiUse/performance\\_domains.htm](http://www.isa.org/Template.cfm?Section=Certified_Control_Systems_Technician&Template=/Content/ContentGroups/MultiUse/performance_domains.htm)
  
- **ISA Certified Industrial Mechanic Body of Knowledge**  
ISA  
[http://www.isa.org/Content/NavigationMenu/Products\\_and\\_Services/Certification3/Certified\\_Industrial\\_Maintenance\\_Mechanic1/Certified\\_Industrial\\_Maintenance\\_Mechanic.htm](http://www.isa.org/Content/NavigationMenu/Products_and_Services/Certification3/Certified_Industrial_Maintenance_Mechanic1/Certified_Industrial_Maintenance_Mechanic.htm)

- **ISA Control Systems Technician Associate Degree Program**

ISA

[http://www.isa.org/Content/NavigationMenu/Products and Services/Certification3/CST in Training2/Model\\_Curriculum/Model\\_Curriculum.htm](http://www.isa.org/Content/NavigationMenu/Products_and_Services/Certification3/CST_in_Training2/Model_Curriculum/Model_Curriculum.htm)

- **ISA Education and Training**

ISA

[http://www.isa.org/Content/NavigationMenu/Products and Services/Education and Training 1/Education\\_and\\_Training1.htm](http://www.isa.org/Content/NavigationMenu/Products_and_Services/Education_and_Training1/Education_and_Training1.htm)

- **ISA Standards**

ISA

<http://www.isa.org/Template.cfm?Section=Committees3&Template=/CommitteeList.cfm&CommitteeTypeID=4>

- **ISA Training Catalog**

ISA

[http://www.isa.org/Template.cfm?Section=Find\\_Training&Template=/Calendar/InstructorTrainingSearch.cfm](http://www.isa.org/Template.cfm?Section=Find_Training&Template=/Calendar/InstructorTrainingSearch.cfm)

- **Manufacturing/Automation Skill Standards**

Texas Skill Standards Board

<http://www.tssb.org/sites/default/files/wwwpages/repos/iict/iict.pdf>

- **Robotics and Automation Technology Vocational Technical Education Framework**

Massachusetts Department of Education

[http://www.doe.mass.edu/cte/frameworks/robotics\\_automationtech.pdf](http://www.doe.mass.edu/cte/frameworks/robotics_automationtech.pdf)

- **Society of Manufacturing Engineers Certifications**

Society of Manufacturing Engineers

<http://www.sme.org/cgi-bin/certhtml.pl?/cert/certification.html&&SME&>



## University and College Programs

- **Associate of Applied Science in Instrumentation Technology**  
Texas State Technical College  
[http://www.waco.tstc.edu/icr/icr\\_aas\\_ccs/curriculum.php](http://www.waco.tstc.edu/icr/icr_aas_ccs/curriculum.php)
- **Associate of Applied Science in Robotics and Automation**  
Western Iowa Technical Community College  
[http://www.witcc.edu/AdvManufacturing/credit\\_requirements.cfm?id=214](http://www.witcc.edu/AdvManufacturing/credit_requirements.cfm?id=214)
- **Automated Controls Option in Electrical/Electronic(s) Engineering Technology (AAS)\***  
Chattanooga State Technical Community College  
<http://www.chattanoogastate.edu/engineering/enelect2.html>
- **Automation Programs**  
Rochester Institute of Technology  
<http://www.rit.edu/programs/automation-technologies-aos>
- **Control and Instrumentation Electronics Design Option in Engineering Technology (BS)\***  
University of Houston–Downtown  
<http://www.uhd.edu/academic/colleges/sciences/engtech/ciet/>
- **Engineering, Engineering Technology, and Manufacturing Programs**  
Lorain County Community College  
<http://www.lorainccc.edu/Academic+Programs/Associates+Degree+and+Certificate+Programs/Engineering-Manufacturing.htm>
- **Engineering Technology Concentration in Instrumentation (AS and BS)\***  
McNeese State University  
<http://www.mcneese.edu/academics/technology>

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\* ABET accredited.

- ***Instrumentation Programs***

Lee College

<http://www.lee.edu/technicalstudies/instrumentation/index.asp>

- ***Manufacturing Systems Engineering Programs***

California State University, Northridge

<http://www.csun.edu/anr/plans/2010/4year/mse.html>

- ***Mechatronics Programs***

University of North Carolina, Asheville

[http://www.unca.edu/ncsu\\_engr/index\\_jem.html](http://www.unca.edu/ncsu_engr/index_jem.html)