



ENERGY SYSTEMS 47.0701.00

TECHNICAL STANDARDS

An Industry Standards Validation Committee developed and approved these standards on April 9 and 16, 2024. The Arizona Career and Technical Education Quality Commission, the validating authority for the Arizona Technical Skills Assessment System, endorsed these technical standards on July 14, 2024.

Note: Arizona's Professional Skills are taught as an integral part of the Energy Systems program.

The Technical Skills Assessment for Energy Systems To Be Determined.

Note: In this document i.e. explains or clarifies the content and e.g. provides examples of the content that must be taught.

STANDARD 1.0 ANALYZE THE FUNDAMENTALS OF ELECTRICITY

- 1.1 Explore the history of electricity (e.g., electricity in the early days, electricity in the modern era, and electricity in the future)
- 1.2 Identify different sources of electricity (i.e., in fossil fuels, renewable energy, mainly hydroelectric, nuclear power, etc.)
- 1.3 Identify the basic units of measurement for electricity (e.g., current, voltage, resistance, and watt)
- 1.4 Explain Kirchhoff's Circuit Law to analyze electrical circuits in series and parallel
- 1.5 Examine AC/DC power concepts and practical applications (e.g., U.S. grid system and microgrid systems)
- 1.6 Define the U.S. grid system and explain the flow of power from the point of generation to the point of consumption
- 1.7 Explain grid operations, including load balancing, frequency regulation, and voltage control
- 1.8 Identify types of energy storage systems and their applications (e.g., batteries, pumped hydro, flywheels, hydrogen, and compressed air)
- 1.9 Identify energy distribution networks, including microgrids and distributed energy resources (DERs)

STANDARD 2.0 INVESTIGATE THE ENERGY INDUSTRY

- 2.1 Define the energy industry (e.g., organizations engaged in activities or processes related to the generation, supply, and sale of energy, including entities that explore energy sources, refine fuel sources, store energy, distribute energy, market energy, and regulate energy systems)
- 2.2 Distinguish between nonrenewable energy sources (e.g., petroleum, natural gas, coal, and nuclear power) and renewable energy sources (e.g. wind power, solar power, hydropower, and biofuels)
- 2.3 Explore the economics of power generation, transmission, and distribution (i.e., methods of converting energy into electricity, how electricity is transmitted and distributed, etc.)
- 2.4 Explore the development of alternative energy and power generation and the integration of alternative energy to the current U.S. power grid and the future of the smart grid technologies
- 2.5 Give examples of the impact of energy production on the economy and the environment (e.g., biofuels, nuclear power, solar power, and wind power)
- 2.6 Describe work performed by the energy system's operator/technician (e.g., assembling, installing, operating, maintaining, and repairing energy systems and installing, operating, maintaining, and repairing energy systems)
- 2.7 Discuss in-demand skills needed by the energy systems operator/technician (i.e., knowledge of engineering science and technology, math knowledge, knowledge of building and construction, ability to problem-solve, cross-team collaboration, motivation and perseverance, analytical thinking skills, etc.)
- 2.8 Describe education and training opportunities for career pathways in the energy industry (i.e., apprenticeships, on-the-job training, university courses, graduate majors in energy engineering, energy management, energy policy, renewable energy, or sustainable energy, etc.)
- 2.9 Explore the environmental impacts of power generation, transmission, and distribution

STANDARD 3.0 DEMONSTRATE WORKPLACE SAFETY AND GOOD HEALTH PRACTICES

- 3.1 Describe OSHA and other state and national programs designed to reduce safety risks and workplace injuries [i.e., safety protocols, training requirements, electronic record-keeping, fall protection guidelines, proper use of respiratory protection, proper clothing and grooming, the HazCom program (labels and SDSs), etc.]
- 3.2 Select and describe the use and care of personal protective equipment (PPE) in various work situations
- 3.3 Demonstrate proper procedures and techniques when lifting, handling, transporting, and unloading materials manually or when using motorized equipment

Note: In this document i.e. explains or clarifies the content and e.g. provides examples of the content that must be taught.

- 3.4 Identify common hazards that can lead to serious accidents or injuries in the workplace (i.e., unsafe practices, unsafe acts, unsafe conditions, etc.)
- 3.5 Describe safety precautions for heat-related illnesses (e.g., heat stress, heat stroke, and heat exhaustion)
- 3.6 Discuss electrical safety standards and electrical procedures to maintain electrical equipment
- 3.7 Discuss safety practices related to mechanical systems and equipment
- 3.8 Discuss safety practices related to fluid-controlled systems and equipment
- 3.9 Identify methods used to establish work zone safety (i.e., danger signs, caution signs, information signs, safety instruction signs, barricades and barriers, etc.)
- 3.10 Describe safety precautions associated with various work areas (e.g., confined spaces, underground work, lockout/tagout procedure, hazmat, and jobsite safeguards and emergency response procedures)
- 3.11 Discuss the safety practices related to hazardous materials and their disposal
- 3.12 Discuss best practices for maintaining a clean work area (e.g., six sigma 5s)
- 3.13 Discuss best practices and legal requirements for routine maintenance and safety checks (i.e., fall protection gear recertification every 6 months, etc.)

STANDARD 4.0 APPLY MATH SKILLS TO ENERGY SYSTEMS

- 4.1 Demonstrate math operations with whole numbers, fractions, and decimals
- 4.2 Use tables of weights and measurements and convert units of length, weight, volume, and temperature using the English and Metric systems of measurement
- 4.3 Apply Ohm's Law to calculate voltage, amperage, and resistance
- 4.4 Apply Kirchhoff's Laws to analyze simple circuits
- 4.5 Identify and use layout and measuring tools (i.e., rulers, tapes, calipers, dividers, gauges, etc.)
- 4.6 Identify angles, distances, and geometric shapes and calculate their area and volume
- 4.7 Use formulas to solve basic problems (i.e., Pythagorean theorem, Kirchhoff's Laws, Ohm's Law, etc.)
- 4.8 Perform calculations using basic trigonometric functions (i.e., sine and cosine)

STANDARD 5.0 READ AND INTERPRET DRAWINGS, SCHEMATICS, AND TECHNICAL DOCUMENTS

- 5.1 Identify types of technical drawings (e.g., civil drawings, architectural drawings, structural drawings, mechanical systems drawings and schematics, electrical drawings, and plumbing drawings)
- 5.2 Identify and describe technical drawing components (i.e., lines, grid lines, symbols, dimensions, construction, tolerances, etc.)
- 5.3 Interpret mechanical drawings and electrical schematics
- 5.4 Diagram simple electrical circuits (e.g., series and parallel)
- 5.5 Read and interpret technical manuals providing instruction for installation, operation, and maintenance (e.g., instruction manuals, spec sheets, and manufacturer's guidelines)
- 5.6 Read and interpret documents outlining safety procedures, precautions, and protective measures

STANDARD 6.0 USE TOOLS AND EQUIPMENT TO ASSEMBLE, INSTALL, OPERATE, AND REPAIR ENERGY SYSTEMS

- 6.1 Identify, select, and properly use common hand tools (i.e., hammers, chisels and punches, screwdrivers, wrenches, pliers and wire cutters, utility knives, come-alongs, clamps, etc.)
- 6.2 Identify, select, and safely use energy system-specific tools (i.e., crimper, wire nuts, lever nuts, cam-locks, etc.)
- 6.3 Identify, select, and properly use common power tools (i.e., drills and bits, hammer drill, pneumatic drills and impact wrenches, saber and reciprocating saws, portable band saw, grinders, pneumatic fastening tools, etc.)
- 6.4 Select and install common fasteners and anchors (i.e., threaded and non-threaded fasteners, anchors; screws, bolts, nuts, rivets, washers, etc.)
- 6.5 Set up, adjust, shut down, and disassemble soldering equipment
- 6.6 Use multimeters to measure electrical circuits (e.g., continuity, amperage, resistance, and voltage)

STANDARD 7.0 EXPLAIN COMMON TESTING FOR COMPONENTS AND SYSTEMS

- 7.1 Identify and explain types of pretests and tests (e.g., service and flow tests, head pressure tests, hydrostatic tests, and steam blow tests)

Note: In this document i.e. explains or clarifies the content and e.g. provides examples of the content that must be taught.

- 7.2 Explain nondestructive examinations (NDEs) used to inspect and evaluate materials, components, or assemblies without destroying their serviceability
- 7.3 Identify and explain the operation of common test equipment (e.g., tachometer, pyrometers, multimeters, automated diagnostics tools, Wiggly voltage tester, and stroboscope)
- 7.4 Read and convert from one scale to another using the test equipment
- 7.5 Define frequency and explain the use of a frequency meter

STANDARD 8.0 ANALYZE THE USE OF PUMPS AND VALVES IN ENERGY SYSTEMS

- 8.1 Identify various pump types (e.g., centrifugal pumps, rotary pumps, reciprocating pumps, metering pumps, and vacuum pumps)
- 8.2 Explain the functions of impellers, seals, volute casings, flow gauges, and pump motors
- 8.3 Identify types of pump gauges (e.g., pressure gauges, vacuum gauges, and mechanical pressure gauges)
- 8.4 Identify various types of valves (e.g., globe valves, butterfly valves, wafer valves, weir valves, needle valves, and ball valves)
- 8.5 Identify valve parts (e.g., stem, actuator yoke, packing box, bonnet, cage, seat ring, plug, and body and gaskets)
- 8.6 Apply principles of proper pump and valve selection for specific applications (e.g., to determine fluid types, temperatures, viscosity, gravity, capacity of flow, system pressure, and pressure drop)
- 8.7 Discuss safe and efficient maintenance procedures for pumps and valves (e.g., disassemble, inspect and evaluate, reassemble, and employ maintenance)
- 8.8 Identify common types of tubing, hose, piping, gaskets, and fittings and explain their applications
- 8.9 Differentiate manual, pneumatic, and hydraulic operational methods
- 8.10 Describe how to connect gauges for intake and discharge

STANDARD 9.0 ANALYZE HYDRAULIC SYSTEMS

- 9.1 Give examples of common applications of hydraulic systems
- 9.2 Identify principles of hydraulics (e.g., pressure, force, and area)
- 9.3 Identify components of a hydraulic system [e.g., reservoir, pump, valve(s), and actuator(s) motor, and cylinder]
- 9.4 Identify problems related to hydraulic systems (i.e., noise, elevated temperature, slow or erratic operation, etc.)
- 9.5 Identify common causes of hydraulic problems (i.e., air and water contamination, fluid level, temperature issues, valve failure, system leaks, etc.)
- 9.6 Perform hydraulics calculation (e.g., force, piston area, pipe requirements, horsepower and torque, and velocity and flow)
- 9.7 Explain NPSHR, NPSHA, and efficiency curves
- 9.8 Describe how to install hydraulic systems and protective devices

STANDARD 10.0 ANALYZE PNEUMATIC SYSTEMS

- 10.1 Explain a pneumatic system and how it works
- 10.2 Explain the physical characteristics of gases
- 10.3 Explain compressing gases
- 10.4 Explain the pneumatic transmission of energy
- 10.5 Explain the principles of compressor operation
- 10.6 Explain compressed-air treatment
- 10.7 Identify and explain pneumatic system components and symbols
- 10.8 Explain pneumatic system safety

STANDARD 11.0 CONDUCT ELECTRICAL MAINTENANCE

- 11.1 Explain fundamental theories related to heat exchange in electrical systems
- 11.2 Identify types of conduit
- 11.3 Explain the difference between conductors and insulators
- 11.4 Explain basic characteristics of series and parallel circuits
- 11.5 Dismantle and reassemble simple circuits
- 11.6 Identify electricity maintenance tasks (i.e., install wiring, check power plugs and cables, repair or replace damaged equipment, inspect electrical systems for safety, etc.)
- 11.7 Identify electrical equipment (e.g., control panels, electrical control systems motors, and motors to perform repairs, installations, and maintenance)

Note: In this document i.e. explains or clarifies the content and e.g. provides examples of the content that must be taught.

- 11.8 Identify electrical tools test instruments (i.e., battery testers, voltage tracers, outlet testers, multimeters, oscilloscope, etc.)
- 11.9 Maintain and properly store electrical tools (i.e., cool down heated tools, clean regularly, lubricate, sharpen bits and blades, calibrate, replace worn parts, battery care. etc.)
- 11.10 Review the National Electric Code (e.g., NFPA 70)

STANDARD 12.0 INVESTIGATE MATERIALS HANDLING AND HAND RIGGING EQUIPMENT

- 12.1 Explain OSHA's standards pertaining to materials handling and storage
- 12.2 Identify common types of materials handling (i.e., manual material handling, mechanical material handling, automated material handling. etc.)
- 12.3 Identify and describe uses for materials handling equipment [i.e., jacks, block and tackle, chain hoists, come-alongs (wire rope hand ratchet puller), etc.]
- 12.4 Explain the operation and applications of motor-driven equipment (i.e., portable generators, air compressors, aerial lifts, forklifts, mobile cranes, etc.)
- 12.5 Compare types, properties, and classifications of lubricants
- 12.6 Read and interpret a lubrication chart
- 12.7 Read and interpret a safety data sheet (SDS) pertaining to lubrication
- 12.8 Explain the EPA hazardous waste control program