

IDAHO ELECTRICAL APPRENTICESHIP YEAR 1 PROGRAM STANDARDS

2016

Approved by the State
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CONTENT STANDARD 1.0: INTRODUCTION TO ELECTRICAL WORK SAFETY

Performance Standard 1.1: General Safety

- 1.1.1 Explain what a material safety data sheet (MSDS/SDS) is and its requirements.
- 1.1.2 Explain safety procedures for trenches.
- 1.1.3 Explain safety for confined space.
- 1.1.4 Explain lockout and tagout.
- 1.1.5 Explain protective clothing to include eye and hearing protection.
- 1.1.6 Explain the use of a safety harness.
- 1.1.7 Explain safety for ladders and scaffolds.
- 1.1.8 State the purpose of arc-fault and ground-fault circuit interrupters.
- 1.1.9 Identify safety handling and use of hand and power tools.

CONTENT STANDARD 2.0: ELECTRICAL THEORY

Performance Standard 2.1: Electrical Qualities and Ohm's Law

- 2.1.1 Explain the structure of the atom.
- 2.1.2 Explain electron flow.
- 2.1.3 State the difference between insulators and conductors.
- 2.1.4 Explain the basic methods of producing electricity.
- 2.1.5 Describe electrical effects such as magnetism, light, and heat.
- 2.1.6 Define a coulomb.
- 2.1.7 Define an ampere.
- 2.1.8 Define an ohm.
- 2.1.9 Define a watt.
- 2.1.10 Determine the resistance of a resistor using the color code or an ohmmeter.
- 2.1.11 Determine whether a resistor is operating within its power rating.
- 2.1.12 Calculate different electrical values using Ohm's law.
- 2.1.13 Select the proper Ohm's law formula from a chart.

Performance Standard 2.2: Static Electricity and Magnetism

- 2.2.1 Discuss the nature of static electricity.
- 2.2.2 Discuss lightning protection.
- 2.2.3 Give examples of both nuisance and useful static charges.
- 2.2.4 Discuss the properties of permanent magnets.
- 2.2.5 Discuss the operation of electromagnets.
- 2.2.6 Determine the polarity of an electromagnet when the direction of the current is known.

CONTENT STANDARD 3.0: ELECTRICAL CIRCUITS

Performance Standard 3.1: Series

- 3.1.1 Discuss the properties of series circuits.
- 3.1.2 List three rules for solving electrical values of series circuits.

3.1.3 Calculate values of voltage, current, resistance, and power for series circuits.

Performance Standard 3.2: Parallel

3.2.1 Discuss the characteristics of parallel circuits.

3.2.2 State three rules for solving electrical values of parallel circuits.

3.2.3 Solve the missing values in a parallel circuit using the three rules and Ohm's law.

3.2.4 Calculate current values using the current divider formula.

Performance Standard 3.3: Combination

3.3.1 Define a combination circuit.

3.3.2 List the rules for parallel circuits.

3.3.3 List the rules for series circuits.

3.3.4 Solve combination circuits using the rules for parallel circuits, rules for series circuits, and Ohm's law.

CONTENT STANDARD 4.0: TOOLS

Performance Standard 4.1: Electrical Testing Equipment

4.1.1 Identify the use of Category I through Category IV meters.

4.1.2 Use an ohmmeter and measure any resistance in electrical equipment or conductor.

4.1.3 Measure voltage between phases and phase to ground.

4.1.4 Take an ampere reading of any load.

4.1.5 Diagram the proper connection of a watt meter.

4.1.6 State the operation characteristics of analog and digital meters.

4.1.7 Recognize the wave form on an oscilloscope.

Performance Standard 4.2: Bending Conduit

4.2.1 Identify the parts of tools used for bending.

4.2.2 Identify the methods and tools used in bending raceways.

4.2.3 Define and identify saddle, offset, concentric, and 90-degree bends.

CONTENT STANDARD 5.0: INTRODUCTION TO THE NATIONAL ELECTRICAL CODE (NEC)

Performance Standard 5.1: NEC Articles 90, 100, and 110

5.1.1 Understand how the NEC began and its purpose.

5.1.2 Understand how changes to the code evolve.

5.1.3 Understand the terminology, and format of the NEC.

5.1.4 State the roles of nationally recognized testing laboratories, the National Electrical Manufacturers Association, and the National Fire Protection Association.

5.1.5 Accurately evaluate a location as accessible, readily accessible, or not readily accessible.

5.1.6 Identify equipment classified as appliances.

5.1.7 State the four categories of branch circuits.

5.1.8 State the difference between a continuous load and a non-continuous load.

5.1.9 Determine minimum vertical clearances for each installation using the NEC.

- 5.1.10 Apply dedicated space requirements to electrical equipment to include the area that is to be clear of foreign systems unless protection is provided.
- 5.1.11 Determine the working clearances of any installation using the NEC.
- 5.1.12 State the difference between a branch circuit and a feeder.
- 5.1.13 State the difference between “grounded” and “grounding” as it applies to a conductor.
- 5.1.14 Define what “in sight” means in the NEC.
- 5.1.15 Give examples of damp, wet, and dry locations using the code book.
- 5.1.16 Determine which conductors are the neutral conductors.
- 5.1.17 Define a separately derived system using the NEC.

**Performance Standard 5.2: Boxes and Enclosures--NEC Articles 312, 314, and other
Appropriate NEC Sections**

- 5.2.1 Determine the cubic inch capacity of boxes when installing conductors # 6 AWG and smaller.
- 5.2.2 State which items use volume allowances of conductor fill when calculating box fill.
- 5.2.3 State how identical switches or receptacles can be mounted side by side, in a two gang box, can have different cubic inch volume allowances.
- 5.2.4 Determine the box size when the number of conductors is known.
- 5.2.5 Know the minimum conductor length to be left inside a box.
- 5.2.6 Explain what must be accessible after installation.
- 5.2.7 State the mounting and supporting provisions for boxes and conduit bodies using the NEC.
- 5.2.8 Determine the type of box needed for various applications using the NEC.
- 5.2.9 Calculate for junction box sizing containing #4 AWG and larger conductors using the NEC

**Performance Standard 5.3: Cables--NEC Articles 320 through 340, and other
appropriate NEC sections**

- 5.3.1 State the distance from the edge of the wood framing member a cable can be installed unless a steel plate is installed.
- 5.3.2 State the requirements for protection of cable in metal framing using the NEC.
- 5.3.3 State the sealing requirements in fire-resistant-rated construction when electrical penetrations are made.
- 5.3.4 Identify what cables are permitted in spaces used for environmental air.
- 5.3.5 Determine the support requirements for MC, AC, and nonmetallic-sheathed cable using the NEC.
- 5.3.6 Identify the conductors in a cable and use the NEC to state how certain conductors can be re-identified.
- 5.3.7 Determine underground installation provisions per the NEC.
- 5.3.8 Identify special application cables using the NEC (This is not to be for installation requirements as this is for first year students).

**Performance Standard 5.4: Raceways and Conductors--NEC Sections 11.14, 240.4,
300.19; NEC Articles 310, 342 through 378; Chapter 9 Tables; Annex C, and other**

appropriate NEC Sections

- 5.4.1 Determine the general provisions for any raceway installation using the NEC.
- 5.4.2 Determine the type of raceways suited for individual installations.
- 5.4.3 Determine the support requirements for various raceways using the NEC.
- 5.4.4 Determine the provisions for nonmetallic and metallic flexible conduit using the NEC.
- 5.4.5 Calculate the electrical trade size conduit required for any circuit or feeder.
- 5.4.6 Determine basic conductor properties using the NEC.
- 5.4.7 Show conductor temperature limitations.
- 5.4.8 Determine the provisions for conductors connected in parallel.
- 5.4.9 Apply conductor ampacity correction factors to include continuous loads.

**Performance Standard 5.5: General Provisions for One-Family Dwellings--NEC
Articles 210, 220, 240, 250, 315, 402, 404, 406, 410, 422, and other appropriate NEC
Sections**

- 5.5.1 Calculate the minimum number of 15 and 20 amp branch circuits in a one-family dwelling.
- 5.5.2 Determine the requirements for single receptacles on individual branch circuits.
- 5.5.3 Determine the branch-circuit ratings allowed for general-purpose receptacles.
- 5.5.4 Demonstrate the layout of general-purpose receptacles in a dwelling.
- 5.5.5 Determine the receptacle rating allowed on various size branch circuits using the NEC.
- 5.5.6 Determine the requirements for receptacles around sink areas using the NEC.
- 5.5.7 Determine the requirements for lighting and switching using the NEC.
- 5.5.8 Determine how and when to use the white conductor as an ungrounded conductor.
- 5.5.9 Determine any general requirement for boxes using the NEC.
- 5.5.10 Determine any illumination requirement for entrances and exits.
- 5.5.11 Determine the allowable use of vegetation such as trees for the mounting of outlets.

**Performance Standard 5.6: Specific Provisions for One-Family Dwellings--NEC
Articles 210, 410, 422, and other appropriate NEC sections**

- 5.6.1 Determine the required ampere rating for any receptacle or branch circuit in kitchens, pantries, dining rooms, breakfast rooms, and similar locations.
- 5.6.2 Determine the requirements for countertop receptacle placement using the NEC.
- 5.6.3 State the minimum number of small appliance branch circuits required and their application.
- 5.6.4 Determine the requirements for appliances both cord and plug and permanently connected.
- 5.6.5 Calculate the load requirements for appliance branch circuits.
- 5.6.6 State the specific provisions for GFCI placement.
- 5.6.7 Identify luminaires permitted in closets and its placement.
- 5.6.8 Define a bathroom by the NEC and discuss the circuit requirements for receptacles, lights and fans.

- 5.6.9 Determine the requirements for receptacles and lighting in attached garages, detached garages, and basements.
- 5.6.10 Determine the requirements for laundry rooms to include the clothes dryer.
- 5.6.11 Determine the lighting and receptacle requirements for attic, crawl space, and HVAC equipment.

Performance Standard 5.7: Load Calculations for One-Family Dwellings--NEC Articles, 210, 220, 230, 250, 310, and other appropriate NEC sections

- 5.7.1 Calculate the general lighting for a one-family dwelling.
- 5.7.2 Specify the volt-amp requirements for small appliance and laundry branch circuits.
- 5.7.3 Apply demand factors to the general lighting load.
- 5.7.4 Apply demand factors to fastened-in-place appliances.
- 5.7.5 Calculate feeder demand loads for household clothes dryers.
- 5.7.6 Calculate feeder demand loads for household cooking equipment.
- 5.7.7 Calculate feeder demand loads for HVAC equipment.
- 5.7.8 Calculate a one-family dwelling or feeder using the standard method.
- 5.7.9 Calculate a one-family dwelling or feeder using the optional method.
- 5.7.10 Calculate service and feeder conductors.
- 5.7.11 Calculate the minimum size neutral conductor.
- 5.7.12 Select the proper grounding electrode conductor.

Performance Standard 5.8: Services and Electrical Equipment for One-Family Dwellings--NEC Articles 110, 225, 230, 240, 250, 300, 310, and other appropriate NEC sections

- 5.8.1 Determine adequate strength for a mast supporting service-drop conductors.
- 5.8.2 Explain the use of service-entrance cable.
- 5.8.3 Define a service lateral and underground service conductors, and explain their provisions.
- 5.8.4 Determine clearances for service and outside overhead wiring.
- 5.8.5 Determine work space required for electrical equipment, services, and panels.
- 5.8.6 Define a panelboard, an enclosure, and a cutout box.
- 5.8.7 Determine the proper application and use of circuit breakers and fuses using the NEC.
- 5.8.8 Determine the appropriate conductor sizing using 310.15(B)(7) or Table 310.15 (B)(16).
- 5.8.9 Size the grounding electrode conductor, equipment grounding conductor, main bonding jumper, bonding jumpers on the supply side or load side of the main breaker or fuse on any one-family dwelling service.
- 5.8.10 Properly install grounded and grounding conductors in subpanels.
- 5.8.11 Prevent objectionable current flow in grounding conductors and equipment.
- 5.8.12 Properly install a panelboard in a separate building or structure.

Performance Standard 5.9: Comprehensive Provisions for Multi-Family Dwellings--NEC Articles 210, 230, 240, 250, 310, Chapter 9, Tables 8 and 9, and other

appropriate NEC sections

- 5.9.1 Determine when more than one service can be installed on a multifamily building.
- 5.9.2 Determine the proper number of disconnects allowed on a service.
- 5.9.3 Determine proper access to a unit's disconnecting means by any occupant.
- 5.9.4 Properly install the grounding electrode conductors to the grounding electrode.
- 5.9.5 Determine the appropriate service or feeder conductor sizing using 310.15(B)(7) or Table 310.15 (B)(16) Determine outdoor receptacle placement.
- 5.9.6 Calculate voltage-drop.

Performance Standard 5.10: General Provisions for Commercial Locations--NEC Articles 210, 220, 310, 410, 430, 440, 600, and other appropriate NEC sections

- 5.10.1 Compare receptacle placement with that of one-family dwellings to show the difference.
- 5.10.2 Determine the receptacle requirements in a commercial bathroom.
- 5.10.3 Determine the sign outlet requirements in a commercial installation.
- 5.10.4 Determine the branch circuit requirements for motors and HVAC equipment.
- 5.10.5 Determine the volt-amp ratings for receptacles (single, duplex, quad, etc.).
- 5.10.6 Determine the maximum number of receptacles permitted on a 15 amp or 20 amp circuit.
- 5.10.7 Identify the NEC accessibility requirements for receptacles in guest rooms of hotels and motels.
- 5.10.8 Determine NEC requirements for showcase and show window.
- 5.10.9 Calculate general lighting load based on square-foot area.
- 5.10.10 Determine the provisions for fluorescent, HID, recessed, LED, and track lighting provisions.
- 5.10.11 Determine the proper use and restrictions when using luminaires as raceways.
- 5.10.12 Determine handhole access requirements.

Performance Standard 5.11: Provisions for Services, Feeders, and Provisions for Commercial Locations--NEC Articles 110, 215, 230, 250, 368, 408, and other appropriate NEC sections

- 5.11.1 Properly install both grounding and grounded conductors on the line side and load side of the service supply conductors.
- 5.11.2 Determine the conditions that require ground-fault protection of equipment.
- 5.11.3 Recognize separately derived systems.
- 5.11.4 Explain how to properly ground and bond separately derived systems.
- 5.11.5 Recognize and explain the use of busways.

CONTENT STANDARD 6.0: SPECIAL OCCUPANCIES

Performance Standard 6.1: Hazardous Locations--NEC Articles 500 through 516

- 6.1.1 Explain what a hazardous location is.
- 6.1.2 Determine if a classified location is Class I, II or III and if it is Division 1 or 2 using the NEC.
- 6.1.3 Identify the NEC requirements pertaining to commercial garages and repair and storage facilities.

- 6.1.4 Identify the NEC requirements for buildings in which aircraft are stored and repaired.
- 6.1.5 Identify the NEC requirements for a motor fuel dispensing facility.

Performance Standard 6.2: Health Care--NEC Articles 500 through 517

- 6.2.1 Identify basic health care terminology used in NEC.
- 6.2.2 Determine the grounding and bonding requirements of any health care facility.
- 6.2.3 Identify patient care areas as general care or critical care and their branch circuit requirements.
- 6.2.4 Determine the tamper-resistant requirements of pediatric facilities.
- 6.2.5 Define the types of essential systems.

Performance Standard 6.3: Other Special Occupancies--NEC Articles 518 through 551

- 6.3.1 Define “places of assembly” according to the NEC.
- 6.3.2 Determine manufactured building requirements.
- 6.3.3 Determine agricultural building requirements.
- 6.3.4 Determine requirements for mobile home parks and recreational vehicle parks.

CONTENT STANDARD 1.0: ELECTRICAL MATHEMATICS

Performance Standard 1.1: Basic Trigonometry

- 1.1.1 Define a right triangle.
- 1.1.2 Use the Pythagorean theorem to solve problems concerning right triangles.
- 1.1.3 Solve problems using sines, cosines, and tangents.

CONTENT STANDARD 2.0: ALTERNATING CURRENT

Performance Standard 2.1: Circuits

- 2.1.1 Discuss the difference between AC and DC.
- 2.1.2 Compute instantaneous values of voltage and current for a sine wave.
- 2.1.3 Compute peak, RMS, and average values of voltage and current.
- 2.1.4 Define the phase relationship of voltage and current in a pure resistive circuit.
- 2.1.5 Identify half-wave and full-wave rectifiers.

Performance Standard 2.2: Inductance in AC Circuits

- 2.2.1 Define the properties of inductance in an AC circuit.
- 2.2.2 Define inductive reactance.
- 2.2.3 Calculate the values of inductive reactance and inductance.
- 2.2.4 Define the relationship of voltage and current in a pure inductive circuit.
- 2.2.5 Calculate values for inductors connected in series and parallel.
- 2.2.6 Define reactive power.
- 2.2.7 Define the Q of a coil.

Performance Standard 2.3: Resistive-Inductive Series Circuits

- 2.3.1 Define the relationship of resistance and inductance in an AC circuit.
- 2.3.2 Define power factor.
- 2.3.3 Calculate the values of voltage, current, apparent power, true power, reactive power, impedance, resistance, inductive reactance, and power factor in an RL series circuit.
- 2.3.4 Calculate the phase angle for current and voltage in an RL circuit.

Performance Standard 2.4: Resistive-Inductive Parallel Circuits

- 2.4.1 Define the operation of a parallel circuit containing resistance and inductance.
- 2.4.2 Calculate the values of voltage, current, apparent power, true power, reactive power, impedance, resistance, inductive reactance, and power factor in an RL parallel circuit.
- 2.4.3 Calculate the phase angle for current and voltage in an RL parallel circuit.

Performance Standard 2.5: Capacitors

- 2.5.1 List three factors that determine the capacitance of a capacitor.
- 2.5.2 Discuss the electrostatic charge.
- 2.5.3 State the difference between polarized and non-polarized capacitors.
- 2.5.4 Calculate the values for series and parallel connections of capacitors.

Performance Standard 2.6: Capacitance in AC Circuits

- 2.6.1 Understand how capacitors function in an AC circuit.
- 2.6.2 Define capacitive reactance.
- 2.6.3 Calculate the value of capacitive reactance in an AC circuit.
- 2.6.4 Calculate the value of capacitance in an AC circuit.
- 2.6.5 Identify the relationship of voltage and resistance in an AC circuit.
- 2.6.6 Calculate the phase angle for current and voltage in an AC circuit.

Performance Standard 2.7: Resistive-Capacitive Series Circuits

- 2.7.1 Identify the relationship of resistance and capacitance in an AC series circuit.
- 2.7.2 Calculate the values of voltage, current, apparent power, true power, reactive power, impedance, resistance, inductive reactance, and power factor in an RC series circuit.
- 2.7.3 Calculate the phase angle for current and voltage in an RC series circuit.

Performance Standard 2.8: Resistive-Capacitive Parallel Circuits

- 2.8.1 Define the operation of a parallel circuit containing resistance and capacitance.
- 2.8.2 Calculate the values of voltage, current, apparent power, true power, reactive power, impedance, resistance, inductive reactance, power factor, and phase angle in an RC parallel circuit.

Performance Standard 2.9: Resistive-Inductive-Capacitive Parallel Circuits

- 2.9.1 Identify the characteristics of AC circuits that contain resistance, inductance, and capacitance connected in parallel.
- 2.9.2 Calculate the values of voltage, current, apparent power, true power, reactive power, impedance, resistance, inductive reactance, power factor, and phase angle in an RLC parallel circuit.

Performance Standard 2.10: Three-Phase Circuits

- 2.10.1 Identify the difference between single-phase and three-phase voltages.
- 2.10.2 Identify a three-phase delta or wye connection.
- 2.10.3 Calculate the voltage and current values for wye and delta circuits.

Performance Standard 2.11: Single-Phase Transformers

- 2.11.1 Understand the different types of transformers and how they work.
- 2.11.2 Calculate the values of voltage, current, and turns for a single-phase transformer.
- 2.11.3 Understand the polarity markings.

Performance Standard 2.12: Three-Phase Transformers

- 2.12.1 Identify the proper connections for three single-phase transformers to form a three-phase bank.
- 2.12.2 Calculate voltage and current for three-phase transformer connections.
- 2.12.3 Identify the proper connections for two single phase transformers to form a three-phase open-delta connection.
- 2.12.4 Calculate the values of voltage and current for a three-phase transformer used to supply both three-phase and single-phase loads.
- 2.12.5 Define harmonics.

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2.12.6 Understand harmonic problems and their solution.

CONTENT STANDARD 3.0: MOTORS

Performance Standard 3.1: Three-Phase Motors

- 3.1.1 Understand the basic operating principals of a three-phase motor.
- 3.1.2 Define a rotating magnetic field.
- 3.1.3 Define the operating principals of a squirrel-cage motor.
- 3.1.4 Identify the correct connections for dual voltage motors.
- 3.1.5 Define the procedure for reversing a three-phase motor.

Performance Standard 3.2: Single-Phase Motors

- 3.2.1 Define the operation of various motor types.
- 3.2.2 Define the basic operation of a split-phase motor.
- 3.2.3 Understand the purpose of a start winding and how it works.
- 3.2.4 Understand the purpose of a centrifugal switch.
- 3.2.5 Recognize the types of starting relays.

Performance Standard 3.3: Motor Load Calculations as per NEC

- 3.3.1 Determine the full load current of any motor according to the NEC.
- 3.3.2 Understand the information given on a motor nameplate and its application.
- 3.3.3 Calculate the branch circuit wire size for any motor.
- 3.3.4 Determine the appropriate circuit protection for any motor.
- 3.3.5 Calculate overloads.
- 3.3.6 Understand the difference between overload protection and short-circuit/ground-fault protection.
- 3.3.7 Calculate a feeder for any set of motors.
- 3.3.8 Calculate the feeder overcurrent device.

CONTENT STANDARD 4.0: NEC COMPLIANCE

Performance Standard 4.1: Box Fill and Junction Box Sizing

- 4.1.1 Calculate box fill for any size wire and combination of devices.
- 4.1.2 Calculate pull and junction boxes.

Performance Standard 4.2: Conductor Ampacity Correction Factors

- 4.2.1 Calculate correction factors for temperature.
- 4.2.2 Calculate correction factors for raceway fill.
- 4.2.3 Calculate correction factors for continuous loads.
- 4.2.4 Calculate correction factors for any combination of the above.
- 4.2.5 Use Table 310.15(B)(16) and similar tables.
- 4.2.6 Apply NEC Chapter 9 notes for derate in nipples.

Performance Standard 4.3: Raceway Fill

- 4.3.1 Use NEC tables to calculate raceway fill using any combination of wire and cable sizes.
- 4.3.2 Use Annex C tables.

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4.3.3 Calculate conduit nipple fill.

Performance Standard 4.4: Grounding and Bonding

- 4.4.1 Define objectionable current.
- 4.4.2 Identify a main bonding jumper.
- 4.4.3 Calculate the grounding electrode conductor.
- 4.4.4 Identify proper installations of grounding electrode systems.
- 4.4.5 Understand the purpose of bonding.
- 4.4.6 Calculate equipment grounding conductors.
- 4.4.7 Use Article 250 to properly ground and bond any system.
- 4.4.8 Use the NEC to answer any grounding question.

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CONTENT STANDARD 1.0: GENERAL ELECTRICAL SAFETY

Performance Standard 1.1: Safety and NFPA 70E

- 1.1.1 Achieve an electrically safe work condition.
- 1.1.2 Interpret arc flash labeling.
- 1.1.3 Choose appropriate levels of PPE for the hazard.
- 1.1.4 Describe the steps to verify your testing equipment.
- 1.1.5 Explain lockout and tagout procedures.
- 1.1.6 Identify the use of Category I through Category IV meters.
- 1.1.7 Identify proper meter maintenance.
- 1.1.8 Explain the use of a safety harness.
- 1.1.9 Explain safety for ladders and scaffolds.
- 1.1.10 Explain what a material safety data sheet (MSDS/SDS) is and its requirements.
- 1.1.11 Explain safety procedures for trenches.
- 1.1.12 Explain safety for confined space.
- 1.1.13 Explain protective clothing to include eye and hearing protection.
- 1.1.14 State the purpose of arc-fault and ground-fault circuit interrupters.
- 1.1.15 Identify safety handling and use of hand and power tools.

CONTENT STANDARD 2.0: BLUEPRINTS

Performance Standard 2.1: Print Reading Fundamentals

- 2.1.1 Recognize site plan, floor plans, elevations, sectional views, wiring diagrams, details, and schedules.
- 2.1.2 Recognize types of electrical schedules to include fixtures, feeders, main switchboard, branch circuit panels, and transformers.
- 2.1.3 Demonstrate the application of building plans and specifications.
- 2.1.4 Locate specific information on building plans.
- 2.1.5 Research additional information from industry-related resources.

Performance Standard 2.2: Residential and Commercial Electrical Symbols

- 2.2.1 Read and interpret electrical symbols used in construction drawings.
- 2.2.2 Identify the electrical installation requirements for a building from symbols.
- 2.2.3 Determine aboveground and underground electrical distribution.
- 2.2.4 Determine electrical materials, measurements, and specifications.

Performance Standard 2.3: Electrical Drawings and Plans

- 2.3.1 Differentiate between the purposes and characteristics of drawings, plans and diagrams.
- 2.3.2 Describe the purpose of and list the primary features included on each type of drawing and plan to include floor plans, pictorial drawings, orthographic elevations, orthographic views, application drawings, location drawings, detail drawings, assembly drawings, site plans, foundation plans, structural plans, and utility plans.
- 2.3.3 Identify the proper drawing or plan for the application.

Performance Standard 2.4: Construction and Maintenance

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- 2.4.1 Describe the different responsibilities of various construction personnel.
- 2.4.2 Identify the major steps on the construction process.
- 2.4.3 Describe the different responsibilities of various maintenance personnel.
- 2.4.4 Compare preventive and predictive maintenance.

Performance Standard 2.5: Residential and Commercial Power and Lighting Systems

- 2.5.1 Compare how power and lighting information is included on residential and commercial plans.
- 2.5.2 Describe the types of electrical equipment included on single-line diagrams.
- 2.5.3 Describe the typical information included on light fixture schedules and how this information is linked to floor plans.
- 2.5.4 Describe the common types of electrical detail drawings.

CONTENT STANDARD 3.0: LOAD CALCULATIONS

Performance Standard 3.1: Single Family Dwelling Unit Calculations

- 3.1.1 Properly define a one-family dwelling.
- 3.1.2 Calculate the general lighting, general use receptacle, small appliance, and laundry demand load for a dwelling.
- 3.1.3 Calculate the appliance demand load for a dwelling.
- 3.1.4 Determine the dryer demand load for a dwelling.
- 3.1.5 Determine the cooking appliance demand load for a dwelling.
- 3.1.6 Determine the heating and air conditioning demand load for a dwelling.
- 3.1.7 Properly size the service equipment and service conductors for a dwelling using the standard calculation as per Article 220.
- 3.1.8 Properly size feeder conductors (main to sub-panel) for a dwelling.
- 3.1.9 Use the optional calculation for a dwelling as per Article 220.
- 3.1.10 Calculate and size the service neutral conductor in a dwelling (neutral load).

Performance Standard 3.2: Multifamily Dwelling Calculations

- 3.2.1 Properly define a multifamily dwelling.
- 3.2.2 Calculate the general lighting, general use receptacle, small appliance, and laundry demand load for a multifamily dwelling.
- 3.2.3 Calculate the appliance demand load for a multifamily dwelling.
- 3.2.4 Determine the dryer demand load for a multifamily dwelling.
- 3.2.5 Determine the cooking appliance demand load for a multifamily dwelling.
- 3.2.6 Determine the heating and air conditioning demand load for a multifamily dwelling.
- 3.2.7 Properly size the service equipment and service conductors for a multifamily dwelling using the standard calculation as per Article 220.
- 3.2.8 Properly size feeder conductors (main to sub-panel) for a multifamily dwelling
- 3.2.9 Use the optional calculation for a multifamily dwelling as per Article 220.
- 3.2.10 Calculate and size the service neutral conductor in a multifamily dwelling (neutral load).

Performance Standard 3.3: Commercial Calculations

- 3.3.1 Determine the lighting demand factor for any commercial building to include stores,

- hotels and motels, warehouses, hospitals, office buildings, schools, restaurants, etc.
- 3.3.2 Determine sign and show-window demand loads.
 - 3.3.3 Determine the demand loads for multi-outlet assemblies.
 - 3.3.4 Determine the receptacle demand loads for offices and banks.
 - 3.3.5 Determine the receptacle demand load for general commercial applications.
 - 3.3.6 Determine the demand loads for commercial kitchens.
 - 3.3.7 Use the optional method for commercial demand load calculations.
Determine the demand load for manufactured home parks, recreational vehicle parks, and marinas.
 - 3.3.8 Determine the ampacity of conductors based on the type of special equipment (e.g., welders, electrical vehicles, HVAC, signs, etc.).
 - 3.3.9 Determine the service size for any commercial installation.

CONTENT STANDARD 4.0: CONDUCTOR CALCULATIONS

Performance Standard 4.1: Raceway and Box Calculations

- 4.1.1 Determine the cross-sectional area of any conductor using NEC Chapter 9, table 5.
- 4.1.2 Determine the cross-sectional area of compact conductors using NEC Chapter 9, Table 5(A).
- 4.1.3 Understand and apply raceway fill limitations.
- 4.1.4 Size any raceway for the required wire fill.
- 4.1.5 Define and size raceway nipples for required wire fill.
- 4.1.6 Calculate conductor fill when using various sizes and/or types of conductors.
- 4.1.7 Calculate raceway size for multi-conductor and optical fiber cables.
- 4.1.8 Determine raceway fill using Annex C of the NEC.
- 4.1.9 Size a wireway for conductor fill.
- 4.1.10 Properly size an outlet or junction box based on wire fill.
- 4.1.11 Properly calculate the box fill of conductors, clamps, support fittings, devices or equipment, and grounding conductors.
- 4.1.12 Size pull and junction boxes for 4 AWG and larger wire.
- 4.1.13 Install conduits containing the same conductors the correct distance apart (4 AWG and larger).
- 4.1.14 Properly size the depth of pull boxes and conduit bodies when conductors enter opposite a removable cover.

Performance Standard 4.2: Conductor Sizing and Protection Calculations

- 4.2.1 Determine conductor properties.
- 4.2.2 Determine applications of insulation types based on NEC.
- 4.2.3 Determine conductor size for loads.
- 4.2.4 Determine conductor sizing based on the termination temperature rating.
- 4.2.5 Properly size the overcurrent device for loads.
- 4.2.6 Properly apply NEC Article 240 rules for small conductors.
- 4.2.7 Apply ampacity adjustment factors for temperature, wire fill, etc.

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- 4.2.8 Identify when the neutral conductor is counted as current carrying when applying ampacity adjustment factors.
- 4.2.9 Apply ampacity adjustment to wireways.
- 4.2.10 Size conductors for continuous loads after ampacity adjustment.
- 4.2.11 Properly size feeders based on loads and adjustment factors.
- 4.2.12 Properly size tap conductors using the 10- and 25-foot rules (NEC Article 240).

Performance Standard 4.3: Voltage Drop Calculations

- 4.3.1 State the recommended voltage drop according to the NEC.
- 4.3.2 Use the information in Chapter 9, Table 8 to calculate the resistance of any conductor based on size and length.
- 4.3.3 Use the voltage drop formulas for single-phase and three-phase systems.
- 4.3.4 Size conductors to account for voltage drop.

Performance Standard 4.4: Motors: Article 430 of the NEC

- 4.4.1 Determine the full load current of any motor according to the NEC.
- 4.4.2 Size the branch circuit wire size for any motor.
- 4.4.3 Determine the appropriate circuit protection for any motor.
- 4.4.4 Use the motor name plate to size overloads.
- 4.4.5 Explain the difference between overload protection and short-circuit/ground-fault protection.
- 4.4.6 Size a feeder for any set of motors.
- 4.4.7 Size the feeder short-circuit/ground-fault overcurrent device.

Performance Standard 4.5: Transformers: Article 450 of the NEC

- 4.5.1 Calculate the high leg voltage of a delta-connected transformer.
- 4.5.2 Calculate the primary and secondary line current of single- and three-phase transformers.
- 4.5.3 Calculate the primary and secondary overcurrent protection for a transformer.
- 4.5.4 Calculate and select the proper conductor size for the primary and secondary of a transformer.
- 4.5.5 Properly size the grounding electrode conductor and bonding jumpers.

CONTENT STANDARD 5.0: MOTOR CONTROLS

Performance Standard 5.1: Basic Principles of Motor Controls

- 5.1.1 Recognize ladder diagrams.
- 5.1.2 Recognize wiring/connection diagrams.
- 5.1.3 Recognize pictorial diagrams.
- 5.1.4 Use and interpret definitions, abbreviations, and graphic symbols used on motor control diagrams.
- 5.1.5 Describe the function of pushbutton stations, solenoids, flow switches, pressure switches, limit switches, and timing relays.
- 5.1.6 Define the basic operation of variable frequency drives.

Performance Standard 5.2: Components of Magnetic Control Circuits

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- 5.2.1 Use a ladder diagram to illustrate a simple two-wire control circuit for a single-phase motor operated by a float switch or similar device.
- 5.2.2 Use a ladder diagram to identify a simple start/stop station operating a motor starter.
- 5.2.3 Identify circuit types classified by power source (e.g., common control circuits, transformer control wiring, and separate control wiring).
- 5.2.4 Identify control devices and their function.
- 5.2.5 Identify remote-control circuits and their function.
- 5.2.6 Identify the components of a magnetic motor starter.
- 5.2.7 Design both two-wire and three-wire controls using start/stop stations and other devices such as float switches.
- 5.2.8 Design a circuit operating a motor starter using two or more start/stop stations.

Performance Standard 5.3: Overcurrent Protection for Control Circuits

- 5.3.1 Use the NEC to properly protect control circuits to include conductor sizes, overcurrent protection, and control transformers.

Performance Standard 5.4: Indicator Lights, Illuminated Pushbuttons, and Selector Switch Truth Tables

- 5.4.1 Understand the use of illumination in motor controls.
- 5.4.2 Interpret symbols used on diagrams.
- 5.4.3 Read truth tables.
- 5.4.4 Diagram the use of a selector switch on a three-wire control for a jogging application.

Performance Standard 5.5: Reversing Motor Controls

- 5.5.1 Understand the operation of a reversing starter with interlocks.
- 5.5.2 Understand the operation of a reversing control station.
- 5.5.3 Understand the operation of a reversing control selector switch.
- 5.5.4 Apply functional indicator lights to reversing controls.
- 5.5.5 Understand reversing operations using limit switches.
- 5.5.6 Understand the operation of reversing a single-phase motor.

Performance Standard 5.6: Sequencing Control and Master Stop Function

- 5.6.1 Interpret a diagram showing the sequencing of several motors.
- 5.6.2 Apply the master stop function to a process using motor controls.

Performance Standard 5.7: Sequencing Control and Master Stop Function

- 5.7.1 Describe the major characteristics of each type of electrical and electronic diagrams.
Compare the special functions included on ladder diagrams and PLC programming diagrams.
- 5.7.2 Compare the applications and component arrangements of wiring diagrams and schematic diagrams.
- 5.7.3

Performance Standard 5.8: Industrial Control System

- 5.8.1 Compare the common component types and voltage levels of power and control circuits.
- 5.8.2 Identify the common numbering systems that are used in control circuit diagrams.
- 5.8.3 Describe the purpose of each logic function and the device arrangements used to form

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CONTENT STANDARD 1.0: GENERAL NEC REQUIREMENTS

Performance Standard 1.1: Electrical Installation Requirements: Articles 90, 100, and 110

- 1.1.1 Identify scope of the NEC.
- 1.1.2 Define terms as they apply to the NEC.
- 1.1.3 Determine the proper termination of conductors.
- 1.1.4 Determine the kinds of warnings, markings, and identification a given installation requires.
- 1.1.5 Determine the proper working clearance for any installation.
- 1.1.6 Determine proper voltage rating.

CONTENT STANDARD 2.0: WIRING AND PROTECTION

Performance Standard 2.1: Use and Identification of Grounded Conductors, Branch Circuits, and Feeders: Articles 200, 210 and 215

- 2.1.1 Properly identify a grounded conductor.
- 2.1.2 Properly apply the general provisions of Article 210.
- 2.1.3 Properly apply the branch circuits ratings of Article 210.
- 2.1.4 Properly install the required outlets of Article 210.
- 2.1.5 Calculate the minimum size and ampacity of any feeder.

Performance Standard 2.2: Branch Circuit, Feeder, and Service Calculations: Article 220

- 2.2.1 Calculate the loads for a single family dwelling.
- 2.2.2 Calculate the loads for a multifamily dwelling.
- 2.2.3 Calculate the loads for a commercial or industrial installation.

Performance Standard 2.3: Outside Branch Circuits and Feeders, Services: Articles 225 and 230

- 2.3.1 Determine the proper installation for conductors and lighting installed outdoors.
- 2.3.2 Determine vertical and horizontal clearance of overhead conductors.
- 2.3.3 Determine proper disconnecting means and installation.
- 2.3.4 Determine the proper installation and protection of conductors.

Performance Standard 2.4: Overcurrent Protection: Article 240

- 2.4.1 Properly size a standard overcurrent device to any conductor.
- 2.4.2 Properly apply the small conductor rules.
- 2.4.3 Calculate transformer secondary conductor protection.
- 2.4.4 Reference requirements for appliance protection.
- 2.4.5 Calculate tap conductor protection.
- 2.4.6 Reference protection for motors and air conditioners.

Performance Standard 2.5: Grounding and Bonding: Article 250

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- 2.5.1 Define the difference between grounding and bonding.
- 2.5.2 Determine the proper grounding and bonding requirements of any system.
- 2.5.3 Properly size the main bonding jumper.
- 2.5.4 Properly size the grounding electrode conductor.
- 2.5.5 Properly size equipment grounding conductors.
- 2.5.6 Determine the various types of grounding conductors.
- 2.5.7 Design a proper grounding electrode system.

Performance Standard 2.6: Surge Protective Devices: Article 285

- 2.6.1 Determine the installation requirements of SPDs.
- 2.6.2 Discuss the difference between Type 1, Type 2, Type 3, and Type 4 SPDs and their use.

CONTENT STANDARD 3.0: WIRING METHODS AND MATERIALS

Performance Standard 3.1: Wiring Methods and Conductors for General Wiring: Articles 300 and 310

- 3.1.1 Determine how to route, splice, protect, and secure conductors and raceways.
- 3.1.2 Determine the general requirements for conductors such as insulation markings, ampacity ratings, and conductors to use in specific installations.
- 3.1.3 Properly use the Article 310 tables.
- 3.1.4 Apply Chapter 9 tables.
- 3.1.5 Apply adjustment factors to any conductor based on wire fill, temperature, and continuous load.
- 3.1.6 Define the meaning of conductor insulation lettering.
- 3.1.7 Determine when a neutral conductor is to be counted as a current-carrying conductor.

Performance Standard 3.2: Enclosures: Articles 312 and 314

- 3.2.1 Determine the use of any enclosure based on the conditions of use.
- 3.2.2 Determine the installation requirements for any enclosure.
- 3.2.3 Properly use boxes and fittings based on internal volume.
- 3.2.4 Determine the requirements for fill of boxes and fittings.
- 3.2.5 Properly size pull and junction boxes for No. 4 AWG conductors and larger.

Performance Standard 3.3: Cables: Articles 320, 330, 334, 338, and 340

- 3.3.1 Determine the installation requirements of Armored Cable.
- 3.3.2 Determine the installation requirements of Metal-Clad Cable.
- 3.3.3 Determine the installation requirements of Nonmetallic-Sheathed Cable.
- 3.3.4 Determine the installation requirements of Service-Entrance Cable.
- 3.3.5 Determine the installation requirements of Underground Feeder and Branch-Circuit Cable (Type UF).
- 3.3.6 Relate temperature concerns, derating, etc. to other appropriate articles in the NEC.

Performance Standard 3.4: Metal Raceways: Articles 342, 344, 348, 350, 352, 356,

358, and 362

- 3.4.1 Determine the installation requirements of Intermediate Metal conduit.
- 3.4.2 Determine the installation requirements of Ridged Metal Conduit.
- 3.4.3 Determine the installation requirements of Flexible Metal Conduit.
- 3.4.4 Determine the installation requirements of Liquidtight Flexible Metal Conduit.
- 3.4.5 Determine the installation requirements of Rigid Polyvinyl Chloride Conduit.
- 3.4.6 Determine the installation requirements of Liquidtight Flexible Nonmetallic Conduit.
- 3.4.7 Determine the installation requirements of Electrical Metallic Tubing.
- 3.4.8 Determine the installation requirements of Electrical Nonmetallic Tubing.
- 3.4.9 Relate conductor fill, derating, etc. to other appropriate articles in the NEC.

Performance Standard 3.5: Metal Wireways, Multioutlet Assemblies, Surface Metal Raceways, Cable Trays: Articles 376, 380, 3886, 392

- 3.5.1 Determine the proper installation of a metal wireway.
- 3.5.2 Calculate the proper conductor fill of a metal wireway.
- 3.5.3 Calculate the proper size of a metal wireway based on conductor size and conduit entries.
- 3.5.4 Determine provisions for properly splicing conductors in a metal wireway.
- 3.5.5 Determine the proper installation of multioutlet assemblies.
- 3.5.6 Determine the proper installation of surface metal raceways.
- 3.5.7 Determine the proper installation and use of cable trays.

CONTENT STANDARD 4.0: EQUIPMENT FOR GENERAL USE

Performance Standard 4.1: Flexible Cords, Flexible Cables, and Fixture Wires: Articles 400 and 402

- 4.1.1 Identify requirements, applications, and construction specifications of cords and cables.
- 4.1.2 Select cords, cables, and fittings listed for specific applications.
- 4.1.3 Identify requirements and specifications of fixture wires.

Performance Standard 4.2: Switches, Receptacles, Cord Connectors, and Attachment Plugs: Articles 404 and 406

- 4.2.1 Determine types and uses of switches.
- 4.2.2 Determine types and uses of receptacles.

Performance Standard 4.3: Switchboards, Switchgear, and Panelboards: Article 408

- 4.3.1 Determine the specific requirements for switchboards, switchgear, and panelboards that control power and lighting circuits.
- 4.3.2 Properly identify the labeling requirements of each circuit in a panelboard or switchboard.
- 4.3.3 Determine proper termination of conductors in panelboards and switchboards.

Performance Standard 4.4: Luminaires, Lampholders, and Lamps: Article 410

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4.4.1 Determine the general requirements of Article 410.

Performance Standard 4.5: Lighting Systems Operating at 30 Volts or Less: Article 411

4.5.1 Determine proper installation of low voltage lighting.

Performance Standard 4.6: Appliances, Fixed Electric Space Heating Equipment: Articles 422 and 424

4.6.1 Calculate and determine proper branch circuit ratings for any appliance.

4.6.2 Calculate and determine proper overcurrent protection for any appliance.

4.6.3 Determine the requirements for nonmotor appliances.

4.6.4 Determine proper disconnecting means.

4.6.5 Determine requirements for heating installations.

Performance Standard 4.7: Motors, Motor Circuits, and Controllers; Air- Conditioning and Refrigeration Equipment: Articles 430 and 440

4.7.1 Determine the proper conductor size for any motor.

4.7.2 Determine the proper overcurrent protection for any motor.

4.7.3 Determine the proper disconnect for any motor.

4.7.4 Determine the proper overload protection for any motor and condition (easy start, hard start, etc.).

4.7.5 Determine the minimum size feeder for a group of motors.

4.7.6 Determine the feeder overcurrent protection.

4.7.7 Determine proper size of circuits and overcurrent devices for air conditioning and refrigeration equipment.

4.7.8 Determine the requirements for the disconnecting means of refrigeration equipment.

CONTENT STANDARD 5.0: SPECIAL OCCUPANCIES

Performance Standard 5.1: Hazardous Locations: Articles 500 through 504

5.1.1 Determine proper wiring of a hazardous location.

Performance Standard 5.2: Commercial Garages, Motor Fuel Dispensing Facilities: Articles 511 and 514

5.2.1 Define a major repair garage.

5.2.2 Define a minor repair garage.

5.2.3 Classify hazardous areas.

5.2.4 Determine proper wiring methods for a commercial garage of any type.

5.2.5 Define a Motor Fuel Dispensing Facility.

5.2.6 Determine proper wiring methods for Motor Fuel Dispensing Facilities.

Performance Standard 5.3: Health Care Facilities: Article 517

5.3.1 Define health care facility types.

5.3.2 Define General Care Areas and Critical Care Areas.

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- 5.3.3 Discuss Essential Electrical Systems.
- 5.3.4 Determine proper wiring and grounding for a health care facility.

Performance Standard 5.4: Assembly Occupancies, Carnivals, Fairs, and Similar Events: Articles 518 through 525

- 5.4.1 Discuss the proper wiring methods for places of assembly.
- 5.4.2 Discuss the proper wiring of carnivals, fairs, and similar events.

Performance Standard 5.5: Agricultural Buildings: Article 547

- 5.5.1 Determine the proper wiring method for any agricultural building.
- 5.5.2 Determine proper grounding for any agricultural building.

Performance Standard 5.6: Marinas and Boatyards: Article 555

- 5.6.1 Determine marina requirements using the NEC.

Performance Standard 5.7: Temporary Installations: Article 590

- 5.7.1 Determine the requirements for temporary installations.

CONTENT STANDARD 6.0: SPECIAL EQUIPMENT

Performance Standard 6.1: Electric Signs and Outline Lighting, Manufactured Wiring Systems: Articles 600 and 604

- 6.1.1 Determine proper installation and requirements of electric signs and associated lighting.
- 6.1.2 Determine proper installation of manufactured wiring systems.

Performance Standard 6.2: Cranes and Hoists: Article 610

- 6.2.1 Determine proper wiring of cranes and hoists.

Performance Standard 6.3: Elevators, Escalators, and Moving Walks: Article 620

- 6.3.1 Determine proper installation requirements of elevators, escalators, and moving walks.

Performance Standard 6.4: Audio Signal Processing, Amplification, Reproduction Equipment: Article 640

- 6.4.1 Determine proper wiring methods for audio equipment.

Performance Standard 6.5: Information Technology Equipment: Article 645

- 6.5.1 Define an IT room.
- 6.5.2 Determine proper installation of wiring in IT rooms.

Performance Standard 6.6: Swimming Pools, Spas, Hot Tubs, Fountains, and Similar Locations: Article 680

- 6.6.1 Determine proper electrical installations for swimming pools.
- 6.6.2 Determine proper electrical installations for spas and hot tubs.
- 6.6.3 Determine proper electrical installations for fountains.

CONTENT STANDARD 7.0: SPECIAL CONDITIONS

Performance Standard 7.1: Emergency Standby Power Systems, Legally Required Power Systems, Optional Standby Power Systems: Articles 700 through 702

- 7.1.1 Determine the proper installation of standby power systems.
- 7.1.2 Determine the difference between emergency standby, legally required standby, and

optional standby power systems.

Performance Standard 7.2: Remote-Control, Signaling, and Power-Limited Circuits: Article 725

- 7.2.1 Define circuit classes.
- 7.2.2 Determine proper installation and requirements of different circuit classes.

Performance Standard 7.3: Fire Alarm Systems: Article 760

- 7.3.1 Define nonpower-limited fire alarm circuits.
- 7.3.2 Define power-limited fire alarm circuits.
- 7.3.3 Determine the proper installation of fire alarm wiring using the NEC.
- 7.3.4 Determine where the use of GFCI and AFCI are restricted.
- 7.3.5 Determine proper cable types.

CONTENT STANDARD 8.0: COMMUNICATION SYSTEMS

Performance Standard 8.1: Optical Fiber Cables and Raceways; Communications Systems: Articles 770 and 800 through 820

- 8.1.1 Determine proper installation of optical fiber cables.
- 8.1.2 Determine proper grounding of communications wiring and equipment.
- 8.1.3 Determine proper installations of communication wiring.

CONTENT STANDARD 1.0: TRADE MATH

Performance Standard 1.1: Basic Math

- 1.1.1 Perform addition, subtraction, multiplication, and division calculations of whole numbers.
- 1.1.2 Perform addition and subtraction calculations of common fractions.
- 1.1.3 Perform multiplication and division calculations of common fractions.
- 1.1.4 Perform addition, subtraction, multiplication, and division calculations of decimal fractions.
- 1.1.5 Perform ratio and proportion calculations.
- 1.1.6 Perform percent, percentage, and discount calculations.
- 1.1.7 Perform angular, length, and converted temperature measure calculations.
- 1.1.8 Perform area calculations.
- 1.1.9 Perform volume calculations.
- 1.1.10 Solve basic equations.
- 1.1.11 Demonstrate the use of order of operations.

CONTENT STANDARD 2.0: GENERAL SAFETY

Performance Standard 2.1: Workplace Safety

- 2.1.1 Describe potential excavation site hazards.
- 2.1.2 Explain proper personal protective equipment (PPE) use.
- 2.1.3 Describe proper material handling, storage, use, and disposal.
- 2.1.4 Describe ladder, stairway, and scaffold hazards and proper use.
- 2.1.5 Describe jobsite electrical hazards and proper lockout/tagout use.
- 2.1.6 Describe proper refrigerant and pressure vessel usage and storage.
- 2.1.7 Identify safety data sheets (SDS) properties of chemicals specific to HVAC.
- 2.1.8 Identify and describe environmental hazards (e.g. lead, silica, asbestos, carbon monoxide).
- 2.1.9 Identify the hazards associated with confined spaces.
- 2.1.10 Use appropriate fire extinguishers and other such safety devices.
- 2.1.11 Identify the importance safety procedures for brazing and soldering.

CONTENT STANDARD 3.0: TOOLS AND MATERIALS

Performance Standard 3.1: Power and Hand Tool Use

- 3.1.1 Describe proper hand tool use.
- 3.1.2 Describe proper power tool use.
- 3.1.3 Identify proper use of various types of torches.
- 3.1.4 Identify proper use of piping and tubing fabrication tools.

Performance Standard 3.2: Tubing and Piping

- 3.2.1 Identify the purpose of the piping, tubing and fittings used in the heating, air-conditioning, and refrigeration industry.
- 3.2.2 Identify appropriate brazing and soldering alloys and materials.

- 3.2.3 Explain the purposes and procedures for protecting piping materials and fabrication, such as valves, fittings, and products from heat.

CONTENT STANDARD 4.0: FUEL GAS PIPING AND VENTING

Performance Standard 4.1: Fuel Gas Piping and Venting

- 4.1.1 Identify HVAC IDAPA (define) rules and statutes.
- 4.1.2 Define key terms as applied to the IFGC.
- 4.1.3 Describe the building structural safety requirements for fuel gas equipment installation.
- 4.1.4 Determine proper fuel gas equipment combustion, ventilation, and dilution air requirements.
- 4.1.5 Identify the requirements for installation of fuel gas fired equipment in a masonry chimney.
- 4.1.6 Identify fuel gas equipment location, access, and service space requirements.
- 4.1.7 Describe proper appliance condensate disposal and clearance reduction methods.
- 4.1.8 Perform gas pipe sizing exercises.
- 4.1.9 Identify proper gas pipe installation methods.
- 4.1.10 Describe proper gas pipe inspection, testing, and purging procedures.
- 4.1.11 Describe chimney and vent types and construction.
- 4.1.12 Determine chimney installation requirements.
- 4.1.13 Determine gas vent installation requirements.
- 4.1.14 Describe gas appliance category I, II, III, IV characteristics.
- 4.1.15 Identify proper gas vent connector installation requirements.
- 4.1.16 Describe category I venting principles.
- 4.1.17 Perform single appliance category I vent sizing exercises.
- 4.1.18 Perform multiple appliance category I vent sizing exercises.
- 4.1.19 Determine capacity penalties for offsets in common vent and vent connectors.
- 4.1.20 Determine specific fuel gas appliance installation requirements.
- 4.1.21 Determine mechanical equipment location, access, and service space requirements.
- 4.1.22 Determine combustion air location and sizing requirements.

CONTENT STANDARD 5.0: ENERGY SOURCES

Performance Standard 5.1: Energy Sources

- 5.1.1 Explain natural, LP gas, and fuel oil combustion characteristics.
- 5.1.2 Describe the application of geothermal systems.
- 5.1.3 Describe the application of renewable energy systems.
- 5.1.4 Describe the application of electric production systems.

CONTENT STANDARD 6.0: BASIC SYSTEMS OVERVIEW

Performance Standard 6.1: Basic Systems Overview

- 6.1.1 Describe fossil-fuel and electrical furnace operations.
- 6.1.2 Describe the typical configuration of residential split air conditioning systems.
- 6.1.3 List various types of commercial air conditioning systems and their application.
- 6.1.4 Describe the configuration of common duct systems.

CONTENT STANDARD 7.0: INTRO TO APPLIED SCIENCE

Performance Standard 7.1: Intro to Applied Science

- 7.1.1 Perform energy conversion calculations.
- 7.1.2 Perform sensible, latent, and total heat calculations.
- 7.1.3 Differentiate between saturated, superheated, and subcooled refrigerant.
- 7.1.4 Explain atmospheric, absolute, and gauge pressure relationship.
- 7.1.5 Convert gauge pressure, absolute pressure, and vacuum.
- 7.1.6 Diagram a basic refrigeration cycle identifying pressure, temperature, and state of refrigerant.
- 7.1.7 List the type and function of the four major refrigeration components.
- 7.1.8 Describe the methods of heat transfer.

CONTENT STANDARD 8.0: APPLIANCE INSTALLATION

Performance Standard 8.1: Appliance Installation

- 8.1.1 Apply NEC standards to HVAC electrical circuit installations.
- 8.1.2 Interpret HVAC manufacturer electrical name plate data.
- 8.1.3 Apply appropriate code standards.
- 8.1.4 Describe gas, oil, and electrical appliance installation, start-up, and checkout procedures.
- 8.1.5 Describe sheet metal, fiberglass, and flex duct installation procedures.
- 8.1.6 Describe split and packaged air conditioning system installation, start-up, and checkout procedures.

CONTENT STANDARD 9.0: INTRODUCTION TO CONSTRUCTION DRAWINGS AND SPECIFICATIONS

Performance Standard 9.1: Introduction to Construction Drawings and Specifications

- 9.1.1 Identify the application of architectural plans and specifications.
- 9.1.2 Interpret mechanical, plumbing, and electrical drawing symbols.
- 9.1.3 Interpret specification documents and apply to plans.
- 9.1.4 Interpret shop drawings and apply to plans and specifications.
- 9.1.5 Describe a submittal and its derivation, routing, and makeup.
- 9.1.6 Develop cut lists for duct runs from shop drawings.
- 9.1.7 Interpret as-built modifications on HVAC mechanical plans.
- 9.1.8 Perform HVAC equipment and material takeoff.

CONTENT STANDARD 10.0: BASIC ELECTRICITY

Performance Standard 10.1: Basic Electricity

- 10.1.1 Describe basic electrical theory.
- 10.1.2 Describe series, parallel, and combination circuit characteristics.
- 10.1.3 Calculate electrical circuit values.
- 10.1.4 Describe electrical meter functions.
- 10.1.5 Measure electrical circuit values.

- 10.1.6 Identify electrical symbols.
- 10.1.7 Draw basic HVAC electrical circuit diagrams.
- 10.1.8 Interpret basic residential HVAC schematic diagrams.
- 10.1.9 Interpret basic commercial HVAC schematic diagrams.
- 10.1.10 Explain AC circuit characteristics.
- 10.1.11 Describe power distribution transformer systems.
- 10.1.12 Calculate HVAC branch circuit conductor, breaker, and disconnect sizes.
- 10.1.13 Describe basic motor theory.
- 10.1.14 Describe the five single-phase motor types.
- 10.1.15 Identify single-phase motor diagrams.
- 10.1.16 Explain single-phase motor starting relay operation.
- 10.1.17 Calculate motor capacitor replacement values.
- 10.1.18 Explain three-phase motor operation.
- 10.1.19 Explain ECM motor operation.
- 10.1.20 Perform Ohm's law calculations to series, parallel, and combination circuits.

CONTENT STANDARD 11.0: INDOOR AIR QUALITY

Performance Standard 11.1: Indoor Air Quality

- 11.1.1 Describe indoor air quality (IAQ) factors as related to HVAC.
- 11.1.2 Identify various indoor air quality pollutant and pollutant pathways.
- 11.1.3 Describe indoor air quality evaluation and measurement tools.
- 11.1.4 Explain appropriate prevention, control, and resolution strategies for IAQ issues.
- 11.1.5 Recognize when to involve IAQ professionals as necessary.

CONTENT STANDARD 12.0: RESIDENTIAL LOAD CALCULATIONS

Performance Standard 12.1: Residential Load Calculations

- 12.1.1 Identify the importance of heat load calculation in building design.
- 12.1.2 Differentiate sensible, latent, and total heat gain/loss.
- 12.1.3 Determine U values and R values for various building construction components.
- 12.1.4 Calculate Btu gain/loss values using HTM and temperature difference factors.
- 12.1.5 Determine heating and cooling load temperature difference and daily range values.
- 12.1.6 Explain the relationship between house orientation and solar heat gain.
- 12.1.7 Perform building component area and volume calculations from construction drawings.
- 12.1.8 Perform winter/summer infiltration calculations using Manual J procedures.
- 12.1.9 Perform heat gain calculations using Manual J procedures.
- 12.1.10 Perform heat loss calculations using Manual J procedures.
- 12.1.11 Determine sensible, latent, and total heat for house block and room values.

CONTENT STANDARD 13.0: BASIC CONTROLS

Performance Standard 13.1: Basic Controls

- 13.1.1 Differentiate between operating and safety controls.
- 13.1.2 Describe the sequence of operation of standing pilot, intermittent, and direct ignition control systems.

- 13.1.3 Interpret basic gas furnace wiring diagrams.
- 13.1.4 Explain oil furnace primary control operation.
- 13.1.5 Describe electric furnace operating sequence.
- 13.1.6 Describe hydronic heating system controls.
- 13.1.7 Describe basic motor circuit troubleshooting procedures.
- 13.1.8 Interpret packaged and split air conditioning systems and wiring diagrams.
- 13.1.9 Identify commercial and industrial air conditioning system control methods.
- 13.1.10 Describe basic electronic control system troubleshooting procedures.

CONTENT STANDARD 14.0: SYSTEM AIR FLOW AND DUCT SIZING

Performance Standard 14.1: System Air Flow and Duct Sizing

- 14.1.1 Describe basic air flow characteristics.
- 14.1.2 Explain duct system pressures.
- 14.1.3 Calculate duct system air flow.
- 14.1.4 Determine proper air flow requirements.
- 14.1.5 Describe air distribution system configurations.
- 14.1.6 Select primary heating/cooling equipment using nationally recognized standards.
- 14.1.7 Determine air-side component pressure drops from manufacturer tables.
- 14.1.8 Sketch a residential duct system layout using nationally recognized standards.
- 14.1.9 Determine duct size based on nationally recognized standards.

CONTENT STANDARD 15.0: BASIC AIR CONDITIONING AND REFRIGERATION

Performance Standard 15.1: Basic Air Conditioning and Refrigeration

- 15.1.1 Explain latent, sensible, and total heat differences.
- 15.1.2 Diagram refrigeration cycle conditions and components.
- 15.1.3 Explain pressure-enthalpy diagrams.
- 15.1.4 Describe compressor design differences, efficiencies, and applications.
- 15.1.5 Explain water/air-cooled condenser operation and performance.
- 15.1.6 Describe metering device design and operation.
- 15.1.7 Describe refrigeration accessory components and operation.
- 15.1.8 Describe evaporator types.
- 15.1.9 Identify proper refrigerant line sizing and installation practices.
- 15.1.10 Explain various refrigerant physical and chemical properties.
- 15.1.11 Explain refrigerant oil properties and application.
- 15.1.12 Describe proper refrigeration system access procedures.
- 15.1.13 Differentiate between recovered, recycled, and reclaimed refrigerant.
- 15.1.14 Describe proper refrigerant recovery, evacuation, and charging procedures.
- 15.1.15 Describe the operation of a variable refrigerant flow system.

CONTENT STANDARD 16.0: INTRODUCTION TO HYDRONIC SYSTEMS

Performance Standard 16.1: Introduction to Hydronic Systems

- 16.1.1 Identify hydronic piping system configurations.
- 16.1.2 Describe hydronic system components.

16.1.3 Explain hydronic systems drain and fill procedures.

16.1.4 Diagram basic hydronic system control circuits.

CONTENT STANDARD 17.0: BASIC SHEET METAL

Performance Standard 17.1: Basic Sheet Metal

17.1.1 Define sheet metal layout terms.

17.1.2 Explain parallel line development procedures.

17.1.3 Layout and fabricate the following sheet metal fitting: Pittsburgh seam and square elbow.

17.1.4 Layout and fabricate the following sheet metal fitting: 90 degree elbow and transition.

17.1.5 Explain radial line development procedures.

17.1.6 Layout and fabricate the following sheet metal fitting: symmetrical tapered duct.

17.1.7 Layout and fabricate the following sheet metal fitting: square to square tapered duct.

17.1.8 Explain triangulation development procedures.

17.1.9 Layout and fabricate the following sheet metal fitting: two-way offset transition.

17.1.10 Layout and fabricate the following sheet metal fitting: tapered duct section.

CONTENT STANDARD 18.0: INTRODUCTION TO SERVICE

Performance Standard 18.1: Introduction to Service

18.1.1 Identify air conditioning system problems.

18.1.2 Prescribe air conditioning system problem solutions.

18.1.3 Identify gas heating system problems.

18.1.4 Prescribe gas heating system problem solutions.

18.1.5 Identify oil heating system problems.

18.1.6 Prescribe oil heating system problem solutions.

18.1.7 Identify electric heating system problems.

18.1.8 Prescribe electric heating system problem solutions.

18.1.9 List gas, oil, and electric heating and air conditioning maintenance procedures.

CONTENT STANDARD 19.0: FUNDAMENTALS OF PSYCHOMETRICS

Performance Standard 19.1: Fundamentals of Psychometrics

19.1.1 Explain psychometric properties.

19.1.2 Diagram psychometric conditions.

19.1.3 Describe comfort conditions as applied to psychometric properties.

19.1.4 Use the psychometric chart to measure enthalpy.

CONTENT STANDARD 20.0: TESTING AND BALANCING

Performance Standard 20.1: Testing and Balancing

20.1.1 Describe air flow and water flow measuring devices.

20.1.2 Explain basic air flow and water flow balancing procedures.

CONTENT STANDARD 21.0: INTRODUCTION TO HVAC CONTROL STRATEGIES

Performance Standard 21.1: Introduction to HVAC Control Strategies

21.1.1 Describe basic HVAC control principles.

21.1.2 Interpret basic HVAC pneumatic control diagrams.

21.1.3 Explain DDC control system basic operation.

CONTENT STANDARD 22.0: ADVANCED HVAC SYSTEMS

Performance Standard 22.1: HVAC Systems

22.1.1 Explain commercial fan coil unit operation.

22.1.2 Explain package unit building system configurations.

22.1.3 Describe building chilled water system operation.

22.1.4 Describe induced and forced draft cooling tower operation.

Performance Standard 22.2: Heat Pump Systems

22.2.1 Explain heat pump heating and cooling cycles.

22.2.2 Describe the purpose and operation of various heat pump components.

22.2.3 Prescribe heat pump charging procedures.

22.2.4 Differentiate heat pump time/temperature and demand defrost control systems.

22.2.5 Explain geothermal heat pump system applications.

22.2.6 Describe water-to-air and air-to-water heat pump operation.

CONTENT STANDARD 23.0: ADVANCED TROUBLESHOOTING

Performance Standard 23.1: Advanced Troubleshooting

23.1.1 Describe air flow troubleshooting procedures.

23.1.2 Determine operating conditions at variable loads.

23.1.3 Describe refrigeration side troubleshooting procedures.

23.1.4 Troubleshoot residential and commercial control systems.

23.1.5 Interpret manufacturer schematics.

23.1.6 Analyze furnace troubleshooting values.

23.1.7 Apply furnace troubleshooting values.

CONTENT STANDARD 24.0: CODE REVIEW

Performance Standard 24.1: Code Review

24.1.1 Apply international fuel gas code standards.

24.1.2 Apply international mechanical code standards.

24.1.3 Apply HVAC rules and statutes as it pertains to the IDAPA administrative code.

CONTENT STANDARD 1.0: INTRODUCTION TO THE PLUMBING PROFESSION

Performance Standard 1.1: Introduction to the Plumbing Profession

- 1.1.1 Describe Idaho Plumbing Code and Administrative Rules requirements.
- 1.1.2 Identify the basic principles on which plumbing is based.
- 1.1.3 Identify and maintain licensing, certification, and industry credentialing requirements.

CONTENT STANDARD 2.0: PLUMBING SAFETY

Performance Standard 2.1: Plumbing Safety

- 2.1.1 Complete OSHA 10 Certification.
- 2.1.2 Identify common unsafe acts and conditions that cause accidents and how to handle these situations to make them safer.
- 2.1.3 Identify job site hazards – work specific to plumbers.
- 2.1.4 Complete First Aid and CPR Certification.
- 2.1.5 Use appropriate fire extinguishers and other safety devices.

CONTENT STANDARD 3.0: INTRODUCTION TO HAND TOOLS AND POWER TOOLS

Performance Standard 3.1: Hand Tools

- 3.1.1 Identify the types of hand tools used in the plumbing profession.
- 3.1.2 Demonstrate proper use and care of basic hand tools.
- 3.1.3 Identify the types of Personal Protective Equipment (PPE) required for hand tool use.

Performance Standard 3.2: Power Tools

- 3.2.1 Identify the types of power tools used in the plumbing profession.
- 3.2.2 Demonstrate proper use and care of basic power tools.
- 3.2.3 Identify the types of Personal Protective Equipment (PPE) required for power tool use.

CONTENT STANDARD 4.0: FITTINGS, PIPE, AND VALVES

Performance Standard 4.1: Fittings and Valves

- 4.1.1 Identify the proper fittings and/or valves for specific systems.
- 4.1.2 Apply the various fittings and valves by type, size, materials and application.

Performance Standard 4.2: Types of Pipe

- 4.2.1 Identify the common types of pipes.
- 4.2.2 Identify the proper pipes for specific systems.

CONTENT STANDARD 5.0: INDUSTRY MATH

Performance Standard 5.1: Basic Mathematics

- 5.1.1 Perform addition, subtraction, multiplication, and division calculations of whole numbers.
- 5.1.2 Perform addition, subtraction, multiplication, and division calculations of common fractions.
- 5.1.3 Perform addition, subtraction, multiplication, and division calculations of decimal fractions.
- 5.1.4 Perform ratio and proportion calculations.
- 5.1.5 Perform percent, percentage, and discount calculations.

- 5.1.6 Perform area calculations.
- 5.1.7 Perform volume calculations.
- 5.1.8 Solve basic equations.
- 5.1.9 Demonstrate the use of order of operations.

Performance Standard 5.2: Applied Mathematics

- 5.2.1 Determine center-to-center and end-to-end lengths for parallel offsets.
- 5.2.2 Calculate the travel for a rolling offset.
- 5.2.3 Solve for end-to-end lengths of pipe.
- 5.2.4 Calculate area, water volumes, weights, and gallons for various geometric shapes.
- 5.2.5 Explain pressure measurement in terms of Pounds per Square Inch (PSI) and inches of mercury.
- 5.2.6 Perform angular, length, and converted temperature measure calculations.
- 5.2.7 Calculate material expansion and/or volume related to heat.

CONTENT STANDARD 6.0: THE UNIFORM PLUMBING CODE (UPC)

Performance Standard 6.1: The Uniform Plumbing Code (UPC)

- 6.1.1 Identify proper code terminology.
- 6.1.2 Identify general plumbing requirements for hanging and securing piping.
- 6.1.3 Identify plumbing fixtures.
- 6.1.4 Perform water heater sizing, combustion air calculations, vent sizing, and installation.
- 6.1.5 Perform water pipe sizing calculations.
- 6.1.6 Explain when and what type of backflow prevention devices, assemblies, and methods are required.
- 6.1.7 Perform drain and waste pipe sizing calculations.
- 6.1.8 Perform indirect waste installation and usage.
- 6.1.9 Describe venting systems (horizontal, vertical wet venting, etc.).
- 6.1.10 Identify proper use of traps and interceptors.
- 6.1.11 Perform proper storm drain sizing and calculations.
- 6.1.12 Perform fuel gas sizing calculations.
- 6.1.13 Identify proper fire-stop installation.
- 6.1.14 Identify the proper use of gray water, reclaimed water, and rainwater systems.
- 6.1.15 Utilize appendices and reference standards.
- 6.1.16 Apply IDAPA Plumbing rules and statutes (Title 54).

CONTENT STANDARD 7.0: CONSTRUCTION DOCUMENTS

Performance Standard 7.1: Isometric Drawings

- 7.1.1 Identify the various plumbing symbols and abbreviations.
- 7.1.2 Complete an isometric drawing with proper symbols.
- 7.1.3 Develop materials list based on isometric drawings.

Performance Standard 7.2: Plan Reading

- 7.2.1 Describe basic plumbing symbols, abbreviations, and specifications.
- 7.2.2 Explain how the specifications relate to the plan.

- 7.2.3 Identify the necessary requirements and locations to install the plumbing fixtures and plumbing appurtenances.
- 7.2.4 Describe the coordination of trades on the job site.
- 7.2.5 Recognize site plan, floor plans, elevations, sectional views, details, and schedules.
- 7.2.6 Locate specific information on building plans.

CONTENT STANDARD 8.0: ADA GUIDELINES

Performance Standard 8.1: ADA Guidelines

- 8.1.1 Identify the necessary requirements according to ADA standards.

CONTENT STANDARD 9.0: KNOWLEDGE OF RELATED INDUSTRIES

Performance Standard 9.1: Knowledge of Related Industries

- 9.1.1 Explain how to use alternating-current meters and instruments in the pipe trades.
- 9.1.2 Apply basic building codes.

CONTENT STANDARD 10.0: CUT AND JOIN PIPES

Performance Standard 10.1: Cut and Join Pipes

- 10.1.1 Join different types of pipes (including PVC, galvanized, steel, plastic, copper, and cast-iron pipes).
- 10.1.2 Measure, mark, and cut different types of pipes using various pipe cutters.
- 10.1.3 Thread a steel pipe with a power-driven vise stand or a pipe-threading machine.

CONTENT STANDARD 11.0: MAINTENANCE AND REPAIR

Performance Standard 11.1: Maintenance and Repair

- 11.1.1 Diagnose water heater problems (e.g. gas, electric, tankless).
- 11.1.2 Identify repairs for residential fixtures.
- 11.1.3 Identify repairs for commercial fixtures.