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DOE–STD–1170-2003
December 2003

DOE STANDARD

ELECTRICAL SYSTEMS FUNCTIONAL AREA QUALIFICATION STANDARD

DOE Defense Nuclear Facilities Technical Personnel

U.S. Department of Energy
Washington, D.C. 20585

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APPROVAL

The Federal Technical Capability Panel consists of senior U.S. Department of Energy managers responsible for overseeing the Federal Technical Capability Program. This Panel is responsible for reviewing and approving the Qualification Standard for Department-wide application. Approval of this Qualification Standard by the Federal Technical Capability Panel is indicated by signature below.

Roy J. Schepens
Chairman
Federal Technical Capability Panel

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ACKNOWLEDGMENT

The Savannah River Site Office is the Sponsor for the Electrical Systems Qualification Standard. The Sponsor is responsible for coordinating the development and/or review of the Functional Area Qualification Standard by subject matter experts to ensure that the technical content of the standard is accurate and adequate for Department-wide application for those involved in the Electrical Systems Program. The Sponsor, in coordination with the Federal Technical Capability Panel, is also responsible for ensuring that the Functional Area Qualification Standard is maintained current.

The following subject matter experts (SMEs) participated in the development and/or review of this Qualification Standard:

- Marc Woodworth — Savannah River Operations Office (Team Leader)
- Jimmy Guerry — Savannah River Operations Office
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DOE-STD-1170-2003

U.S. DEPARTMENT OF ENERGY
FUNCTIONAL AREA QUALIFICATION STANDARD

Electrical Systems

PURPOSE

DOE Manual 426.1-1, Federal Technical Capability Manual, commits the Department to continuously strive for technical excellence. The Technical Qualification Program, along with the supporting Technical Qualification Standards, complements the personnel processes that support the Department's drive for technical excellence. In support of this goal, the competency requirements defined in the Technical Qualification Standards should be aligned with and integrated into the recruitment and staffing processes for technical positions. The Technical Qualification Standards should form the primary basis for developing vacancy announcements, qualification requirements, crediting plans, interviewing questions, and other criteria associated with the recruitment, selection, and internal placement of technical personnel. Office of Personnel Management minimum qualifications standards will be greatly enhanced by application of appropriate materials from the technical Functional Area Qualification Standards.

The Technical Qualification Standards are not intended to replace the Office of Personnel Management (OPM) Qualifications Standards nor other Departmental personnel standards, rules, plans, or processes. The primary purpose of the Technical Qualification Program is to ensure that employees have the requisite technical competency to support the mission of the Department. The Technical Qualification Program forms the basis for the development and assignment of DOE personnel responsible for ensuring the safe operation of defense nuclear facilities.

APPLICABILITY

The Electrical Systems Functional Area Qualification Standard establishes common functional area competency requirements for Department of Energy personnel who provide assistance, direction, guidance, oversight, or evaluation of contractor technical activities that could impact the safe operation of DOE's defense nuclear facilities. The technical Functional Area Qualification Standard has been developed as a tool to assist DOE Program and Field offices in the development and implementation of the Technical Qualification Program in their organization. For ease of transportability of qualifications between DOE elements, Program and Field offices are expected to use this technical Functional Area Qualification Standard without modification or additions. Needed additional office/site/facility specific technical competencies should be handled separately. Satisfactory and documented attainment of the competency requirements contained in this technical Functional Area Qualification Standard ensures that personnel possess the requisite competence to fulfill their functional area duties and responsibilities. Office/Facility-Specific Qualification Standards supplement this technical Functional Area Qualification Standard and establish unique operational competency requirements at the Headquarters or Field element, site, or facility level.

IMPLEMENTATION

This technical Functional Area Qualification Standard identifies the minimum technical competency requirements for Department of Energy personnel. Although there are other competency requirements associated with the positions held by DOE personnel, this Functional Area Qualification Standard is limited to identifying the specific technical competencies. The competency statements define the expected knowledge and/or skill that an individual must meet. Each of the competency statements is further explained by a listing of supporting knowledge and/or skill statements.

The competencies identify a familiarity level, a working level, or an expert level of knowledge; or they require the individual to demonstrate the ability to perform a task or activity. These levels are defined as follows:

Familiarity level is defined as basic knowledge of or exposure to the subject or process adequate to discuss the subject or process with individuals of greater knowledge.

Working level is defined as the knowledge required to monitor and assess operations/activities, to apply standards of acceptable performance, and to reference appropriate materials and/or expert advice as required to ensure the safety of Departmental activities.

Expert level is defined as a comprehensive, intensive knowledge of the subject or process sufficient to provide advice in the absence of procedural guidance.

Demonstrate the ability is defined as the actual performance of a task or activity in accordance with policy, procedures, guidelines, and/or accepted industry or Department practices.

Headquarters and Field elements shall establish a program and process to ensure that DOE personnel possess the competencies required of their position. That includes the competencies identified in this technical Functional Area Qualification Standard. Documentation of the completion of the requirements of the Standard shall be included in the employee's training and qualification record.

Equivalencies should be used with the utmost rigor and scrutiny to maintain the spirit and intent of the TQP. Equivalencies may be granted for individual competencies based upon objective evidence of previous education, training, certification, or experience. Objective evidence includes a combination of transcripts, certifications, and, in some cases, a knowledge sampling through a written and/or oral examination. Equivalencies shall be granted in accordance with the Technical Qualification Program Plan of the office qualifying the individual. The supporting knowledge and/or skill statements, while not requirements, should be considered before granting equivalency for a competency.

Training shall be provided to employees in the Technical Qualification Program who do not meet the competencies contained in the technical Functional Area Qualification Standard. Training may include, but is not limited to, formal classroom and computer based courses, self-study, mentoring, on the job training, and special assignments. Departmental training will be based upon appropriate supporting knowledge and/or skill statements similar to the ones listed for each of the competency statements. Headquarters and Field elements should use the supporting knowledge and/or skill statements as a basis for evaluating the content of any training used to

provide individuals with the requisite knowledge and/or skill required to meet the technical Functional Area Qualification Standard competency statements.

EVALUATION REQUIREMENTS

Attainment of the competencies listed in this technical Functional Area Qualification Standard should be documented by a qualifying official, immediate supervisor, or the team leader of personnel in accordance with the Technical Qualification Program Plan of the office qualifying the individual.

CONTINUING EDUCATION, TRAINING, AND PROFICIENCY

DOE personnel shall participate in continuing education and training as necessary to improve their performance and proficiency and ensure that they stay up-to-date on changing technology and new requirements. This may include courses and/or training provided by:

- Department of Energy
- Other government agencies
- Outside vendors
- Educational institutions

Beyond formal classroom or computer based courses, continuing training may include

- Self Study
- Attendance at symposia, seminars, exhibitions
- Special assignments
- On-the-job experience

A description of suggested learning proficiency activities and the requirements for the continuing education and training program for Electrical Systems personnel are included in Appendix A of this document.

DUTIES AND RESPONSIBILITIES

The following are the typical duties and responsibilities expected of personnel assigned to the Electrical Systems Functional Area:

1. Review the management and oversight of the design and construction process.

2. Maintain and update knowledge and skills in electrical codes and technology as used at a given site. Site specific electrical codes are normally defined in the contract(s).

3. Prepare and review contracting mechanisms (cost plus award fee, cost plus fixed fee, etc.), contractor performance evaluations, and contract specifications, etc.

4. Serve as a subject matter expert and technical resource for electrical systems personnel in training and other technical matters.

5. Inspect/evaluate electrical systems for safe and efficient operation, maintenance and testing.

6. Conduct/perform accident investigations, root cause analysis and problem-solving activities.

7. Participate in establishing and/or reviewing Department of Energy electrical policy (as defined by applicable codes, standards, and orders) and requirements.

8. Evaluate contractor compliance with relevant Department of Energy Orders, standards, codes, Management & Operating contractor maintenance procedures, etc.

9. Evaluate electrical programs/operations/safety.

10. Review safety documentation.

11. Verify the application of quality assurance principles to electrical systems and safety.

Position-specific duties and responsibilities for Electrical Systems personnel are contained in their Office/Facility-Specific Qualification Standard or Position Description.

BACKGROUND AND EXPERIENCE

The U. S. Office of Personnel Management's Qualification Standards Handbook establishes minimum education, training, experience, or other relevant requirements applicable to a particular occupational series/grade level, as well as alternatives to meeting specified requirements.

The preferred education and experience for Electrical Systems personnel is:

1. Education:

   Bachelor of Science degree in Electrical Engineering from an accredited institution or meet the alternative requirements specified in the Qualification Standards Handbook for the GS-0800, Professional Engineering Series.

2. Experience:

   Industrial, military, Federal, State, or other directly related background that has provided specialized experience in electrical systems. Specialized experience can be demonstrated through possession of the competencies outlined in this Standard.

REQUIRED TECHNICAL COMPETENCIES

Each of the competency statements defines the level of expected knowledge and/or skill that an individual must possess to meet the intent of this Technical Qualification Standard. **The supporting knowledge and/or skill statements further describe the intent of the competency statements but are not requirements.**

NOTE: When U.S. Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

GENERAL TECHNICAL

1. Electrical systems personnel shall demonstrate a working level knowledge of electrical and circuit theory, terminology, theorems, laws, and analysis.

Supporting Knowledge and/or Skills

a. Explain the basic law of electrostatics.

b. Define the following terms and their relationship in energized circuits:

- Resistance
- Capacitance
- Inductance
- Reactance

c. Explain the following fundamental laws of circuit analysis:

- Ohm's Law
- Kirchoff's law

d. Explain the use of the following theorems in network analysis and describe their application in circuit reduction techniques:

- Thevenin's Theorem
- Norton's Theorem
- Maximum Power Transfer Theorem
- Superposition Theorem

e. Discuss the fundamental relationships in direct current (DC) circuits among voltage, current, resistance, and power.

f. Explain the treatment of inductance and capacitance values in steady-state direct current circuits.

g. Discuss the fundamental relationships in alternating current (AC) circuits among voltage, current, resistance, reactance, impedance, power, and power factor.

h. Describe how the following methods produce a voltage:

- Electro-chemistry
- Static electricity
- Magnetic induction
- Piezo-electric effect
- Thermo-electricity
- Photoelectric effect
- Thermonic emission

i. Using appropriate data, calculate the total resistance for a circuit containing combinations of parallel and series resistance.

j. Using appropriate data for a circuit, calculate the reactance of that circuit.

2. Electrical systems personnel shall have a working level knowledge of direct current (DC) generators.

Supporting Knowledge and/or Skills

a. Describe the relationship between shaft speed, field flux and generated voltage.

b. Define the following:

- Electromotive force
- Excitation
- Compounding
- Armature
- Terminal voltage
- Load current
- Shunt windings
- Series windings

c. State the purpose of the following components of a direct current machine:

- Armature
- Rotor
- Stator
- Field

d. Describe self-excited and separately excited generators.

e. Describe the operation of compound-wound generators.

f. Describe how the terminal voltage of a direct current generator is adjusted.

g. State the basis behind each direct current generator rating.

h. Describe the internal losses found in a direct current generator.

i. Describe the differences in construction between a shunt-wound and a series-wound direct current generator with respect to the relationship between the field and the armature.

j. Describe the relationship between the shunt and series fields for cumulatively-compounded and differentially-compounded direct current generators.

k. Describe the voltage-versus-current characteristics for a flat-compounded, over-compounded, and under-compounded direct current generator.

3. Electrical systems personnel shall have a working level knowledge of direct current (DC) motors.

Supporting Knowledge and/or Skills

a. Describe the basic construction and operation of the following four types of direct current motors:

- Shunt
- Separately excited
- Compound-wound
- Series

b. State the function of torque in a direct current motor and how it is developed.

c. Describe the function of counter-electromotive force (CEMF) and how it is developed in a direct current motor.

d. Describe the relationship between field current and magnetic field size in a direct current motor.

e. Describe how to adjust the speed of a direct current motor.

f. Describe the relationship between armature current and torque produced in a direct current motor.

g. Describe the torque-versus-speed characteristics for a shunt-wound and a series-wound direct current motor.

h. Explain why starting resistors may be necessary for large direct current motors.

4. Electrical systems personnel shall demonstrate a working level knowledge of battery construction, voltage production, and hazards.

Supporting Knowledge and/or Skills

a. Using a cutaway drawing of a simple multi-cell storage battery, identify the following components and discuss their function:

- Positive terminal
- Negative terminal

- Electrode
- Cell

b. Describe the hazards associated with storage batteries.

c. Define the following terms:

- Voltaic cell
- Battery
- Electrode
- Electrolyte
- Specific gravity
- Ampere-hour
- Electrolysis
- Equalizing Charge
- Float Charge
- Pilot Cell

d. Describe the operation of a simple voltaic cell.

e. Explain the relationship between specific gravity and state of charge of a lead-acid battery.

f. Describe the relationship between total battery voltage and individual cell voltage for a series-connected battery.

g. Explain the advantage of connecting a battery in parallel with respect to current-carrying capability.

h. Describe the difference between primary and secondary cells with respect to recharge capability.

i. State the advantages of each of the following types of batteries:

- Carbon-zinc cell
- Alkaline cell
- Nickel-cadmium cell
- Edison cell
- Mercury cell

j. Explain how gas generation is minimized for a lead-acid battery and the steps to prevent hydrogen buildup.

k. Explain how heat is generated in a lead-acid battery.

l. Describe the various uses of battery banks in DOE facilities.

m. Describe how batteries are tested.

5. Electrical systems personnel shall demonstrate a working level knowledge of basic alternating current (AC) theory.

Supporting Knowledge and/or Skills

a. Define the effective value of an alternating current relative to direct current (DC).

b. Describe the relationship between maximum, average, and root-mean-square (RMS) values of voltage and current in an alternating current waveform.

c. Using a diagram of two sine waves, describe the phase relationship between the two waves.

6. Electrical systems personnel shall demonstrate a working level knowledge of the construction and operation of alternating current (AC) generators.

Supporting Knowledge and/or Skills

a. Describe the basic construction and operation of a simple alternating current generator.

b. Describe the development of a sine-wave output in an alternating current generator.

c. Define the following terms in relation to alternating current generation:

- Radians/second
- Hertz
- Period

d. Using the type and application of an alternating current generator, describe the operating characteristics of that generator including methods of voltage production, advantages of each type, and methods for paralleling.

e. State the purpose of the following components of an alternating current generator:

- Field
- Armature
- Prime mover
- Rotor
- Stator
- Slip rings

f. Using the speed of rotation and number of poles, calculate the frequency output of an alternating current generator.

g. List the three losses found in an alternating current generator.

h. Given the prime mover input and generator output, determine the efficiency of an alternating current generator.

i. Describe the basis for the kilowatt and kilovolt-ampers ratings of an alternating current generator.

j. Describe the conditions that must be met prior to paralleling two alternating current generators including, consequences of not meeting these conditions.

k. Describe the difference between a stationary field, rotating armature alternating current generator and a rotating field, stationary armature alternating current generator.

l. Explain the differences between a wye-connected and delta-connected alternating current generator including advantages and disadvantages of each type.

7. Electrical systems personnel shall demonstrate a working level knowledge of various types of alternating current (AC) motors, including operating characteristics, method of torque production, and the advantages of specific motor types.

Supporting knowledge and/or Skills

a. Describe how an alternating current motor produces a rotating magnetic field.

b. Describe how an alternating current motor produces torque.

c. Using field speed and rotor speed, calculate percent slip in an alternating current motor.

d. Explain the relationship between speed and torque in an alternating current induction motor.

e. Describe how torque is produced in a single-phase alternating current motor.

f. Explain why an alternating current synchronous motor does not have starting torque.

g. Describe how an alternating current synchronous motor is started.

h. Describe the effects of over and under-exciting an alternating current synchronous motor.

i. State some applications of the following types of alternating current motors:

- Induction
- Single-phase
- Synchronous

j. Describe the differences in starting and operating characteristics of premium efficiency motors.

k. Describe the characteristics and operation of motor controllers.

l. Explain the following motor terms:

- Nameplate Revolutions Per Minute (RPM)
- National Electrical Mainframe Association (NEMA) frame size
- Service factor
- Insulation class
- National Electrical Mainframe Association (NEMA) design designation (letter)
- Non-symmetrical load

8. Electrical systems personnel shall demonstrate a working level knowledge of alternating current (AC) reactive components, including inductive and capacitive reactance and phase relationships in reactive circuits.

Supporting knowledge and/or Skills

a. Define the following:

- Inductive reactance
- Capacitive reactance
- Impedance
- Resonance
- Power factor
- Non-symmetrical load

b. Describe the effect of the phase relationship between current (I) and voltage (E) in an inductive circuit.

c. Describe the effect on phase relationship between current (I) and voltage (E) in a capacitive circuit.

d. Determine the value for total current (IT) in a simple parallel resistance-capacitance-inductance (R-C-L) alternating current circuit.

e. Describe the relationship between apparent, true, and reactive power.

f. Describe the indications of an unbalanced load in a three-phase power system.

g. Discuss circuit considerations required for non-symmetrical loads.

9. Electrical systems personnel shall demonstrate a working level knowledge of electrical transmission and distribution systems.

Supporting Knowledge and/or Skills

a. Explain the differences between transmission and distribution systems.

b. Identify and discuss the advantages and disadvantages associated with underground and above-ground distribution systems.

c. Describe the function and importance of the following control and protective devices:

- Circuit breakers
- Protective relays
- Fuses
- Transient protection

d. Compare and contrast the characteristics of three-phase and single-phase distribution systems.

e. Discuss the principles associated with ensuring continual power availability during electrical outages.

f. Explain the following terms as they relate to power systems:

- Fault current
- Available fault current
- Fault duty

g. Discuss the safety considerations associated with high voltage transmission systems.

h. Explain the requirements for and uses of alternate power supplies.

i. Discuss the uses of different voltages in a facility.

j. Discuss the reasons for using single phase versus 3-phase power systems in a facility.

10. Electrical systems personnel shall demonstrate a working level knowledge of transformers.

Supporting Knowledge and/or Skills

a. Define the following terms as they apply to transformers:

- Mutual induction
- Turns ratio
- Impedance ratio
- Efficiency

b. Describe the differences between a wye-connected and delta-connected transformer.

c. Using the type of connection and turns ratios for the primary and secondary of a transformer, calculate voltage, current, and power for each of the following types:

- Delta - Delta
- Delta - Wye
- Wye - Delta
- Wye - Wye

d. State the applications of each of the following types of transformers:

- Distribution
- Power
- Control
- Auto
- Isolation
- Instrument potential
- Instrument current

e. Describe the hazardous materials that are associated with transformers.

11. Electrical systems personnel shall demonstrate a working-level knowledge of Uninterruptible Power Supplies (UPS).

Supporting knowledge and/or Skills

a. Describe how a UPS works.

b. Identify the various UPS component.

12. Electrical systems personnel shall demonstrate a working-level knowledge of variable frequency (speed) drives (VFD).

Supporting knowledge and/or Skills

a. Describe the major components and operation of a VFD.

b. Give examples where VFD's are used.

13. Electrical personnel shall demonstrate a working level knowledge of electrical test instruments and measuring devices.

Supporting Knowledge and/or Skills

a. Describe the purpose and method of operation of the following in-place measuring devices:

- Voltmeter
- Ammeter
- Ohmmeter
- Wattmeter
- Ampere-hour meter
- Power factor meter
- Ground detector
- Synchroscope
- Meggar
- Power Quality Monitors

b. Describe safe methods for using the following portable test equipment:

- Ammeter
- Voltmeter
- Ohmmeter

14. Electrical systems personnel shall demonstrate a working level knowledge of safety and health fundamentals related to electrical systems and components.

Supporting Knowledge and/or Skills

a. Briefly discuss the commonly employed safety practices described in NFPA 70E.

b. Discuss the hazards associated with the use of corrosives (acids and alkalies).

c. Describe the general safety precautions necessary for the handling, storage, and disposal of corrosives.

d. Discuss the hazards associated with:

- Battery fluids and materials
- Transformer oils
- Cleaning solvents
- Epoxies
- Insulating and protective gases

e. Identify and discuss elements of an electrical safety program, including the following:

- Two-man rule
- Protective equipment
- Lockout and tagout
- Grounding
- Stored energy
- Component labeling

15. Electrical systems personnel shall demonstrate a familiarity level knowledge of the principles and concepts of natural phenomena hazards and their effect on electrical systems.

Supporting Knowledge and/or Skills

a. Discuss the potential impact of lightning on electrical systems at defense nuclear facilities.

b. Discuss various methods of lightning protection as preventive measures (e.g., surge suppressors, Faraday cages, etc.).

c. Briefly describe the safety measures and design features commonly used as safeguards against natural hazards and identify the relevant industry consensus

standards that codify accepted design and installation practices for these safeguards.

16. Electrical systems personnel shall demonstrate a working level knowledge of electrical diagrams, including:

- **One-line diagrams**
- **Schematics**
- **Construction drawings**
- **As-built drawings**
- **Wiring diagrams**

Supporting Knowledge and/or Skills

a. Using a schematic, identify an electrical component by its symbology.

b. Using a logic diagram for a control circuit, identify and describe the effects of an action taken.

c. Using a one-line diagram, identify power sources and loads.

d. Using a one-line diagram or schematic diagram, analyze the effects of a component failure in a system.

e. Using a construction drawing, identify the emergency power supplies.

f. Discuss the origin and purpose of "as-built" drawings.

17. Electrical systems personnel shall demonstrate a familiarity level knowledge of maintenance management practices related to electrical activities.

Supporting Knowledge and/or Skills

a. Define each of the following maintenance-related terms and explain their relationship to each other.

- Corrective
- Planned
- Preventive
- Reliability Centered
- Predictive

b. Discuss the importance of maintaining a proper balance of preventive and corrective maintenance.

c. Identify typical maintenance performance indicators, and discuss their importance.

d. Discuss the relationship between maintenance and Conduct of Operations, Qualify Assurance, and Configuration Management.

e. Discuss the requirements for receiving and inspecting parts, materials, and equipment.

f. Describe the difference between temporary and permanent repairs/work and the requirements and controls in place to prevent inadvertent modifications.

18. Electrical systems personnel shall demonstrate a familiarity level knowledge of the following principles as they apply to the design, construction and operation of nuclear facilities.

Supporting Knowledge and/or Skills

a. Discuss electrical power distribution with the regard to the following elements (IEEE Red Book or other sources can be used as a guide in developing the discussion):

- Basic design considerations and electrical distribution design
- Voltage considerations
- Surge voltage protection techniques
- System protective devices
- Power factor and its effects in electrical distribution systems
- Power switching, transformation, and motor-control apparatus
- Cable system basics
- Busway design

b. Discuss protection and coordination with regard to the following elements(the IEEE Buff book or other sources can be used as a guide in developing the discussion:

- Fault calculations
- Short-circuit current calculations for single and three-phase circuits.
- Instrument transformer basics
- Protective relay selection and application
- Fuses selection and application
- Low-voltage circuit breaker fundamentals
- Ground-fault protection fundamentals
- Conductor, motor, transformer, generator, and bus and switchgear protection
- Maintenance, testing, and calibration of electrical systems

c. Discuss electrical system grounding with regard to the following elements (the IEEE Green book or other source can be used as a guide in developing the discussion):

- Electrical system grounding fundamentals
- Electrical equipment grounding fundamentals
- Static and lightning grounding fundamentals

d. Discuss emergency and standby power with regard to the following elements (the IEEE Orange Book or other source can be used as a guide in developing the discussion):

- Emergency and standby power guidelines
- Generator and electric utility system fundamentals
- Stored energy system fundamentals
- Protection device fundamentals

19. Electrical systems personnel shall demonstrate a familiarity level knowledge of line filtering (power line conditioning).

Supporting knowledge and/or Skills

a. Discuss which systems would benefit from line filtering.

b. Discuss the types of noise for which systems benefiting from line filtering would be susceptible to without implementation of line filtering.

REGULATORY

NOTE: When U.S. Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

20. Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy, DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information.

Supporting Knowledge and/or Skills

a. State the purpose of the Order.

b. Define the following terms:

- Event
- Condition
- Facility
- Notification report
- Occurrence report
- Reportable occurrence

c. Discuss the Department's policy regarding the reporting of occurrences as outlined in the Order.

d. State the different categories of reportable occurrences and discuss each.

e. Review a sample of Occurrence Reports and Operating Experience Weekly reports for issues on electrical safety and discuss the lessons learned.

21. Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy Standard, DOE-STD-1073-93, Guide for Operational Configuration Management Program.

Supporting Knowledge and/or Skills

a. Describe the purpose and objectives of the Operational Configuration Management Program.

b. Discuss the following elements of the Configuration Management Program:

- Design requirements
- Document control
- Change control
- Assessments
- Design reconstitution adjunct
- Material condition and aging adjunct

c. Discuss the purpose, concepts, and general process for applying the graded approach to operational configuration management.

- Using the guidance in DOE-STD-1073-93, discuss the System Engineer concept as it applies to oversight of safety systems. Specifically address the areas of configuration management, assessment of system status and performance, and technical support for operation and maintenance activities or for Documented Safety Analysis reviews.

22. Electrical Systems Personnel shall demonstrate a familiarity level of knowledge of Department of Energy, DOE Order 430.1A, Life Cycle Asset Management.

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, and application of DOE Order 430.1A, Life Cycle Asset Management. Include in this discussion, key terms, essential elements, and personnel responsibilities and authorities.

b. Discuss the project management terminology for which definitions are provided in DOE Order 430.1A.1, Life Cycle Asset Management.

c. Discuss in detail the roles played by various management levels within the Department as they relate to the project management system.

d. Discuss the purpose of "critical decisions." Include in this discussion the responsible authorities for critical decisions.

e. Describe the process by which projects are designated.

23. Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy, DOE Order 414.1A Change 1, Quality Assurance, as it pertains to electrical systems.

Supporting Knowledge and/or Skills

a. Describe the types of documents related to electrical systems that should be controlled by a document control system.

b. Discuss the requirements for revision and distribution of controlled documents.

c. Discuss the determination of calibration frequency for electrical test equipment.

d. Describe the effect of using inappropriate calibration standards on electrical test equipment.

e. Discuss the key elements of the procurement process for electrical systems as described in DOE Order 414.1A Change 1, Quality Assurance.

24. Electrical systems personnel shall demonstrate a familiarity level knowledge of 10 CFR 830 Subpart B, 10 CFR 830.203, Unreviewed Safety Question Process, 10 CFR 830 Appendix A item H, and DOE Guide 424.1-1, Implementation Guide for Addressing Unreviewed Safety Question (USQ) Requirements.

Supporting Knowledge and/or Skills

a. Discuss the reasons for performing an Unreviewed Safety Question determination.

b. Describe the situations for which a safety evaluation is required to be performed.

c. Define the conditions for an Unreviewed Safety Question.

d. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the performance of safety evaluations.

e. Describe the actions to be taken by a contractor upon identifying information that indicates a potential inadequacy of a previous safety analyses or, a possible reduction in the margin of safety, as defined in the Technical Safety Requirements.

25. Electrical systems personnel shall demonstrate a familiarity level knowledge of the Technical Safety Requirements as described in 10 CFR 830 Subpart B, 10 CFR 830.205, Technical Safety Requirements and 10 CFR 830 Appendix A item G.

Supporting Knowledge and/or Skills

a. Discuss the purpose of the Technical Safety Requirements.

b. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the Technical Safety Requirements.

d. Define the following terms and discuss the purpose of each:

- Safety Limit
- Limiting Control Settings
- Limiting Conditions for Operation
- Surveillance Requirements

e. Describe the general content of each of the following sections of the Technical Safety Requirements:

- Use and Application
- Safety Limits
- Operating Limits
- Surveillance Requirements
- Administrative Controls
- Basis
- Design Features

26. Electrical systems personnel shall demonstrate a familiarity level knowledge of Documented Safety Analyses as described in 10 CFR 830 Subpart B, 10 CFR 830.204, 10 CFR 830 Appendix A item F.

Supporting Knowledge and/or Skills

a. Discuss the basic purposes and objectives of a Documented Safety Analysis.

b. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities regarding the development and maintenance of a Documented Safety Analysis.

c. Define the following terms and discuss the purpose of each:

- Safety Basis
- Design Features
- Safety Evaluation Report

d. Describe the requirements for the scope and content of a Documented Safety Analysis and discuss the general content of each of the required sections of a Documented Safety Analysis.

e. Discuss the uses that contractor management makes of a Documented Safety Analysis.

27. Electrical systems personnel shall demonstrate a familiarity level knowledge of the following Department of Energy Standards and Order related to natural phenomena hazards:

- **DOE-STD-1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities**
- **DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components**
- **DOE-STD-1022-94, Natural Phenomena Hazards Site Characterization Criteria**
- **DOE Order 420.1A, Facility Safety**

Supporting Knowledge and/or Skills

a. Describe the purpose, scope, and application of the requirements detailed in the listed standards and Order.

b. Discuss the graded approach process that Department line management uses to determine an appropriate level of coverage by electrical systems personnel. Include in this discussion the factors that may influence the level of coverage.

c. Determine contractor compliance with the listed documents as they apply to contract design requirements and electrical system activities at a defense nuclear facility.

28. Electrical systems personnel shall demonstrate a familiarity level knowledge of functional classifications for safety systems and the design expectations associated with electrical systems that carry these functional classifications, as described in DOE O 420.1A, Facility Safety.

Supporting knowledge and/or Skills

a. Define the term “safety-class” and discuss the implications of an electrical system carrying this functional classification.

b. Define the term “safety-significant” and discuss the implications of an electrical system carrying this functional classification**.**

ADMINISTRATIVE

NOTE: When U.S. Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

29. Electrical systems personnel shall demonstrate the ability to communicate (both oral and written) when working or interacting with the contractor, stakeholders, and other internal and external organizations.

Supporting Knowledge and/or Skills

a. Identify the various internal and external groups with whom electrical systems personnel must interface in the performance of their duties.

b. Apply written communication skills in the development of:

- Assessment reports
- Technical reports
- Technical papers

c. Apply effective and appropriate communications skills when interfacing with the contractor.

MANAGEMENT, ASSESSMENT, AND OVERSIGHT

NOTE: When U.S. Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

30. Electrical systems personnel shall demonstrate the ability to evaluate contractor activities and reports controlled by Department of Energy, DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information.

Supporting Knowledge and/or Skills

a. Using an occurrence report related to an electrical system or component and using DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information, as a reference, identify the following:

- Causes
- Corrective actions
- Lessons learned
- Whether corrective actions have been completed

31. Electrical systems personnel shall demonstrate a familiarity level knowledge of financial management practices and the application of contractor resources to meet commitments to the quality, safety, cost, and schedule of electrical systems.

Supporting Knowledge and Skills

a. Describe the process for preparing cost estimates and budgets.

b. Describe and contrast direct and indirect costs. List ways to reduce indirect costs.

c. Define and explain the relationship between the following terms:

- Budgeted cost of work scheduled (BCWS)
- Budgeted cost of work performed (BCWP)
- Actual cost of work performed (alternating current WP)
- Earned value (EV)

d. Describe the types of earned value, and how they are measured.

e. Describe the types of data required to forecast cost and schedule performance.

f. Define the term "estimate at completion" (EAC).

g. Discuss the importance of formal change control in relation to project management.

32. Electrical systems personnel shall demonstrate the ability to perform project management duties as required to provide electrical systems technical support to a project.

Supporting Knowledge and/or Skills

a. Evaluate project scope for completeness related to a new electrical system design or major modification.

b. Track project related cost.

c. Evaluate a project's critical path schedule(logic and duration).

d. Monitor project progress and identify any areas of weakness to management.

33. Electrical systems personnel shall demonstrate a familiarity level knowledge of the Department of Energy (DOE) project management system including the application of contractor resources to meet commitments to quality, safety, cost, and schedule.

Supporting Knowledge and/or Skills

a. Explain the purpose of project management and describe the phases of a typical project.

b. Describe the primary roles and responsibilities of electrical systems personnel as outlined in DOE Order 430.1, Life Cycle Management Asset Management.

c. Describe typical documents and data sources utilized by electrical systems personnel in project management.

d. Identify and explain the major elements of a project, and discuss their relationship.

e. Explain the purpose and use of a project execution plan.

f. Discuss the role of configuration management as it relates to project management.

g. Explain the use of safety plans in the management of projects.

h. Discuss the relationship between work breakdown structure (WBS) and cost and schedule.

i. Describe the purpose and use of work packages and/or planning packages.

j. Describe the purpose of schedules, and discuss the use of milestones and activities.

k. Describe the critical path method of scheduling.

l. Explain the concept of a project management baseline and describe the four baselines used in project management.

34. Electrical systems personnel shall demonstrate a working level knowledge of assessment techniques, reporting, and follow-up actions as they apply to contractor performance.

Supporting Knowledge and/or Skills

a. Describe the role of electrical systems personnel in performance oversight of government-owned, contractor-operated (GOCO) facilities.

b. Describe the assessment requirements and limitations associated with the interface of electrical systems personnel and contractor employees.

c. Describe how planning, observations, interviews, and document research are used during an assessment.

d. Explain the essential elements of a performance-based assessment including investigation, fact-finding, and reporting. Include a discussion of the essential elements and processes of the following assessment activities:

- Exit interviews
- Closure process
- Tracking to closure
- Follow-up
- Contractor corrective action implementation

e. Describe the actions to be taken if the contractor challenges the assessment findings and explain how such challenges can be avoided.

35. Electrical systems personnel shall demonstrate the ability to assess the activities of contractor and/or Federal electrical systems employees and make all necessary reports.

Supporting Knowledge and/or Skills

a. Describe the methods by which noncompliance is determined and communicated to contractor and Department management.

b. Describe the role of electrical systems personnel in the contractor performance evaluation process.

c. Participate in the evaluation of a contractor's performance.

d. Conduct an interview as part of an evaluation of an occurrence.

e. Develop an assessment report.

f. Participate in formal meetings between Department management and senior contractor management to discuss the results of electrical systems assessments.

36. Electrical systems personnel shall demonstrate a working level knowledge of problem analysis principles and the ability to apply techniques necessary to identify problems, determine potential causes of problems, and identify corrective action(s).

Supporting Knowledge and/or Skills

a. Describe and explain the application of problem analysis techniques including the following:

- Root cause analysis
- Causal factor analysis
- Change analysis
- Barrier analysis
- Management oversight risk tree (MORT) analysis

b. Describe and explain the application of the following root cause analysis processes in the performance of occurrence investigations:

- Event and causal factors charting
- Root cause coding
- Recommendation generation

c. Using event and/or occurrence data, apply problem analysis techniques and identify the problems and how they could have been avoided.

d. Participate in at least one contractor or Department problem analysis and critique the results.

e. Using data, interpret two fault tree analyses.

37. Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) maintenance management requirements as defined in DOE Order 4330.1B, Maintenance Management Program (non-nuclear facilities) or DOE Order 430.1A Life Cycle Asset Management (nuclear facilities).

Supporting Knowledge and/or Skills

a. Explain the Department's role in the oversight of contractor maintenance operations.

b. Identify the key elements of a contractor maintenance plan as required by the DOE Orders referenced above.

c. Describe configuration control and its relationship to the maintenance work control process and the maintenance history file.

d. Describe the mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

e. Review a contractor preventive maintenance activity and describe the preventive maintenance factors to be considered as the activity is planned.

f. Discuss the importance of post-maintenance testing and the elements of an effective post-maintenance testing program.

g. Review the results of post-maintenance testing activities and discuss the acceptance of post-maintenance testing.

h. Discuss the importance of maintaining a maintenance history.

i. Review a maintenance history file and discuss the potential implications of repeat maintenance items.

j. Explain the intent of a Maintenance Problem Analysis Program and discuss a maintenance problem where this program has been employed.

38. Personnel shall demonstrate a working level knowledge of the functional interfaces between safety system software components and the system-level design.

Knowledge, Skills, and Abilities

a. Identify how system-level requirements are established and then assigned to hardware, software, and human components of a digital instrumentation and control system.

b. Identify the typical requirements that define functional interfaces between safety system software components and the system-level design, as described in standards such as ANSI/IEEE 830, *IEEE Guide to Software Requirements Specifications* and IEEE 7-4.3.2, *Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations.*

c. Identify the specific records that must be maintained and the requirements for maintaining these records to document the development of safety system software.

d. Review a development project for safety system software. Explain how the functional interfaces between components and the system level design were established and controlled.

39. Personnel shall demonstrate a working level knowledge of the relationships between the problems being addressed by safety analysis and design codes, the design requirements for the codes, and the components of the codes.

Knowledge, Skills, and Abilities

a. Identify how functional requirements and applicability of safety analysis and design computer codes are defined, documented, and controlled relative to modeling and data assumptions, design constraints, sizing and timing conditions and input/output parameters.

b. Review a development project for safety analysis or design software. Explain how the problem being addressed by the software was translated into functional requirements, how the requirements were established and controlled, and how the code was reconciled with the original problem.

APPENDIX A
CONTINUING EDUCATION, TRAINING AND PROFICIENCY PROGRAM

The following list represents suggested continuing education, training, and other opportunities that are available for DOE personnel after completion of the competency requirements in this technical Functional Area Qualification Standard. It is extremely important that personnel involved with this program maintain their proficiency through continuing education, training, reading, or other activities such as workshops, seminars, and conferences. The list of suggested activities was developed by the Subject Matter Experts involved in the development of the Functional Area Qualification Standard and is not all-inclusive.

LIST OF CONTINUING EDUCATION, TRAINING, AND OTHER ACTIVITIES

Electrical Systems personnel shall participate in an Office/Facility-specific continuing training and qualification program that includes the following elements:

1. Continuing technical education and/or training covering topics directly related to the electrical systems area as determined appropriate by management. This may include courses/training provided by Department of Energy, other government agencies, outside vendors, or local educational institutions. Continuing training topics should also address identified weaknesses in the knowledge or skills of the individual personnel.

2. Attend seminars, symposia, or technical meetings related to Electrical Systems.

3. Engage in self-study of new regulations, requirements, or advances related to Electrical Systems.

4. Participation in practical exercises such as emergency or operational drills, simulations, or laboratory-type exercises.

5. Specific continuing training requirements shall be documented in Individual Development Plans.

Suggested resources:

Institute of Electrical and Electronics Engineers, Inc. (IEEE)
3 Park Avenue, 17th Floor
New York, New York 10016-5997
http://www.ieee.org

The Instrumentation, Systems, and Automation Society (ISA)
67 Alexander Drive
PO Box 12277
Research Triangle Park, NC 27709
http://www.isa.org

National Fire Protection Association (NFPA)
(NFPA 70 - National Electrical Code)
1 Batterymarch Park
P.O. Box 9101
Quincy, Massachusetts 02269-9101
http://www.nfpa.org/nec/nechome.asp

AVO International Training Institute
4271 Bronze Way,
Dallas, Texas 75237-1017 USA
http://www.avointl.com/us/training

Electrical Systems Self Study Guide
http://cted.inel.gov/cted/tq_tm_index.html

CONCLUDING MATERIAL

Review Activity:
DOE
DP-NNSA
EH
EM
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Field and Operations Offices
AL
CH
ID
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OH
OR
RF
RL
SF
SR
Carlsbad Field Office (CBFO)
Office of River Protection

Area Offices:
Amarillo Area Office
Argonne Area Office
Brookhaven Area Office
Fermi Area Office
Kirtland Area Office
Los Alamos Area Office
Princeton Area Office
Rocky Flats Area Office
Y-12 Area Office

Preparing Activity:
DOE-EH-22

Project Number:
TRNG-0037