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DOE STANDARD

ELECTRICAL SYSTEMS AND SAFETY OVERSIGHT FUNCTIONAL AREA QUALIFICATION STANDARD

DOE Defense Nuclear Facilities Technical Personnel

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

AREA TRNG

APPROVAL

The Federal Technical Capability Panel consists of senior U.S. Department of Energy (DOE) 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.

Karen L. Boardman, Chairperson
Federal Technical Capability Panel

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ACKNOWLEDGMENT

The U.S. DOE, Richland Operations Office (RL) is the sponsor for the Electrical Systems and Safety Oversight Functional Area Qualification Standard (FAQS). The sponsor is responsible for coordinating the development and/or review of the FAQS 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 and Safety Oversight program. The sponsor, in coordination with the Federal Technical Capability Panel, is also responsible for ensuring that this FAQS is maintained current.

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

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U.S. DEPARTMENT OF ENERGY
FUNCTIONAL AREA QUALIFICATION STANDARD

Electrical Systems and Safety Oversight

PURPOSE

DOE Manual (M) 426.1-1A, *Federal Technical Capability Manual*, commits the Department to continuously strive for technical excellence. The Technical Qualification Program (TQP), 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. Sections I and II of this FAQS 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. The U.S. Office of Personnel Management (OPM) minimum qualifications standards will be greatly enhanced by application of appropriate materials from the technical FAQSs.

The technical qualification standards are not intended to replace the OPM qualifications standards nor other Departmental personnel standards, rules, plans, or processes. The primary purpose of the TQP is to ensure that employees have the requisite technical competency to support the mission of the Department. The TQP 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 and Safety Oversight FAQS establishes general and specific functional area competency requirements for all DOE Electrical Systems and Safety Oversight 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 and, when appropriate, to other DOE facilities. The technical FAQSs have been developed as a tool to assist DOE program and field offices in the development and implementation of the TQP in their organization. For ease of transportability of qualifications between DOE elements, program and field offices are expected to use Sections I and II of this FAQS without modification or additions. Sections III, IV, V, VI, and VII should be used by the program and field offices to assist them with the specific technical qualifications for that office. These sections may have information added or deleted at the option of the office. Satisfactory and documented attainment of the competency requirements contained in this technical FAQS (see the Federal Technical Capability Program Directives and Standards page at http://www.hss.energy.gov/deprep/ftcp/directives/directives.asp for an example of the Electrical Systems and Safety Oversight FAQS qualification card that may be modified for sections III, IV, V, VI, and VII to meet the program or field office needs) ensures that personnel possess the minimum requisite competence to fulfill their functional area duties and responsibilities common to the DOE complex. Office/site/facility-specific qualification standards should use Sections III, IV, V, VI, and VII (as applicable) to supplement Sections I and II of this FAQS and establish

unique operational competency requirements at the Headquarters or field element, site, or facility level.

It should be noted that the competency elements of management and leadership, general technical knowledge, regulations, administrative capability and assessment and oversight are all embodied in the competencies listed in this Standard. All of the factors above have a bearing on safety. Although the focus of this Standard is technical competence, elements, such as, good communication, recognized credibility, ability to listen and process information, and the ability to guide an effort to get it right the first time are recognized as important aspects of safety.

IMPLEMENTATION

Sections I and II of this Electrical Systems and Safety Oversight FAQS identifies the minimum technical competency requirements for DOE personnel. Although there are other competency requirements associated with the positions held by DOE personnel, this FAQS is limited to identifying the general technical competencies in Section I and II (that are the core competencies all candidates are required to meet), and specific technical competencies in Sections III, IV, V, VI, and VII (which are optional and based upon the candidates assigned duties). The competency statements define the expected knowledge and/or skill that a candidate must meet. Each of the competency statements is further described by a listing of supporting knowledge and/or skill statements, which although not required, do describe the intent of the competency statement(s). In selected competencies, expected knowledge and/or skills have been designated as “mandatory performance activities”. General technical competencies, Sections I and II, are mandatory for all candidates and specific technical competencies, Sections III, IV, V, VI, and VII, are to be used as guidance for the individual DOE program or office to establish a candidate’s required competencies based upon the candidate’s assigned duties. Once competencies are selected for a candidate by the qualifying official (who can be a supervisor), these competencies and associated mandatory performance activities are not optional.

The competencies identify a familiarity level, a working level, or an expert level of knowledge; or they require the candidate 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 recognize the need to seek and obtain appropriate expert advice (e.g., technical, legal, safety) or consult appropriate reference materials 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 positions. That includes the competencies identified in this technical FAQS. Documentation of the completion of the requirements of the Standard shall be included in the employee's training and qualification record. Satisfactory attainment of the competency requirements contained in this technical FAQS may be documented using the example Electrical Systems and Safety Oversight FAQS qualification card that can be obtained from the Federal Technical Capability Program Directives and Standards page at http://www.hss.energy.gov/deprep/ftcp/directives/directives.asp.

Equivalencies should be used sparingly and with the utmost rigor and scrutiny to maintain the spirit and intent of the TQP. Equivalencies may be granted for individual competencies based on 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 TQP Plan of the site/office/Headquarters organization qualifying the individual. The supporting knowledge and/or skill statements and mandatory performance activities should be considered before granting an equivalency for a competency.

Training shall be provided to employees in the TQP who do not meet the competencies contained within their qualification card. 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 on 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 FAQS competency statements.

EVALUATION REQUIREMENTS

Attainment of the competencies listed in this technical FAQS shall be documented in accordance with the TQP Plan or policy of the site/office/Headquarters organization qualifying the individual.

Unless stated otherwise within the program or site TQP Plan, attainment of the competencies listed in the Electrical Systems and Safety Oversight FAQS should be evaluated and documented by a qualifying official or immediate supervisor, using a combination of the following methods.

- Satisfactory completion of a written examination
- Satisfactory completion of an oral examination
- Satisfactory accomplishment of an observed task or activity directly related to a competency
- Documented evaluation of equivalencies (such as applicable experience in the field) without a written examination.

Field element managers/Headquarters program managers shall qualify candidates as possessing the basic technical knowledge, technical discipline competency, and position-specific knowledge, skills, and abilities required for their positions. Final qualification should be performed using one or a combination of the following methods:

- Satisfactory completion of a comprehensive written examination. The minimum passing grade should be 80 percent.
- Satisfactory completion of an oral examination by a qualified Senior Technical Safety Manager (STSM) or a qualification board of technically qualified personnel to include at least one qualified STSM.
- Satisfactory completion of a walkthrough of a facility with a qualifying official for the purpose of verifying a candidate's knowledge and practical skills of selected key elements.

For oral examinations and walkthroughs, qualifying officials or board members should ask critical questions intended to integrate identified learning objectives during qualification. Field element managers/Headquarters program managers or designees should develop formal guidance for oral examinations and walkthroughs that includes:

- Standards for qualification
- Use of technical advisors by a board
- Questioning procedures or protocol
- Pass/fail criteria
- Board deliberations and voting authorization procedures
- Documentation process

INITIAL QUALIFICATION, REQUALIFICATION, AND TRAINING

Qualifications of Electrical Systems and Safety Oversight personnel shall be conducted in accordance with the requirements of DOE M 426.1-1A.

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:

- DOE
- 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 activities and the requirements for the continuing education and training program for Electrical Systems and Safety Oversight personnel are included in Appendix A of this document.

DUTIES AND RESPONSIBILITIES

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

1. Oversee the contractor's electrical work activities and programs.

2. Identify electrical problem and analyze trends; identify and classify electrical hazards; implement appropriate codes and standards [Occupational Safety and Health Administration (OSHA); National Electrical Code (NEC); National Fire Protection Association (NFPA) 70-series; Institute of Electrical and Electronics Engineers (IEEE), including the C-2 National Electrical Safety Code (NESC); DOE-HDBK-1092-2004, *Electrical Safety Handbook*; etc.]; oversee electrical inspection programs and electrical safety and system assessment programs; and oversee electrical safety, operational systems and facilities.

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

4. Review and provide oversight of the electrical equipment maintenance management (safety & systems) program.

5. 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).

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

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

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

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

10. Participate in establishing and/or reviewing DOE electrical policy (as defined by applicable codes, standards, and Orders) and requirements.

11. Evaluate contractor compliance with relevant DOE Orders, standards, codes, Management and Operating (M&O) contractor maintenance procedures, etc.

12. Evaluate electrical programs/operations/safety.

13. Review safety documentation.

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

15. Verify that safety documentation and design documentation are coordinated.

Position-specific duties and responsibilities for Electrical Systems and Safety Oversight personnel are contained in their office/site/facility-specific qualification standard and/or position description.

BACKGROUND AND EXPERIENCE

The OPM 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 and Safety Oversight personnel are:

1. Education:

   Bachelor of Science degree in Electrical Engineering (electrical power option preferred), or in an applicable discipline, 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 for electrical duties assigned. Specialized experience can be demonstrated through possession of the competencies outlined in this Standard.

REQUIRED TECHNICAL COMPETENCIES

The competencies contained in this Standard are distinct from those competencies contained in the General Technical Base (GTB) Qualification Standard. All Electrical Systems and Safety Oversight personnel must satisfy the competency requirements of the GTB Qualification Standard prior to or in parallel with the competency requirements contained in this Standard. Each of the general technical competency (Section I and II) statements defines the level of expected knowledge and/or skill that a candidate must possess to meet the intent of this Standard. The specific technical competency (Section III, IV, V, VI, and VII) statements shall be required only if selected for use by the assigned qualifying official based upon the candidate's assigned duties. Each of the competency statements is further described by a listing of supporting knowledge and/or skill statements, which although not requirements, do describe the intent of the competency statement(s). In selected competencies, expected knowledge and/or skills have been designated as "mandatory performance activities." The mandatory performance activities and mandatory competencies in general competencies and specific competencies (based upon the candidates' assigned duties) are not optional.

NOTE: When regulations, DOE directives, or other industry standards are referenced in this FAQS, the most recent revision should be used.

GENERAL TECHNICAL COMPETENCIES

I. KNOWLEDGE OF ELECTRICAL THEORY & EQUIPMENT

1. Electrical personnel shall demonstrate a working level knowledge of electrical and circuit theory, theorems, terminology, 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
- Thermionic 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.

k. Discuss the importance of step potential.

l. Discuss the importance of touch potential.

2. Electrical personnel shall demonstrate a working level knowledge of basic AC theory.

Supporting Knowledge and/or Skills

a. Define the effective value of an AC relative to DC.

b. Describe the relationship between maximum, average, and Root-Mean-Square (RMS) values of voltage and current in an AC waveform.

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

3. Electrical personnel shall demonstrate a working level knowledge of the construction and operation of AC generators (such as operating characteristics, method of torque production, and the advantages of specific motor types).

Supporting Knowledge and/or Skills

a. Describe the basic construction and operation of a simple AC generator.

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

c. Define the following terms in relation to AC generation:

- Radians/second
- Hertz
- Period

d. Using the type and application of an AC 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 AC 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 AC generator.

g. List the three losses found in an AC generator.

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

i. Describe the basis for the kilowatt and kilovolt-amperes ratings of an AC generator.

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

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

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

4. Electrical personnel shall demonstrate a working level knowledge of the construction and operation of AC motors (such as operating characteristics, method of torque production, and the advantages of specific motor types).

Supporting knowledge and/or Skills

a. Describe how an AC motor produces a rotating magnetic field.

b. Describe how an AC motor produces torque.

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

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

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

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

g. Describe how an AC synchronous motor is started.

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

i. State some applications of the following types of AC 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 Manufacturers Association (NEMA) frame size
- Service factor
- Insulation class
- National Electrical Manufacturers Association (NEMA) design designation (letter)
- Non-symmetrical load

m. Describe the importance of rotational checks prior to placing a three phase motor in service.

5. Electrical personnel shall demonstrate a working level knowledge of 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) AC 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.

6. Electrical personnel shall demonstrate a working level knowledge of electrical transmission and distribution systems (IEEE Brown Book; reference IEEE Std-399).

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 three-phase power systems in a facility.

k. Discuss which systems would benefit from line filtering.

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

m. Define the terms, harmonics, positive, negative and zero sequence currents.

n. Describe the sources of harmonics.

o. Describe the effect of harmonics on the power system and equipment.

p. Describe the typical means of mitigating harmonics and their effects.

q. Describe how load calculations are made to determine/verify system or facility power requirements.

7. Electrical 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.

f. Describe the conditions that must be met prior to paralleling two transformers, including consequences of not meeting these conditions.

8. Electrical 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 components.

c. Describe the use of UPS in safety systems (such as a radiation criticality accident alarm system).

9. Electrical personnel shall demonstrate a working level knowledge of Variable Frequency (speed) Drives (VFDs).

Supporting knowledge and/or Skills

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

b. Give examples where VFDs are used in safety systems and in other applications.

c. Describe the importance of line filtering for VFD equipment.

d. Describe the importance of proper selection of the cable and lead wires for use with VFDs to minimize the effect of electromagnetic interference on nearby equipment and adjacent systems.

e. Describe other issues related the transients and harmonics generated by use of VFDs, and how they need to be addressed to obtain reliable and safe system operation and long cable life (IEEE Emerald Book; reference IEEE Std-1100 and IEEE Std-1050).

10. 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, and explain how to use the correct electrical instrument/measuring device in accordance with the manufactures specifications and instructions (i.e. within the devices rated voltage of 600 volts or less):

- 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

c. Describe the importance of tolerances and calibration requirements for test instruments.

d. Describe the importance of different category meters (such as CAT I, CAT II, CAT II, and CAT IV; reference UL 3111-1).

e. Describe the types of meters used for over 600 volts.

11. Electrical personnel shall demonstrate a familiarity level knowledge of the principles and concepts of natural phenomena hazards such as static electricity (NFPA 77) and their effects on personnel and 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. Reference the following:

- 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*

12. Electrical personnel shall demonstrate a working level knowledge of 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 DC 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 DC generator is adjusted.

g. State the basis behind each DC generator rating.

h. Describe the internal losses found in a DC generator.

i. Describe the differences in construction between a shunt-wound and a series-wound DC 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 DC generators.

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

13. Electrical personnel shall demonstrate a working level knowledge of DC motors.

Supporting Knowledge and/or Skills

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

- Shunt
- Separately excited
- Compound-wound
- Series

b. State the function of torque in a DC motor and explain how it is developed.

c. Describe the function of a Counter-Electromotive Force (CEMF) and explain how it is developed in a DC motor.

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

e. Describe how to adjust the speed of a DC motor.

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

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

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

14. Electrical personnel shall demonstrate a working level knowledge of battery construction, voltage production, and hazards (IEEE Std-450, etc.).

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 list 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.

II. ELECTRICAL ISSUE IDENTIFICATION & REPORTING

15. Electrical personnel shall demonstrate a working level knowledge of surveillance and assessment techniques, reporting, and follow up actions for electrical systems and programmatic elements of an electrical safety program, such as management systems, problem remediation and trends processes, inspection programs, training and qualification programs, and oversight of contractor assurance systems.

Supporting Knowledge and/or Skills

a. Describe the role of electrical personnel in performance oversight of Government-owned, Contractor-operated (GOCO) facilities.

b. Describe the assessment requirements and limitations associated with the interface of electrical 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.

f. Describe the methods by which noncompliance is determined and communicated to the contractor and Departmental management.

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

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

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

j. Develop an assessment report.

k. Participate in formal meetings between Departmental management and senior contractor management to discuss the results of electrical assessments.

16. Electrical personnel shall demonstrate the ability to communicate technical issues (both orally 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 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.

17. Electrical personnel shall demonstrate a familiarity level knowledge with the Environmental Safety and Health (ES&H) reporting requirements as noted in DOE M 231.1-1A, *Environment, Safety and Health Reporting Manual*.

Supporting Knowledge and/or Skills

a. Using an occurrence report related to an electrical system or component and using DOE M 231.1-2 as a reference, identify the following:

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

b. State the purpose of the DOE Order (O) 231.1A and DOE M 231.1-2.

c. Define the following terms:

- Event
- Condition
- Facility
- Notification report
- Occurrence report
- Reportable occurrence
- Near miss
- Hazardous energy control

d. Discuss the Department's policy regarding the reporting of occurrences as outlined in the Order and Manual.

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

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

18. Electrical personnel shall demonstrate a working level knowledge of problem analysis principles and the ability to apply the 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.

19. Electrical personnel shall demonstrate the ability to perform electrical safety and system walkdowns, and observe and report nonconformance to OSHA 29 CFR 1910, 29 CFR 1926, NFPA-70 (National Electrical Code), NFPA-70E, and IEEE C2- NESC.

Supporting Knowledge and/or Skill

a. Coordinate and conduct two or more electrical safety and system walkdowns of applicable contractor facilities and document issues in a report.

b. For each report finding (if any), cite noncompliance to one or more of the above mentioned requirements documents, describe the “as found” condition, and explain how it is not in compliance with the cited requirement(s).

SPECIFIC TECHNICAL COMPETENCIES

III. SAFETY & HEALTH RELATED TO ELECTRICAL SYSTEMS and COMPONENTS
This section is optional and should be used by the program and/or field offices to assist them with specific technical qualifications for that office.

20. Electrical personnel shall demonstrate a working level knowledge of how electrical hazards are addressed via the Integrated Safety Management System (ISMS) process, including applicable site contractor(s) job planning (job hazard analysis and identification and integration of hazard controls within work package) and application of hazard controls during the work control process.

Supporting Knowledge and/or Skills

a. Describe and explain the how the ISMS process addresses and controls electrical hazards.

b. Describe and explain the contractors' electrical work control process in the following areas:

- Work planning
- Hazard identification via hazard analysis
- Hazard controls
- Work performance
- Work feedback

21. Electrical personnel shall demonstrate a working level knowledge of 29 CFR 1910. 331-335; 29 CFR 1910.269; and NFPA 70E, Article 110, *Electrical Safety-Related Work Practices*.

Supporting Knowledge and/or Skills

a. Describe and explain electrical training and qualification programs.

b. Describe and explain electrical safety program elements.

22. Electrical personnel shall demonstrate a working level knowledge of the site contractor's procedure/work control program, how electrical work performed by the site contractor is within planned controls, and the specific work control requirements for each job observed. The level of rigor of these jobs should allow the candidate to review the functional areas, requirements, and workscope for compliance with 29 CFR 1910, 29 CFR 1926, and NFPA 70E.

Note: To safely observe electrical work on or near energized electrical conductors, the candidate must be previously trained to the appropriate requirements. Candidates are not to cross any shock or arc flash boundary without the appropriate training and understanding of the potential hazards.

Supporting Knowledge and/or Skills

a. Describe and explain electrical safety-related work practices and the establishment of electrically safe work conditions (29 CFR 1910.147, 29 CFR 1910.331-335, and NFPA 70E, Article 120) including, but not limited to, Lockout/Tagout (LOTO), de-energization requirements, zero-energy checks, and the electrically-safe-work-condition verification process.

b. Describe and explain the electrical hazards/risk identification and classification processes (29 CFR 1910, 29 CFR 1926, and NFPA 70E, Article 130).

c. Describe and explain how to conduct electrical work on or near live parts, including, but not limited to, energized electrical work permits (elements and exemptions), shock and arc-flash hazard analyses, arc flash calculation methodology, arc flash reduction techniques, approach boundaries, and associated Personal Protective Equipment (PPE) (NFPA 70E, Article 130; IEEE Std-1584; etc.).

d. Describe and explain safety-related maintenance requirements, including grounding and bonding, safety equipment, clear space requirements, substations, switchgear, panels, motor control centers, premises wiring, controller equipment, fuses and circuit breakers, rotating equipment, hazardous locations, batteries and battery rooms, portable electric tools and equipment, and personal safety and protective equipment (NFPA 70E, Chapter 2; IEEE Std-450; etc.).

e. Describe and explain the safety requirements for special equipment such as Research and Development (R&D) electrical safety requirements and work practices for such R&D equipment, i.e., laser operations and power electronic equipment, etc. (NFPA 70E, Article 400; American National Standards Institute (ANSI); etc.).

f. Describe and explain the installation safety requirements for power systems protection; flash protection; guarding of live parts; wiring design and protection; wiring methods, components, and equipment; specific purpose equipment and installations [cranes and hoists, elevators, Heating, Ventilating and Air-conditioning (HVAC), X-ray equipment, motor controllers, etc.]; and hazardous locations (NFPA 70 and NFPA 70E, Chapter 4).

23. From the jobs observed in Competency 22 above, electrical personnel shall demonstrate the ability to assess how well contractor management systems (lessons learned and other feedback processes) are integrated with the work planning and ISMS process and how lessons learned are addressed by each contractor's ISMS feedback process (DOE P 450.4, *Safety Management System Policy*).

Supporting Knowledge and/or Skills

a. Describe and explain the contractors' lessons learned program.

b. Describe and explain how electrical lessons learned are integrated into the contractors' work planning process.

c. Describe and explain how feedback from the workers who have completed an electrical job is integrated into the contractors' work planning process.

24. Electrical personnel shall demonstrate a working level knowledge of 29 CFR 1910; 29 CFR 1926; and NFPA 70E, Article 420 requirements.

Supporting Knowledge and/or Skill

a. Describe and explain wiring methods, bonding of enclosures, temporary wiring, and permitted use of cable trays.

b. Describe and explain safety positioning and connection of switches.

c. Describe and explain switch/panelboard location and access requirements.

d. Describe and explain enclosures for damp and wet locations.

e. Describe and explain conductor identification requirements.

f. Describe and explain permitted and non-permitted use of flexible cords and cables.

g. Describe and explain portable cables over 600 volts.

h. Describe and explain motor, transformer, and capacitor general use equipment.

25. Electrical personnel shall demonstrate a working level knowledge of the safety requirements in DOE-HDBK-1092-2004, *Electrical Safety Handbook*.

Supporting Knowledge and/or Skill

a. Describe and explain hazards identification, classification, PPE, and associated work practices.

b. Describe and explain equipment configuration, and operational practices.

c. Describe and explain training and qualifications requirements.

26. Electrical personnel shall demonstrate a working level knowledge of the requirements related to safe work practices for laser operations (NFPA 70E, Chapter 3, etc.).

Supporting Knowledge and/or Skill

a. Describe and explain fail-safe interlocks.

b. Describe and explain controlled areas.

c. Describe and explain laser characteristics.

d. Describe and explain safety training and qualifications.

e. Describe and explain safeguarding of personnel.

IV. ELECTRICAL MAINTENANCE MANAGEMENT FOR NUCLEAR AND NON-NUCLEAR FACILITIES

This section is optional and should be used by the program and/or field offices to assist them with specific technical qualifications for that office.

27. Electrical personnel shall demonstrate a familiarity level knowledge of the DOE maintenance management requirements as defined in DOE O 433.1A, *Maintenance Management Program for DOE Nuclear Facilities*, and DOE Guide 433.1-1, *Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1* (IEEE Yellow Book; reference IEEE Std-902).

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, quality 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.

g. Discuss the importance and methods of establishing acceptance criteria for inspection and testing.

28. Electrical personnel shall demonstrate a familiarity level knowledge of the safety requirements for electrical equipment maintenance as defined by NFPA 70B, manufactures requirements, American Society for Testing and Materials (ASTM), ANSI, etc.

Supporting Knowledge and/or Skill

a. Describe and explain electrical preventive maintenance program elements.

b. Describe and explain training requirements; special precautions relating to electronic equipment, e.g., equipment de-energization; zero-energy checks; prevention of shock; and grounding requirements for maintenance actions.

c. Describe and explain Ground Fault Circuit Interrupter (GFCI) and Ground-Fault Protection for Equipment (GFPE) maintenance requirements, e.g., trip tests, records keeping, and approved listing of test equipment.

d. Describe and explain testing and test methods, precautions and safety, qualifications of test operators, test equipment, and protective device testing.

e. Describe and explain de-energizing and grounding of equipment to provide protection for electrical maintenance personnel, such as grounding requirements and symptoms and causes of inadequate grounding.

f. Describe and explain grounding system inspection, testing and monitoring, and solutions for inadequate grounding.

g. Describe and explain maintenance and servicing of transformers, cables, breakers, and motors.

29. Electrical personnel shall demonstrate a familiarity level knowledge of safety-related maintenance requirements as defined in 29 CFR 1910.269 and NFPA 70E, Chapter 2.

Supporting Knowledge and/or Skill

a. Describe and explain grounding and bonding.

b. Describe and explain safety equipment and clear space requirements.

c. Describe and explain electrical systems and components.

d. Describe and explain hazardous locations.

e. Describe and explain PPE.

f. Identify and discuss elements of an electrical safety program, such as the two-man rule, stored energy, and component labeling.

V. ELECTRICAL DESIGN & INSTALLATION (SAFETY AND SYSTEMS)

This section is optional and should be used by the program and/or field offices to assist them with specific technical qualifications for that office.

30. Electrical personnel shall demonstrate a working level knowledge of the current *National Electrical Code* and the requirements for wiring design and protection (NFPA 70 and NFPA 70E, Chapter 4).

Supporting Knowledge and/or Skill

a. Describe and explain the use of listed and labeled Nationally Recognized Test Laboratory (NRTL) electrical equipment.

b. Describe and explain branch circuit identification.

c. Describe and explain GFCI protection for personnel.

d. Describe and explain outside circuits and conductors for 600 volts (or less) systems.

e. Describe and explain overcurrent protection for 600 volts (or less) and greater-than 600 volts circuits.

f. Describe and explain grounding and bonding requirements as noted in NFPA 70E, Article 410.10.

31. Electrical personnel shall demonstrate a familiarity level knowledge with the requirements for the installation of lightning protection systems (NFPA 780; UL 96, *Lightning Protection Components*; and UL 96A, *Installation Requirements for Lightning Protection Systems*).

Supporting Knowledge and/or Skill

a. Describe and explain the principles of lightning.

b. Describe and explain how lightning protection system work and their associated requirements.

32. Electrical personnel shall demonstrate a working level knowledge of electrical diagrams, such as one-line diagrams, schematics, construction drawings, as-built drawings, and 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.

33. Electrical personnel shall demonstrate a familiarity level knowledge of the configuration management process as applied to electrical documentation (e.g., documenting, controlling, revising, and issuance of electrical drawings) and drawings that are updated and issued “as built” (DOE-STD-1073-2003, *Configuration Management Program* and DOE O 414.1C, *Quality Assurance*).

Supporting Knowledge and/or Skills

a. Discuss the change control process described in DOE-STD-1073-2003.

b. Describe the purpose and objectives of the operational configuration management program, and explain how it relates to electrical systems.

c. Discuss the following elements of the configuration management program as they relate to electrical systems:

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

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

- Using the guidance in DOE-STD-1073-2003, 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 (DSA) reviews.
- Using DOE O 414.1C, discuss how the pedigree of electrical equipment should be maintained when supporting a nuclear related activity, and/or performing a safety function.

34. Electrical personnel shall demonstrate a familiarity level knowledge with battery installations, maintenance, testing, and replacement as described in NFPA 70E, Chapter 3; IEEE Std-450; IEEE C2 - NESC; manufactures recommendations; etc.

Supporting Knowledge and/or Skill

a. Describe and explain connections and capacities.

b. Describe and explain DC systems grounding and ground-fault detection.

c. Describe and explain DC circuit protection and alarms.

35. Electrical personnel shall demonstrate a familiarity level knowledge with ventilation and battery room requirements as cited in 29 CFR 1910; 29 CFR 1926; NFPA 70E, Chapter 3; IEEE Std-450; IEEE C2 – NESC; etc.

Supporting Knowledge and/or Skill

a. Describe and explain DC systems grounding and ground-fault detection.

b. Describe and explain ventilation requirements for different battery types.

c. Describe and explain battery room restrictions, barriers, illumination, and enclosure requirements.

d. Describe and explain battery protection requirements.

VI. ELECTRICAL VITAL SAFETY SYSTEMS (VSS)*

This section is optional and should be used by the program and/or field offices to assist them with specific technical qualifications for that office. *This section also applies to safety significant, safety class, and defense-in-depth structures, systems, and components.

36. Mandatory Performance Activity: Electrical personnel shall demonstrate a familiarity level of knowledge of 10 CFR 830, *Nuclear Safety Management*, and DOE O 414.1C as related to electrical safety programs, processes, and systems, to include:

- **Knowledge of site VSS interfaces for electrical, software, and instrument and control systems (complete competency 38);**
- **The basic purpose of the Unreviewed Safety Question (USQ) process;**
- **General purpose and constitution of the DSA;**
- **Purpose and content of Technical Safety Requirements (TSR) documentation.**
- **Review and evaluate a USQ determination, including walking down the proposed change/potential inadequacy with the cognizant contractor electrical VSS system engineer or DOE Facility Representative (FR).**
- **Review and evaluate an authorization agreement, and then discuss TSRs (and/or other controls) with the cognizant contractor electrical VSS system engineer.**
- **Review and evaluate a Safety Evaluation Report (SER) and discuss with the cognizant contractor electrical VSS system engineer.**
- **Walkdown a facility with Safety System Oversight (SSO) person, safety analyst, or cognizant contractor electrical VSS engineer and identifying the safety controls contained in a TSR.**
- **Complete a review of a hazard analysis or accident analysis, including walking down the scope of work area or accident scenario with the cognizant contractor electrical VSS system engineer or DOE FR.**

Supporting Knowledge and/or Skills

a. Discuss the reasons for performing an USQ determination.

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

c. Define the conditions for an USQ.

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 TSRs.

f. Discuss the purpose of the TSRs.

g. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the TSRs.

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

- Safety limit
- Limiting control settings
- Limiting conditions for operation
- Surveillance requirements

i. Describe the general content of each of the following sections of the TSRs:

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

j. Discuss the basic purposes and objectives of a DSA.

k. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities regarding the development and maintenance of a DSA.

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

- Safety basis
- Design features
- Safety evaluation report

m. Describe the requirements for the scope and content of a DSA and discuss the general content of each of the required sections of a DSA.

n. Discuss the uses that contractor management makes of a DSA.

37. Electrical personnel shall demonstrate a familiarity level knowledge of all assigned electrical power VSS and how they are addressed during the design, construction, and operation of nuclear facilities

Supporting Knowledge and/or Skills

a. **Mandatory Performance Activity:** Walkdown electrical power VSSs with the cognizant contractor electrical VSS system engineer or DOE FR. Locate and identify major components, subsystems, and interfaces.

b. Identify all assigned electrical power VSS (site-specific), and discuss the functional classifications, safety functions, and functional requirements of these systems.

c. Discuss electrical power distribution with the regard to the following elements (IEEE Red Book; reference IEEE Std-141 or another 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

d. Discuss protection and coordination with regard to the following elements (IEEE Buff book; reference IEEE Std-242 or another 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 (IEEE Blue Book; reference IEEE Std-1015)
- Ground-fault protection fundamentals
- Conductor, motor, transformer, generator, and bus and switchgear protection
- Maintenance, testing, and calibration of electrical systems

e. Discuss electrical system grounding with regard to the following elements (IEEE Green book; reference IEEE Std-142 or another source can be used as a guide in developing the discussion):

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

f. Discuss emergency and standby power with regard to the following elements (IEEE Orange Book; reference IEEE Std-446 or another source can be used as a guide in developing the discussion):

- Emergency and standby power guidelines
- Generator and electric utility system fundamentals (IEEE Brown Book; reference IEEE Std-399)
- Stored energy system fundamentals
- Protection device fundamentals

38. Electrical personnel shall demonstrate a familiarly level knowledge of the possible functional interfaces/relationships between all electrical VSS and instrument and control safety software, analysis safety software, and design safety software.

Supporting Knowledge and/or Skills

a. **Mandatory Performance Activity:** With the assistance of the cognizant software quality assurance (SQA) subject matter expert, 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 as described in DOE O 414.1C, *Quality Assurance* and DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830, Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance.*

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.

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

d. Identify the typical requirements that define functional interfaces between safety software components and the system-level design, as described in DOE O 414.1C, *Quality Assurance*, and DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830, Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance*.

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

f. 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. Mandatory Performance Activity: Electrical personnel shall demonstrate the ability to perform a quarterly walkthrough, bi-annual status walkthrough, or an assessment and generate a report identifying observations and/or findings.

Supporting Knowledge and/or Skill

a. Describe and explain the communications that need to be made to the contractor staff with regard to establishing a point of contact, schedule, assistance (if any), etc.

b. For each report finding (if any), cite the appropriate requirement(s), describe the “as found” condition, and explain how it is not in compliance with the cited requirement(s).

c. For each report observation (if any), describe the “as found” condition and explain why it may be an issue.

40. During a walkthrough of assigned electrical VSS, the electrical personnel shall demonstrate a familiarity level knowledge of functional classifications for safety systems and the design expectations associated with all assigned electrical systems that carry these functional classifications, as described in DOE O 420.1B, *Facility Safety*, and its associated guide DOE G 420.1-1.

Supporting Knowledge and/or Skills

a. **Mandatory Performance Activity:** During the mentioned walkthrough electrical personnel shall: identify all equipment that performs a safety class, safety significant, and/or defense in depth safety function; explain the related purpose, scope, and application of DOE O 420.1B; describe key terms, essential elements, design expectations, critical decisions, and personnel responsibilities/authorities.

b. Discuss the project management terminology for which definitions are provided in DOE O 420.1B.

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.

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

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

41. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety systems criteria for VSS (IEEE Stds-308-2001, 323-2003, 379-2000, 384-1992, and 603-1998; DOE O 420.1B; DOE G 420.1-1; etc.)

Supporting Knowledge or Skills

a. Identify and describe the following requirements for principal design criteria of electrical power systems supporting VSS (Class 1E power systems): design basis and design basis events, independence, the equipment qualification process for Class 1E power systems, single-failure criterion, requirements for connecting of non-Class 1E systems to Class 1E systems, and Class 1E protection requirements.

b. Identify and describe the requirements for supplementary design criteria of electrical power systems supporting VSS (Class 1E power systems): Class 1E power systems, AC power systems, DC power systems,; instrumentation and control power systems, and execute and sense-and-command features.

c. Describe the relationship between surveillance and test requirements and design of electrical systems supporting the VSS.

d. Discuss the Equipment Qualification process for Class 1E power systems in support of VSS: principles of equipment qualification, qualification methods, the qualification program, and documentation requirements.

e. Discuss the concept of ”independence;” identify some of the general criteria for attaining ”independence,” e.g., physical separation, electrical isolation and devices, methods of achieving independence, and associated circuits; describe the general concept of ”specific separation criteria”, e.g., area classification and separation distances; discuss the major requirements for circuit breakers and fuses to be considered as “isolation” devices.

f. State the general requirement for the single-failure criterion (SFC) and identify the major conditions used to apply the SFC to safety systems design: independence and redundancy; nondetectable, cascaded, common-cause failures; design basis events; and shared systems.

42. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for emergency, standby, and UPS systems for VSS (IEEE Stds-387-1984, 650-1990, and 944-1986; DOE O 420.1B; DOE G 420.1-1; etc.).

Supporting Knowledge or Skills

a. Identify and discuss the principal design criteria for standby power supplies supporting VSS: capability, ratings, interactions, design and application considerations, and design features.

b. Identify and discuss some of the design application requirements for UPS supporting VSS: performance requirements, UPS sizing and capacities, and UPS configurations.

c. Identify some of the key Class 1E performance characteristics for Class 1E static battery chargers and inverters supporting VSS: input conditions, output requirements, surge withstand capability, and reverse current flow prevention.

43. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for VSS accident monitoring instrumentation (IEEE Std-497-2002, DOE O 420.1B, DOE G 420.1-1, etc.).

Supporting Knowledge or Skills

a. Identify and discuss the selection criteria used for identifying the “‘type variables” for accident monitoring instrumentation.

b. Identify some key performance criteria of accident monitoring instrumentation.

44. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for VSS Motor Control Centers (MCC) (IEEE Std-649-1991, DOE O 420.1B, DOE G 420.1-1, etc.).

Supporting Knowledge or Skills

a. Identify the three qualification alternatives for VSS MCC equipment.

b. Identify the three major elements of the qualification process for VSS MCC, equipment specification, the qualification program, and the documentation requirement.

c. Discuss the qualification procedural requirements for VSS MCCs relating to aging, seismic qualification, and harsh environment events.

45. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for digital computers supporting VSS (IEEE Std-7-4.3.2-2003, Annex E; DOE O 420.1B; DOE G 420.1-1; etc.).

Supporting Knowledge or Skills

a. Discuss some of the configuration requirements for communications independence relating to communications between computers in different safety channels.

b. Discuss some of the configuration requirements for communications independence relating to communications between safety and non-safety computers.

46. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for VSS protection systems (IEEE Stds-741-1997 and 833-1988, DOE O 420.1B, DOE G 420.1-1, etc.).

Supporting Knowledge or Skills

a. Identify the key general design criteria for VSS protection systems (IEEE Std-741, Section 4.)

b. Identify the major criteria for establishing bus voltage monitoring schemes (IEEE Std-741, Section 5.1.2 a) - h)).

c. Identify the major requirement for selecting protective devices for direct-geared valve actuator motors (IEEE Std-741, Section 5.5, first paragraph, first sentence).

47. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for Instrumentation and Control (I&C) equipment grounding of VSS (IEEE Std-1050-1996, DOE O 420.1B, DOE G 420.1-1, etc.).

Supporting Knowledge or Skills

a. Discuss some design considerations for electrical noise minimization noise sources, noise-coupling methods, and techniques for electrical noise minimization.

b. Describe the purpose or use of, and advantages and disadvantages for single-point ground systems, multi-point ground systems, and floating ground systems.

c. Identify the IEEE Standard citing requirements for VSS I&C equipment signal cable shield grounding requirements (IEEE Std-1050-1996).

48. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety design requirements for VSS Motor Operated Valves (MOV) (IEEE Stds-1290-1996, DOE O 420.1B, DOE G 420.1-1, etc.).

Supporting Knowledge or Skills

a. Identify the IEEE Standard, citing requirements for motor applications, protection, and control for MOV motor applications (IEEE Std-1290).

VII. ELECTRICAL SAFETY REQUIREMENTS AND PRACTICES

This section is optional and should be used by the program and/or field offices to assist them with specific technical qualifications for that office.

49. Electrical personnel shall demonstrate a familiarity level knowledge of electrical safety requirements and practices in the following list of regulatory and consensus standards documents, including the relationship between these documents and which are "enforceable" in your site's contractors contract such as OSHA (29 CFR 1910 and Subpart S, and 29 CFR 1926 Subparts K and V); NFPA 70E, *Standard for Electrical Safety in the Workplace/Maintenance*; NFPA-70B, *Recommended Practice of Electrical Equipment Maintenance*; DOE-HDBK-1092-2004, *Electrical Safety Handbook*; and 10 CFR 851, *Worker Safety and Health Program*.

Supporting Knowledge and/or Skills

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

b. Discuss the graded approach process that Department line management uses to determine an appropriate level of coverage by electrical 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.

50. Electrical personnel shall demonstrate a familiarity level knowledge of DOE O 414.1C, *Quality Assurance*, as it pertains to electrical systems.

Supporting Knowledge and/or Skills

a. **Mandatory Performance Activity:** Describe how electrical equipment is procured based upon its safety function and/or nuclear related activity using quality assurance criteria and appropriate national or international consensus standards.

b. Describe what is meant by implementing quality assurance criteria using a graded approach.

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

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

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

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

g. Discuss the key elements of the procurement process for electrical systems as described in DOE O 414.1C, Quality Assurance.

51. Electrical personnel shall demonstrate a familiarity level of knowledge of DOE O 430.1B, *Real Property Asset Management*, with regard to life cycle asset management.

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 how various problem analysis processes can be used to enhance maintenance programs (DOE G 433.1-1, *Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1*).

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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 FAQS. It is extremely important that personnel involved with this program maintain their proficiency primarily by regularly demonstrating their competency through on-the-job performance, supplemented with 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 FAQS and is not all-inclusive.

Based on the knowledge and experience of the subject matter experts, it is suggested that the following activities support the maintenance of proficiency in the Electrical Systems and Safety Oversight Functional Area after completion of the competencies in the Standard and other requirements of the TQP.

LIST OF CONTINUING EDUCATION, TRAINING, AND OTHER ACTIVITIES

1. Continuing technical education and/or training covering topics directly related to the electrical area as determined appropriate by management. This may include courses/training provided by DOE, 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 and Safety Oversight.

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

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 (IDPs).

6. Review of lessons learned publications.

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CONCLUDING MATERIAL

Review Activity:
EM
FE
HS
NA
NE
SC

Preparing Activity:
RL

Project Number:
TRNG-0050

Field and Operations Offices:
NNSA SC
CH
CBFO
ID
OH
OR
ORP
RL
SR

Site Offices:
Ames
Argonne
Brookhaven
Fermi
NNSA Kansas City
NNSA Livermore
NNSA Los Alamos
NNSA Nevada
NNSA Pantex
NNSA Pittsburgh Naval Reactors
NNSA Pittsburgh Naval Reactors ID
NNSA Sandia
NNSA Savannah River
NNSA Schenectady Naval Reactors
NNSA Y-12
Pacific Northwest
Stanford
Thomas Jefferson

Project Offices:
Portsmouth Paducah
Strategic Petroleum Reserve

Others:
Consolidated Business Center
Naval Petroleum Reserves