U.S. Department of Energy Orders Self-Study Program

DOE O 420.1A

FACILITY SAFETY

NATIONAL NUCLEAR SECURITY ADMINISTRATION
SERVICE CENTER

CHANGE NO: 1
DOE O 420.1A
Level: Familiar
Date: 11/15/04

DOE ORDER O 420.1A
FACILITY SAFETY
FAMILIAR LEVEL

OBJECTIVES

Given the familiar level of this module and the listed resources, you will be able to perform the following:

1. State the purpose of implementing U.S. DOE Order O 420.1A.
2. State who is responsible for complying with the requirements of this Order.
3. State the general and design requirements for nuclear safety.
4. State the general programmatic requirements for an acceptable fire protection program.
5. State the fire protection design requirements for a comprehensive fire protection program.
6. State the objectives of the nuclear criticality safety program.
7. State the general requirements for evaluating and documenting a nuclear criticality safety program.
8. State the specific requirements for a contractor criticality safety program.
9. State the design requirements for natural phenomenon mitigation.
10. State the natural phenomena hazards assessment approaches for new and existing sites.
11. State the objectives of the system engineering program.

RESOURCES

DOE O 420.1A, Facility Safety, 1-23-03.
ANSI/ANS-8.1-1983, R88, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.
ANSI/ANS-8.3-1986, Criticality Accident Alarm System.
ANSI/ANS-8.5-1986, Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material.
ANSI/ANS-8.6-1983, R88, Safety in Conducting Subcritical Neutron-Multiplication Measurements in Situ.
ANSI/ANS-8.7-1975, R87, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials.
ANSI/ANS-8.9-1987, Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials.
ANSI/ANS-8.10-1983, R88, Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement.
ANSI/ANS-8.12-1987, R93, Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors.
ANSI/ANS-8.15-1981, R87, Nuclear Criticality Control of Special Actinide Elements.
ANSI/ANS-8.17-1984, R89, Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors.
ANSI/ANS-8.19-1984, R89, Administrative Practices for Nuclear Criticality Safety.
ANSI/ANS-8.21-1995, Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors.

Note: If you think that you can complete the practice at the end of this level without working through the instructional material and/or the examples, complete the practice now. The course manager will check your work. You will need to complete the practice in this level successfully before taking the criterion test.

INTRODUCTION

The objective of DOE O 420.1A is to establish facility safety requirements related to the following five areas that are addressed in the familiar level of this module.

- Section 4.1, Nuclear Safety
- Section 4.2, Fire Protection
- Section 4.3, Nuclear Criticality Safety
- Section 4.4, Natural Phenomena Hazards Mitigation
- Section 4.5, Systems Engineering Program

Sections 4.2 and 4.4 of this Order apply to all DOE nuclear and non-nuclear facilities. Sections 4.1 and 4.3 apply to all DOE non-reactor nuclear facilities that are classified as hazard categories 1, 2, or 3; and explosives facilities.

Section 4.5 applies to all DOE hazard category 1, 2, and 3 nuclear facilities.

The Order also applies to the universe of contractors awarded contracts for management and operating contracts.

The following activities and facilities are excluded from this Order:

- Activities that are regulated through a license by the Nuclear Regulatory Commission (NRC) or a state under an agreement with the NRC, including activities certified by the NRC under section 1701 of the Atomic Energy Act;
- Activities conducted under the authority of the Director, Naval Nuclear Propulsion Program, as described in Public Laws 98-525 and 106-65;
- Activities conducted under the Nuclear Explosives and Weapons Safety Program relating to the prevention of accidental or unauthorized nuclear detonations to the extent a requirement under this part cannot be implemented for a particular facility in a manner that does not compromise the effectiveness of such activities;
- Activities that are regulated by the Department of Transportation or pursuant to 49 CFR 173.7(b)
- Accelerator facilities that are covered by DOE O 420.2A; and fusion facilities.

Throughout the module you will find examples and practices to help familiarize you with the material. The practices will also help prepare you for the criterion test.

Before continuing, you should obtain a copy of the Order. You should be familiar with the ANSI standards listed as resources. However, it is not necessary to secure copies of the standards listed for this module. Copies of the Orders are available at the DOE Directives, Regulations, and Standards Portal Home Page or through the course manager. Spend some time reviewing the documents so that you are familiar with the sections each contains. You will need to refer to these documents to complete the examples, practice, and criterion test.

SECTION 1, NUCLEAR SAFETY

OBJECTIVE

To ensure DOE non-reactor nuclear facilities are designed and constructed to protect the public, workers, and the environment from nuclear hazards.

REQUIREMENTS

All new construction shall conform to the model building codes applicable for the state or region, supplemented with additional safety requirements associated with the hazards in the facility in a graded manner.

General Requirements

A safety analysis shall guide the application of these requirements to identify safety structures, systems, and components (SSCs) for a facility and establish the significance to the safety of the functions performed by those SSCs. The safety analysis considers facility hazards, natural phenomena hazards, and external man-induced hazards. Factors such as proximity to nearby facilities such as airports, pipelines, and barge traffic peculiar to the site shall be considered. A safety analysis shall be performed at the earliest practical point in conceptual or preliminary design, so that required functional attributes of safety SSCs

can be specified in the detailed design. The safety analysis shall be performed according to safety analysis report (SAR) guidance.

Design Requirements

Non-reactor nuclear facilities shall be designed to provide multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment. The design shall include

- minimization of material at risk,
- the use of conservative design margins and quality assurance,
- the use of successive physical barriers for protection against the release of radioactivity,
- the provision of multiple means to ensure critical safety functions,
- the use of equipment and administrative controls that restrict deviations from normal operations and provide for recovery from accidents to achieve a safe condition,
- means to monitor accident releases required for emergency responses, and
- emergency plans for minimizing the effects of an accident.

All nuclear facilities with uncontained radioactive materials (as opposed to material contained within drums, grout, and vitrified materials) shall have means to confine them. Such confinement shall act to minimize the spread of radioactive materials and the release of radioactive materials in facility effluents during normal operations and potential accidents. For a specific nuclear facility, the number and arrangement of confinement barriers and their required characteristics shall be determined on a case-by-case basis. Factors that shall be considered in confinement system design shall include type, quantity, form, and conditions for dispersing the material. Engineering evaluations, trade-offs, and experience shall be used to develop practical designs that achieve confinement system objectives. The adequacy of confinement systems to perform the required functions shall be documented and accepted through the SAR.

Facilities shall be designed to:

- facilitate safe deactivation, decommissioning, and decontamination at end of life;

- facilitate inspections, testing, maintenance, and repair and replacement of safety SSCs as part of an overall reliability, availability, and maintainability program;
- keep occupational radiation exposure within statutory limits and incorporate as low as reasonably achievable (ALARA) principles in design, including design provisions to facilitate decontamination during the operational period; and
- minimize the production of wastes and the mixing of radioactive and non-radioactive wastes.

Explosives Safety Requirements

The safety design of all new DOE explosives facilities and all modifications to existing explosives facilities shall conform to the DOE explosives safety requirements established in the DOE Explosives Safety Manual, DOE M 440.1-1. Facility structural design and construction shall comply with the requirements of TM5-1300, Structures to Resist the Effects of Accidental Explosions, and DOE/TIC-11268, A Manual for the Prediction of Blast and Fragment Loading of Structures. Blast-resistant design for personnel and facility protection shall be based on the TNT equivalency of the maximum quantity of explosives and propellants permitted. According to TM5-1300, the TNT equivalency shall be increased by 20% for design purposes.

SECTION 2, FIRE PROTECTION

OBJECTIVES

The objectives of this section are to establish requirements for a comprehensive fire and related hazards protection program for facilities sufficient to minimize the potential for:

- the occurrence of a fire or related event;
- a fire that causes an unacceptable on-site or off-site release of hazardous or radiological material that shall threaten the health and safety of employees, the public, or the environment;
- vital DOE programs suffering unacceptable interruptions as a result of fire and related hazards;
- property losses from a fire and related events exceeding defined limits established by DOE; and

- critical process controls and safety-class systems being damaged as a result of a fire and related events.

General Programmatic Requirements

The following eleven features shall be included in an acceptable fire protection program:

- A policy statement that incorporates the requirements of this Section, related DOE directives, and other applicable Federal, state and local fire protection requirements.
- Comprehensive, written fire protection criteria that reflects additional site-specific aspects of the fire protection program, including the organization, training, and responsibilities of the fire protection staff, administrative aspects of the fire protection program, and requirements for the design, installation, operability, inspection, maintenance and testing of fire protection systems.
- Written fire safety procedures governing the use and storage of combustible, flammable, radioactive, and hazardous materials to minimize the risk from fire.
- A system to ensure that the requirements of the DOE fire protection program are documented and incorporated in the plans and specifications for all new facilities and for significant modifications of existing facilities.
- Fire hazards analyses for all nuclear facilities, significant new facilities, and facilities that represent unique or significant fire safety risks.
- Access to a qualified and trained fire protection staff, including fire protection engineers, technicians, and fire fighting personnel to implement the requirements of this Order.
- A needs assessment that establishes the minimum required capabilities of site fire fighting forces.
- Written pre-fire strategies, plans, and standard operating procedures to enhance the effectiveness of site fire fighting forces.
- A comprehensive, documented fire protection self-assessment program that includes all aspects of the fire protection program. Assessments shall be performed on a regular basis at a frequency established by DOE.
- A program to identify, prioritize, and monitor the status of fire protection-related appraisal findings/recommendations until final resolution is achieved.

- A process for reviewing and recommending approval of fire safety equivalencies and exemptions to the DOE authority who has jurisdiction for fire safety.

Fire Protection Design Requirements

A comprehensive fire protection program should include:

- A reliable water supply of adequate capacity for fire suppression.
- Noncombustible or fire-resistive construction, where appropriate. Complete fire-rated barriers that are commensurate with the fire hazard to isolate hazardous occupancies and to minimize fire spread and loss potential consistent with defined limits as established by DOE.
- Automatic fire extinguishing systems throughout all significant facilities and in all areas subject to loss of safety class systems, significant life safety hazards, unacceptable program interruption, or fire loss potential in excess of defined limits.
- Redundant fire protection systems in areas where safety class systems are vulnerable to fire damage and where no redundant safety capability exists outside of the fire area.
- A means to summon the fire department in case of a fire.
- A means to notify and evacuate building occupants in case of a fire.
- Physical access and appropriate equipment to facilitate effective intervention by the fire department.
- A means to prevent the accidental release of significant quantities of contaminated products of combustion and fire fighting water to the environment.
- Fire and related hazards that are unique to DOE and are not addressed by industry codes and standards shall be protected by isolation, segregation, or use of special fire control systems.
- Fire protection systems shall be designed so that their inadvertent operation, inactivation, or failure of structural stability shall not result in the loss of vital safety functions or inoperability of safety class systems.

Note: You do not have to do example 1 on the following pages, but it is a good time to check your skill and knowledge of the information covered. You may do example 1 or go to section 3.

EXAMPLE 1

Using the familiar level of this module and the resources, complete the following exercises.

1. State in your words what the DOE hopes to achieve by implementing DOE O 420.1A.

2. State the primary objective of a non-reactor nuclear facility design.

3. State three design requirements of a non-reactor nuclear facility.

4. State three programmatic requirements of a fire protection program.

5. List three components that should be included in the design of a comprehensive fire protection program.

Note: When you are finished, compare your answers to those contained in the example 1 self-check. When you are satisfied with your answers, go to section 3.

EXAMPLE 1 SELF-CHECK

Using the familiar level of this module and the resources, complete the following exercises.

1. State in your words what the DOE hopes to achieve by implementing DOE O 420.1A.

   The objective of this Order is to establish facility safety requirements related to: nuclear safety design, criticality safety, fire protection and natural phenomena hazards mitigation, and a systems engineering program.

2. State the primary objective of a non-reactor nuclear facility design.

   The objective of a non-reactor nuclear facility design is to provide multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment.

3. State three design requirements of a non-reactor nuclear facility

   Any three of the following constitute a correct answer.
   - Minimization of material at risk;
   - The use of conservative design margins and quality assurance;
   - The use of successive physical barriers for protection against the release of radioactivity;
   - The provision of multiple means to ensure critical safety functions;
   - The use of equipment and administrative controls that restrict deviations from normal operations and provide for recovery from accidents to achieve a safe condition;
   - Means to monitor accident releases required for emergency responses; and
   - Emergency plans for minimizing the effects of an accident.
   - All nuclear facilities with uncontained radioactive materials (as opposed to material contained within drums, grout, and vitrified materials) shall have means to confine them. Such confinement shall act to minimize the spread of radioactive materials and the release of radioactive materials in facility

effluents during normal operations and potential accidents. For a specific nuclear facility, the number and arrangement of confinement barriers and their required characteristics shall be determined on a case-by-case basis. Factors that shall be considered in confinement system design shall include type, quantity, form, and conditions for dispersing the material. Engineering evaluations, trade-offs, and experience shall be used to develop practical designs that achieve confinement system objectives. The adequacy of confinement systems to perform the required functions shall be documented and accepted through the SAR.

- Facilitate safe deactivation, decommissioning and decontamination at end of life;
- Facilitate inspections, testing, maintenance, and repair and replacement of safety sscs as part of an overall reliability, availability, and maintainability program;
- Keep occupational radiation exposure within statutory limits and incorporate alara principles in design, including design provisions to facilitate decontamination during the operational period; and
- Minimize the production of wastes and minimize the mixing of radioactive and non-radioactive wastes.

4. State three programmatic requirements of a fire protection program.

   Any three of the following constitutes a correct answer.

   - A policy statement that incorporates the requirements of this section, related DOE directives, and other applicable federal, state and local fire protection requirements.
   - Comprehensive, written fire protection criteria that reflects additional site-specific aspects of the fire protection program, including the organization, training and responsibilities of the fire protection staff, administrative aspects of the fire protection program, and requirements for the design, installation, operability, inspection, maintenance and testing of fire protection systems.

- Written fire safety procedures governing the use and storage of combustible, flammable, radioactive, and hazardous materials to minimize the risk from fire.
- A system to ensure that the requirements of the DOE fire protection program are documented and incorporated in the plans and specifications for all new facilities and for significant modifications of existing facilities.
- Fire hazards analyses for all nuclear facilities, significant new facilities, and facilities that represent unique or significant fire safety risks.
- Access to a qualified and trained fire protection staff, including fire protection engineers, technicians, and fire fighting personnel to implement the requirements of this Order.
- A needs assessment that establishes the minimum required capabilities of site fire fighting forces.
- Written pre-fire strategies, plans, and standard operating procedures to enhance the effectiveness of site fire fighting forces.
- A comprehensive, documented fire protection self-assessment program that includes all aspects of the fire protection program. Assessments shall be performed on a regular basis at a frequency established by DOE.
- A program to identify, prioritize and monitor the status of fire protection-related appraisal findings/recommendations until final resolution is achieved.
- A process for reviewing and recommending approval of fire safety equivalencies and exemptions to the DOE authority who has jurisdiction for fire safety.

5. List three components that should be included in the design of a comprehensive fire protection program.

   Any three of the following constitute a correct answer.

   - A reliable water supply of adequate capacity for fire suppression.
   - Noncombustible or fire-resistive construction.
   - Automatic fire extinguishing.
   - Redundant fire protection systems.

- A means to summon the fire department in case of a fire.
- A means to notify and evacuate building occupants in case of a fire.
- Physical access and appropriate equipment to facilitate effective intervention by the fire department.
- A means to prevent the accidental release of significant quantities of contaminated products of combustion and fire fighting water to the environment.
- Fire and related hazards that are unique to DOE and are not addressed by industry codes and standards shall be protected by isolation, segregation, or use of special fire control systems.
- Fire protection systems shall be designed so that their inadvertent operation, inactivation, or failure of structural stability shall not result in the loss of vital safety functions or inoperability of safety class systems.

SECTION 3, NUCLEAR CRITICALITY SAFETY

OBJECTIVES

The objectives shall be to establish nuclear criticality safety program requirements to ensure that:

- Criticality safety is comprehensively addressed and receives an objective review, with all identified risks reduced to acceptably low levels, and management authorization of the operation is documented; and
- The public, workers, government and private property, the environment, and essential operations are protected from the effects of a criticality accident.

REQUIREMENTS

Operations with fissionable materials that pose a criticality accident hazard shall be evaluated and documented to demonstrate that the operation shall be subcritical under normal and credible abnormal conditions. Fissionable material operations shall be conducted so that consequences to personnel and property that result from a criticality accident shall be mitigated. No single credible event or failure shall result in a criticality accident having unmitigated consequences.

General Requirements

The nuclear criticality safety program shall be evaluated and documented and shall include:

- nuclear criticality safety evaluations for normal and credible abnormal conditions that document the parameters, limits, and controls required to ensure that the analyzed conditions are subcritical;
- implementation of limits and controls identified by the nuclear criticality safety evaluations;
- reviews of operations to ascertain that limits and controls are being followed and that process conditions have not been altered such that the applicability of the nuclear criticality safety evaluation has been compromised; and

- assessments of the need for criticality accident detection devices and alarm systems, and installation of such equipment where total risk to personnel shall be reduced.

Specific Requirements

The Contractor Criticality Safety Program for non-reactor nuclear facilities shall include the following requirements:

- The basic elements and control parameters of programs for nuclear criticality safety shall satisfy the ANSI/ANS nuclear criticality safety standards listed as resources for this module.
- Process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. Either the control of two independent process parameters or a system of multiple controls on a single process parameter shall provide protection.
- Where a significant quantity of fissionable material is being processed and criticality safety is a concern, passive engineered controls such as geometry control shall be considered as a preferred control method. Where passive engineered control is not feasible, the preferred order of controls is: active engineered controls, followed by administrative controls. The double contingency analysis shall justify the chosen controls. Full advantage may be taken of any nuclear characteristics of the process materials and equipment. All dimensions, nuclear properties, and other features upon which reliance is placed shall be documented and verified before beginning operations, and control shall be exercised to maintain them.
- The uncertainty in the bias is interpreted as a measure of the accuracy of the calculation and the precision of the experimental data. It is assumed to include the precision of the calculation if the calculation is stochastic, and the accuracy of the experimental data if the experiment is a mock-up of a referenced system.
- In those facilities where the mass of fissionable material exceeds the limits established in ANSI/ANS-8.3-1986 and the probability of a criticality accident is greater than 10-6 per year, a criticality alarm system (CAS) conforming to ANSI/ANS-8.3-1986 shall be provided to cover occupied areas in which the expected dose exceeds 12 rads in free air.

- In those facilities where the mass of fissionable material exceeds the limits established in ANSI/ANS-8.3-1986 and the probability of a criticality accident is greater than 10-6 per year, but there are no occupied areas in which the expected dose exceeds 12 rads in free air, a criticality detection systems (CDS) shall be provided.
- In those facilities where the mass of fissionable material exceeds the limits established in ANSI/ANS-8.3-1986, but a criticality accident is determined to be impossible due to the physical form of the fissionable material, or the probability of occurrence is determined to be less than 10-6 per year), neither a CAS nor a CDS is required.
- If a criticality accident is possible wherein a slow increase in reactivity could occur leading from subcriticality to supercriticality to self- shutdown without setting off emplaced criticality alarms, then a CAS might not be adequate for protection against the consequences of such an accident. To aid in protecting workers against the consequences of slow criticality accidents in facilities where analysis has shown that slow criticality accidents are credible, CASs should be supplemented by warning devices such as audible personnel, area radiation monitors, area dosimeters, or integrating CASs.
- Neither a CAS nor a CDS is required to be installed for handling or storage of fissionable material when sufficient shielding exists that is adequate to protect personnel. However, a means to detect fission product gasses or other volatile fission products should be provided in occupied areas immediately adjacent to such shielded areas, except for systems where no fission products are likely to be released.
- It is acceptable to DOE to follow DOE-STD-3007-93, Guidelines for Preparing Criticality Safety Evaluations at Department of Energy non-Reactor Nuclear Facilities, when preparing Criticality Safety Evaluations.
- DOE Elements shall ensure that the contractor will have a program to detect inadvertent accumulation of significant quantities of fissionable material.
- The fire protection program shall establish guidelines for fire fighting within, or adjacent to, moderation controlled areas.

SECTION 4, NATURAL PHENOMENA HAZARDS (NPH) MITIGATION

OBJECTIVES

To ensure that all DOE facilities are designed, constructed, and operated so that the general public, workers, and the environment are protected from the impact of NPHs.

APPLICABILITY

The provisions of this section apply to DOE sites and facilities. The provisions of this section cover all natural phenomena hazards such as seismic, wind, flood, and lightning.

REQUIREMENTS

Natural Phenomena Mitigation Design Requirements

Systems, structures, and components shall be designed, constructed and operated to withstand the effects of natural phenomena as necessary to ensure:

- the confinement of hazardous material,
- the operation of essential facilities,
- the protection of government property, and
- the protection of life safety for occupants of DOE buildings.

The design process shall consider:

- potential damage and failure of systems, and
- damage to structures and components due to direct and indirect natural phenomena effects.

The seismic requirements of Executive Order 12699 shall be addressed. Systems, structures, and components for new DOE facilities, and additions or major modifications to existing systems, structures, and components shall be designed, constructed and operated to meet the requirements in this Order. Any additions and modifications to existing DOE facilities shall not degrade the performance of existing systems, structures and components

to the extent that the objectives in this section cannot be achieved under the effects of natural phenomena.

Natural Phenomena Hazards Assessment

The design and evaluation of facilities to withstand natural phenomena shall be based on an assessment of the likelihood of future natural phenomena occurrences. The natural phenomena hazards assessment shall be conducted commensurate with a graded approach and the potential hazard of the facility.

For new sites: natural phenomena hazards assessment shall be conducted commensurate with a graded approach to the facility. Site planning shall consider the consequences of all natural phenomena hazards.

For existing Sites; if there are significant changes in natural phenomena hazards assessment methodology or site-specific information, the natural phenomena hazards assessments shall be reviewed and shall be updated, as necessary. A review of the natural phenomena hazards assessment shall be conducted at least every 10 years. The review shall include recommendations to DOE on the need for updating the existing natural phenomena hazards assessments based on identification of any significant changes in methods or data.

Note: You do not have to do Example 2 on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do the Example 2 or go directly to the practice.

EXAMPLE 2

1. List three requirements for evaluating and documenting a nuclear criticality safety program.

2. Explain the application of double contingency in regards to criticality accidents.

3. State the maximum time interval between natural phenomena hazards assessments.

EXAMPLE 2 SELF-CHECK

1. List three requirements for evaluating and documenting a nuclear criticality safety program.

   Any three of the following constitutes a correct answer.

   - Nuclear criticality safety evaluations shall be conducted for normal and credible abnormal conditions. The evaluation should document the parameters, limits, and controls required to ensure that the analyzed conditions are subcritical.
   - Limits should be implemented and controls identified by the nuclear criticality safety evaluations.
   - Operations should be reviewed to ascertain that limits and controls are being followed and that process conditions have not been altered such that the applicability of the nuclear criticality safety evaluation has been compromised.
   - Needs should be assessed for criticality accident detection devices and alarm systems, and equipment shall be installed where total risk to personnel will be reduced.

2. Explain the application of double contingency in regards to criticality accidents.

   Process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. Either the control of two independent process parameters or a system of multiple controls on a single process parameter shall provide protection.

3. State the maximum time interval between natural phenomena hazards assessments.

   Ten years.

Note: When you are finished, compare your answers to those contained in the Example 2 Self-Check. When you are satisfied with your answers, go to Section 5.

SECTION 5, SYSTEM ENGINEERING PROGRAM

OBJECTIVE

A Systems Engineering Program shall be established for DOE category 1, 2, and 3 nuclear facilities. The objective of the Program shall be to ensure continued operational readiness of the systems within its scope. The Program shall include the elements described in Section 4.5.1 of this Order, and shall provide for the designation of a qualified Cognizant System Engineer (CSE) for each such system in Category 1, 2, and 3 nucl;ear facility. The Program shall be incorporated into the Integrated Safety Management System (ISMS), include flow down of implemented procedures on the site and facility level, and shall provide for the CSE

PROGRAM ELEMENTS

The System Engineering Program shall include and integrate the elements of ;

- identification of systems within its scope,
- configuration management, and
- CSE support to operations and maintenance.

SCOPE AND IDENTIFICATION OF SYSTEMS

This program shall be applied to active safety class and safety significant structures, systems and components (SSC), as defined in the nuclear facility's DOE approved safety basis and other active systems that perform an important defense-in-depth function for protection of the public, workers, or environment within the contest of the safety basis, as designated by the facility line management (hereafter collectively referred to as systems).

CONFIGURATION MANAGEMENT

Configuration management shall be used to develop and maintain consistency among the system requirements and performance criteria, system documentation, and physical configuration. Configuration management shall integrate the elements of system

requirements and performance criteria, system assessments, change control/work control, and document control.

Documents that define the system design basis (or when the design basis is not clearly defined, the identification of system requirements and performance criteria essential to the systems performance of its safety function, the basis for the requirements, and how the current system configuration satisfies the requirements and criteria) and supporting documents shall be compiled and kept current using a formal change control/work control program.

System assessments shall include periodic review of system operability, reliability, and material condition during facility inspections required by DOE O 433.1, *Maintenance Management Program for DOE Nuclear Facilities,* dated 6-01-01. These periodic reviews shall assess the systems ability to perform its design and safety functions. System and component performance shall be monitored and compared to established performance standards.

Work on systems, including maintenance and repair, shall be controlled under a formal change control/work control process to ensure that changes are not inadvertently introduced and that required system performance is not compromised. Systems shall be tested after modification to ensure continued capability to fulfill system requirements.

COGNIZANT SYSTEM ENGINEERING SUPPORT FOR OPERATIONS AND MAINTENANCE

A CSE shall be designated for each system. The CSE shall provide technical assistance in support of line management responsibility to ensure operational readiness of the system. The CSE shall ensure that the configuration of assigned system(s) is being effectively managed according to the elements of Section 4.5.1.2, of this Order (Configuration Management). The CSE shall:

- remain appraised of operational status and ongoing modification activities,
- assist operations to review key system parameters and evaluate system performance;
- initiate actions to correct problems,

- remain cognizant of system-specific maintenance/operations history and industry operating experience,
- identify trends from operations,
- provide assistance in determining operability or correcting out-of-specification conditions or evaluating questionable data,
- provide or support analysis to determine operability when the system is suspected of inoperable degradation,
- review and concur with design changes, and
- provide input to development of special operating/test procedures.

The qualification requirements for CSEs shall be consistent with those defined for Technical staff positions described in DOE O 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*, dated 11-15-94, in Chapter II, section 2.c, "Technical Staff for Reactor Facilities," and in Chapter IV, Section 2.f "Technical Staff for Non-reactor Nuclear Facilities." These requirements shall be incorporated into the contractor training programs required by DOE 5480.20A. Development plans for CSEs should be part of the overall training and development program. Initial qualification requirements for CSEs shall be established. Qualification and training requirements shall include:

- knowledge of the related facility safety basis,
- the system functional classification and basis,
- applicable codes and standards pertaining to the system,
- requirements for design and procurement or replacement of the system, including quality assurance requirements, and familiarity with the existing condition of the system, and
- a working knowledge of the facility's operation.

When evaluating and individual's qualification for assignment as a CSE appropriate consideration should be given to an individuals formal education, prior training and work experience as described in Chapter I, Section 13 of DOE O 5480.20A. Consistent with the graded approach, large complex, or very important systems may require assignment of one or more technical staff level personnel, while small simple, less important systems may require assignment of technical level personnel.

GRADED APPROACH

Implementation of these System Engineering Program requirements should be tailored to facility hazards and the systems relied upon to prevent or mitigate those hazards. A graded approach is defined within DOE Rules and Orders, and should consider such as:

- Remaining Facility lifetime and the significance of remaining operations. Facilities undergoing deactivation , and decontamination and decommissioning may be undergoing frequent changes, modifications and in some cases, removal of systems as being no longer needed to support the safety basis of those operations. In these cases the System Engineer Program may require more attention than would be the case for a facility in normal operations. After deactivation, and for a facility in long term surveillance and maintenance, there may be less need for attention.
- Multiple CSEs and multiple systems. The functions of a System Engineer Program are already required through the necessity of maintaining the integrity of a facilities safety basis. Typically these functions are accomplished by various parts of a contractor's operating organization. This operating structure may continue, but one person shall be designated as the CSE for each system, and must maintain overall cognizance of the system, and be responsible for CSE support for operations and maintenance,
- Safety importance of the system. Not all systems are equal in importance, as measured by the likelihood and consequences of the hazard that they prevent or mitigate from causing harm through a potential accident. The level of detail involved in the configuration management function, relative to system documentation should be tailored to the importance of the system.

Note: You do not have to do Example 3 on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do the Example 3 or go directly to the practice.

EXAMPLE 3

1. What is the objective of the System Engineering Program.

2. List the three elements of the System Engineering Program.

3. Provide the scope of the System Engineering Program.

4. What documents are required by the System Engineering Program configuration management?

5. What are the Cognizant Systems Engineers responsibilities to Operations and Maintenance support

EXAMPLE 3 SELF-CHECK

1. What is the objective of the System Engineering Program.

   A Systems Engineering Program shall be established for DOE category 1, 2, and 3 nuclear facilities. The objective of the Program shall be to ensure continued operational readiness of the systems within its scope. The Program shall include the elements described in Section 4.5.1 of this Order, and shall provide for the designation of a qualified Cognizant System Engineer (CSE) for each such system in Category 1, 2, and 3 nucl;ear facility. The Program shall be incorporated into the Integrated Safety Management System (ISMS), include flow down of implemented procedures on the site and facility level, and shall provide for the CSE

2. List the three elements of the System Engineering Program.

   - identification of systems within its scope,
   - configuration management, and
   - CSE support to operations and maintenance.

3. Provide the scope of the System Engineering Program.

   This program shall be applied to active safety class and safety significant structures, systems and components (SSC), as defined in the nuclear facility's DOE approved safety basis and other active systems that perform an important defense-in-depth function for protection of the public, workers, or environment within the contest of the safety basis, as designated by the facility line management.

4. What documents are required by the System Engineering Program configuration management?

   Documents that define the system design basis (or when the design basis is not clearly defined, the identification of system requirements and performance criteria essential to the systems performance of its safety function, the basis for the requirements, and how the current system configuration satisfies the requirements and criteria) and supporting documents shall be compiled and kept current using a formal change control/work control program.

5. What are the Cognizant Systems Engineers responsibilities to Operations and Maintenance support

   The CSE shall:

   - remain appraised of operational status and ongoing modification activities,
   - assist operations to review key system parameters and evaluate system performance;
   - initiate actions to correct problems,
   - remain cognizant of system-specific maintenance/operations history and industry operating experience,
   - identify trends from operations,
   - provide assistance in determining operability or correcting out-of-specification conditions or evaluating questionable data,
   - provide or support analysis to determine operability when the system is suspected of inoperable degradation,
   - review and concur with design changes, and
   - provide input to development of special operating/test procedures.

PRACTICE

This practice is required if your proficiency is to be verified at the Familiar Level. The practice will prepare you for the criterion test. You will need to refer to the resources to answer the questions in the practice correctly. The practice and criterion test will also challenge additional analytical skills that you have acquired in other formal and on-the-job training.

1. State the activities to which the requirements for nuclear and explosives safety design apply.

2. State the provisions that are associated with defense in depth for non-reactor nuclear facilities.

3. List the site-specific aspects of the written fire protection criteria.

4. State the conditions under which criticality accident alarm systems should be supplemented with warning devices.

5. List the issues that should be addressed in the design of systems, structures and components constructed and operated to withstand the effects of natural phenomena.

6. State when a natural phenomena hazards assessment should be reviewed for existing sites.

7. What are the purposes for configuration management as it applies to the System Engineering Program?

8. List the qualification and training program requirements for CSEs.

9. What should be considered when applying the graded approach in implementing The Systems Engineering Program?

Note: The course manager will check your practice and verify your success at the Familiar Level. When you have successfully completed this practice, go to the General Level module.

CHANGE NO: 1
DOE O 420.1A
LEVEL: GENERAL
DATE: 11/15/04

DOE O 420.1A
FACILITY SAFETY
GENERAL LEVEL

OBJECTIVES

Given the familiar level of this module, a scenario, and an analysis, you will be able to perform the following:

1. Describe the actions you would expect DOE and/or the contractor to take in the situation described in the scenario; and
2. State which requirements included in the resources apply to the situation described in the scenario.

Note: If you think that you can complete the practice at the end of this level without working through the instructional material and/or the examples, complete the practice now. The course manager will check your work. You will need to complete the practice in this level successfully before taking the criterion test.

RESOURCES

DOE Orders Self Study Program, DOE Order O 420.1A, Familiar Level, 11/15/04
DOE Order O 420.1A, Facility Safety, dated 1/23/03.
ANSI/ANS-8.1-1983, R88, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.
ANSI/ANS-8.3-1986, Criticality Accident Alarm System.
ANSI/ANS-8.5-1986, Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material.
ANSI/ANS-8.6-1983, R88, Safety in Conducting Subcritical Neutron-Multiplication Measurements in Situ

ANSI/ANS-8.7-1975, R87, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials.
ANSI/ANS-8.9-1987, Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials.
ANSI/ANS-8.10-1983, R88, Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement.
ANSI/ANS-8.12-1987, R93, Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors.
ANSI/ANS-8.15-1981, R87, Nuclear Criticality Control of Special Actinide Elements.
ANSI/ANS-8.17-1984, R89, Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors.
ANSI/ANS-8.19-1984, R89, Administrative Practices for Nuclear Criticality Safety.
ANSI/ANS-8.21-1995, Use of Fixed Neutron Absorbers in Nuclear Facilities outside Reactors.

INTRODUCTION

The familiar level of this module introduced DOE O 420.1A. Several requirements from the resources were discussed. In the general level of this module, students are asked to apply the information contained in the resources to a series of questions related to the Order. Students are also presented with a scenario that depicts a work situation related to the Order. The example scenario includes a situation, the actions taken to remedy the situation, and the requirements related to the situation. Students will be asked to review the actions taken and decide if they are correct. Students will also be asked to decide if the correct requirements were cited in each situation. Please refer to the resources to make your analysis and answer the questions. You are not required to complete the example. However, doing so will help prepare you for the criterion test.

Note: You do not have to do the example on the following page, but it is a good time to check your skill and knowledge of the information covered. You may do the example or go on to the practice.

EXAMPLE SCENARIO

While conducting a programmatic audit of gloveboxes, it was determined that the total quantity of nuclear material in a glovebox exceeded the posted nuclear material safety limits (NMSL). The amount of fissile material in the glovebox was recalculated, including the totals for uranium and americium, following the receipt of recent laboratory analysis results for one fissile solution bottle. When the mass amounts of fissile material were recalculated, it was determined that the information on the glovebox material balance card was incorrect. When the recalculations were performed, the resulting amount of nuclear material exceeded the NMSL. The criticality safety engineer determined that this was a possible nuclear criticality safety infraction. Additionally, potential criticality safety infractions involving the volume measurement of fissile material were identified in two other gloveboxes.

During a fact-finding meeting, a team determined that differences in the techniques used to measure fissile material mass and a backlog of waste fissile material that was not reanalyzed could have created a potential for other infracted gloveboxes.

Further investigation of the incident revealed the following information.

- Solution bottle volumes are not consistently measured.
- Many bottles of backlog material have not been characterized for uranium and americium content.
- Multiple databases are being used throughout the site that are not consistent with each other, nor do they reflect actual bottle statistics.
- The best available laboratory data on solution bottles is not being reliably transmitted to operations personnel.
- Gloveboxes and drums may be loaded very close to their maximum NMSL limits.
- When tolerances associated with the above problems are combined, some of the NMSL limits may be exceeded.

Immediate actions taken by contractor.

- A no-intrusion order was issued for all gloveboxes containing backlog fissile liquids, pending completion of the audit and written guidance from criticality safety engineering.
- A fact-finding meeting was scheduled for all appropriate personnel when information-gathering activities were complete.

Other actions taken by the contractor.

- Reconcile database conflicts.
- Perform a floor level check, verify fissile mass inventory in each bottle, and perform a backlog bottle inventory.
- Evaluate the issue of accurate volume measurement and determine the cause of the volume discrepancies.
- Issue criticality safety engineering guidance to allow verification of volume measurements in the building.
- Issue a building operations order defining requirements for verifying actinide content of backlog fissile solution bottles.
- Verify how the laboratory analysis data is provided to the owner of the material.

Requirements that apply to this situation include the following.

- DOE Elements shall ensure that a contractor responsible for a DOE non-reactor nuclear facility shall establish a nuclear criticality safety program that applies to fissionable materials that are produced, processed, stored, transferred, disposed, or otherwise handled. (DOE O 420.1A, section 4.3.1.)
- Fissionable materials shall be produced, processed, stored, transferred, disposed, or otherwise handled so that the probability of a criticality accident is acceptably low. Additionally, all persons, all government, public, and private property, and the environment shall be protected from damaging effects and hazards that may arise from a criticality accident. (DOE O 420.1A, section 4.3.3)
- A CSE shall be designated for each system. The CSE shall provide technical assistance in support of line management responsibility to ensure operational readiness of the system. The CSE shall ensure that the configuration of assigned system(s) is being effectively managed according to the elements of Section

4.5.1.2, of attachment 2 to this Order (Configuration Management). The CSE shall remain appraised of operational status and ongoing modification activities, assist operations to review key system parameters and evaluate system performance, initiate actions to correct problems, remain cognizant of system-specific maintenance/operations history and industry operating experience, identify trends from operations, provide assistance in determining operability or correcting out-of-specification conditions or evaluating questionable data, provide or support analysis to determine operability when the system is suspected of inoperable degradation, review and concur with design changes, and provide input to development of special operating/test procedures. (DOE O 420.1A, section 4.5.1)

EXAMPLE SELF-CHECK

Your answer does not have to match the following exactly. You may have added more corrective actions or cited other requirements from the resources that apply. To be considered correct, you answer must include, at least the following.

The actions taken by the contractor were appropriate. One additional action should have been considered.

- The shift manager should have terminated operations in all gloveboxes.

The requirements cited in the situation were correct. Additional requirements that should have been included are

- American National Standard ANS-8.19, Administrative Practices for Nuclear Criticality Safety, section 6.4 requires criticality safety staff members to remain familiar with current operations. Feedback that glovebox users could not verify these limits might have alerted criticality safety engineers that the limits were not verifiable.

- The nuclear criticality safety program shall be evaluated and documented and shall include:
  - Nuclear criticality safety evaluations for normal and credible abnormal conditions that document the parameters, limits, and controls required to ensure that the analyzed conditions are subcritical.
  - Implementation of limits and controls identified by the nuclear criticality safety evaluations.
  - Reviews of operations to ascertain that limits and controls are being followed and that process conditions have not been altered such that the applicability of the nuclear criticality safety evaluation has been compromised.
  - Assessment of the need for criticality accident detection devices and alarm systems, and installation of such equipment where total risk to personnel will be reduced.
- A Systems Engineering Program shall be established for DOE category 1, 2, and 3 nuclear facilities. The objective of the Program shall be to ensure continued operational readiness of the systems within its scope. The program shall include the elements described in section 4.5.1 of this Order, and shall provide for the

designation of a qualified cognizant system engineer (CSE) for each such system in a category 1, 2, or 3 nuclear facility. The program shall be incorporated into the Integrated Safety Management System (ISMS), including flow down of implementing procedures on the site and facility level.

PRACTICE

This practice is required if your proficiency is to be verified at the general level. The practice will prepare you for the criterion test. You will need to refer to the resources to answer the questions in the practice correctly. The practice and criterion test will also challenge additional analytical skills that you have acquired in other formal and on-the-job training.

Please review the following scenario and answer the following questions.

1. Was the situation handled correctly? If not, what should have been done?
2. Was the list of requirements relevant to the resources in this module complete and correct? If not, state the correct or omitted requirements.

SCENARIO

On Wednesday, November 26, 1997, at 1500 hours, the fire system cognizant engineer notified the building emergency director that 3 of 7 sprinklers removed from the facility for testing by the manufacturer did not pass their test.

The company that manufactured the sprinklers had notified customers of potential defects with their brass sprinklers. They requested companies to remove a portion of their sprinklers and return them for testing. Seven sprinklers were removed and replacements were installed. The seven were shipped to the manufacturer for testing. The testing determined that 3 of the 7 exhibited swollen O-rings that prevented them from flowing water at the Underwriters Laboratory (UL) recommended test pressure of 7 psi. The three that failed did not flow water until they reached pressures of 12, 20, and 50 psi.

An investigation of the incident revealed that:

- Excess hydrocarbon caused swollen o-rings in the sprinklers. The swelling prevented the sprinklers from flowing water at the UL recommended pressure of 7 psi. The exact source of the hydrocarbon was not positively identified.
- The fire suppression systems remained operable because the water pressure provided to these sprinklers is 100 psi.

Actions taken by the contractor.

- Notifications were made.
- Arrangements were made to have the vendor replace all the brass sprinklers.
- Thorough engineering analysis to determine the source of hydrocarbons and adequacy of the system as installed.

Requirements that apply to this situation include the following.

- Basic requirements of a fire protection program shall include a reliable water supply of acceptable capacity for fire suppression. (DOE Order 5480.7A, section 9)

Write your answers to questions 1 and 2 and then bring the completed practice to the course manager for review.

Note: The course manager will check your practice and verify your success at the general level. When you have successfully completed this practice, the course manager will give you the criterion test.