U.S. DEPARTMENT OF ENERGY CONTINUING TRAINING SELF-STUDY PROGRAM

DOE O 452.1D

NUCLEAR EXPLOSIVE AND WEAPON SURETY PROGRAM

DOE O 452.2D

NUCLEAR EXPLOSIVE SAFETY

National Nuclear Security Administration

DOE O 452.1D
NUCLEAR EXPLOSIVE AND WEAPON SURETY PROGRAM
DOE O 452.2D
NUCLEAR EXPLOSIVE SAFETY
FAMILIAR LEVEL

OBJECTIVES

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

1. What are the objectives of implementing U.S. Department of Energy (DOE) O 452.1D?
2. Define the following terms as they apply to this Order:
   - Abnormal environment
   - High explosive detonation
3. What are the objectives of implementing DOE O 452.2D?
4. What are the general requirements of DOE O 452.2D?
5. What are the person-to-person requirements as stated in DOE M 452.1-1A?
6. What are the basic requirements of electrical equipment?
7. What are the requirements that support the nuclear explosive-like assemblies (NELA) standards that are defined in DOE O 452.2D?
8. What are the marking requirements for nuclear explosives and NELAs?

RESOURCES

DOE O 452.1D, Nuclear Explosive and Weapon Surety Program, 4/14/09.
DOE O 452.2D, Nuclear Explosive Safety, 4/14/09.
DOE M 452.2-1A, Nuclear Explosive Safety Manual, 4/14/09.

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 familiar level of this module is divided into three sections. In the first section, we will discuss the objectives, terms, and requirements of DOE O 452.1D. In the second section, we will discuss the objectives, responsibilities, and requirements of DOE O 452.2D. In the third section, we will discuss the five chapters of DOE M 452.2-1A. We have provided examples throughout the module and a practice to help familiarize you with the material. The examples and practice will also help prepare you for the criterion test.

Before continuing, you should obtain a copy of all the resources listed for this module. Copies of the Orders are available on the DOE directives website at http://www.directives.doe.gov/directives/read.html or through the course manager. Spend some time reviewing the documents so 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, DOE O 452.1D, NUCLEAR EXPLOSIVE AND WEAPON SURETY PROGRAM

Objectives

To prevent accidents and inadvertent or unauthorized use of U.S. nuclear weapons and nuclear explosives.

In conjunction with the Department of Defense (DoD), to protect the public health and safety by providing dual-agency judgment and responsibility for the safety, security, and use control (surety) of nuclear weapons.

To establish nuclear explosive surety standards and nuclear weapon design surety requirements.

To address surety vulnerabilities during all phases of the nuclear weapon life cycle and to upgrade surety during weapon stockpile refurbishments and/or new weapon development.

To establish requirements and responsibilities for planned nuclear explosive operations (NEOs).

Definitions

The following terms have been selected from definitions listed in DOE O 452.1D. Students should be able to define the following terms in their words.

Abnormal Environment
In DOE operations, an environment that is not expected to occur during nuclear explosive operations and associated activities. In DoD operations, as defined in a weapon's stockpile-to-target sequence and military characteristics, those environments in which the weapon is not expected to retain full operational reliability.

Deflagration
A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and accelerate without input of heat from another source. Deflagration is a surface phenomenon, with the reaction products flowing away from the unreacted material along the surface at subsonic velocity.

High-Explosive Detonation
A violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure. A detonation is a reaction that proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium, forming a propagation shock wave that is originally of supersonic velocity.

Pit
A fissile component, or set of fissile components, designed to fit in the central cavity of an implosion system.

Positive Measures
Design features, safety rules, procedures, or other controls used individually or collectively to provide nuclear explosive surety. Positive measures are intended to ensure a safe response in applicable operations. Some examples of positive measures are strong-link switches; other safety devices; administrative procedures and controls; general and specific nuclear explosive safety rules; design control of electrical equipment and mechanical tooling; and physical, electrical, and mechanical restraints incorporated in facilities and transport equipment.

Surety
Safety, security, and use control of nuclear explosives.

Use Control
The application of systems, devices, or procedures that allow timely authorized use of a nuclear explosive while precluding or delaying unauthorized nuclear detonation.

Requirements

In this section, we will discuss some of the requirements included in DOE O 452.1D. Requirements related to the following elements will be discussed:

- Nuclear explosive surety standards
- Application and intent of the surety standards
- Nuclear explosive security
- Nuclear explosive use control
- Nuclear weapon design surety
- Nuclear weapon surveillance program
- Training and qualification of personnel
- Exemptions
- Records

Nuclear Explosive Surety Standards

All NEOs must meet the following qualitative surety standards:

- Nuclear explosive operations must have controls to prevent adverse environments and unauthorized acts that could lead to unintended nuclear detonation or main charge high explosive detonation/deflagration.
- Nuclear explosive operations must have controls to prevent unintended nuclear detonation and main charge high explosive (HE) detonation/deflagration, given an adverse environment or unauthorized act.
- There must be controls to prevent unauthorized access, intentional physical damage, misuse, and theft of nuclear explosives.
- There must be controls (a combination of site, facility, or nuclear explosive operation-specific as appropriate) to prevent malevolent acts that could lead to deliberate unauthorized use.
- New and refurbished nuclear weapons must have design attributes to prevent nuclear detonation and main charge HE nuclear explosive safety.

Application and Intent of the Surety Standards

The term "prevent" implies an absolute assurance, which cannot be guaranteed and is rarely achievable. Nonetheless, prevention of unintended/unauthorized nuclear detonation and unintended main charge high explosive (HE) detonation/deflagration is a primary goal in the design and performance of nuclear explosive operations.

A primary target of nuclear explosive surety controls is to protect nuclear explosive main charge HE from environments capable of initiating it, including those environments to which main charge detonator cable assemblies are exposed.

"Environment" means the aggregate of surrounding conditions, circumstances, objects, and influences. An "adverse environment" is one that is capable of producing an unwanted response. The adverse environments of interest for the surety standards are those that, if unmitigated, might lead to nuclear detonation or main charge HE detonation/deflagration.

Nuclear Explosive Security
NNSA implements departmental requirements in accordance with the 470-series directives. Safeguards and security measures must be documented in the site safeguards and security plan. The security standard must be met to ensure adequate nuclear explosive security for all NEOs conducted by the Department and its contractors. The Nuclear Explosive Safety Study Group (NESSG) must evaluate security operations for potential adverse nuclear explosive safety (NES) impacts.

Nuclear Explosive Use Control
The use control (UC) standard must be met for all NEOs conducted by the Department and its contractors to ensure adequate UC measures. Additional UC requirements are specified in DOE O 452.4A, *Security and Control of Nuclear Explosives and Nuclear Weapons*, or its successor directive. Use control measures must be evaluated in accordance with the provisions of DOE O 452.4A to ensure all objectives are achieved. The NESSG must evaluate UC measures for potential adverse NES impacts.

Nuclear Weapon Design Surety
Nuclear weapon design surety must be an integral part of the design and development of new weapons and the refurbishment of existing weapons.

- Documented consideration of surety must begin at the conception phase and continue throughout all weapon program phases.
- Surety-related surveillance program information must be explicitly considered in nuclear weapon design and development activities.
- New or refurbished nuclear weapon designs must meet subsequent surety design requirements unless there are overriding reasons for not doing so and explicitly documented agreements to this effect are reached between the Secretary of Energy and the Secretary of Defense. The following must be incorporated in new or refurbished nuclear weapon designs:
  - Nuclear detonation safety
    Nuclear weapons must incorporate design features that minimize the possibility of accidental and/or inadvertent nuclear detonation. The following are design goals for nuclear weapons delivered to the DoD.
    - Normal Environment. Prior to receipt of the enabling input signals, and the arming signal, the probability of a premature nuclear detonation shall not exceed one in a billion per nuclear weapon lifetime.
    - Abnormal Environment. Prior to receipt of the enabling input signals, the probability of a premature nuclear detonation shall not exceed one in a million per credible nuclear weapon accident or exposure to abnormal environments.
    - One-Point Safety. The probability of achieving a nuclear yield greater than four pounds of trinitrotoluene equivalent in the event of a one-point initiation of the weapon's HE shall not exceed one in a million.
  - Fissile material dispersal safety
    Nuclear weapons will incorporate design features for reducing fissile material dispersal from the pit under credible abnormal environments unless there are

overriding reasons for not doing so and the responsible military service requests and adequately justifies an exception approved by the Secretary of Energy.

- Use control
  Nuclear weapons must incorporate UC design features that allow timely authorized use of a nuclear weapon while precluding or delaying unauthorized nuclear detonation. The following are requirements for nuclear weapons delivered to DoD.
  - The protection of nuclear weapons shall include a combination of administrative (e.g., personnel security) and technical measures (e.g., physical security and UC) designed to prevent deliberate unauthorized nuclear detonation. These measures shall be consistent with DoD operational requirements and shall continually be assessed against existing and emerging threats as well as technological opportunities for improvement.
  - Use control capabilities will be upgraded for all warheads during weapon refurbishment.
- Inadvertent criticality
  Design nuclear weapons that will not inadvertently go critical in normal and abnormal environments as verified by the design agency.
- Multipoint initiation
  Multipoint initiation in abnormal environments must be evaluated as part of the design process.

Surety Research and Development (R&D)
Research and development on a broad range of safety and control methods and devices must be conducted to improve the surety of nuclear weapons and nuclear weapon systems significantly by accomplishing the following:

- Identify and characterize physical processes that can lead to unacceptable nuclear explosive response.
- Identify and address safety issues.
- Identify areas to improve safety.
- Provide UC options with delay or denial capability that, at a minimum, are equivalent to that associated with current nonviolent disablement systems.
- Pursue technologies that render the unauthorized use of U.S. nuclear weapons impossible without their remanufacture.

Nuclear Weapon Surveillance Program
The nuclear weapon surveillance program, which involves routine periodic examination, evaluation, and testing of stockpile weapons and weapon components to ensure they meet design requirements and are performing effectively—must include safety and UC components.

Training and Qualification of Personnel
Each organization responsible for and/or involved in NEOs and activities that may affect the safety and UC of a nuclear explosive or nuclear weapon must implement training and qualification programs for personnel.

- Training and qualification requirements must be commensurate with the particular responsibilities assigned.
- Nuclear explosive and weapon surety training must include specific training on the specific nuclear explosive and weapon hazards and controls for the responsibilities.

Exemptions
Exemptions must be requested when release is sought from a requirement in DOE O 452.1D. The exemption process is outlined in DOE O 251.1C, *Departmental Directives Program*, or successor directive. The approval authority is the Deputy Administrator for Defense Programs with concurrence from the Central Technical Authority (CTA).

Records
Records (documentation) must be maintained in accordance with National Archives and Records Administration-approved DOE or site-specific records retention and disposition schedules per DOE O 243.1, *Records Management Program.*

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 2.

EXAMPLE 1

Using the familiar level of this module and the resources, answer the following questions.

1. What is the purpose of DOE O 452.1D, *Nuclear Explosive and Weapon Surety Program*?

2. What are the qualitative surety standards?

3. What are the design goals for nuclear weapons delivered to the DoD?

4. What is the definition of high explosive detonation?

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 2.

EXAMPLE 1 SELF-CHECK

1. What is the purpose of DOE O 452.1D, *Nuclear Explosive and Weapon Surety Program*?
   The purpose of DOE O 452.1D is as follows:
   - To prevent accidents and inadvertent or unauthorized use of U.S. nuclear weapons and nuclear explosives.
   - In conjunction with the Department of Defense (DoD), to protect the public health and safety by providing dual-agency judgment and responsibility for the safety, security, and use control (surety) of nuclear weapons.
   - To establish nuclear explosive surety standards and nuclear weapon design surety requirements.
   - To address surety vulnerabilities during all phases of the nuclear weapon life cycle and to upgrade surety during weapon stockpile refurbishments and/or new weapon development.
   - To establish requirements and responsibilities for planned nuclear explosive operations (NEOs).

2. What are the qualitative surety standards?
   The qualitative surety standards are:
   - Nuclear explosive operations must have controls to prevent adverse environments and unauthorized acts that could lead to unintended nuclear detonation or main charge high explosive detonation/deflagration.
   - Nuclear explosive operations must have controls to prevent unintended nuclear detonation and main charge high explosive detonation/deflagration, given an adverse environment or unauthorized act.
   - There must be controls to prevent unauthorized access, intentional physical damage, misuse, and theft of nuclear explosives.
   - There must be controls (a combination of site, facility, or nuclear explosive operation-specific as appropriate) to prevent malevolent acts that could lead to deliberate unauthorized use.
   - New and refurbished nuclear weapons must have design attributes to prevent nuclear detonation and main charge high explosive nuclear explosive safety.

3. What are the design goals for nuclear weapons delivered to the DoD?
   - Normal Environment. Prior to receipt of the enabling stimuli and the arming signal, the probability of a premature nuclear detonation shall not exceed one in a billion per nuclear weapon lifetime.
   - Abnormal Environment. Prior to receipt of the enabling stimuli, the probability of a premature nuclear detonation shall not exceed one in a million per credible nuclear weapon accident or exposure to abnormal environments.
   - One-Point Safety. The probability of achieving a nuclear yield greater than four pounds of trinitrotoluene equivalent in the event of a one-point initiation of the weapon's high explosive shall not exceed one in a million.

4. What is the definition of high explosive detonation?
   High explosive detonation is a violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure. A detonation is a reaction that proceeds through the reacted material toward the un-reacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium, forming a propagation shock wave that is originally of supersonic velocity.

SECTION 2, DOE O 452.2D, NUCLEAR EXPLOSIVE SAFETY

This section will address the purpose, requirements, and responsibilities contained in DOE O 452.2D.

Purpose

DOE O 452.2D establishes requirements to implement the NES elements of DOE O 452.1D for routine and planned NEOs.

Requirements

Nuclear Explosive Safety Program
NEOs require special consideration because of the potentially high consequences of an accident or unauthorized act. A formal, comprehensive NES program must include the following.

- Nuclear Explosive Safety Evaluations. NEOs must not be performed until a NES study has been conducted, the NESS report has been approved, and approved prestart findings have been closed.
- Nuclear Explosive Operating Procedures. NEOs must be performed in accordance with approved written procedures.
- One-Point Safety. NEOs involving a nuclear explosive not certified to be one-point safe must be conducted only at Nevada Test Site, except if it is determined that a nuclear explosive no longer meets the one-point safety criteria, all assembly/disassembly production plant operations, including onsite transportation, and offsite transportation with that nuclear explosive must be discontinued in a safe manner. Before operations with that nuclear explosive can be resumed, a path forward must be developed, a NES evaluation must be conducted, the NES evaluation report must be approved, and approved pre-start findings must be closed. Tooling and equipment must be evaluated as required to ensure that their use does not cause a one-point safety violation of a nuclear explosive certified to be one-point safe.
- Nuclear Explosive Areas (NEAs). Authorized energy sources must be identified and documented. Unauthorized energy sources must not be available in an NEA during NEOs. Ignition sources in NEAs must be identified and eliminated or minimized and controlled to prevent adverse interaction with combustible/flammable materials and the nuclear explosive. Combustible and flammable materials in NEAs must be identified and eliminated or minimized and controlled to prevent adverse interaction with the nuclear explosive.
- Electrical Testing. Except as authorized in accordance with anomalous units, nuclear explosives must not be subjected to redundant electrical tests or electrical troubleshooting except with authorized test equipment and procedures that have been subjected to a NES evaluation and found to be acceptable for the specific application.
- Anomalous Units. If it is determined that a nuclear explosive is no longer in a condition covered by a NES evaluation, all operations with that nuclear explosive and in the associated facility must be discontinued in a safe manner, resulting in a safe and stable nuclear explosive configuration. Before operations with the anomalous unit can be resumed, a design agency special instruction engineering release must be developed, and the NEO change control process must be completed. A decision to resume other activities

in the facility must include consideration of possible interactions with the anomalous unit.

- Supplemental Nuclear Explosive Safety Rules. Supplemental NESRs may be developed as needed to support specific tests, operations, or characteristics of a nuclear explosive.
- Nuclear Explosive Safety Evaluations. NES evaluations are required before an NEO is authorized; periodically for ongoing NEOs; and when proposed changes or emerging information affect an approved NEO. NES evaluations must be performed in accordance with DOE M 452.2-2, *Nuclear Explosive Safety Evaluation Processes,* or successor directive.
- Procedures. Written procedures (paper or electronic) control the interactions among the nuclear explosive, the operating facility, equipment, and personnel.
- Two-Person Concept. DOE M 452.2-1A requires organizations responsible for NEOs and associated activities and facilities to establish and implement the two-person concept.
- Facilities. Facilities used for NEOs must be characterized, evaluated, and specifically approved for that use.
- Equipment. Organizations responsible for NEOs and associated activities and facilities must verify that all equipment used in NEOs meet the following requirements. DOE M 452.2-1A or successor directive, specifies additional requirements for electrical equipment used in NEAs.
  - Design specifications and technical requirements must be documented.
  - Designs must ensure nuclear explosives will remain in a safe condition should a system or component of the tool/equipment fail.
  - Each item used in an NEO must be specifically approved for that operation. Unapproved movable items must be excluded from the NEA. Positive measures must be used to preclude use of facility equipment that is not approved for the NEO and impracticable to remove.
  - Equipment intended to apply energy to a nuclear explosive must incorporate features that limit energy to a known safe level.

- Maintenance of Facilities, Tooling, and Other Equipment. Organizations responsible for NEOs and associated activities and facilities must review maintenance programs and activities for impact on NES. Maintenance implementation plans must include a detailed description of maintenance activity control and approval, including limitations on materials that are allowed in NEAs.
- Personnel. Each organization responsible for and/or involved in NEOs and associated activities must implement training, qualification, and certification programs for personnel that manage, oversee, perform, or directly support these operations and activities.
- Transportation of Nuclear Explosives.
  - Organizations responsible for NEOs and associated activities and facilities must establish requirements and procedures to ensure safe onsite transportation of nuclear explosives.
  - Offsite transportation of nuclear explosives is performed by the Office of Secure Transportation and begins when the loaded conveyance is closed and ends with the opening of the conveyance at its destination.
  - Transportation operations and shipping configurations, including all items in the

conveyance, are subject to the NES evaluation requirements.

- Mixed Venues. Nuclear explosives must not be transported or staged with any other assembly that could be mistaken for a nuclear explosive.
- Positive Verification.
  - Organizations responsible for NEOs and associated activities and facilities must develop and implement a verification process to ensure use of qualified personnel who are fit for duty, operationally ready facilities, correct equipment that is current in any required calibration and preventive maintenance, and current approved procedures.
  - The configuration and condition of a nuclear explosive and its safety features must be known or determined as early as practical during any planned NEO.

- Change Control. Organizations responsible for NEOs and associated activities and facilities must establish and implement a NES change evaluation process. This NES evaluation is separate and independent from the unreviewed safety question process required by 10 CFR 830, "Nuclear Safety Management," and must be completed before approval and implementation of the change. All proposed changes to authorized NEOs are subject to the NEO change control process.
- Configuration Management. Organizations responsible for NEOs and associated activities and facilities must develop and implement a configuration management program incorporating elements applicable to NEOs and associated activities and facilities. To ensure consistency with design requirements and the safety basis, the configuration management program must specifically include the following:
  - Control of the physical configuration of a nuclear explosive and its components; the tooling, equipment, and procedures used in NEOs and associated activities; and the interface with the facilities in which these operations and activities are conducted;
  - Unique identification of special tooling and equipment used in NEOs;
  - Positive identification of tooling and equipment requiring calibration/testing within a calibration/testing control program; and
  - Incorporation of approved changes into all affected documents, including design documents, drawings, procedures, and safety basis documents and programs, including maintenance and training.

- Nuclear Explosive-like Assemblies. All NELA operations must meet the following qualitative NELA standards:
  - There must be controls to minimize the possibility of accidental, inadvertent, or deliberate unauthorized assembly of a nuclear explosive in place of a NELA configuration.
  - There must be controls to minimize the possibility of accidental, inadvertent, or deliberate unauthorized transfer of a nuclear explosive in place of a NELA configuration.
  - Organizations responsible for NELA operations must implement the NELA requirements in accordance with DOE M 452.2-1A.

- Marking Instructions. Nuclear explosives and NELAs must be marked to distinguish configurations capable of a nuclear detonation from those that are not. Organizations responsible for NEOs or NELA operations must implement marking requirements in accordance with DOE M 452.2-1A.

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 example 2 or go to section 3.

EXAMPLE 2

1. What are four elements that must be included in a nuclear explosives configuration management program?

2. What are the requirements for equipment used in NEOs?

3. What are the NELA standards?

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 3.

EXAMPLE 2 SELF-CHECK

1. What are four elements that must be included in a nuclear explosives configuration management program?
   - Control of the physical configuration of a nuclear explosive and its components
   - Identification of special tooling and equipment used in NEOs
   - Identification of tooling and equipment that requires calibration or testing
   - Incorporation of approved changes into all affected documents

2. What are the requirements for equipment used in NEOs?
   All tooling and equipment used in NEOs specifically meet the following requirements:
   - Design specifications and technical requirements must be documented.
   - Designs must ensure nuclear explosives will remain in safe condition should a system or component of the tool/equipment fail.

3. What are the NELA standards?
   - There must be controls to minimize the possibility of accidental, inadvertent, or deliberate unauthorized assembly of a nuclear explosive in place of a NELA configuration.
   - There must be controls to minimize the possibility of accidental, inadvertent, or deliberate unauthorized transfer of a nuclear explosive in place of a NELA configuration.
   - Organizations responsible for NELA operations must implement the NELA requirements in accordance with DOE M 452.2-1A.

SECTION 3, DOE M 452.2-1A, NUCLEAR EXPLOSIVE SAFETY MANUAL

This section will address the four chapters of DOE M 452.2-1A: Two-Person Concept, Electrical Equipment, Nuclear Explosive-Like Assembly, and Marking Requirements.

Two-Person Concept

The two-person concept is implemented to ensure no lone individual has unrestricted access to a nuclear explosive. Site offices may also require two-person concept protection for other operations.

Each person on a two-person concept team must

- be certified in the Human Reliability Program
- have authorized access to the nuclear explosive area (NEA)
- have technical knowledge of the task being performed
- be knowledgeable of pertinent safety and security requirements
- be in a position to detect incorrect or unauthorized acts and take appropriate action

The two-person concept may be implemented using either zone coverage or person-to-person coverage.

Zone Coverage

Zone coverage is designed to protect configurations that do not require person-to-person coverage. Zone coverage requires a two-person concept team in an NEA when a nuclear explosive is not protected by a dual-lock system or other NES-approved security system.

Person-to-Person Coverage

Person-to-person coverage is the more stringent form of the two-person concept. Person-to-person coverage is designed to protect configurations that are particularly vulnerable to inadvertent acts (errors of omission or commission) or deliberate unauthorized acts. Configurations requiring person-to-person coverage include the following:

- Exposed conventional high explosive (CHE) main charge in an NEA
- Main charge HEs with accessible detonator cable assemblies in an NEA
- Nuclear explosives connected to category 1 electrical equipment

Application of Person-to-Person Coverage

Configurations requiring person-to-person coverage must be determined based on specific system characteristics. The application of person-to-person coverage allows recognition of the protection provided by design safety features and physical protection.

Assembly/Disassembly Operations Involving Conventional High Explosive

For assembly operations involving CHE main charge, person-to-person coverage of the CHE components must begin when the CHE container is opened in an NEA.

Coverage continues until the nuclear explosive is in a configuration in which the application of design-specific environmental stimuli or unique or coded signals is necessary for nuclear detonation or detonation of the main charge HE.

For disassembly operations, this requirement applies in reverse.

Assembly/Disassembly Operations Involving Insensitive High Explosive (IHE)
For assembly operations involving IHE main charge, person-to-person coverage must be provided for main charge components located in an NEA, and assemblies containing these components, that have accessible detonator cables attached.

Coverage continues until the nuclear explosive is in a configuration in which the application of design-specified environmental stimuli or unique or coded signals is necessary for nuclear detonation or detonation of the main charge HE.

For disassembly operations this requirement applies in reverse.

For purposes of person-to-person coverage, systems with installed and un-actuated (safe/reset) mechanical safe and arm devices are not considered to have accessible detonator cables. Configurations with physical protection that precludes immediate and unrestricted access to the configuration by a lone individual are not considered to be exposed. When such physical protection is in place, zone coverage provides adequate protection for configurations that would otherwise require person-to-person coverage.

Person-to-Person Coverage Requirements
When a configuration requires person-to-person coverage, a qualified two-person concept team must be either working on or controlling access to the configuration. Specific person-to-person coverage requirements are as follows:

- Lone individuals must not be allowed within the immediate vicinity (approximately six feet) of a configuration that requires person-to-person coverage.
- The two people providing person-to-person coverage must each be responsible for the safe conduct of the operations.
- During the performance of operations on a configuration requiring person-to-person coverage
  - the two-person concept team must be in the immediate vicinity of the configuration;
  - each person on the two-person concept team must observe all operations, ensure that only authorized operations are performed, and ensure that operations are performed correctly; and
  - a reader-worker process that includes the following must be incorporated:
    - The procedure must be read aloud, the operation must be performed, and the completion of the operation must be documented in the stated sequence.
    - One of the two people performing the operation may read the procedure aloud to the other person provided that both people can move away from the immediate vicinity of the configuration while the reading is accomplished.
    - If both people cannot move away from the immediate vicinity of the configuration while the reading is accomplished, then a third person must read the procedure aloud to the other people.
- When operations are not being performed on a configuration requiring person-to-person coverage

  - the two-person concept team must be in the immediate vicinity of the configuration when another individual is in the immediate vicinity of the configuration;
  - the two-person concept team is not required to be in the immediate vicinity of the configuration when other individuals are not in the immediate vicinity of the configuration. However, team members must remain in a position to directly observe the approach of any individual to the configuration.

- Only one configuration requiring person-to-person coverage is allowed in a vacated bay or cell. This requirement does not apply to emergency evacuations.

Electrical Equipment

Category 1 Electrical Equipment
Electrical equipment intended for connection to an electrical circuit of a nuclear explosive or HE subassembly is referred to as category 1 electrical equipment. Category 1 electrical equipment must meet the following minimum requirements:

- Electrical equipment must use the lowest practical values of internal and output currents and voltages.
- Electrical equipment must not apply unacceptable stimuli as the result of a single-point failure.
- Each item of electrical equipment must have safety characteristics independent of the nuclear explosive's safety features.
- Each item of electrical equipment and its interface with a nuclear explosive require the performance and documentation of a comprehensive safety analysis, including consideration of relevant abnormal environments.
- Each drawing issue of electrical equipment and its interface with a nuclear explosive requires a completed NES evaluation.
- Procedures must be established to operate, control, calibrate, maintain, and store electrical equipment.
- A record of approved category 1 electrical equipment must be established and maintained.
- Software must not be relied upon to ensure the safe state of the unit under test. If software is used to achieve a safe state then a separate means of verification must also be employed.
- Testers must be designed such that software is incapable of causing safety feature bypass.
- Software failure must not compromise the safety attributes of the equipment or unit under test.
- Category 1 electrical equipment requires two-person concept protection.
  - Person-to-person coverage is required during calibration and all operations that afford internal access to electrical equipment and associated cables and adapters.
  - Zone coverage is required for fully assembled electrical equipment and associated cables and adapters when that equipment is not protected by a dual-lock system or other NES-approved security system.

Category 2 Electrical Equipment
Electrical equipment that is not intended for connection to an electrical circuit of a nuclear

explosive or HE subassembly but makes mechanical connection to, or could come in contact with, a nuclear explosive or HE subassembly is referred to as category 2 electrical equipment. Category 2 electrical equipment must be clearly identified and meet the following minimum requirements:

- Electrical equipment must not be connected to the electrical circuitry of a nuclear explosive.
- Electrical equipment must be positioned in a manner to preclude contact with a nuclear explosive except when a mechanical connection is required to perform its intended and authorized function.
- The potential for inadvertent connection between the electrical equipment and the nuclear explosive circuitry must be minimized.
- Positive electrical isolation must be established and demonstrated for electrical equipment and its mechanical connection to a nuclear explosive. Electrical isolation must account for normal and credible abnormal conditions. The electrical isolation scheme used must be clearly identified and documented using one of the following subcategories, listed in priority order:
  - Path-on isolation reducing leakage or fault current, from electrical energy sources associated with the equipment, to a defined safe value. This must be verified annually.
  - Path-off isolation reducing leakage or fault current, from electrical energy sources associated with the equipment, to a defined safe value. This must be verified annually.
  - An electrical isolation scheme requiring at least two independent failures before exposing the nuclear explosive to unacceptable leakage or fault current from electrical energy sources associated with the equipment. Each failure mechanism must be identified.

A record of approved electrical equipment must be established and maintained.

Category 3 Electrical Equipment
Movable and facility electrical equipment used in an NEA that is not intended for connection to an electrical circuit of a nuclear explosive or HE subassembly and does not make mechanical connection to, and cannot come in contact with, a nuclear explosive or HE subassembly is referred to as category 3 electrical equipment.

Nuclear Explosive-Like Assembly Requirements

Nuclear Explosive-Like Assembly Definition
An assembly with components representing the main charge HE and pit that has the potential for component substitution resulting in accidental, inadvertent, or deliberate unauthorized assembly or transfer of a nuclear explosive may be considered a NELA.

A NELA represents a nuclear explosive in the U.S. nuclear weapons program, including assemblies for development, testing, training, or other purposes.

A NELA contains one of the following:

- Mock HE and high-fidelity dummy pit—referred to as an "inert NELA."
- Live HE and high-fidelity dummy pit—referred to as a "high explosive NELA."
- Mock HE and live pit—referred to as an "inert-with-live-pit NELA."

Assembly/Disassembly of Nuclear Explosive-Like Assemblies
NELAs must not be assembled or disassembled in proximity to nuclear explosives where components may be interchanged. A two-person concept team is required to perform all assembly/disassembly operations on inert-with-live-pit NELAs.

Verification of Nuclear Explosive-Like Assembly Components Before Assembly

Inert Nuclear Explosive-Like Assemblies

Repeated compliance with the verification requirements of this section is not necessary for repeated disassembly and reassembly training operations provided the mock HE and high-fidelity dummy pit remain in a training area where main charge HE and live pits are not authorized.

- Mock HE verification requirements:
  - All mock HE used in place of live main charge HE must be non-detonable and must be clear or colored pink. Where possible, preference must be given to noncombustible formulations. Live main charge HE must not be colored pink.
  - Pink mock HE used in place of live main charge HE must be chemically verified before assembling the NELA. Clear mock HE refers to LEXAN or similar inert substances and does not require chemical verification.
  - An auditable record of chemical verification of the mock HE must be available.

- High-fidelity dummy pit verification requirements:
  - The pit must be verified by radiation detection means before assembly into an inert NELA to verify the absence of radioactive material. If radiation is detected, the pit must be assayed by using gamma spectrometry/multichannel analyzer to verify the absence of fissile material. This verification must be either performed or observed using person-to-person coverage.
  - After dummy pit verification, the pit must be controlled until the pit is assembled into the basic NELA configuration or until the pit is delivered into an assembly area where live pits are not authorized. This control must be achieved by a two-person concept team or a dual-lock or other NES-approved security system.
  - An auditable record of radiation detection verification of the high-fidelity dummy pit must be available.

High Explosive Nuclear Explosive-Like Assemblies

High explosive NELAs and inert-with-live-pit NELAs must not be assembled or disassembled in proximity where components may be interchanged.

- High-fidelity dummy pit verification requirements:
  - The pit must be verified by radiation detection means before assembly into an HE NELA to verify the absence of radioactive material. If radiation is detected, the pit must be assayed by using gamma spectrometry/multichannel analyzer to verify the absence of fissile material. This verification must be either performed or observed

using person-to-person coverage.
  - After dummy pit verification, the pit must be controlled until the pit is assembled into the basic NELA configuration. This control must be achieved by a two-person concept team or a dual-lock or other NES-approved security system.
  - An auditable record of radiation detection verification of the high-fidelity dummy pit must be available.

- Main charge HE introduction sequence:
  - The high-fidelity dummy pit verification must be accomplished before introduction of the main charge HE and dummy pit into the same immediate assembly area of the HE NELA.

Inert-with-Live-Pit Nuclear Explosive-Like Assemblies

Inert-with-live-pit NELAs and HE NELAs must not be assembled or disassembled in proximity where components may be interchanged.

- Mock HE verification requirements:
  - All mock HE used in place of live main charge HE must be nondetonable and must be clear or colored pink. Where possible, preference must be given to noncombustible formulations. Live main charge HE must not be colored pink.
  - Pink mock HE used in place of live main charge HE must be chemically verified before assembling the NELA. Clear mock HE refers to LEXAN or similar inert substance and does not require chemical verification.
  - An auditable record of chemical verification of the mock HE must be available.

- Mock HE two-person concept verification requirements:
  - In addition to the mock HE verification requirements, another chemical verification of all mock HE used in place of live main charge HE must be accomplished before assembly into an inert-with-live-pit NELA. This verification must be either performed or observed using person-to-person coverage.
  - After the mock HE two-person concept verification, the mock HE must be controlled until the mock HE is assembled into the basic NELA configuration. This control must be achieved by a two-person concept team or a dual-lock or other NES-approved security system.
  - An auditable record of two-person concept chemical verification of the mock HE must be available.

- Live pit introduction sequence:
  - The mock HE verifications must be accomplished before introduction of the live pit and mock HE into the same immediate assembly area of the inert-with-live-pit NELA.

Offsite Transportation of Nuclear Explosive-Like Assemblies

A configuration assembled as an inert-with-live-pit NELA must not be transferred to the custody of the Department of Defense.

Identification Requirements

NELAs that are shipped between DOE sites must be identified externally with the following

information:

- NELA contents identified as one of the following:
  - Inert NELA
  - High explosive NELA
  - Inert-with-live-pit NELA
- Name and agency of responsible person at the shipping location
- Name and agency of person who authorized the shipment at the receiving location

Permission to Ship Between DOE Agencies

The shipping agency must obtain permission from the receiving agency to ship before shipment of a NELA.

Nuclear Explosive-Like Assembly Survey Before Transfer

Before offsite transfer and upon receipt of a NELA, the NELA must be surveyed in its shipping configuration by a radiation detection means to verify the absence or presence of fissile material. Anomalies or ambiguities detected by radiation detection means must be resolved before shipment or release.

Nuclear Explosive-Like Assembly Survey Upon Receipt

Upon receipt of a NELA, the NELA must be surveyed in its shipping configuration by a radiation detection means to verify the absence or presence of fissile material. Anomalies or ambiguities detected by radiation detection means must be resolved before release.

An auditable record of this survey must be available.

Marking Requirements

Nuclear explosives and NELAs must be permanently marked in accordance with the following requirements. Additional markings such as serial numbers and configuration identification may also be required by design agencies.

Permanent Marking Legends

Nuclear Explosives

A "NUCLEAR" permanent marking legend must be applied to nuclear explosives (i.e., units containing a live pit and an HE main charge).

Nuclear Explosive-Like Assemblies

Inert Nuclear Explosive-Like Assemblies. The "INERT" permanent marking is applied to a NELA containing mock HE or void in place of the live main charge HE and a dummy pit or void. Using the permanent marking "INERT" does not preclude the presence of materials that may present a hazard to personnel.

High Explosive Nuclear Explosive-Like Assemblies. The "HIGH EXPLOSIVE" permanent marking is applied to a NELA containing live main charge HE and a dummy pit or void.

Inert-with-Live-Pit Nuclear Explosive-Like Assemblies. The "INERT-WITH-LIVE-PIT"

permanent marking is applied to a NELA containing mock HE, in place of the live main charge HE, and a live pit. Using the permanent marking "INERT-WITH-LIVE-PIT" does not preclude the presence of materials that may present a hazard to personnel.

Permanent Marking Location

Nuclear explosives and NELAs must be permanently marked on an external surface. The permanent marking must be on a part that encloses the live main charge or mock HE. The marking location must be specified by the applicable design agency.

Permanent Markings

Nuclear explosives and NELAs must be marked in accordance with the following requirements. The particular marking method must be specified by the applicable design agency.

- The permanent marking method must produce the most durable mark possible, consistent with acceptable deleterious effect on the material to which the marking is applied.
  - The preferred marking methods are mechanical engraving (with or without fill) and impression-die stamping.
  - Other acceptable methods are impression freehand, impression sandblast, and surface conversion.
- The preferred marking size is 1/4-inch characters with 1/4-inch spacing between lines, if space permits.

Permanent Marking Obliteration

When a nuclear explosive or NELA is altered or disassembled to the point that its permanent marking is no longer valid, the permanent marking must be obliterated in accordance with the following requirements:

- Methodology
  - The preferred method of obliteration is overprinting the letter "X" on each letter of the permanent marking legend using the same permanent marking method as that used to apply the original marking.
  - If obliteration by overprinting is not feasible for technical reasons, the permanent marking must be removed using a method specified by the applicable design agency.
- Components that will be reassembled. Permanent marking need not be obliterated on marked components that will be reassembled into the same configuration in accordance with the following requirements:
  - General Requirements
    - After the marked component is removed, the disassembled components must be controlled until the disassembled components and marked component are reassembled into the same configuration.
    - Control must be achieved by a two-person concept team or a dual-lock or other NES-approved security system.

- Nuclear explosives
  - Nuclear explosive components must not be assembled or disassembled in proximity to NELAs, where components may be interchanged.
- Nuclear explosive-like assemblies
  - NELAs must not be assembled or disassembled in proximity to nuclear explosives, where components may be interchanged.
  - Inert NELAs must not be assembled or disassembled in proximity to HE or inert-with-live-pit NELAs, where components may be interchanged.
- High explosive nuclear explosive-like assemblies.
  - HE NELAs must not be assembled or disassembled in proximity to inert or inert-with-live-pit NELAs, where components may be interchanged.
  - Inert-with-live-pit NELAs must not be assembled or disassembled in proximity to HE or inert NELAs, where components may be interchanged.

PRACTICE

This practice is required if your proficiency is to be verified at the familiar level. If you are to be qualified as a facility representative, 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. What is the definition for the following terms?
   - Abnormal environment
   - Deflagration
   - High-explosive detonation

2. What are three of the quality surety standards for nuclear explosives?

3. What are the objectives of DOE O 452.1D, *Nuclear Explosive and Weapon Surety Program?*

4. What are the requirements for transporting nuclear explosives as described in DOE O 452.2D, *Nuclear Explosive Safety*?

5. When is a nuclear explosive safety evaluation required?

6. What is the definition of one-point safety criteria?

7. What are three sources and/or materials that must be identified, documented, and/or controlled in nuclear explosive areas?

8. What is the condition in which zone coverage is applicable to protect configurations that are vulnerable to inadvertent acts?

9. What is the definition of the term "immediate vicinity" as it applies to person-to-person coverage?

10. What are the preferred marking methods for nuclear explosives and NELAs?

Note: The course manager will check your practice and verify your success at the familiar level. If you are to be qualified at the familiar level and have successfully completed this practice, go to the general level module.

DOE O 452.1D
NUCLEAR EXPLOSIVE AND WEAPON SURETY PROGRAM
DOE O 452.2D
NUCLEAR EXPLOSIVE SAFETY
GENERAL LEVEL

OBJECTIVES

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

1. What are the key elements you would look for in the contractor's action plan to correct the situation described in the scenario?
2. What are the requirements, sections, or elements of the DOE O 452.1D and O 452.2D that apply to the situation described in the scenario?

RESOURCES

DOE Orders Self-Study Program, DOE O 452.1D and O 452.2D, Familiar Level, June 2011.
DOE O 452.1D, Nuclear Explosive and Weapon Surety Program, 4/14/09.
DOE O 452.2D, Nuclear Explosive Safety, 4/14/09.
DOE M 452.2-1A, Nuclear Explosive Safety Manual, 4/14/09.

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 familiar level of this module introduced DOE O 452.1D and DOE O 452.2D. Several requirements from the Orders and the manual were discussed. In the general level of this module, students are asked to apply the information contained in the familiar level, the Orders and the manual to a scenario that depicts a work situation related to the directives. 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 contractor's actions 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 Orders and the manual 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

The following is an incident involving nuclear explosives safety.

The incident involved three production technicians performing an operation to bond filler blocks to two nuclear explosives.

The three technicians discussed the situation before the bonding process began. They agreed to a plan of action and proceeded as follows. They placed the two nuclear explosives side by side, approximately four feet apart. The bonding material was placed on a table within two feet of both nuclear explosives. The nuclear explosives were high explosive main charge with unprotected detonator cables. Each nuclear explosive was individually uncovered. A fixture was installed that is required for the bonding process. All three technicians remained within arm's length of each other and with unobstructed vision during the bonding process. Two technicians worked on the bonding and the third technician stood in the center of the two assembly stands to make bonding material readily available. The procedure was performed quickly and without incident.

A safety engineer conducting a walkthrough passed by the nuclear explosive area as the technicians were completing the bonding process. The engineer reported this incident as a violation of the two-person concept. The contractor's management challenged the violation. Management's position was that two qualified people were present during the operation and the two-person concept was not violated.

Take some time to review the example scenario and the actions the contractor took or didn't take to correct the situation. Then decide if the contractor's actions were complete and correct. Finally, identify the requirements, sections, or elements of DOE O 452.1D and DOE O 452.2D that apply to this scenario.

Write your answer below and then compare your answer to the one contained in the example self-check.

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 Order that apply. To be considered correct, your answer must include, at least the following.

The contractor's position is not valid.

The configuration (a high explosive main charge with unprotected detonator cables) requires person-to-person coverage. When a configuration requires person-to-person coverage, two designated individuals, each having technical knowledge of the task being performed, shall be observing or working on the configuration. Specific requirements are as follows:

- No lone individual shall be allowed within the immediate vicinity (approximately six feet) of a configuration that requires person-to-person coverage.
- When operations are being performed on a configuration that requires person-to- person coverage, the two persons providing person-to-person coverage shall be in the immediate vicinity of the configuration. Both shall observe all operations and ensure that only correct and authorized operations are performed.
- When operations are not being performed on a configuration that requires person-to-person coverage, the two persons providing person-to-person coverage do not have to be in the immediate vicinity when other personnel are not in the immediate vicinity. However, they shall remain in a position to directly observe the approach of any individual to the configuration.
- The two individuals providing person-to-person coverage are each responsible for the safe conduct of the operations.

The concern in this scenario is that two nuclear explosives were in a configuration requiring person-to-person coverage. Two persons are required for each nuclear explosive or the nuclear explosive must be covered to preclude immediate and unrestricted access by a lone individual. Four technicians instead of three were required to satisfy the person-to-person coverage requirement in this scenario.

The contractor should have taken corrective actions similar to the following:

- Establish and implement a person-to-person training course as part of the continuing training program.
- Review the nuclear explosive safety (NES) training plan to ensure that the training adequately addresses the person-to-person rule when detonator cables are exposed.
- Check the effectiveness of the training to ensure attendees know the requirements and procedures included in the two-person concept.

DOE M 452.2-1, chapter II, section 4 applies to this scenario.

- No lone individual must be allowed within the immediate vicinity (approximately six feet) of a configuration that requires person-to-person coverage.
- The two people providing person-to-person coverage must each be responsible for the safe conduct of the operations.

- During the performance of operations on a configuration requiring person-to-person coverage
    - the two-person concept team must be in the immediate vicinity of the configuration;
    - each person on the two-person concept team must observe all operations, ensure that only authorized operations are performed, and ensure that operations are performed correctly; and
    - a reader-worker process must be incorporated.

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 Orders and 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, sections, and elements complete and correct? If not, state the correct or omitted requirements.

SCENARIO

On August 1, 2006, the assistant facility manager for zone 4 magazines reported that three partial nuclear explosive assemblies had been transported in 1993 from zone 12 to the zone 4 magazines in an unapproved configuration. Zones 4 and 12 are on the same site. The aft sections of the assemblies had been removed and shipped offsite for upgrading. Protective covers had been installed on the partial assemblies during staging in the production bays. These covers are approved by the NES study for that purpose, but are not approved for use during transportation between zones. Disposition instructions for the three units specified that the units were to be retained in on-line storage until repairs on the aft sections were complete. To make room in the production bays, the assemblies were transported to magazines. No approved covers existed in 2003 and records are being searched to identify the process that authorized the move in 2003.

No injuries to personnel and no damage to nuclear explosives or facilities resulted from this event.

Immediate actions taken by contractor:

- The transportation of partial nuclear explosives assemblies to the magazines was stopped until that process could be reviewed for adequate controls.

Additional corrective actions taken by the contractor:

- A search of 1993 records was conducted to identify the approval documents used for the move.
- The authorization basis for the magazines was reviewed to verify that provision is made for the location of the subassemblies.
- Controls were issued to prevent any additional movement of unapproved configurations.
- A safety evaluation screen was submitted to examine the feasibility of installing metal covers on the three subassemblies.
- The metal cover installation operation was approved through a safety evaluation screen process, a procedure was written, and the covers were installed on the subassemblies.
- Revised the operating procedures to clarify the approved transportation configuration for subassemblies involved in these specific occurrences. Specifically, provide a picture of the subassembly as well as direction that the metal cover needs to be installed.
- The transportation supervisor made positive pre-movement checks to ensure compliance with the requirements.

- Established a requirement that the part number of the item to be moved be checked against the listing of the nuclear explosive configurations that are approved for transportation by truck/trailer onsite and for staging in zone 4 magazines.

Requirements stated in this module that are related to this scenario include the following:

- DOE O 452.2D, page 7
  Nuclear explosives must be transported in conveyances specifically reviewed and approved through the NES evaluation process.

- Criteria must be established for protecting nuclear explosives during transportation. The criteria and tie-down designs for specific nuclear explosive configurations must be reviewed and approved through the NES evaluation process

Write your answers on the next page 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.