
Nuclear Explosive Safety

Course No: N02-006

Credit: 2 PDH

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**ADMINISTRATIVE CHANGES TO DOE M 452.2-1A
NUCLEAR EXPLOSIVE SAFETY MANUAL**

Locations of Changes:

Page	Paragraph	Changed	To
4	7	<u>CONTACT</u> . The Director, Nuclear Weapon Surety and Quality Division, is responsible for updating and maintaining this Manual. Questions concerning this Manual should be addressed to 202-586-5624.	<u>CONTACT</u> . The Associate Administrator for Safety and Health is responsible for updating and maintaining this Manual. Questions concerning this Manual should be addressed to 202-586-3885.

MANUAL

DOE M 452.2-1A

Approved: 4-14-09
Admin Chg 1: 7-10-13

NUCLEAR EXPLOSIVE SAFETY MANUAL



U.S. DEPARTMENT OF ENERGY
Nuclear Weapon Surety and Quality Division

AVAILABLE ONLINE AT:
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INITIATED BY:
National Nuclear Security Administration
Office of Safety and Health

NUCLEAR EXPLOSIVE SAFETY MANUAL

1. PURPOSE. This Department of Energy (DOE) Manual provides supplemental details on selected topics to support the requirements of DOE O 452.2D, *Nuclear Explosive Safety*, dated 4-14-09.
2. CANCELLATIONS. DOE M 452.2-1, *Nuclear Explosive Safety Manual*, dated 6-12-06. Cancellation of a directive does not, by itself, modify or otherwise affect any contractual obligation to comply with the directive. Contractor requirements documents (CRDs) that have been incorporated into or attached to a contract remain in effect until the contract is modified to either eliminate requirements that are no longer applicable or substitute a new set of requirements.
3. APPLICABILITY.

- a. DOE Elements. Except for the exclusion in paragraph 3c, this Manual applies to all those Departmental elements that are involved in performing, managing, overseeing, or directly supporting nuclear explosive operations (NEOs) or associated activities, including those created after the Manual is issued. (Go to <http://www.directives.doe.gov/pdfs/reftools/org-list.pdf> for the most current listing of Departmental elements.).

The Administrator of the National Nuclear Security Administration (NNSA) shall ensure that NNSA employees and contractors comply with their respective responsibilities under this Manual. Nothing in this Manual must be construed to interfere with the NNSA Administrator's authority under section 3212(d) of Public Law (P.L.) 106-65 to establish Administration specific policies, unless disapproved by the Secretary.

- b. DOE Contractors. The Contractor Requirements Document (CRD) in Attachment 1 sets forth requirements of this Manual, as applicable. This CRD must be included in all contracts that involve performing, managing, overseeing, or directly supporting NEOs or associated activities.

- c. Exclusions.

- (1) The following Departmental elements are excluded: Office of the Chief Financial Officer, Office of the Chief Information Officer, Office of Civilian Radioactive Waste Management, Office of Congressional and Intergovernmental Affairs, Office of Economic Impact and Diversity, Energy Information Administration, Office of Electricity Delivery and Energy Reliability, Office of Energy Efficiency and Renewable Energy, Office of Environmental Management, Office of Fossil Energy, Office of Hearings and Appeals, Office of Human Capital Management, Office of Intelligence and Counterintelligence, Office of Legacy Management,

Office of Management, Office of Nuclear Energy, Office of Policy and International Affairs, Office of Public Affairs, Office of Science, Bonneville Power Administration, Southeastern Power Administration, Southwestern Power Administration, and Western Area Power Administration.

- (2) In accordance with the responsibilities and authorities assigned by Executive Order 12344, codified at 50 USC sections 2406 and 2511 and to ensure consistency through the joint Navy/DOE Naval Nuclear Propulsion Program, the Deputy Administrator for Naval Reactors (Director) will implement and oversee requirements and practices pertaining to this Manual for activities under the Director's cognizance, as deemed appropriate.
4. SUMMARY. This Manual is composed of four chapters that provide supplemental requirements to ensure adequate nuclear explosive safety for NEOs conducted by DOE, NNSA, and DOE/NNSA contractors. These chapters specify mandatory procedures and management processes. Chapter I discusses two-person concept requirements. Chapter II discusses electrical equipment requirements. Chapter III establishes nuclear explosive-like assembly requirements. Chapter IV establishes marking requirements for nuclear explosives and nuclear explosive-like assemblies.
5. DEFINITIONS. Definitions of words or phrases used here but defined in DOE O 452.1D or DOE O 452.2D are not repeated here.
 - a. Dummy Pit. A component or set of components designed to simulate a live pit, but which does not contain fissile material and cannot therefore create a nuclear explosive if placed in the central cavity of an implosion system. A "high-fidelity" dummy pit is one that also has dimensions representative of a live pit.
 - b. Human Reliability Program (HRP). A program established by 10 CFR 712 to ensure that individuals who occupy positions affording access to certain materials, nuclear explosive devices, facilities, and programs meet the highest standards of reliability and physical and mental suitability.
 - c. Mock High Explosive. A material that is designed to simulate the main charge high explosive, but which is non-detonable and clear or colored pink.
 - d. Permanent Marking. A durable method, normally by metal deformation, of indicating on an external area of an assembly whether it is a nuclear explosive or a nuclear explosive-like assembly.
 - e. Two-Person Concept (TPC). TPC is implemented to ensure no lone individual has unrestricted access to a nuclear explosive or other crucial asset as specified by this manual.

6. REFERENCES.

- a. Title XXXII of P. L. 106-65, National Nuclear Security Administration Act, as amended, which established a separately organized agency within the Department of Energy.
- b. DOE O 452.1D, *Nuclear Explosive and Weapon Surety Program*, 4-14-09.
- c. DOE O 452.2D, *Nuclear Explosive Safety*, 4-14-09.
- d. DOE O 461.1A, *Packaging and Transfer or Transportation of Materials of National Security Interest*, 04-26-04.
- e. 10 CFR Part 712, *Human Reliability Program*.

7. CONTACT. The Associate Administrator for Safety and Health, is responsible for updating and maintaining this Manual. Questions concerning this Manual should be addressed to 202-586-3885.



STEVEN CHU
Secretary of Energy

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CHAPTER I. TWO-PERSON CONCEPT

1. BASIC REQUIREMENTS.

The two-person concept (TPC) is implemented to ensure no lone individual has unrestricted access to a nuclear explosive. A TPC team must be in the nuclear explosive area (NEA) when a nuclear explosive is not protected by a dual-lock system or other NES-approved security system. The TPC is also required in the Metrology Laboratory as specified in Chapter II paragraph 2.c of this Manual. Site offices may also require TPC protection for other operations.

Each person on a two-person concept team must—

- a. be certified in the Human Reliability Program,
- b. have authorized access to the NEA,
- c. have technical knowledge of the task being performed,
- d. be knowledgeable of pertinent safety and security requirements, and
- e. be in a position to detect incorrect or unauthorized acts and take appropriate action.

2. IMPLEMENTATION OPTIONS.

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

a. Zone Coverage.

Zone coverage is a term used to identify two-person concept implementation that meets the basic requirements of paragraph 1 without the additional requirements specified to protect configurations that require person-to-person coverage.

b. 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.

- (1) 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 [such as insensitive high explosive (IHE), coded-signal-controlled detonators, and unique-signal-operated strong-link

devices] and physical protection (such as closed shipping and storage containers and specially designed covers).

- (2) Configurations requiring person-to-person coverage include the following:
 - (a) Exposed conventional high explosive (CHE) main charge in an NEA.
 - (b) Main charge high explosives (HEs), both CHE and IHE, with accessible detonator cable assemblies in an NEA.
 - (c) Nuclear explosives connected to Category 1 electrical equipment. (Category 1 electrical equipment is described in Chapter II, paragraph 2, of this Manual.)

3. WHEN TO APPLY PERSON-TO-PERSON COVERAGE.

- a. Assembly/Disassembly Operations Involving Conventional High Explosive.
 - (1) 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.
 - (2) 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.
 - (3) For disassembly operations, this requirement applies in reverse.
- b. Assembly/Disassembly Operations Involving Insensitive High Explosive.
 - (1) 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.
 - (2) 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.
 - (3) For disassembly operations this requirement applies in reverse.
- c. For purposes of person-to-person coverage, systems with installed and unactuated (safe/reset) mechanical safe and arm detonators 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.

4. HOW TO APPLY PERSON-TO-PERSON COVERAGE.

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.

- a. Lone individuals must not be allowed within the immediate vicinity (approximately 6 feet) of a configuration that requires person-to-person coverage.
- b. The two people providing person-to-person coverage must each be responsible for the safe conduct of the operations.
- c. During the performance of operations on a configuration requiring person-to-person coverage—
 - (1) the two-person concept team must be in the immediate vicinity of the configuration;
 - (2) 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
 - (3) a reader-worker process that includes the following must be incorporated.
 - (a) The procedure must be read aloud, the operation must be performed, and the completion of the operation must be documented in the stated sequence.
 - (b) 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.
 - (c) 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.
- d. When operations are not being performed on a configuration requiring person-to-person coverage—
 - (1) 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;

- (2) 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.
- e. Only one configuration requiring person-to-person coverage is allowed in a vacated bay or cell. This requirement does not apply to emergency evacuations.

CHAPTER II. ELECTRICAL EQUIPMENT

1. BASIC REQUIREMENTS.

For purposes of defining electrical equipment requirements, this Manual categorizes electrical equipment used in NEAs as Category 1, Category 2, or Category 3. Electrical equipment categorization is intended to ensure that controls are implemented commensurate with the various levels of potential electrical threat.

2. 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 be clearly identified and meet the following minimum requirements.

a. General Requirements.

- (1) Category 1 electrical equipment must have a safety requirements document that identifies the safety features.
- (2) Category 1 electrical equipment must use the lowest practical values of internal and output currents and voltages.
- (3) Category 1 electrical equipment must not apply unacceptable stimuli as the result of a single-point failure.
- (4) Each item of Category 1 electrical equipment must have safety characteristics independent of the nuclear explosive’s safety features.
- (5) Each item of Category 1 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.
- (6) Each drawing issue of Category 1 electrical equipment and its interface with a nuclear explosive requires a completed NES evaluation.
- (7) Procedures must be established to operate, control, calibrate, maintain, and store Category 1 electrical equipment.
- (8) A record of approved Category 1 electrical equipment must be established and maintained. The record must identify each item of Category 1 electrical equipment by its unique designation and/or part number and associate it with the nuclear explosives for which it is authorized and the NES evaluations that examined its specific applications.

b. Computer-Controlled Electrical Equipment.

- (1) Software must not be relied upon to assure 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.
- (2) Testers must be designed such that software is incapable of causing safety feature bypass.
- (3) Software failure must not compromise the safety attributes of the equipment or unit under test.

c. Two-Person Concept.

Category 1 electrical equipment requires two-person concept protection. (The TPC is delineated in Chapter I of this Manual.)

- (1) Person-to-person coverage is required during calibration and all operations that afford internal access to Category 1 electrical equipment and associated cables and adapters, and while Category I electrical equipment is connected to a nuclear explosive.
- (2) Zone coverage is required for fully assembled Category 1 electrical equipment and associated cables and adapters when that equipment is not protected by a dual-lock system or other NES-approved security system.

3. 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.

a. General Requirements.

- (1) Category 2 electrical equipment must not be connected to the electrical circuitry of a nuclear explosive.
- (2) Category 2 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.
- (3) The potential for inadvertent connection between the Category 2 electrical equipment and the nuclear explosive circuitry must be minimized.

b. Positive Electrical Isolation.

Positive electrical isolation must be established and demonstrated for Category 2 electrical equipment that makes a mechanical connection to a nuclear explosive. Electrical isolation must account for both normal and credible abnormal conditions (such as equipment faults or lightning strikes). The electrical isolation scheme used must be clearly identified and documented using one of the following subcategories, listed in priority order.

- (1) 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.
- (2) 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.
- (3) 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.

c. Records.

A record of approved Category 2 electrical equipment must be established and maintained. The record must identify each item of Category 2 electrical equipment by its unique designation and/or part number and associate it with the nuclear explosive operations for which it is authorized.

4. CATEGORY 3 ELECTRICAL EQUIPMENT.

Moveable 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."

5. NES EVALUATIONS AND CHANGE CONTROL.

Electrical equipment used in NEAs and proposed changes to electrical equipment, procedures, and interfaces with a nuclear explosive are subject to the NES evaluation and NEO change control processes required by DOE O 452.2D, *Nuclear Explosive Safety*, and detailed in DOE M 452.2-2, *Nuclear Explosive Safety Evaluation Processes*.

CHAPTER III. NUCLEAR EXPLOSIVE-LIKE ASSEMBLY (NELA) REQUIREMENTS

The following requirements support the NELA standards defined in DOE O 452.2D.

1. 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. A NELA represents a nuclear explosive in the U.S. nuclear weapons program, including assemblies for development, testing, training, or other purposes.
- b. A NELA contains one of the following.
 - (1) Mock HE and high-fidelity dummy pit—referred to as an “Inert NELA.”
 - (2) Live HE and high-fidelity dummy pit—referred to as a “High Explosive NELA.”
 - (3) Mock HE and live pit—referred to as an “Inert-with-Live-Pit NELA.”

2. ASSEMBLY/DISASSEMBLY OF NUCLEAR EXPLOSIVE-LIKE ASSEMBLIES.

NELAs must not be assembled or disassembled in close 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.

3. VERIFICATION OF NUCLEAR EXPLOSIVE-LIKE ASSEMBLY COMPONENTS BEFORE ASSEMBLY.

a. Inert Nuclear Explosive-Like Assemblies.

Repetition of 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.

(1) Mock High Explosive Verification Requirements.

- (a) 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.
- (b) 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.

- (c) An auditable record of chemical verification of the pink mock HE must be available.

(2) High-Fidelity Dummy Pit Verification Requirements.

- (a) Before assembly into an Inert NELA, the pit must be verified by radiation detection means to verify the absence of radioactive material. If radiation is detected, the pit must be assayed by using gamma spectrometry/multi-channel analyzer to verify the absence of fissile material. This verification must be either performed or observed using person-to-person coverage.
- (b) 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.
- (c) An auditable record of radiation detection verification of the high-fidelity dummy pit must be available.

b. High Explosive Nuclear Explosive-Like Assemblies.

High Explosive NELAs and Inert-with-Live-Pit NELAs must not be assembled or disassembled in close proximity where components may be interchanged.

(1) High-Fidelity Dummy Pit Verification Requirements.

- (a) Before assembly into a High Explosive NELA, the pit must be verified by radiation detection means to verify the absence of radioactive material. If radiation is detected, the pit must be assayed by using gamma spectrometry/multi-channel analyzer to verify the absence of fissile material. This verification must be either performed or observed using person-to-person coverage.
- (b) 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.
- (c) An auditable record of radiation detection verification of the high-fidelity dummy pit must be available.

(2) Main Charge High Explosive 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 High Explosive NELA.

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

Inert-with-Live-Pit NELAs and High Explosive NELAs must not be assembled or disassembled in close proximity where components may be interchanged.

(1) Mock High Explosive Verification Requirements.

- (a) 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.
- (b) 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.
- (c) An auditable record of chemical verification of the mock HE must be available.

(2) Mock High Explosive Two-Person Concept Verification Requirements.

- (a) 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.
- (b) 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.
- (c) An auditable record of two-person concept chemical verification of the mock HE must be available.

(3) Live Pit Introduction Sequence.

The mock HE verifications required by paragraphs 3c(1) and 3c(2) 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.

4. OFFSITE TRANSPORTATION OF NUCLEAR EXPLOSIVE-LIKE ASSEMBLIES.a. Inert-with-Live-Pit NELA Transfer Restriction.

A configuration assembled as an Inert-with-Live-Pit NELA must not be transferred to the custody of the Department of Defense.

b. Identification Requirements.

NELAs that are shipped between DOE sites must be identified externally (e.g., stencil or tag) with the following information.

(1) NELA contents identified as one of the following.

(a) Inert NELA.

(b) High Explosive NELA.

(c) Inert-with-Live-Pit NELA.

(2) Name and agency of responsible person at the shipping location.

(3) Name and agency of person who authorized the shipment at the receiving location.

c. Permission to Ship Between DOE Agencies.

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

d. Nuclear Explosive-Like Assembly Survey Before Transfer.

(1) Before offsite transfer of a NELA, the NELA must be surveyed in its shipping configuration by 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.

(2) An auditable record of this survey must be available.

e. Nuclear Explosive-Like Assembly Survey Upon Receipt.

(1) 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.

(2) An auditable record of this survey must be available.

CHAPTER IV. 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.

1. PERMANENT MARKING LEGENDS.

a. 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).

b. Nuclear Explosive-Like Assemblies.

(1) 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.

(2) 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.

(3) 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.

Note: Using the permanent marking “INERT” or “INERT WITH LIVE PIT” does not preclude the presence of materials that may present a hazard to personnel.

2. PERMANENT MARKING LOCATION.

Nuclear explosives and NELAs must be permanently marked on an external surface.

a. The permanent marking must be on a part that encloses the live main charge or mock HE.

b. The marking location must be specified by the applicable design agency.

3. 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.

- a. 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.
 - (1) The preferred marking methods are mechanical engraving (with or without fill) and impression-die stamping.
 - (2) Other acceptable methods are impression freehand, impression sandblast, and surface conversion.
- b. The preferred marking size is ¼-inch characters with ¼-inch spacing between lines, if space permits.

4. 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.

- a. Methodology.
 - (1) 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.
 - (2) 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.
- b. 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.

- (1) General Requirements.
 - (a) 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.
 - (b) Control must be achieved by a two-person concept team or a dual-lock or other NES-approved security system.

(2) Nuclear Explosives.

Nuclear explosive components must not be assembled or disassembled in close proximity to NELAs, where components may be interchanged.

(3) Nuclear Explosive-Like Assemblies.

NELAs must not be assembled or disassembled in close proximity to nuclear explosives, where components may be interchanged.

- (a) Inert Nuclear Explosive-Like Assemblies. Inert NELAs must not be assembled or disassembled in close proximity to High Explosive or Inert-with-Live-Pit NELAs, where components may be interchanged.
- (b) High Explosive Nuclear Explosive-Like Assemblies. High Explosive NELAs must not be assembled or disassembled in close proximity to Inert or Inert-with-Live-Pit NELAs, where components may be interchanged.
- (c) Inert-with-Live-Pit Nuclear Explosive-Like Assemblies. Inert-with-Live-Pit NELAs must not be assembled or disassembled in close proximity to High Explosive or Inert NELAs, where components may be interchanged.

**CONTRACTOR REQUIREMENTS DOCUMENT
DOE M 452.2-1A, NUCLEAR EXPLOSIVE SAFETY**

This Contractor Requirements Document (CRD) establishes the requirements for Department of Energy (DOE) contractors, including National Nuclear Security Administration (NNSA) contractors, whose contracts involve the performance, management, oversight, or direct support of DOE/NNSA nuclear explosive operations (NEOs) or associated activities.

Regardless of the performer of the work, the contractor is responsible for complying with the requirements of this CRD. The contractor is responsible for flowing down the requirements of this CRD to subcontractors at any tier to the extent necessary to ensure the contractor's compliance with the requirements.

All contractors with this CRD incorporated in their contracts must comply with the following requirements.

1. TWO-PERSON CONCEPT.

Contractors responsible for NEOs and associated activities and facilities must establish and implement the two-person concept to ensure no lone individual has unrestricted access to a nuclear explosive.

- a. Basic Requirements. A two-person concept team must be in the nuclear explosive area (NEA) when a nuclear explosive is not protected by a dual-lock system or other NES-approved security system. Two-person concept coverage is also required in the Metrology Laboratory as specified in paragraph 2a(3) of this CRD. Contractors must also establish and implement two-person concept protection for other operations as required by the site office.

Contractors must ensure that each person on a two-person concept team—

- (1) is certified in the Human Reliability Program,
- (2) has authorized access to the NEA,
- (3) has technical knowledge of the task being performed,
- (4) is knowledgeable of pertinent safety and security requirements, and
- (5) is in a position to detect incorrect or unauthorized acts and take appropriate action.

- b. Implementation Options. Contractors must ensure appropriate implementation of the two-person concept using either zone coverage or person-to-person coverage.

- (1) Zone Coverage. Zone coverage is a term used to identify two-person concept implementation that meets the basic requirements of paragraph 1a

without the additional requirements specified to protect configurations that require person-to-person coverage.

- (2) 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.
 - (a) Configurations requiring person-to-person coverage must be based on specific system characteristics. The application of person-to-person coverage allows recognition of the protection provided by design safety features [such as insensitive high explosive (IHE), coded-signal-controlled detonators, and unique-signal-operated strong-link devices] and physical protection (such as closed shipping and storage containers and specially designed covers).
 - (b) Configurations requiring person-to-person coverage include the following.
 - 1 Exposed conventional high explosive (CHE) main charge in an NEA.
 - 2 Main charge high explosives (both CHE and IHE) with accessible detonator cable assemblies in an NEA.
 - 3 Nuclear explosives connected to Category 1 electrical equipment. (Category 1 electrical equipment is described in paragraph 2.a of this CRD.)
- c. When to Apply Person-to-Person Coverage. Contractors must use the following guidance to determine when person-to-person coverage is needed.
 - (1) Assembly/Disassembly Operations Involving Conventional High Explosive.
 - (a) For assembly operations involving CHE main charge, person-to-person coverage of the CHE components begins when the CHE container is opened in an NEA.
 - (b) Coverage must continue 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.
 - (c) For disassembly operations, this requirement applies in reverse.

- (2) Assembly/Disassembly Operations Involving Insensitive High Explosive.
 - (a) For assembly operations involving IHE main charge, contractors must ensure person-to-person coverage for main charge components located in an NEA, and assemblies containing these components, that have accessible detonator cables attached.
 - (b) Coverage must continue 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.
 - (c) For disassembly operations, this requirement applies in reverse.
- (3) For purposes of person-to-person coverage, systems with installed and unactuated (safe/reset) mechanical safe and arm detonators 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 exposed. When such physical protection is in place, zone coverage provides adequate protection for configurations that would otherwise require person-to-person coverage.
- d. How to Apply Person-to-Person Coverage. When a configuration requires person-to-person coverage, contractors must ensure a qualified two-person concept team is either working on or controlling access to the configuration so that the following coverage requirements are met.
 - (1) No lone individual is allowed within the immediate vicinity (approximately 6 feet) of a configuration that requires person-to-person coverage.
 - (2) The two people providing person-to-person coverage are each responsible for the safe conduct of the operations.
 - (3) During the performance of operations on a configuration requiring person-to-person coverage—
 - (a) the two-person concept team must be in the immediate vicinity of the configuration;
 - (b) 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
 - (c) a reader-worker process that includes the following must be incorporated.

- 1 The procedure must be read aloud, the operation must be performed, and the completion of the operation must be documented in the stated sequence.
 - 2 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.
 - 3 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.
- (4) When operations are not being performed on a configuration requiring person-to-person coverage—
- (a) 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 and
 - (b) the team members must remain in a position to observe the approach of any individual to the configuration.
- (5) Only one configuration requiring person-to-person coverage is allowed in a vacated bay or cell. This requirement does not apply to emergency evacuations.

2. ELECTRICAL EQUIPMENT.

Contractors responsible for NEOs and associated activities and facilities must establish and implement controls for electrical equipment used in NEAs commensurate with the various levels of potential electrical threat. For this purpose, NNSA recognizes three categories of electrical equipment used in NEAs.

- a. 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.” Contractors must ensure Category 1 electrical equipment is clearly identified and meets the following minimum requirements.
 - (1) General Requirements.
 - (a) Category 1 electrical equipment must have a safety requirements document that identifies the safety features.
 - (b) Category 1 electrical equipment must use the lowest practical values of internal and output currents and voltages.

- (c) Category 1 electrical equipment must not apply unacceptable stimuli as a result of a single-point failure.
 - (d) Category 1 electrical equipment must have safety characteristics independent of the nuclear explosive's safety features.
 - (e) Each item of Category 1 electrical equipment and its interface with a nuclear explosive must have a comprehensive safety analysis, including consideration of relevant abnormal environments.
 - (f) Each drawing issue of Category 1 electrical equipment and its interface with a nuclear explosive must have a NES evaluation.
 - (g) Procedures must be established to operate, control, calibrate, maintain, and store the Category 1 electrical equipment.
 - (h) A record of approved Category 1 electrical equipment must be established and maintained. The record must identify each item of Category 1 electrical equipment by its unique designation and/or part number and associate it with the nuclear explosives for which it is authorized and the NES evaluations that examined its specific applications.
- (2) Computer-controlled Category 1 electrical equipment must be designed as follows:
- (a) Software must not be relied upon to assure 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.
 - (b) Testers must be designed such that software is incapable of causing safety feature bypass.
 - (c) Software failure must not compromise the safety attributes of the equipment or unit under test.
- (3) Two-Person Concept. Contractors must ensure that Category 1 electrical equipment is protected by implementation of the TPC as delineated in paragraph 1 of this CRD.
- (a) Person-to-person coverage is required during calibration and all operations that afford internal access to equipment and associated cables and adapters, and while Category 1 electrical equipment is connected to a nuclear explosive.
 - (b) Zone coverage is required for fully assembled Category 1 electrical equipment and associated cables and adapters when that equipment

is not protected by a dual-lock system or other NES-approved security system.

- b. 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.” Contractors must ensure Category 2 electrical equipment is clearly identified and meets the following minimum requirements.

(1) General Requirements.

- (a) Category 2 electrical equipment must not be connected to the electrical circuitry of a nuclear explosive.
- (b) Category 2 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.
- (c) The potential for inadvertent connection between Category 2 electrical equipment and the nuclear explosive circuitry must be minimized.

(2) Positive Electrical Isolation. Contractors must ensure positive electrical isolation is established and demonstrated for Category 2 electrical equipment that makes a mechanical connection to a nuclear explosive. Electrical isolation must account for both normal and credible abnormal conditions (such as equipment faults or lightning strikes). Contractors must ensure the electrical isolation scheme used is clearly identified and documented using one of the following subcategories, listed in priority order.

- (a) 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.
- (b) 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.
- (c) 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.

- (3) Records. Contractors must establish and maintain a record of approved Category 2 electrical equipment. The record must identify each item of Category 2 electrical equipment by its unique designation and/or part number and associate it with the nuclear explosive operations for which it is authorized.
 - c. Category 3 Electrical Equipment. Moveable 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.” Contractors must ensure that Category 3 electrical equipment cannot make physical contact with a nuclear explosive.
 - d. NES Evaluations and Change Control. Contractors must ensure that all electrical equipment used in an NEA and proposed changes to electrical equipment, procedures, and its interfaces with a nuclear explosive are subject to the NES evaluation and NEO change control processes required by DOE O 452.2D and detailed in DOE M 452.2-2, or its successor directive.
3. NUCLEAR EXPLOSIVE-LIKE ASSEMBLY (NELA) REQUIREMENTS.

To support the NELA Standards in DOE O 452.2D, or its successor directive, contractors must ensure the following requirements are met.

- a. 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.
 - (1) A NELA represents a nuclear explosive in the U.S. nuclear weapons program, including assemblies for development, testing, training, or other purposes.
 - (2) A NELA contains one of the following.
 - (a) Mock HE and high-fidelity dummy pit—referred to as an “Inert NELA.”
 - (b) Live HE and high-fidelity dummy pit—referred to as a “High Explosive NELA.”
 - (c) Mock HE and live pit—referred to as an “Inert-with-Live-Pit NELA.”
- b. Assembly/Disassembly of Nuclear Explosive-Like Assemblies. Contractors must ensure NELAs are not assembled or disassembled in close proximity to nuclear explosives where components may be interchanged. Contractors must ensure a

two-person concept team performs all assembly/disassembly operations on Inert-with-Live-Pit NELAs.

- c. Verification of Nuclear Explosive-Like Assembly Components before Assembly. Contractors must verify major NELA components before NELA assembly as specified below.
- (1) Inert Nuclear Explosive-Like Assemblies. Repetition of 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.
- (a) Mock High Explosive Verification Requirements
- 1 All mock HE used in place of live main charge HE must be nondetonable and clear or colored pink. Where possible, preference must be given to noncombustible formulations. Live main charge HE must not be colored pink.
 - 2 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.
 - 3 An auditable record of chemical verification of the pink mock HE must be available.
- (b) High-Fidelity Dummy Pit Verification Requirements.
- 1 Before assembly into an Inert NELA, the pit must be verified by radiation detection means to verify the absence of radioactive material. If radiation is detected, the pit must be assayed using gamma spectrometry/multi-channel analyzer to verify the absence of fissile material. This verification must be either performed or observed using person-to-person coverage.
 - 2 After dummy pit verification, the pit must be controlled until it is assembled into the NELA configuration or until it 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.
 - 3 An auditable record of radiation detection verification of the high-fidelity dummy pit must be available.

- (2) High Explosive Nuclear Explosive-Like Assemblies. Contractors must ensure High Explosive NELAs and Inert-with-Live-Pit NELAs are not assembled or disassembled in close proximity where components may be interchanged.
 - (a) High-Fidelity Dummy Pit Verification Requirements.
 - 1 Before assembly into a High Explosive NELA, the pit must be verified by radiation detection means to verify the absence of radioactive material. If radiation is detected, the pit must be assayed using a gamma spectrometry/multi-channel analyzer to verify the absence of fissile material. This verification must be either performed or observed using person-to-person coverage.
 - 2 After dummy pit verification, the pit must be controlled until it 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.
 - 3 An auditable record of radiation detection verification of the high-fidelity dummy pit must be available.
 - (b) Main Charge High Explosive 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 High Explosive NELA.
- (3) Inert-with-Live-Pit Nuclear Explosive-Like Assemblies. Contractors must ensure Inert-with-Live-Pit NELAs and High Explosive NELAs are not assembled or disassembled in close proximity where components may be interchanged.
 - (a) Mock High Explosive Verification Requirements.
 - 1 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.
 - 2 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.

- 3 An auditable record of chemical verification of the mock HE must be available.

(b) Mock High Explosive Two-Person Concept Verification Requirements.

- 1 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.
- 2 After the mock HE two-person concept verification, the mock HE must be controlled until it 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.
- 3 An auditable record of two-person concept chemical verification of the mock HE must be available.

(c) Live Pit Introduction Sequence. The mock HE and mock HE two-person 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.

d. Offsite Transportation of Nuclear Explosive-Like Assemblies.

- (1) Inert-with-Live-Pit NELA Transfer Restriction. Contractors must ensure a configuration assembled as an Inert-with-Live-Pit NELA is not transferred to the custody of the Department of Defense.
- (2) Identification Requirements. Contractors must ensure NELAs that are shipped between DOE sites are identified externally (e.g., stencil or tag) with the following information.
 - (a) NELA contents identified as one of the following.
 - 1 Inert NELA.
 - 2 High Explosive NELA.
 - 3 Inert-with-Live-Pit NELA.
 - (b) Name and agency of responsible person at the shipping location.

- (c) Name and agency of person who authorized the shipment at the receiving location.
- (3) Permission to Ship between DOE Agencies. Contractors must ensure the shipping agency obtains permission from the receiving agency to ship before shipment of a NELA.
- (4) Nuclear-Explosive-Like Assembly Survey before Transfer.
 - (a) Before offsite transfer of a NELA, contractors must ensure the NELA is surveyed in its shipping configuration using 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.
 - (b) Contractors must ensure an auditable record of this survey is available.
- (5) Nuclear Explosive-Like Assembly Survey upon Receipt.
 - (a) Upon receipt of a NELA, contractors must ensure the NELA is 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.
 - (b) Contractors must ensure an auditable record of this survey is available.

4. MARKING REQUIREMENTS.

Nuclear explosives and NELAs must be marked to distinguish configurations capable of a nuclear detonation from those that are not. Contractors responsible for NEOs or NELA operations must permanently mark nuclear explosives and NELAs in accordance with the following instructions.

a. Permanent Marking Legends.

- (1) Nuclear Explosives. Contractors must ensure a “NUCLEAR” permanent marking legend is applied to nuclear explosives (i.e., units containing a live pit and an HE main charge).
- (2) Nuclear Explosive-Like Assemblies.
 - (a) Inert Nuclear Explosive-Like Assemblies. Contractors must ensure 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.

- (b) High Explosive Nuclear Explosive-Like Assemblies. Contractors must ensure the “HIGH EXPLOSIVE” permanent marking is applied to a NELA containing live main charge HE and a dummy pit or void.
 - (c) Inert-with-Live-Pit Nuclear Explosive-Like Assemblies. Contractors must ensure 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.
 - b. Permanent Marking Location. Contractors must ensure nuclear explosives and NELAs are permanently marked on an external surface.
 - (1) The permanent marking must be on a part that encloses the live main charge or mock HE.
 - (2) The marking location must be specified by the applicable design agency.
 - c. Permanent Markings. Contractors must ensure nuclear explosives and NELAs are marked in accordance with the following requirements. The particular marking method must be specified by the applicable design agency.
 - (1) Contractors must ensure the permanent marking method produces the most durable mark possible consistent with acceptable deleterious effect on the material to which the marking is applied.
 - (a) The preferred marking methods are mechanical engraving (with or without fill) and impression-die stamping.
 - (b) Other acceptable methods are impression freehand, impression sandblast, and surface conversion.
 - (2) Contractors should use the preferred marking size, ¼-inch characters with ¼-inch spacing between lines, if space permits.
 - d. Permanent Marking Obliteration. When a nuclear explosive or NELA is altered or disassembled to the point that its permanent marking is no longer valid, contractors must ensure the permanent marking is obliterated in accordance with the following requirements.
 - (1) Methodology.
 - (a) 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.

- (b) If obliteration by overprinting is not feasible for technical reasons, contractors must remove the permanent marking using a method specified by the applicable design agency.
- (2) 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.
 - (a) General Requirements.
 - 1 After the marked component is removed, contractors must control the disassembled components until the disassembled components and marked component are reassembled into the same configuration.
 - 2 Contractors must ensure control is achieved by a two-person concept team or a dual-lock or other NES-approved security system.
 - (b) Nuclear Explosives. Contractors must ensure nuclear explosive components are not assembled or disassembled in close proximity to NELAs, where components may be interchanged.
 - (c) Nuclear Explosive-Like Assemblies. Contractors must ensure NELAs are not assembled or disassembled in close proximity to nuclear explosives, where components may be interchanged.
 - 1 Inert Nuclear Explosive-Like Assemblies. Contractors must ensure Inert NELAs are not assembled or disassembled in close proximity to High Explosive or Inert-with-Live-Pit NELAs, where components may be interchanged.
 - 2 High Explosive Nuclear Explosive-Like Assemblies. Contractors must ensure High Explosive NELAs are not assembled or disassembled in close proximity to Inert or Inert-with-Live-Pit NELAs, where components may be interchanged.
 - 3 Inert-with-Live-Pit Nuclear Explosive-Like Assemblies. Contractors must ensure Inert-with-Live-Pit NELAs are not assembled or disassembled in close proximity to High Explosive or Inert NELAs, where components may be interchanged.