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MEASUREMENT SENSITIVE

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DOE TECHNICAL STANDARD

EXPLOSIVES SAFETY

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

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FOREWORD

1. This Department of Energy (DOE) Standard has been approved to be used by DOE, including the National Nuclear Security Administration, and their contractors.

2. Comments (recommendations, additions, and deletions) and data, that may be of use in improving this document, should be e-mailed to thomas.garcia@nnsa.doe.gov or sent to:

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3. This Standard is the successor to DOE-STD-1212-2012. It provides requirements for an Explosives Safety Program.

4. This official version of the Standard may be found online at:

   https://www.standards.doe.gov/standards-browse

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1. SCOPE/PURPOSE

1.1. This Technical Standard provides the basic technical requirements for an explosives safety program necessary to ensure safe operations involving explosives, explosives assemblies, pyrotechnics and propellants, and assemblies containing these materials.

1.2. This Technical Standard establishes safety controls and standards not addressed in other existing DOE or non-DOE regulations and is intended to close the safety gap created by DOE's unique activities to govern the DOE explosives safety process and ensure explosives safety is commensurate with the risk.

1.3. This Technical Standard is based on the Cardinal Principle of Explosives Safety, which is to limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives, consistent with safe and efficient operations.

2. APPLICABILITY

2.1. This Technical Standard applies to all DOE sites engaged in any of the following activities involving explosives, pyrotechnics, or propellants as well as assemblies containing these materials:

- Developing
- Manufacturing
- Handling
- Storing
- Transporting
- Processing
- Testing

2.2. Existing facilities that do not meet the requirements of this technical standard may continue to be used for the balance of their functional lives if the following two conditions are met and documented:

2.2.1. The current operation presents no significantly greater risk than that assumed when the facility was originally designed.

2.2.2. It can be demonstrated clearly that a modification to bring the facility into compliance is not feasible.

3. ADMINISTRATION AND MANAGEMENT

3.1. NA-513 *Office of Worker Safety and Health Services* is the National Nuclear Security Administration (NNSA) Office of Primary Interest (OPI) for this Technical Standard. NA-513 shall act as the Preparing Activity

for this Technical Standard. The DOE/NNSA Explosives Safety Committee (ESC) shall review, evaluate, and recommend proposed changes to this Technical Standard. The changes shall be consonant with state-of-the-art technical changes in the field and include lessons learned from DOE/NNSA, other Governmental, and Industry experience and mishaps. NA-513 shall evaluate proposed changes to this Technical Standard on an annual basis. The OPI may decide to submit a section into RevCom for review and approval.

3.1.1. The DOE/NNSA ESC shall evaluate proposed changes at the request of the OPI.

3.1.2. Throughout this Standard, requirements are denoted by the words “shall” and “should.”

Note: The use of the word “may” with reference to application of a procedure or method denotes an acceptable means of performing the task.

3.1.2.1. “Shall” requirements are mandatory.

Note 1: Relief from a "shall" requirement requires an exemption (see section 3.2 of this chapter).

Note 2: A contractor may use an approved equivalency as an alternative approach to meet a "shall" requirement, (see section 3.3 of this chapter).

3.1.2.2. “Should” requirements are advisory.

Note: Relief from a “should” requirement requires a waiver (see section 3.4 of this chapter).

3.2. **Exemption**

3.2.1. Exemptions are the release from requirements in this Standard.

3.2.2. Exemptions are approved by the Head of DOE Field Element (DOE/NNSA Field/Operations/ Production Office) or designee, and documented for the OPI in a memorandum.

3.2.3. Central Technical Authority (CTA) or designee concurrence is required prior to the granting of exemptions for nuclear safety directives or successor documents identified in the current version of DOE O 410.1, Central Technical Authority Responsibilities Regarding Nuclear Safety

Requirements. CTA or designee concurrence is required for exemptions involving hazard category 1, 2, or 3 nuclear facilities.

3.2.4. Exemptions are processed by the Head of the DOE Field Element or designee. Follow DOE-O-251.1D Appendix E for the Exemption Process.

3.3. **Equivalency**

3.3.1. Equivalencies represent an alternative approach to meeting a “shall” requirement of the Standard intended to achieve an equivalent level of safety.

3.3.2. Required documentation for an equivalency:

- Description of the condition.
- Requirement(s) being affected.
- Reason why requirement cannot be achieved.
- Alternate approach.
- Contractor Explosives Safety Authority Having Jurisdiction (AHJ) determination of equivalent safety.
- Contractor Explosives Safety AHJ explanation of additional risk (if applicable).

3.3.3. The Contractor Explosives Safety AHJ shall evaluate, determine, and document that the proposed alternate approach complies with the intent of the provisions of this Standard.

3.3.4. The Contractor Explosives Safety AHJ shall provide a determination of equivalent safety.

3.3.4.1. If the equivalency introduces additional risk, the Contractor Explosives Safety AHJ shall include an explanation of the additional risk.

3.3.5. Equivalencies shall be coordinated with the Federal Explosives Safety Subject Matter Expert (SME) (DOE/NNSA Sites).

3.3.6. Equivalencies that do not introduce additional risk are approved by the Contractor Facility Manager.

3.3.6.1. Equivalencies that introduce additional risk are approved by the Head of DOE Field Element.

3.4. **Waiver**

3.4.1. A Waiver provides relief from a “should” requirement.

3.4.2. A Waiver is where the conditions, practices, means, methods, or processes to be used are determined to be safe and necessary.

3.4.3. The Contractor Explosives Safety AHJ shall evaluate, determine, and document that the proposed waiver complies with the intent of the provisions of this Standard. This documentation shall include a determination regarding the safety and necessity of the waiver.

3.4.4. Waivers are approved by Contractor Facility Management.

3.4.5. Required documentation for a waiver:

- Description of the condition.
- Requirement being affected.
- Reason why compliance is not achieved.
- Compensatory measures taken to provide protection.
- Any proposed corrective actions and schedule.
- Contractor Explosives Safety AHJ determination.
- Duration of the waiver.

4. EXPLOSIVES SAFETY PROGRAM (ESP) REQUIREMENTS

4.1. All DOE sites within the scope of this Technical Standard shall establish and maintain a site-specific ESP based on the requirements in this Technical Standard and 10 CFR 851.24. ESPs shall address all applicable explosives operations and activities. The ESP shall include:

4.1.1. The organizational structure for site Explosives Safety operations and activities. Address the following committees as they apply:

4.1.1.1. A Contractor Explosives Development Committee to approve each phase of an explosives development program.

4.1.1.2. A Contractor Explosives Storage Review Committee to establish and approve storage review intervals for all bulk explosives stored at the facility.

4.1.2. The process to resolve technical conflicts between Explosives Safety requirements and other functional area technical requirements.

4.1.3. The process to apply specific Explosives Safety provisions to meet Level-of-Protection criteria.

4.1.4. The process to interact with other safety disciplines supporting explosives operations and activities performed at the site.

4.1.5. The hazard analysis process in support of explosives operations and activities, with a graded approach.

4.1.6. The training and qualification program to support explosives operations and activities.

5. ROLES AND RESPONSIBILITIES

5.1. NNSA Associate Administrator for Safety, Infrastructure, and Operations.

5.1.1. Designates Explosives Approval Authority (EAA) to approve qualification of Insensitive High Explosive (IHE) Material and/or Subassembly.

5.1.2. Exercises responsibilities delegated by the Administrator under this Standard.

5.2. Central Technical Authority (CTA)

5.2.1. Concurs with exemptions to this Technical Standard involving hazard category 1, 2, or 3 nuclear facilities.

5.3. Explosives Approval Authority (EAA)

5.3.1. Approves Qualification of Insensitive High Explosive Material and/or Subassembly.

5.4. Head of DOE Field Element (DOE/NNSA Field/Operations/Production Office).

5.4.1. Verifies that the facilities, activities, and programs under their purview operate in compliance with the requirements of this Technical Standard.

5.4.2. Approves exemptions to this Technical Standard.

5.4.2.1. Exemptions involving hazard category 1, 2, or 3 nuclear facilities require CTA concurrence.

5.4.3. Approves equivalencies to this Technical Standard that introduce additional risk.

5.4.4. Approves Explosives Safety Site Plans.

5.4.5. Approves site and general construction plans for explosives facilities.

5.4.6. Provides oversight of the Contractor ESP.

5.4.7. Appoints a primary and alternate field element representative to the DOE/NNSA Explosives Safety Committee (ESC). Ensures an appointed member attends each DOE/NNSA ESC Meeting.

5.5. **Federal Explosives Safety Subject Matter Expert (SME) (DOE/NNSA Sites).**

5.5.1. Reviews and recommends approval or disapproval to the Head of DOE Field Element or designee for:

5.5.1.1. Exemptions to this Technical Standard.

5.5.1.2. Equivalencies to this Technical Standard that introduce additional risk.

5.5.2. Reviews the Explosives Safety Site Plans (ESSP) and recommends approval or disapproval to the Head of DOE Field Element or designee.

5.5.3. Performs assessments of the Contractor ESP in accordance with DOE O 226.1, Implementation of Department of Energy Oversight Policy (current version).

5.5.4. Familiarizes themselves with the Contractor ESP and the explosives operations and activities under their contract.

5.6. **DOE/NNSA ESC Chair.**

5.6.1. Performs duties identified in this Technical Standard and the approved DOE/NNSA ESC Charter.

5.7. **Contractor Facility Manager**

5.7.1. Establishes and maintains a site-specific ESP.

5.7.2. Assigns a Contractor Explosives Safety Program Manager.

5.7.3. Appoints a primary and alternate Explosives Safety Subject-Matter-Expert as the Contractor Explosives Safety AHJ and Voting Member on the DOE/NNSA Explosives Safety Committee. Ensures an appointed member attends each DOE/NNSA ESC Meeting.

5.7.4. Approves equivalencies that provide equivalent safety.

5.8. **Contractor Facility Management**

5.8.1. Implements the Explosives Safety requirements of this Technical Standard into operations and activities involving explosives.

5.8.2. Verifies that the site training and qualification program addresses explosives workers.

5.8.3. Verifies that explosives-related activities performed on-site by entities other than DOE/NNSA contractors/subcontractors are coordinated through the Contractor Explosives Safety AHJ.

5.8.4. Transmits the ESSP to the Head of DOE Field Element or Designee for review and approval.

5.8.5. Selects hazard analysis methodology and addresses the results.

5.8.6. Approves explosives area electrical hazard classification analyses.

5.8.7. Establishes the levels of approval required for operating procedures, based on the operation's inherent risk.

5.8.8. Establishes the frequency/interval of inspections, operational checks, storage review, and other items as identified in this Technical Standard.

5.8.9. Approves waivers.

5.9. **Contractor Explosives Safety Program Manager**

5.9.1. Assists Contractor Facility Management in implementing the requirements of this Technical Standard.

5.9.2. Performs site-specific explosives safety assessments to verify compliance with the requirements of this Technical Standard.

5.9.3. Recommends approval of the ESSP to Contractor Facility Management.

5.10. **Contractor Explosives Safety Authority Having Jurisdiction (AHJ)**

5.10.1. Assists Contractor Facility Management so that the level of explosives safety provided to site-specific explosives operations and activities is commensurate with the requirements of this Technical Standard.

5.10.2. Provides site-specific determinations, interpretations, and clarifications to the requirements of this Technical Standard.

5.10.3. Interfaces with other disciplines to resolve site-specific conflicts between national codes and standards and this Technical Standard.

5.10.4. Reviews and recommends approval of electrical hazard classification analyses.

5.10.5. Provides documented determinations and recommendations to Contractor Facility Management regarding proposed equivalencies and waivers to the requirements of this Technical Standard.

6. GENERAL OPERATIONAL SAFETY

6.1. Cardinal Principle

6.1.1. The Cardinal Principle of Explosives Safety is to limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives, consistent with safe and efficient operations.

6.1.2. The Cardinal Principle shall be observed at any location or in any operation involving explosives.

6.2. Protection of Explosives

6.2.1. Explosives are energetic materials that can react violently and should be protected from abnormal stimuli or environments, including:

- Friction forces;
- Excessive pressures and temperatures;
- Impact, shock, and pinching;
- Deformation;
- Electrical sparks, abrasive or welding sparks, and open flame;
- Contamination; and
- Contact with incompatible materials.

6.3. Equipment Checks

6.3.1. Before being used in the explosives process, and at established intervals, processing and test equipment shall be checked for:

- Proper design;
- Proper function;
- Specified clearances between parts in relative motion;
- Abnormal metal to metal rubbing of moving parts potentially contacting explosive materials;
- Cracks, voids, or screw threads where explosives may accumulate; and
- Contamination that is incompatible with the process materials.

6.3.2. This checkout may require the use of mock explosives in process or test conditions.

6.3.3. Explosive materials shall not be pinched or confined between equipment lids or covers and their mating surfaces. These surfaces shall be cleaned before cover placement. This includes pressing operations.

6.4. **Inspection Frequency**

6.4.1. When this Technical Standard calls for an inspection, but the inspection interval is not specified, Contractor Facility Management shall establish the inspection interval.

6.4.2. Inspection intervals shall be modified when operational experience dictates a need.

6.5. **Hazard Identification and Communication**

6.5.1. Contractor Facility Management shall identify and maintain a current list of explosives and other hazardous materials used in conjunction with their operations.

6.5.2. Contractor Facility Management shall educate and train employees in the hazards and precautions required for handling explosives and materials used in conjunction with explosives.

6.6. **Work Environment**

6.6.1. Where solid bare explosive pieces are handled:

6.6.1.1. The floor should be resilient or covered with a resilient material.

6.6.1.2. All hard objects that explosives could strike in a handling incident should be covered with a resilient material where practical.

Note: Physical safety systems demonstrated to preclude the explosives from being dropped or struck could meet these requirements.

6.6.2. A procedure should be established to account for hand tools that may be inadvertently dropped into an explosives processing operation, thus creating a hazard.

6.6.3. Personnel shall be assigned in such a manner that each worker’s presence is monitored frequently and assistance can be provided or aid summoned in the event of an emergency.

6.7. General Explosives Area Controls

6.7.1. Smoking, Matches, Lighters, Metal Articles

6.7.1.1. There shall be no smoking in explosives storage, processing, or test areas, except in designated locations.

6.7.1.2. No matches, lighters, or other fire, flame, or spark producing devices shall be taken into an explosives control area except with written authorization. If authorized to be carried, matches shall be contained in a metal carrying device too large to fit into pockets. “Strike anywhere” matches shall not be used.

6.7.1.3. Operating personnel should not carry metal articles (e.g., keys, jewelry, knives, coins) in explosives processing areas where such items could constitute a hazard if dropped into the process.

6.7.2. Cooking and Eating

6.7.2.1. Food or beverages shall not be consumed in explosives buildings, except in designated areas.

6.7.2.2. There shall be no personal dishes or utensils in an explosives building, except in designated eating areas.

6.7.2.3. Coffee pots, hot plates, ovens (including microwaves), and portable electric heaters shall not be permitted in rooms where:

- Explosives may be present.
- Combustible vapors or dust may be present.
- Electrical classification of appliances is not compatible with the area.

6.7.3. Access to Explosives Areas

6.7.3.1. Access control procedures shall be established for entry to all explosives areas.

6.8. Concurrent Contact Operations

6.8.1. The preferred setup for explosives operations is to perform each operation in a separate location to preclude any adverse operation interaction. Because such an arrangement is frequently impractical, concurrent operations may be permitted if the following conditions exist:

6.8.1.1. Potential equipment-operator interactions between the two operations have been analyzed and the risk is not appreciably greater than that for both operations considered separately.

6.8.1.2. Explosive materials in either operation are not exposed to stress conditions such as elevated temperature (melting or heat conditioning), elevated pressures (pressing or extruding), or deformation/shear (machining or cutting).

6.8.1.3. Mixing of materials in the concurrent operations does not create compatibility problems.

6.8.1.4. Each operator is aware at all times of concurrent operations in his or her area.

6.9. **Contamination Prevention**

6.9.1. Precautions shall be taken to avoid mutual contamination when two or more incompatible explosives or materials are handled on a single line or within one building or room.

Note: This includes vacuum systems and explosives scrap collection.

Note: Inadvertent mixing of incompatible explosives materials can be hazardous not only to manufacturing facilities and personnel but also to the user if such materials are loaded into explosives devices.

6.9.2. When two or more explosives are used in a line or within a building and mixing is not intended, the materials shall be segregated in separate locations.

6.9.2.1. Containers shall be clearly marked with the weight and contents identified.

6.9.2.2. Care shall be exercised to properly segregate material in service magazines and in operating buildings.

6.9.3. When a different explosive is to be used in process equipment, the equipment shall be thoroughly cleaned, and excess explosive from the previous job should be removed from the bay.

Note: This eliminates the hazards caused by mixing materials.

6.9.4. In any explosives operation, permanent service lines shall be labeled as to their contents.

6.9.4.1. Valves and switches on service lines whose operation can result in a hazardous situation shall be labeled as to their function.

7. EXPLOSIVES FACILITY DESIGN/SITE CRITERIA

7.1. Explosive Facilities

7.1.1. Permanent explosives facilities shall comply with Unified Facilities Criteria (UFC) 3-340-02.

7.1.1.1. DOE/TIC-11268 may be used as a supplement as it often resolves some special DOE design considerations and may result in a more economical design.

Note: As an example, it describes how to reduce blast overpressure from an explosion due to a high-altitude location.

7.1.2. Portable magazines should be ventilated and resistant to water, fire, and theft.

7.1.2.1. Portable magazines may be made of any material that meets these requirements.

Note: Type 2 portable magazines that comply with 27 Code of Federal Regulations (CFR) Part 555.208 meet these criteria.

7.1.3. Portable magazines shall be sited per Department of Defense Explosives Safety Regulation (DESR) 6055.09 as aboveground magazines.

7.2. Blast Resistant Design

7.2.1. Blast-resistant design for personnel and facility protection shall be based on the TNT (Trinitrotoluene) equivalency of the maximum quantity of explosives and propellants.

7.2.2. TNT equivalency shall be increased by 20% for design purposes in accordance with UFC 3-340-02.

7.3. Criteria for Lightning Protection Systems

7.3.1. Lightning protection shall be designed in accordance with National Fire Protection Association (NFPA) 780, Standard for the Installation of Lightning Protection Systems, and Chapter 42 of this Technical Standard.

7.4. Unproven Facility Design

7.4.1. For an unproven facility design, either a validated model or full-scale test is required to validate structural adequacy unless a high degree of confidence can be provided by calculations or other technical bases.

7.4.1.1. Prior to full-scale testing, test plans shall be provided to the Head of DOE Field Element (DOE/NNSA Field/Operations/Production Office) for concurrence.

7.5. Design of New Facilities

7.5.1. The design of new explosives facilities and major modifications to existing explosives facilities shall conform to the following:

7.5.1.1. The requirements established in this Technical Standard.

7.5.1.2. The methods of analysis and design, as well as protective design features specified in UFC 3-340-02.

Note: It is not intended that existing physical facilities be changed arbitrarily to comply with these provisions, except as required by law.

7.5.1.3. The following documents may be used to assist the design and analysis of blast-resistant design. The most current and updated version should be used.

- DOE/TIC-11268
- Department of Defense Explosives Safety Board (DDESB) TP-12
- DDESB TP-13
- DDESB TP-15
- DDESB TP-16
- DDESB TP-17

7.5.2. Studies necessary to provide the technical basis for location, engineering, design, and operation (under normal and potential design basis accident conditions) of buildings shall follow the stricter of this Technical Standard or DESR 6055.09 for establishing explosives quantity-distance (QD) separation.

7.5.3. To maintain maximum, long-term flexible use of facilities, Contractor Facility Management is encouraged to consider installing dual-rated (i.e., Class I, Division 1 and Class II, Division 1) permanent wiring and equipment in explosives operating rooms. As a minimum, installation should allow for easy conversion to dual-rated wiring and equipment.

7.6. Site and General Construction Plans

7.6.1. Site and general construction plans for explosives facilities, as well as plans for changes in utilization of facilities or mission changes that adversely affect the explosives QD requirements, shall be submitted to the Head of DOE Field Element (DOE/NNSA Field/Operations/Production Office) for review and approval. Plans shall be forwarded for:

7.6.1.1. New construction or major modifications of facilities for explosives activities.

Note: When modifications or rehabilitation plans for existing facilities do not introduce additional hazards or do not increase the net explosives capacity or chemical agent hazard for which the facility was designed or sited, site and general construction plans are not required to be submitted to the Head of DOE Field Element (DOE/NNSA Field/Operations/Production Office) for review.

7.6.1.2. Facilities for activities not involving explosives that are in such proximity to explosives as to be exposed to hazards or for which a reasonable doubt may exist regarding possible exposure to hazards.

7.6.1.3. Facilities for activities not involving explosives that become exposed to blast, fire, or fragment hazards; or potential toxic chemical agent release due to change in facility mission or facilities usage.

7.6.2. When the review of site and general construction plans is required, Contractor Facility Management shall:

7.6.2.1. Indicate specifically in the letter of transmittal its approval of the proposal, along with changes, modifications, or specific precautionary measures considered necessary.

7.6.2.2. Comply with applicable requirements of DESR 6055.09 for site plan submission.

7.6.2.3. Retain a copy of the complete site plan and the final safety submission, together with DOE/NNSA Field/Operations/Production Office letter(s) of approval, as a permanent record at the facility/site of origin.

7.6.2.4. Keep facility maps current with the latest site plan approval and reconciled with the facility master planning document.

7.6.3. DESR 6055.09 identifies minimum distances for protection from fragment hazards and blast overpressure.

7.6.3.1. The methods of calculation presented in DDESB TP-13 may be used to establish a smaller fragment exclusion zone.

Note: It is not intended that these minimum fragment distances be applied to operating facilities or dedicated support functions within an operating line. For these exposures, the DOE criteria presented in this Technical Standard for Class I, II, III, or IV Level-of-Protection activities with appropriate QD separations are the required protection levels.

7.6.4. In addition to this Technical Standard, the following are resource documents for the siting and design of explosives facilities:

- DOE Order 420.1
- DOE Order 430.1
- 10 CFR Part 830
- UFC 3-340-02
- DOE/TIC-11268
- DESR 6055.09
- DDESB TP-13
- AMCR 385-100
- TR-828
- AD 411445
- AFWL-TR-74-102
- HNDM-1110-01-2

8. HAZARD ANALYSIS

8.1. Hazard Analysis

8.1.1. Before starting any operation involving explosives, a documented hazard analysis shall be performed per 10 CFR 851.21.

8.1.1.1. Hazard analyses shall be performed using a graded approach applicable to the specific explosives operation.

8.1.2. When an explosives operation changes, new hazards shall be addressed in a supporting hazard analysis which then becomes part of the original hazard analysis.

8.1.3. When modifying facility or process equipment, a documented analysis shall be performed to validate uniform standards are adhered to throughout the facility.

8.1.4. Contractor Facility Management shall address the results of a hazard analysis. Hazard prevention and abatement shall be conducted per 10 CFR 851.22.

8.2. Similar Processes

8.2.1. A single hazard analysis may be performed for similar processes performed in a single facility, provided that the “worst case” process is the basis for the hazard analysis.

8.2.1.1. Selection criteria for the worst-case process are:
- Sensitivity of materials;
- Quantity of materials;
- Number of personnel potentially affected; and
- Impact on other operations and activities.

8.2.1.2. As a new process is considered for inclusion under an existing hazard analysis, each step of the new process shall be evaluated to determine if it is within the scope of the existing hazard analysis, and to identify any hazards not addressed in the existing hazard analysis.

8.3. High Risk

8.3.1. Hazard analysis supporting explosives synthesis, formulation, manufacturing, testing, or disposal operations shall be performed and revalidated as a team effort. The team shall consist of a minimum of three personnel, to include at least one technical member and one operator. The following makeup is recommended:
- Team Leader, who is familiar with the analysis methodology used.
- Technical Member(s), who is familiar with the process being analyzed.
- Scribe, who writes notes of meetings and interviews and drafts reports.
- Operator who actually performs the work being analyzed.
- Explosives Safety Subject Matter Expert.

Note: A technical member is an individual who has expertise in a particular technical discipline (e.g. engineering, chemistry, physics, and safety).

8.3.2. Contractor Facility Management shall select the analysis methodology used (e.g., What if Analysis, Fault Tree Analysis, Event Tree Analysis).

8.3.3. Employees and employee representatives shall be consulted on the hazard analysis.

8.3.4. The result of the hazard analysis shall be provided to employees involved in or affected by the operation.

8.3.5. The hazard analysis shall be updated and revalidated at least every five years.

8.4. Electrical Hazard Classification Analysis

8.4.1. If a documented analysis is used to determine the electrical hazard classification for areas where explosives operations or activities are conducted, the analysis shall be reviewed by the Contractor Explosives Safety AHJ and approved by Contractor Facility Management.

8.4.2. The scope of the analysis shall identify the specific location and specific explosives operation or activity.

8.4.3. The analysis should be limited to the following:

- Enclosed areas, (e.g. rooms, bays, chambers).
- Normal operating conditions.

8.4.4. The analysis should consider the following:

- The physical configuration of the explosives, (encased, bare, consolidated, powder, packaged, unpackaged).
- The explosives operation or activity being conducted.
- Other activities or operations being conducted in the same area.
- Migration of explosive or ignitable gases, vapors or dust mixtures to or from adjacent areas.

Note: The analysis shall be updated and revalidated if any of these change.

9. OPERATING PROCEDURES

9.1. Procedures

9.1.1. Operating procedures shall be written and approved for each operation involving explosives.

9.1.2. Operating procedures shall implement all applicable controls derived from supporting hazard analysis prior to the procedure being approved for use.

Note: Operating procedures that were not prepared using the current hazard analysis shall be evaluated to verify that all applicable controls (new or revised) derived from the current hazard analysis are implemented prior to the procedure being approved for use.

9.2. **Approval**

9.2.1. New or revised operating procedures shall be reviewed and approved prior to use.

9.2.2. Contractor Facility Management should establish levels of approval based on the operation's inherent risk.

9.2.3. The review and approval process shall include line and safety organizations.

9.3. **Operating Procedures Content**

9.3.1. The introduction to the procedure should include the following:

9.3.1.1. A statement of the scope, nature of the operation and its objectives, and defining what facilities and equipment are covered.

9.3.1.2. The name of the department responsible for the operation and the procedure.

9.3.1.3. If the procedure serves as the basis for an exemption, equivalency, or waiver from the requirements of this Technical Standard, a statement to this effect and a specific reference shall be included.

9.3.2. The materials and equipment section should present the following information:

9.3.2.1. All significant tools, supplies, chemicals, and equipment necessary to perform the operation should be listed in the procedure or in a separate required document.

9.3.2.2. Specifications for approved chemicals, supplies, tooling, and equipment should be referenced where applicable.

9.3.2.3. An explanation of any specific hazard involved in the handling of chemicals or explosives, or a reference to a document that describes the hazards.

9.3.3. The safety section of the procedure should present the following information or reference a safety document that specifies the requirements:

9.3.3.1. General safety rules to be observed and techniques to be applied that verify safety of operations, prevent personnel injury or illness, and prevent equipment damage.

9.3.3.2. Additional or specific emergency controls not addressed by the facility emergency plan.

9.3.3.3. Protective equipment used during the operation.

9.3.3.4. The number of personnel (workers and casuals) and explosives weight limits associated with the operation being conducted.

9.3.4. The operations section should consist of sequential directions written or pictured in clear, concise steps that describe how to perform a particular operation:

9.3.4.1. General directions for operation of all major explosives handling equipment.

9.3.4.2. Particular emphasis should be placed on safety interlocks and controls, and their proper use.

9.3.4.3. If a particular operation requires that no other operation be performed concurrently in the same work area, this requirement shall be stated clearly in the procedure.

9.4. Special or Experimental Procedures

9.4.1. In addition to the applicable requirements listed for Operating Procedures, the following shall also be addressed:

9.4.1.1. Field operations (remote to normally occupied areas) shall include procedures to verify prompt response of both fire and emergency medical services.

9.4.1.2. Personnel involved with the operation shall be briefed or trained on any unique aspects of the operation and emergency procedures.

9.4.2. When a special or experimental operation shall be conducted a number of times, an Operating Procedure should be written and approved.

10. TRAINING

10.1. Explosives Safety Training

10.1.1. Personnel shall be properly trained before they are assigned to explosives operations or operate any explosives transport vehicle.

10.1.2. The training for explosives work serves to assist in conducting work safely and developing safety awareness and shall verify that personnel:

- Develop and maintain a safe attitude towards work with explosives.
- Define and understand the potential hazards involved.
- Learn correct skills to perform tasks safely.
- Are prepared for unexpected hazardous conditions.
- Read and understand the appropriate operating procedures.

10.2. **Training and Qualification Programs**

10.2.1. Each Site's Training and Qualification Program shall address Explosives Safety training.

10.2.2. An employee shall not be permitted to continue working with explosives if the supervisor, with counsel from medical personnel, determines that he or she is unable to perform the task safely. Possible reasons include:

- Physical injury or illness.
- Disease.
- Mental or emotional disturbances.

10.3. **Unexploded Ordnance (UXO) Qualification**

10.3.1. Personnel in charge of UXO removal/disposal should be US citizens and have successfully completed training at a US Military Explosives Ordnance Disposal (EOD) school.

10.3.1.1. Personnel shall provide documentation of completed training and have a minimum of 18 months operational EOD experience.

10.3.2. Personnel performing UXO removal or disposal shall have completed training at a US Military EOD school or have equivalent training or experience.

10.3.3. All other personnel engaged in UXO operations shall be trained thoroughly in applicable UXO recognition and Explosives Safety.

10.3.4. Personnel requiring access to areas known or suspected to contain UXOs shall be required to complete UXO awareness training and comply with any site-specific additional UXO area access requirements.

10.3.5. Sites containing UXOs shall establish site-specific UXO awareness training.

11. QUANTITY-DISTANCE

11.1. Explosives Safety Site Plan Submission and Approval

11.1.1. Contractor Facility Management shall verify that ESSPs are submitted to the Head of DOE Field Element (DOE/NNSA Field/Operations/Production Office) for review and approval.

11.1.2. Where there is an increase in risk, an ESSP shall be resubmitted and approved prior to start of operations for the following conditions:

- There is an increase in explosive weight.
- The facility undergoes a major modification.
- The required Level-of-Protection changes.

11.1.3. Risk based explosives siting, as described in DDESB TP-14 is another tool to address explosives QD determinations of equivalency of safety.

11.1.4. The site plan package shall contain the following:

11.1.4.1. A QD Chart containing the following:

- Each sited facility potential explosion site (PES) listing maximum net explosives weight (NEW) for each applicable Hazard Division (HD).
- Actual and required distance to exposed sites (ES).
- QD criteria used for siting each PES - ES relationship.

11.1.4.2. Map(s) showing each PES, its clear zone, and all ESs within the clear zone.

11.1.4.3. Personnel limits for the explosives facility.

11.1.4.4. Description(s) of explosives and non-explosives operations within the clear zone.

11.1.4.5. Justification(s) for facilities not meeting current criteria for the operation that address:

- Bringing the facility up to current standards is not feasible, and
- Operations present no significantly greater risk than that assumed when the facility was originally constructed.

11.1.5. If the siting has any unique characteristics, explain what they are and what criteria is being applied.

Note: If a facility is built to control blast effects and fragments, QD to other facilities do not apply.

11.1.6. A letter of transmittal shall accompany each site plan or group of site plans. The letter shall contain the following:

11.1.6.1. Reason for submittal (preliminary or final siting of new facility, site plan/plans for grandfathered facility/facilities, change in operation with increased or decreased QD requirement).

11.1.6.2. Request for site plan approval.

11.1.6.3. For a grandfathered facility, note whether the facility meets current criteria for the operation being conducted.

11.2. **Quantity-Distance Criteria**

11.2.1. QD criteria shall account for the types and severity of hazards each explosive material presents, the construction and orientation of facilities to which the criteria are applied, and the degree of protection desired for personnel and facilities adjacent to the explosives operations.

Note: The United Nations (UN) hazard classification system defines the types and severities of explosives hazards.

11.2.2. Hazard Divisions

11.2.2.1. Explosives shall be classified based on their reactions to specific initiating influences.

11.2.2.2. Personnel shall use the UN hazard classification system for DOE explosives classification, Table 11.1 lists the hazard divisions of Class 1.

Table 11.1 Division of Class 1

HD Designators	Hazards
1.1	Mass detonating
1.2.1	Non-mass explosion, fragment producing with NEW for QD > 1.6 lbs
1.2.2	Non-mass explosion, fragment producing with NEW for QD ≤ 1.6 lbs
1.2.3	Non-mass explosion, fragment producing based on single package test only No reaction greater than burning from the external fire test, bullet impact test or slow cook-off test
1.3	Mass fire, minor blast or fragment
1.4	Moderate fire, no significant blast or fragment
1.5	Explosive substance, very insensitive (with a mass explosion hazard)
1.6	Explosive article, extremely insensitive

11.2.2.3. Classification tests (described by TB 700-2) and additional tests (as desired), including UN ST/SG/AC/10/1 and UN ST/SG/AC/10/11, shall be used to assign energetic materials to the appropriate HD SCG (Storage Compatibility Group). Supplemental tests may be used for additional characterization when material properties or anticipated material environments are expected to significantly influence the explosives classification.

11.2.2.4. Although Department of Transportation (DOT) hazard classifications require the use of the Bureau of Explosives' (BOE) Impact Apparatus to determine impact sensitivity, other impact apparatus may be used, providing:

- Test results for at least two reference explosives are compared to results for the reference explosives on the BOE Impact Apparatus; and
- A minimum of 10 trials each is run for the reference explosives and the explosives being classified.

11.2.3. The principles and tables presented in DESR 6055.09 shall be used to determine the total quantities of explosives in adjacent magazines, operating buildings, or other explosive facilities that shall be applied to QD tables, and inert storage locations.

Note 1: When the levels of protection required by this Technical Standard differ from the requirements of DESR 6055.09, this Technical Standard shall take precedence.

Note 2: The minimum separation distances required for the facilities are based on the desired Level-of-Protection and total quantities of explosives.

Note 3: The total quantity of explosives is determined by defining and examining the maximum credible event (MCE). If an explosives event occurs, the MCE is the largest credible amount of explosives that could be involved (not necessarily the total quantity of explosives present).

Note 4: Requirements for onsite de minimis or residual quantities of explosives can be found in Section 17.7.

11.2.4. Transport Vehicles

11.2.4.1. Explosives loaded vehicles in holding yards are considered aboveground magazines for QD purposes. They shall be kept in groups, and each group shall be limited to a maximum of 250,000 lbs (113,398 kg) of high explosives (HE).

11.2.4.2. When a classification yard, interchange yard, inspection station or specified location is the site where explosives are interchanged between the common carrier and facility transportation, QD provisions do not apply provided that vehicles are moved expeditiously to a suitable location.

11.2.5. Utilities Installations

11.2.5.1. Permanent DOE controlled underground utilities installations (excluding building service lines) should be separated from explosives locations containing HD 1.1 materials (see Table 11.2).

Table 11.2 QD Separation for Protection of Underground Service Installations

Quantity of explosives (Maximum)		Distance	
Lbs.	**(kg)**	**Feet**	**(Meters)**
≤ 10,000	(4,535.9)	80	(26)
20,000	(9,071.8)	85	(28)
50,000	(22,679.6)	110	(36)
100,000	(45,359.2)	140	(46)
250,000	(113,398.1)	190	(62)

Note: If the potential donor building is designed to contain the effects of an explosion, the formula: $D=3.0\ W^{1/3}$ can be used to determine separation distances for less than 20,000 lbs (9,071.8 kg).

11.2.5.2 Privately owned or operated utilities installations (aboveground and underground) shall be separated from explosives locations by at least public traffic route distances. Installations that include structures should be separated from explosives facilities by inhabited building distance.

11.2.5.3. Certain auxiliary power facilities, transformer stations, etc., present fire hazards to explosives facilities. Transformers and associated electrical switching apparatus serving one explosives facility or complex that do not present a fire hazard to the facility (i.e., dry type, "less flammable" oil insulated) shall be located as specified in NFPA 70 and FMDS 5-4/14-18.

11.2.5.4. Normal oil insulated transformers shall be located at least 50 ft from an explosives facility or as specified in DESR 6055.09.

Note: See Section 36.3 for additional electrical supply system requirements.

11.2.6. Storage Tanks for Petroleum and Hazardous Materials

11.2.6.1. Storage tanks for petroleum and hazardous materials shall be sited using Storage Tanks for Hazardous Materials criteria as specified in DESR 6055.09.

11.2.7. Small Quantities of HD 1.1 Explosive Substances

11.2.7.1. Use Table 11.3 to determine distances for small quantities of explosive substances.

Note: For many situations, it can be demonstrated that adequate personnel protection is provided at distances considerably less than those distances identified in DESR 6055.09.

Table 11.3 Minimum QD Requirements for Small Amounts of Explosive Substances Having HD 1.1 Classification

NEW	Inhabited Building Distance	Public Traffic Route Distance	Intraline Distance
Less than 0.0066 lb	0 ft	0 ft	0 ft
(0.003 kg)	(0 m)	(0 m)	(0 m)
0.0066 lb – 0.022 lb	16.40 ft	9.84 ft	6.56 ft
(0.003 kg – 0.01 kg)	(5 m)	(3 m)	(2 m)
0.022 lb – 0.55 lb	49.21 ft	29.52 ft	16.40 ft
(0.01 kg – 0.25 kg)	(15 m)	(9 m)	(5 m)

12. LEVEL-OF-PROTECTION CRITERIA

12.1. Required Level-of-Protection

12.1.1. The Level-of-Protection required for an explosives activity is based on the hazard class (accident potential) of the explosives activity involved.

12.1.2. Each bay (i.e., storage, handling, or processing building) that houses an explosives activity shall have a Level-of-Protection based on the hazard class determined for the activity.

12.1.3. Level-of-Protection may be provided by equipment design, structural design, operation separation, or provision of operational shields.

12.2. Hazard Class 0

12.2.1. Explosives operations involve the intentional initiation of explosives materials or articles.

Note: Examples are explosives testing, firing activities associated with training, and destruction of explosives by detonation.

12.2.2. Areas used to conduct Class 0 activities shall protect all personnel from injury due to blast, fragments, and structural collapse of buildings. This protection may be achieved by measures (or combination of measures) to include control of fragments and overpressure by suppression, containment, or distance (location) as follows:

12.2.2.1. No structural damage to any facility due to overpressure, fragments, or debris.

12.2.2.2. No fragment or debris impact to operators.

12.2.2.3. Operator protection from any injurious thermal flux.

12.2.2.4. Overpressure, fragment, and debris impact to surrounding areas limited to approved site plans and DESR 6055.09 for intentional detonation of explosives criteria.

12.3. **Hazard Class I**

12.3.1. Explosives operations involve activities with a high accident potential where: (1) energies approach the upper safety limits, (2) loss of control of interfacing energy is likely to exceed safety limits, and (3) research and development where safety implications have not been fully characterized.

Note: Examples are screening, blending, pressing, extrusion, drilling of holes, dry machining, machining explosives and metal in combination, some environmental testing, new explosives development and processes, explosives disposal by burning and some destructive testing.

12.3.2. Operations shall be conducted remotely because any personnel exposure is unacceptable.

12.3.3. Bays for Class I activities shall comply with the requirements for Class II bays, and, in addition, provide protection to prevent serious personal injuries to personnel performing the activity and personnel in other occupied areas. This protection can be achieved by controlling blast and debris through suppression, containment, or establishing an exclusion area with positive access control. Serious injury prevention is satisfied when personnel are not exposed to:

12.3.3.1. Overpressures greater than 5 psi maximal effective pressure, which should not exceed 2.3 psi peak positive incident pressure (2.3 psi is

specified in the DESR 6055.09 as required protection for all personnel exposed to remote operations).

12.3.3.2. Structural collapse of a facility or building from overpressure or debris impact. Structural collapse is a structural component's failure as a direct result of loss of structural integrity. This collapse does not result in explosion propagation, fatalities, or severe personal injuries.

12.3.3.3. Hazardous fragment or debris having an impact energy greater than 11 ft lbs.

12.3.3.4. Thermal fluxes are limited to prevent the onset of second-degree burns. This value is specified in DESR 6055.09, as required protection for all personnel assigned to perform remote operations.

12.3.3.5. Transients shall be protected as specified in DESR 6055.09 using "Accidental Ignition or Initiation of Explosives" criteria.

12.4. **Hazard Class II**

12.4.1. Explosives operations involve activities with moderate accident potential due to the explosives type, condition of the explosives, or nature of the operations. These activities involve energies that do or may interface with the explosives are normally well within the safety boundaries for the explosives involved, but where the loss of control of these energies could approach the safety limits.

Note: Examples are weighing, some wet machining, assembly and disassembly, some environmental testing, and some packaging operations.

12.4.2. Class II activities have an accident potential greater than Class III activities, but personnel exposure in contact operations is acceptable.

12.4.3. For Class II operations, access ramps and site roads are not considered occupied areas.

12.4.4. Bays for Class II activities shall comply with the requirements for Class III bays, and, in addition, provide protection to prevent fatalities and severe personnel injuries in all occupied areas other than the bay of occurrence. Prevention of fatalities and severe injuries is satisfied when personnel in occupied areas other than the bay of occurrence are not exposed to the following:

12.4.4.1. Overpressures greater than 15 psi maximal effective pressure. The threshold pressure for eardrum rupture is 5 psi; one-half of the

threshold pressure for lung damage is 15 psi (see chapter I-11.1 of UFC 3-340-02).

12.4.4.2. Structural collapse resulting from overpressure or debris impact. Structural collapse is a structural component's failure as a direct result of a facility losing structural integrity. This collapse does not result in explosives propagation, fatalities, or severe personnel injuries.

12.4.4.3. Hazardous fragments or debris generated in acceptor-occupied areas having an impact energy of 58 ft-lbs or greater, (see chapter I-11.3 of UFC 3-340-02).

12.5 **Hazard Class III**

12.5.1. Explosives operations involve activities with low accident potential.

Note: Examples are activities during storage and operations incidental to storage or removal from storage.

12.5.2. Bays for Class III activities shall provide protection from explosion propagation from bay to bay within buildings and between buildings that are located at intraline or intermagazine distance.

12.5.3. If intermediate storage of explosives is within an operating building containing Class II or Class I operations, the intermediate storage or staging bay shall require Class II Level-of-Protection.

12.5.4. Minimum separation distances may be reduced when explosives bays are designed to adequately contain the effects of an accident (blast pressures and missiles).

12.6. **Hazard Class IV**

12.6.1. Explosives operations involve activities with IHE or IHE subassemblies where the probability of accidental initiation or transition from burning to detonation is negligible.

Note: Examples are processing and storage activities with IHE and IHE subassemblies.

12.6.2. The following explosives activities with IHE and IHE subassemblies shall remain Class I:

- Pressing.
- Some machining (see Paragraph 24.2.4).
- Dry blending.
- Dry milling.

- Dry screening.

12.6.3. Bays for Class IV activities shall provide protection from fire hazards effects.

12.6.3.1. This protection may be achieved by HD 1.3 aboveground magazine distance separation or by a design that contains the effects of an accident.

12.6.3.2. Because accidental detonation is not considered credible, Class IV bays shall be sited and designed as acceptors rather than donors for the effects of blast overpressure, structural collapse, and missiles (hazardous fragments).

13. REMOTE OPERATIONS

13.1. Personnel Protection

13.1.1. Explosives operations that present a high accident potential as defined in Paragraph 12.3.1 shall be performed remotely.

13.1.2. Personnel involved in remote operations shall be provided the required Level-of-Protection for the hazard class of the operation.

13.1.3. Transient personnel shall be provided protection in accordance with the requirements in DESR 6055.09.

13.2. Access and Equipment Controls

13.2.1. Administrative and/or engineered controls shall be used to prevent entry into a hazardous location in which a remote operation is occurring or to prevent the operation from proceeding when personnel enter.

13.2.1.1. Roads shall be blocked at a minimum public traffic route distance (K24) or hazardous fragment distance from buildings where hazardous (remote) operations are being performed, whichever is greater.

Note: Hazardous fragment distance may be satisfied by providing equivalent protection.

13.2.1.2. Corridors leading to bays in which hazardous (remote) operations are being performed shall be marked to warn of the danger with established barriers.

13.2.1.3. When practical, visual methods should be used to monitor remote operations to enable viewing of the operating area conditions before

entering. Audio monitoring and video recording should also be considered.

13.2.1.4. Remote operating equipment should be interlocked to access doors for each remote operation.

13.2.1.5. Lights or similar warning devices shall conspicuously identify locations where remote operations are performed to indicate when remote operations are under way.

14. LIMITS AND CONTROL

14.1 Explosives Limits

14.1.1. The quantity of explosives at an operating location shall be the minimum necessary to carry out the operation safely and efficiently.

14.1.1.1. When practical, this quantity shall be subdivided and separated to prevent propagation of detonation.

14.1.1.2. Supplies exceeding this minimum quantity shall be removed from the operating area.

14.1.2. In no case shall the quantity of explosives permitted in an operating building exceed the maximum permitted by QD criteria.

14.1.3. QD criteria and requirements for application of these criteria are presented in Chapter 11.

14.1.4. IHE limits for pressing, dry blending, dry milling, dry screening, and certain machining operations (see Paragraph 24.2.4) should be the same as those established for HE operations.

14.2. Personnel Limits

14.2.1. The number of personnel at an operating location shall be the minimum consistent with safe and efficient operation.

14.2.2. Only jobs necessary to the performance of a hazardous explosives operation should be performed in the same location as the hazardous operation.

14.2.3. Only personnel needed for hazardous operations shall be allowed in hazardous locations.

14.2.4. Personnel limits shall allow for necessary casuals.

14.2.5. Sufficient personnel shall be available to perform a hazardous operation safely and to obtain help and aid the injured if an accident occurs.

14.2.6. Contractor Facility Management shall specify explosives activities that may be performed alone.

14.2.6.1. No person shall perform explosives work with a high risk of serious injury alone.

14.2.6.2. Prompt and easy communications with other employees shall be provided.

14.3. **Limit Control**

14.3.1. Posting and Recording

14.3.1.1. All rooms, bays, and buildings containing explosives shall have, posted in a conspicuous place, a standardized posting stating the maximum amount of explosives and the maximum number of workers and casuals permitted in the controlled area at any one time.

14.3.1.2. Maximum explosives and personnel limits for all buildings and bays for each explosives area shall be documented and maintained on file.

14.3.2. Limit Review and Approvals

14.3.2.1. Contractor Facility Management personnel with authority and jurisdiction over an operating bay or building shall review explosives and personnel limits for each location periodically and recommend changes as required.

14.3.2.2. When the use of a location changes, personnel and explosives limits shall be reviewed and limits reestablished as required.

14.3.2.3. Changes in explosives and personnel limits shall be reviewed and approved in the same manner as operating procedures (see Chapter 9).

14.3.2.4. A procedure shall be established for the approval of temporary changes in explosives and personnel limits for an operating location.

14.3.3. Personnel Controls

14.3.3.1. A system shall be established to control the presence of personnel within explosives operating areas.

14.3.3.2. The movement of transients in the vicinity of an explosives operating area should be controlled when their presence creates a congestion problem or other safety concern.

14.3.4. Explosives Controls

14.3.4.1. A verifiable system shall be established to control the amount of explosives present in an explosives facility.

15. PERSONAL PROTECTIVE EQUIPMENT

15.1. Clothing

15.1.1. Flame-retardant clothing may be desired for explosives operations with the potential for flash fire.

15.1.1.1. The clothing shall not have cuffs.

15.1.1.2. The clothing should not have metallic fasteners.

15.1.2. Operating procedures shall include protective clothing requirements.

15.1.3. Cotton or other antistatic outer and undergarments, including socks, should be worn where generation of static electricity would create a hazard.

15.2. Footwear

15.2.1. Personnel working in areas where electrostatic sensitive explosive powders or materials are handled shall wear conductive, non-sparking footwear.

Note: Exception: Personnel working on electrical or electronic equipment shall not wear conductive footwear unless protected by insulated mats, ground fault circuit interrupters (GFCI), etc.

15.2.2. When conductive footwear is worn, the conductivity shall be tested immediately prior to each use.

15.2.3. Personnel working in areas where explosives contamination may be present shall wear non sparking footwear or bootie shoe coverings.

15.3. Wristbands

15.3.1. When conductive wristbands are worn, the conductivity shall be tested immediately prior to each use.

16. INSENSITIVE HIGH EXPLOSIVES QUALIFICATION

16.1. Revisions to Insensitive High Explosives (IHE) Test Description and Criteria

16.1.1. Revisions to LLNL-TR-679331/LA-UR-15-29238, “IHE Material and IHE Subassembly Qualification Test Description and Criteria” shall be approved by the proponent organizations (Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Pantex) and shall be reviewed for concurrence by the DOE/NNSA Explosives Safety Committee. Once concurrence is obtained, the Chair shall issue a letter of concurrence to the submitting organization.

16.2. Insensitive High Explosive (IHE) Materials

16.2.1. In scales that are conservative to the relevant nuclear weapon application, IHEs shall meet the following requirements:

Note: For more information refer to Attachment A of this chapter - IHE QUALIFICATION BACKGROUND

16.2.1.1. Does not transition from deflagration to detonation (DDT).

16.2.1.2. Does not transition from shock to detonation (SDT).
- Under 3.5 GPa, 3 μs 1-dimensional shock insult at 25°C.
- Under 5.3 GPa, 0.5 μs 1-dimensional shock insult at 25°C.
- Under 1.5 GPa, 3 μs 1-dimensional shock insult when heated to 10°C below the cook-off temperature of the explosive.

16.2.1.3. Passes IHE criteria outlined in LLNL-TR-679331/LA-UR-15-29238, "IHE Material and IHE Subassembly Qualification Test Description and Criteria."
- Skid test
- Bullet test

16.2.2. The qualification and approval process described herein is limited to DOE and nuclear weapons applications.

16.3. IHE Qualification Testing

16.3.1. Any explosive that is a candidate for classification as an IHE shall be subjected to the DOE qualification tests listed in Table 16.1.

Note: This includes three tiers of tests. Test procedures are contained in LLNL-TR-679331/LA-UR-15-29238.

Table 16.1 Required Testing to Qualify IHE Materials

Tier 1: Prerequisites	Tier 2: IHE Material Qualification	Tier 3: Demonstration Tests[1]
Interim Hazard Classification	DDT Test and SDT Test	Skid Test and Bullet Test

[1] Minimum of 20 drops per test series

16.3.2. Some or all of the test requirements of this section may be met by analogy as indicated below:

16.3.2.1. The DOE/NNSA Explosives Safety Committee determines the acceptability of analogy in lieu of test data.

16.3.2.2. Analogy submitted in lieu of test data shall include rationale.

16.3.2.3. Approved IHEs (listed in Table 16.2) with complete test data shall be used for baseline comparison purposes.

16.3.3. The DOE/NNSA Explosives Safety Committee may request additional information depending on circumstances surrounding the analogous information submitted.

16.3.4. A candidate IHE can be placed in one of the following analogy categories to define required tests depending on the type and extent of change in the candidate IHE relative to the baseline IHE and the potential effects of these changes on specific initiation mechanisms (shock, thermal, mechanical, impact):

16.3.4.1. If the analogy can be fully credited, no testing is required.

Note: For example; the candidate IHE involves the same energetic and inert components as the approved baseline IHE, the only change being a volume-percent decrease in the energetic component content.

16.3.4.2. If the analogy can be partially credited, partial testing is required. Sufficient testing is required to verify that no chemical or physical incompatibilities have been introduced that would de-stabilize the base IHE.
Note 1: For example; the candidate IHE formulation modifies an inert component of the approved baseline IHE.

Note 2: In this case, test data normally generated by the requesting facility during their explosive development scale-up phasing process may be submitted in lieu of the qualification tests of Table 16.1.

Note 3: During the development phase, the Contractor Explosives Development Committee (EDC), or equivalent, may dictate restrictions consistent with an IHE that are internal to their facility only.

16.3.4.3. If the analogy cannot be credited, full testing is required.

Note: For example; the candidate IHE involves the addition of an untested (IHE tests) energetic component to the approved baseline IHE.

16.4. **IHE Qualification Process**

16.4.1. IHE Materials qualified by previous methods shall remain qualified and are listed in Table 16.2

Table 16.2 Approved IHEs

TATB TATB/KEL-F (or equivalent) Formulations

16.4.2. The organization with the need for IHE determination (hereafter shall be referred to as the Requestor) shall perform or have performed the appropriate tests in accordance with the requirements of LLNL-TR-679331/LA-UR-15-29238, after coordinating need for material qualification with the appropriate Headquarters (HQs) Program Office (e.g., NA-11, NA-12, or NA-19).

16.4.3. The Requestor submits the test data, for the candidate explosive, to the DOE/NNSA ESC Chair.

16.4.4. The DOE/NNSA ESC Chair assigns a Task Group for review and recommendation of approval/disapproval of the candidate explosives material.

16.4.5. If the request is not recommended for approval, the Task Group documents the rationale and requirements that were not met and provides this information to the DOE/NNSA ESC Chair who then communicates with the Requester through the DOE/NNSA ESC Chair.

16.4.6. If the request is recommended for approval, the Task Group assembles the test data and provides this information to the DOE/NNSA ESC Chair with a recommendation to approve the candidate explosive.

16.4.7. The DOE/NNSA ESC Chair prepares a written recommendation on the approval of the candidate explosive, and submits it along with the supporting explosives package to the NNSA/NA-50 Associate

Administrator for Safety, Infrastructure, and Operations; the Explosives Approval Authority (EAA) or designee.

16.4.8. The NNSA/NA-50 EAA approves or denies the candidate explosive for qualification as an IHE, and provides written documentation of their decision to the DOE/NNSA ESC Chair.

16.4.9. The DOE/NNSA ESC Chair provides documentation of the EAA's decision to requestor, and if approved, the IHE is added to Table 16.2.

16.5. IHE Subassemblies Testing

16.5.1. IHE Subassemblies are composed of IHE hemispheres or spheres with booster charges, with or without detonators that, as an assembly are so insensitive that the probability of accidental initiation or transition from burning to detonation is negligible, and therefore meet IHE criteria at a system-relevant scale.

16.5.2. Main charge materials that do not qualify as IHE materials in Section 16.3 may be used as main charges in an IHE Subassembly, provided they meet IHE criteria at a smaller, system-relevant scale.

16.5.3. Any explosive Subassembly that is a candidate for classification as an IHE Subassembly shall be subjected to DOE qualification tests as listed in Table 16.3. These tests shall be planned with consideration of worst-case scenarios. Testing approaches and methods are contained in LLNL-TR- 679331 / LA-UR-15-29238. The qualification approach evaluates each material in the assembly as follows:

16.5.4. Verify main charge is incapable of DDT and therefore meets IHE criteria for a material

16.5.4.1. Verify main charge meets IHE material criteria for SDT, as shown in Table 16.1, Tier 2 and defined in LLNL-TR-679331/LA-UR-15-29238.

16.5.4.2. Verify detonator material is incapable of DDT in a scale conservative to its relevant application.

Note: Electrical threat to detonator is not part of this qualification.

16.5.4.3. Verify booster is incapable of DDT in a scale conservative to its relevant application

Table 16.3 DOE Qualification Tests for IHE Subassemblies*

Test	Results
DDT	No DDT in main charge, booster, and detonator materials tested at scales relevant to application, plus margin for conservatism.
SDT	No SDT in main charge material per tests in Table 12.1 for both ambient and heated materials.
Multiple Bullet Impact	No detonation or violent reaction of main charge with a 3-round bullet impact burst in worst-case configuration.
Skid Test	No burning or violent reaction of main charge (as evidenced by visible fireball) up to a specified height and test angle using Subassembly configuration modified for impact in worst-case geometry.

* Tests are not required for subassemblies when main charge and booster charge explosives have been qualified as IHE by tests in Table 16.1.

Note: The test plan shall specify applicable testing for cased and/or uncased configurations with or without detonators.

16.5.5. Some or all of these test requirements may be met by analogy as indicated below:

16.5.5.1. The DOE/NNSA Explosives Safety Committee determines the acceptability of analogy in lieu of test data.

16.5.5.2. Analogy submitted in lieu of test data shall include rationale.

16.5.5.3. Approved IHE Subassemblies with complete test data shall be used for baseline comparison purposes.

16.5.6. The DOE/NNSA Explosives Safety Committee may request additional information depending on circumstances surrounding the analogous information submitted.

16.5.7. A candidate IHE Subassembly can be placed in one of the following analogy categories to define required tests depending on the type and extent of change in the candidate IHE Subassembly relative to the baseline IHE Subassembly and the potential effects of these changes on specific initiation mechanisms (shock, thermal, mechanical, impact):

16.5.7.1. If the analogy can be fully credited, no testing is required.

Note: For example; materials and scales remain the same and only minor changes that do not affect explosive characteristics.

16.5.7.2. If the analogy can be partially credited, partial testing is required.

Note: For example; minor changes to explosive materials or components.

16.5.7.3. If the analogy cannot be credited, full testing is required.

Note: For example; a significant change to materials or configurations.

16.6. **IHE Subassembly Qualification Process**

16.6.1. IHE Subassemblies qualified by previous methods shall remain qualified and are listed in Table 16.4.

16.6.2. The Requestor submits a test plan to the DOE/NNSA ESC Chair and the test plan shall be coordinated with the appropriate DOE/NNSA site, after coordinating need for subassembly qualification with the appropriate HQs Program Office (e.g., NA-11, NA-12, or NA-19).

16.6.3. The DOE/NNSA ESC Chair assigns a Task Group for review and approval/disapproval of the test plan.

16.6.4. The ESC Task Group reviews the test plan for compliance with the IHE subassembly requirements and provides input (if necessary), and approves/denies the test plan. They then communicate their decision to the DOE/NNSA ESC Chair.

16.6.5. The DOE/NNSA ESC Chair communicates the approval/disapproval to the Requestor.

16.6.6. If the test plan is approved, the Requestor submits the test data, for the candidate subassembly, to the DOE/NNSA ESC Chair.

16.6.7. The DOE/NNSA ESC Chair submits the test data to the Task Group for review and recommendation of approval/disapproval of the candidate subassembly.

16.6.8. If the request is not recommended for approval, the Task Group documents the rationale and requirements that were not met and provides to the Requestor through the DOE/NNSA ESC Chair.

16.6.9. If the request is recommended for approval, the Task Group provides the DOE/NNSA ESC Chair with recommendation to approve the candidate subassembly.

16.6.10. The DOE/NNSA ESC Chair prepares a written recommendation on the approval of the candidate subassembly, and submits it along with the supporting subassembly package to the NNSA/NA-50 EAA.

16.6.11. The NNSA/NA-50 EAA approves or denies the candidate subassembly for qualification as an IHE subassembly.

16.6.12. The EAA provides written documentation of their decision to the DOE/NNSA ESC Chair.

16.6.13. If approved, the DOE/NNSA ESC Chair provides documentation of the EAA's decision to requestor. If approved, the IHE Subassembly is added to Table 16.4.

Table 16.4 Approved IHE Subassemblies

B61*3/4/6/7/8/10/11/12	W80*	W81*	B83*
W84	W87	W89	

*** Approval limited to boosters of the size tested or smaller.**

Note: Any redesign that dimensionally increases the booster size requires resubmission of an experimental plan and additional testing as another IHE Subassembly.

16.7. **IHE Weapons**

16.7.1. IHE weapons are those weapons listed in JNWPS TP-20-7, and are exempt from storage and transportation limits when stored or transported alone or in combination with each other.

Note: This classification is valid only if storage containers provide adequate spacing between individual units. JNWPS TP-20-7 specifies the spacing requirements for materials stored or transported out of containers.

Attachment A – IHE QUALIFICATION BACKGROUND

BACKGROUND

The DOE IHE definition differs from that of Department of Defense (DoD)/UN Extremely Insensitive Substance (EIS) due to different risks and consequences associated with nuclear weapons application. The critical difference in risk is the possibility of special nuclear material (SNM) dispersal.

Detonation is the response that impacts nuclear safety. Inadvertent nuclear yield should not be possible in modern weapons, so SNM dispersal is the critical nuclear safety improvement that IHE enables. SNM dispersal requires shock from explosive in direct contact, according to DOE-HDBK-3010-94 and NUREG/CR-6410. Absence of a detonation greatly reduces the likelihood of dispersal. A shock from any High Explosive violent reaction (HEVR) scenario, such as a violent deflagration, would be weak.

Prompt Shock-to-Detonation Transition (SDT) cannot be excluded under all conditions because an IHE shall detonate to function as designed. The threshold should be clearly defined because nuclear safety requires that we know the SDT characteristics of an explosive. It is also important to confirm that the SDT characteristics are reasonably consistent across the lifecycle temperature range. SDT insults are generated with a gas gun which develops a sustained, 1D, shock pulse. These 1D shock pulses do not have a system-relevant scale, so all IHE materials and subassemblies undergo the same test.

Deflagration-to-Detonation Transition (DDT) is the build-up of a burning reaction to a detonation. Ignition is a complex phenomenon governed by many competing processes. We assume ignition of a burning reaction in qualification testing since we cannot guarantee that ignition shall never occur in the various relevant hazard scenarios. Whether the ignited materials transition to a detonation is equally complex but is controlled by a few key variables, including the strength of confinement, charge size, and the state of the explosive. The DDT test is a large test with high confinement, and large margin. Deliberate ignition verifies DDT is not possible in the material in any scale relevant to a nuclear weapon. The inclusion of DDT testing eliminates the need for many standard ignition and reaction violence tests like ODTX, Susan, Spigot, Friction, Bonfire, and Slow Cookoff.

Unknown to Detonation Transition (XDT). In some hazard scenarios with detonable solid rocket motors, initiation has been observed under conditions that are insufficient to develop either an SDT or DDT initiation. This response mode is termed XDT, where “X” stands for the unknown transition to detonation. It is believed that the XDT mechanism is the result of a process that includes severe damage and break-up of a bare energetic material in an unconfined space, expansion of this damaged material, and subsequent re-compaction of damaged material to develop ignition or initiation. The process is known to be highly complex and geometry dependent. There are no credible threats to nuclear weapons that include a geometry that allows this process to progress. Also, the final stage of both DDT and XDT is facilitated by the same underlying mechanism, shock initiation of damaged explosives. If an HE passes a conservatively-designed DDT test, then we can be

confident that XDT is not a possibility under similar stimulus and geometry. Therefore, a test for XDT does not need to be included as a qualification test.

High explosive violent reaction (HEVR) is a commonly used term to describe an unacceptable level of reaction. There is, however, no clear definition, either theoretically or empirically, of HEVR. DOE Order 452.1E and the D&P Manual both refer to HEVR as "ranging from a fast deflagration of the high explosive up to and including a detonation of the high explosive". There is no threshold for what might constitute a fast deflagration. In other cases, including dispersal of material outside a facility perimeter, HEVR is essentially being defined in terms of causing a secondary effect rather than in terms of the phenomenon itself.

Without a clear or consistent definition, it is impossible to define one or more tests with meaningful criteria to evaluate the candidate explosive for its propensity to undergo HEVR. Hence the absence of that specific term in the definition of IHE. Historical IHE test definitions similarly did not exclude the possibility of HEVR in an IHE.

We can make some observations on the implications of the new definition to the potential for HEVR: the material properties that underlie DDT behavior also underlie HEVR responses, including the propensity for thermal ignition, deflagration rate, and shock sensitivity. Therefore, an explosive that meets the DDT criteria in the new definition is likely to be relatively benign in any HEVR.

DEFINITIONS

Scales conservative to a relevant nuclear weapon application: The scale of a given experiment is related to HE configuration in US nuclear weapons. This is related to the main charge with a margin of conservatism. The scale is not the same as classified scaled weapons experiments.

Scales conservative to its relevant application: The scale of a given experiment is related to the HE configuration and confinement of the given application. For example, a booster application has a shorter run length and lower confinement relative to a main charge.

REFERENCE DOCUMENTS

The following documents set forth some of the procedures to be referenced when planning the IHE and IHE subassembly testing required by Table 16.1 and Table 16.3:

- TB 700-2
- MHSMP-84-22 Rev.1
- UN ST/SG/AC.10/11/Rev.1
- LLNL-TR-679331, LA-UR-15-29238, 2015
- DOE HDBK-3010
- NUREG-1320
- JNWPS TP-20-7

17. LABORATORY OPERATIONS

17.1. Operational Requirements

17.1.1. Laboratory personnel shall conduct work involving explosives materials in accordance with approved operating procedures supported by documented hazard analysis.

17.1.2. The quantity of explosives present in a laboratory shall be the minimum required for the operations and should be at or below assigned limits.

17.1.3. Storage of explosives not in process is allowed provided the explosives are secured when the laboratory is unoccupied.

17.1.4. Explosives shall be configured to preclude exceeding the maximum credible event (MCE).

17.1.5. Open flames shall be prohibited in laboratories where explosives or flammable solvent vapors are or may be present unless allowed by an approved hazard analysis or procedure.

17.1.6. Disposal of explosives through laboratory drains shall be forbidden unless the drain plumbing has no traps and is designed to handle explosives (i.e., is provided with a sump or other device for the collection of solids).

Note 1: Even if a drain is designed to handle explosives, deliberate disposal of explosives in these drains should be avoided. These drains should be used only to clean up explosives spills.

Note 2: Special care should be exercised to prevent entrance of compounds into drains that may react with iron or rust to form sensitive salts (e.g., picrates and picric acid).

17.1.7. Suitable guards shall be provided for all glass or fragile equipment that shall withstand reduced or elevated pressure.

17.2. Blast Shields

17.2.1. If determined through a documented hazard analysis that a laboratory operation presents a credible risk of explosives initiation, controls shall be incorporated, such as the use of blast shields or performing the operation remotely. Table 17.1 lists shields that have been tested and found acceptable for the indicated quantities of explosive.

17.2.2. If an experiment poses a metal-fragment hazard (as opposed to a glass-fragment hazard) and the experiment cannot be conducted remotely, the proposed shield should be tested and approved under conditions simulating an explosion in the experimental setup but with at least 125% of the anticipated explosive content.

17.2.3. The shield shall be anchored to the hood frame or bench top when it is being used for protection against more than 0.16 oz (5 grams) of TNT equivalent.

Note: Shields listed in Table 17.1 were not tested for metal-fragment penetration (unless specifically indicated) and thus may not offer effective protection when the explosive is closely confined in a heavy-walled metal container (“heavy-walled” is defined here as wall thickness to diameter ratio greater than 0.01).

17.2.4. Other blast shields may be approved for use after successfully passing a test of 125% of the rated explosive charge.

17.2.5. For confined areas, a blast vent having less strength than the shield should be provided.

17.2.6. When explosives operations require personnel to reach around a shield to manipulate equipment, exposure shall be minimized.

Table 17.1 Blast Shields for Laboratory Operations

Shield	Minimum distance from explosive	Explosives limit
Leather gloves, jackets, or coats, and plastic face shields	----	**50 mg**
3 mm tempered glass	**8 cm**	**50 mg**
7 mm Lucite/equivalent material	**15 cm**	**2.5 g**
20 mm Lucite/equivalent material	**15 cm**	**10 g**
15 mm laminated resistant glass	**20 cm**	**20 g**
25.4 mm Lexan/Lexguard	**30 cm**	**50 g**
2 units each of **25.4 mm** plate glass laminated with **12.4 mm** polycarbonate with a **9.5 mm** air gap between units (glass sides facing the explosive)	**30 cm**	**50 g** (steel confined)

Note 1: Blast testing has shown that laminated tempered glass is superior to monolithic tempered glass, and polycarbonate is superior to acrylic plastics, such as Lucite. Laminated tempered glass is recommended instead of monolithic tempered glass and polycarbonate is recommended in lieu of acrylic.

Note 2: The shields are recommended to be of equal or greater thickness than those listed in the table.

Note 3: Proof testing is highly recommended.

Note 4: When designing and/or replacing a blast shield with a polycarbonate, it should be UV stabilized, treated for abrasion resistance, and have met Mil Spec P-46144C.

Note 5: When designing or replacing a blast shield with laminated glass, it should be coated with a 0.1 mm fragment-resistant film on the viewer's side to minimize spalling.

Note 6: The shield, shield frame, and anchoring system shall be designed to resist maximum credible overpressure and fragments.

17.3. Heating Operations

17.3.1. During synthesis, formulation, or experimental work, heat may be applied to initiate or maintain reaction, to increase solubility, etc.

17.3.2. Heat shall be applied indirectly using steam, a water bath, oil bath, or an approved laboratory electrical heating device such as a mantle.

17.3.3. Caution shall be exercised to verify that reactive material does not come in direct contact with the heating elements.

17.3.4. If an experiment requires a blast shield, any heating device shall be mounted so that temperature can be controlled from the operator side of the shield.

17.3.5. If an experiment requires a blast shield, any heating device should be mounted so it can be separated quickly from the reaction vessel without operator exposure.

Note: During design of the experiment, consideration should be given to providing emergency cooling for the reaction vessel or its contents.

17.3.6. Heating systems that are operated unattended shall have dual controls, an override shutoff, or some other protection against failure of the primary heating control.

17.3.6.1. Heating of explosives with devices without these controls shall be monitored at all times

Note: If the operator leaves for any reason, the heating device should be turned off.

17.3.7. Requirements in paragraph 17.3.6. may not apply to systems capable of totally containing the effects of an explosion.

17.3.8. Periodic checks should be made to verify that an experiment is proceeding satisfactorily and that the apparatus is not boiling dry, malfunctioning, etc.

17.3.9. In the case of remotely controlled operations, provisions shall be made for observation using mirrors, television monitors, etc.

17.4. **Laboratory Setups**

17.4.1. Equipment and apparatus shall be clean, in good condition, and in good working order.

17.4.2. All glassware and apparatus shall be inspected for cracks, defects, etc., before use.

17.4.3. Defective or damaged equipment shall be removed from service.

17.4.4. Setups shall be geometrically and structurally stable.

17.4.5. Work areas should be neat and uncluttered.

17.5. **Low Concentration of Explosives in Solution**

17.5.1. After explosives are in dilute solution (less than 25% explosives by weight), the primary hazard shall be considered as that associated with the solvent and not the explosive.

Note: Where supported by technical data and approved by the EDC, a solvent/ explosives solution greater than 25% may also be similarly classified.

17.5.2. If the explosive recrystallizes or precipitates out of solution, safety requirements for explosives shall apply.

17.6. **Explosives Sample Control**

17.6.1. Samples shall be delivered to a laboratory only at specific designated locations.

17.6.2. Each sample shall be properly identified and labeled.

17.6.3. Upon completion of required tests or analyses, the sample should be removed from the laboratory.

17.6.4. A safety information sheet should accompany all samples of new experimental explosive material submitted to a laboratory for analysis.

17.7. **De minimis or Residual Quantities**

17.7.1. Based on a total mass size less than the critical diameter, primary explosives 1 mg or less and secondary explosives 10 mg or less are considered non-detonable by abnormal stimuli or environment (see Paragraph 6.2.1). Locations with explosives in these quantities are therefore exempt from the following requirements.

- Electrical equipment requirements.
- Posting of fire symbol signs and placards.
- Quantity/distance requirements.
- Posting of explosives limits.
- Personnel Limits.

17.8. **Laboratory Wiring and Equipment**

17.8.1. Permanent wiring and equipment for existing laboratory areas are not required to meet the requirements of Chapter 36.

17.8.2. Process equipment used for synthesis, heating, drying, mechanical mixing, and blending shall be dual-rated (Class I, Division 1 and Class II, Division 1).

17.8.3. Weighing equipment shall be Class II, Division 1 or mechanical.

17.8.4. Synthesis, heating, drying, mechanical mixing, blending, and weighing operations shall be isolated from non-rated wiring, electrical equipment, and instrumentation in a manner that prevents dust or vapors reaching an ignition source.

17.8.5. When laboratory equipment cannot meet the requirements of Paragraphs 17.8.2, 17.8.3, and 17.8.4, apply Paragraphs 36.4.3 and 36.4.4.

18. INSPECTION

18.1. Inspections

18.1.1. Explosives shall be inspected to verify proper identification.

18.1.2. Incoming explosives raw materials shall be inspected for foreign bodies that could cause operating or safety problems in processing operations.

18.1.3. Pressed explosive billets shall be inspected for foreign bodies, voids, or cracks that could cause operating or safety problems in processing operations.

18.1.4. Explosives pieces and assemblies shall have their physical parameters measured where improper dimensions could cause safety problems in processing operations.

18.2. Inspection Methods

18.2.1. The following are examples of acceptable inspection methods:

- Screening
- Visual inspection
- Magnetic separation
- Radiography
- Chemical analysis
- Physical dimension

18.3. Equipment Inspection Design and Operation

18.3.1. Pinch points shall be eliminated or steps taken to preclude explosives contamination of pinch points.

18.3.2. Threaded fasteners or threads of measuring equipment shall be protected from explosives contamination.

18.3.3. Care shall be taken to prevent parts of the measuring or handling equipment from becoming loose and getting into the explosives.

18.3.4. Inspection fixtures shall be designed to secure the explosives piece or assembly effectively to prevent toppling, rolling, or dropping during measurement operations.

Note: This is especially critical if the explosives assembly is in motion (e.g., spinning, vibrating) during measurement.

19. EXPLOSIVES DEVELOPMENT AND FORMULATION SCALEUP

19.1. Contractor Explosives Development Committee (EDC)

19.1.1. A committee shall be established at each DOE/NNSA facility engaged in explosives development to be the approving authority for each phase of an explosives development program.

19.1.2. This committee is referred to in this Technical Standard as the EDC, but it may have a different name at each DOE/NNSA facility.

19.1.3. Individuals selected to serve on the EDC should have considerable experience in explosives handling, processing, chemistry, sensitivity and safety.

19.1.4. The EDC shall approve phase-by-phase, modified formulations and sensitivity data as follows:

19.1.4.1. Shall review and approve data generated in each phase of a development project that involves a new explosive or new explosive formulation before the next phase begins.

19.1.4.2. Shall review and approve compositional modifications to previously evaluated explosive formulations and may approve minor modifications to the explosives formulation for a given phase of development without requiring all of the developmental steps and tests.

19.1.4.3. May waive some developmental phase tests if comparable sensitivity data for the subject material are available from another source.

19.2. Development Process

19.2.1. All DOE/NNSA explosives handling facilities shall establish an administrative process that defines the basic steps for developing and evaluating new explosives and explosive formulations.

19.2.2. The process shall require that each development effort proceed in phases from small to large quantities. The quantities of materials that may be handled in each phase shall be limited as specified below in Table 19.1.

19.2.3. The EDC shall be responsible for establishing criteria for acceptable explosive behavior in each test of each phase of the explosives development process.

19.2.4. The development process should consist of three phases plus sensitivity and compatibility testing, when required.

Table 19.1 Scaleup Process Guidelines for New Explosives and Formulations

Quantity of New Material[a]	Recommended Data[a]	Data Desired	Additional Recommendations
Synthesis			
Specified by the lab performing the synthesis	Impact, friction, spark, thermal stability	Before using the new ingredient in a formulation	----
Formulation			
Compatibility Testing: 2 g	Thermal compatibility of new ingredient with other ingredients of formulation	Before proceeding to Phase I	Materials should be processed remotely
Phase I			
10 g	Impact, friction, thermal stability	Before non-remote processing and handling in Phase I or scaleup to Phase II	Materials should be processed remotely before passing sensitivity and stability tests
Phase II			
500 g[b]	Compatibility[c], impact, friction, spark, thermal stability, thermal characterization before elevated temperature pressing	[d, e]	[f]
Phase III			
Specified by EDC	Compatibility, high-speed machining, drop, skid	Before Phase III machining or handling of billets 7 kg or greater	Composition of formulation shall be fixed

a. Quantities and recommended data apply to both new formulations and explosive ingredients.
b. The EDC may allow more than 500 g in Phase II where larger quantities are needed for some tests.
c. Compatibility of explosives and formulations with materials contacting the explosives in test and production assemblies.
d. Before proceeding to Phase II if the composition of a formulation is modified so that the composition is no longer within the limits specified by the EDC.
e. Before proceeding to Phase III if:
   1. The formulation to be scaled up to Phase III differs from that tested in Phase I, or
   2. The explosive or formulation prepared for Phase II development is produced by techniques different from those used in Phase I.
f. Materials investigated in this phase should be produced by techniques similar to those that shall be used to produce larger batches in a subsequent phase.

19.3. Sensitivity Testing

19.3.1. Before mixing a new explosive with other materials, the sensitivity and stability of the explosive should be determined and should comply with the criteria set by the EDC. Recommended tests include the following:

- Drop-weight impact
- Friction

- Spark
- Thermal stability

Note: Thermal stability tests should include two or more of the following:
- Differential thermal analysis or differential scanning calorimetry
- Thermal gravimetric analysis
- Gas evolution rate at elevated temperature (chemical reactivity test, vacuum stability)
- Time-to-explosion analysis

19.4. **Compatibility Testing**

19.4.1. If a proposed formulation contains new ingredients (explosive or non-explosive), the new ingredients should be tested for compatibility with the other ingredients before preparing batches for Phase I testing.

19.4.2. Compatibility tests should include any of the stability tests listed under Paragraph 19.3.1.

19.4.3. No more than 2g of the new formulation should be prepared, handled, or stored before compatibility testing.

19.4.4. Formulations for compatibility testing should be processed remotely, whenever possible.

19.5. **Phase I—Preliminary Development**

19.5.1. Whenever possible, material should be processed remotely.

19.5.2. The total quantity of material that may be processed, handled, or stored at any one time in Phase I should not exceed 10g.

19.5.3. The new explosive or formulation should be subjected to sensitivity and stability tests.

Note 1: As a minimum, drop-weight impact, friction, spark sensitivity, and thermal stability tests should be performed.

Note 2: Thermal stability testing need not be performed here if one or more of the compatibility tests listed under Paragraph 19.3.1 have already been conducted on the new formulation.

19.5.4. If the new explosive or formulation has acceptable sensitivity and compatibility results, it may be scaled up to Phase II.

Note: The EDC may impose handling or processing restrictions or precautions on the material if its performance in any of the above tests is questionable.

19.5.5. After Phase I testing of a formulation is complete, the EDC shall define, on the basis of the test results, what variations in composition are permissible during Phase II development without retesting.

19.6. **Phase II—Experimental Characterization and Development**

19.6.1. The total quantity of materials processed or handled at any one time in Phase II should not exceed 500g.

Note: No limit exists on the quantity that may be stored, other than the storage facility limits for Group L explosives.

19.6.2. Materials investigated in Phase II should be produced by techniques similar to those that shall be used to produce larger batches in a subsequent scaleup phase.

19.6.3. A thermal characterization test and evaluation should be run before pressing the new material at elevated temperature.

19.6.4. The Phase I sensitivity and stability tests should be rerun in Phase II if any of the following conditions apply:

19.6.4.1. The formulation to be scaled up to Phase III differs from that tested in Phase I. In this case, testing should be completed before Phase III scaleup.

19.6.4.2. The explosive or formulation prepared for Phase II development is produced by techniques different than those used in Phase I.

Note: Testing should be completed before Phase III scaleup.

19.6.4.3. During Phase II, the composition of a formulation is modified to an extent that the composition is no longer within the limits specified by the EDC (see Paragraph 19.5.5). Testing should be completed before proceeding with Phase II.

19.6.4.4. The compatibility of explosives and formulations with materials contacting the explosives in test and production devices shall be evaluated before any such device is assembled.

Note: If compatibility testing is required, one or more of the tests listed under Paragraph 19.3.1 should be recommended.

19.7. **Phase III—Full-Scale Testing and Production Development**

19.7.1. The maximum quantity of materials processed or handled in Phase III shall be defined in the EDC grant of authorization to proceed with Phase III.

Note: No limit is imposed for storage facilities except the limits imposed by the QD tables.

19.7.2. All additional testing necessary to define storage compatibility grouping should be completed before committing bulk quantities of the material to storage (see Section 32.4).

19.7.3. During Phase III development, the composition of all formulations should be fixed.

19.7.4. Any new explosive material that is to be contact machined shall be subjected to a machining overtest.

Note: Reaction threshold should be determined if possible.

19.7.5. If billets of 7kg or greater are to be produced in Phase III, skid testing should be performed and EDC criteria for this test should be met.

19.7.6. Paragraph 19.6.4 should also apply to Phase III development.

20. SYNTHESIS AND FORMULATION

20.1. Synthesis

20.1.1. Synthesis operations are conducted both on laboratory and pilot scales. The EDC shall approve new operations and materials. In the laboratory, the new material shall initially be prepared on a small scale and characterized as to sensitivity, physical, and explosive properties. Also, the laboratory shall develop processing techniques for the material. If laboratory studies determine that the explosive is of continuing interest, it may be advanced to the Pilot Plant where processing techniques shall be refined and scaled up. The Pilot Plant shall produce sufficient material for larger scale physical, explosive, and sensitivity characterizations.

20.1.2. Laboratory Scale Synthesis

20.1.2.1. Before initiation of work, the subject matter expert who is directing or conducting the synthesis shall analyze each explosives or potential explosives experiment for the type and magnitude of hazards. They

shall be responsible for planning the proper selection of conditions, quantity of explosives, and safety devices to be employed.

20.1.2.2. Experiments should be designed to minimize the amount of explosives involved and to use the mildest conditions that yields the desired information.

20.1.2.3. New explosives materials shall be afforded extra protection against impact, pinching, friction, pressure, sparks, contamination, and deterioration.

Note: If it is necessary to subject explosives to any of these conditions, the operation shall be conducted remotely or adequate personnel shielding shall be provided.

20.1.3. Pilot or Processing Scale Synthesis

20.1.3.1. Alarms should be provided for coolant flow to the reactor, for reaction vessel agitation, and for reactor temperature. These alarms should be energized whenever coolant supply or agitation is critical to prevent a runaway reaction.

20.1.3.2. When agitation is critical, the reactor should be equipped with at least two sources of power to maintain agitation in the event of failure. For example, a reactor might employ an air or inert gas bubble tube as a backup for a mechanical agitator.

20.1.3.3. The reaction vessel should be equipped with an emergency system that automatically cools the vessel or opens or closes a vessel dump valve as required by the process.

Note: Contact operations should be conducted with a means to activate the emergency system manually.

20.1.3.4. An alarm or monitor should be provided for the critical exhaust ventilation system to warn operating personnel if airflow rates drop below a predetermined level.

20.1.3.5. Emergency plans shall be established for the synthesis area, specifying action to be taken in the event an alarm sounds.

20.1.3.6. Before operations begin, all equipment shall be set up and checked for proper function.

20.1.3.7. Prior to use with any hazardous material, new or infrequently used equipment shall be tested in a “dry run.”

20.1.3.8. Before starting any process operation, the transfer lines to be used should be properly labeled and their function specified in the operating procedure.

20.1.3.9. All control valves shall be correctly identified according to function.

20.1.3.10. Safety equipment and clothing shall be worn as defined in operating procedures.

20.1.3.11. Explosives warning signs shall be conspicuously displayed on any processing vessel in which explosive materials are to be left overnight.

20.1.3.12. All explosives synthesis process equipment shall be maintained routinely.

20.1.3.13. Equipment with defects that could affect safe operations shall be tagged to prevent its use until repairs are completed.

20.1.3.14. Transfer hoses and portable equipment not involved in the process shall be removed from the work area and stored in their proper places.

20.1.3.15. Agitator blades on reactors and mixers shall be inspected regularly for proper clearance to verify that there is no pinch point or metal to metal contact.

20.1.3.16. Any vessel that can be sealed and that can operate above atmospheric pressure shall be equipped with overpressure protection.

20.1.3.17. All closed vessels should be purged with inert gas before flammable liquids are introduced.

20..1.3.18. Inert gas pressure should be used to transfer flammable liquids when gravity flow or pumping is not practical.

20.2. **Formulation**

20.2.1. Formulation operations considered in this section involve combining compounds or mixtures when one or more of the ingredients are explosive.

20.2.2. Explosives should be loaded into mixers, mills, and deaerators as an operator attended, contact operation. However, the starting, operating, and stopping of such equipment with explosives present shall be accomplished remotely. As an exception, mixing type operations involving a low-energy transfer may be allowed as a contact operation (e.g., slurry coating and melt agitation).

20.2.3. Equipment used for explosives formulation shall be checked for proper operation before adding explosives.

20.2.4. Equipment shall be examined for proper clearances and for metal-to-metal rubbing of moving parts with the potential to contact explosives.

20.2.5. Bearings should be sealed to preclude explosives contamination.

20.2.6. Fast action deluge systems shall be considered for equipment (e.g., mixers, mills, and deaerators) used for easily ignitable explosives formulations.

20.2.7. Hot water, cold water, or steam may be applied to mixers and mills. Heating fluid temperatures shall not exceed known safe operating temperatures for the explosives involved. When roll milling, allowance shall also be made for viscous shear heating of the explosives in process. Heated systems shall comply with the requirements of Paragraphs 21.3.1 and 21.3.4.

20.2.8. Mixing

20.2.8.1. Mixer seals and gaskets shall be checked on a regular schedule and cleaned or replaced as required.

20.2.8.2. Checks should be made to verify that maximum particle sizes of ingredients or hard agglomerates of proposed mixes are less than the blade to blade or blade to bowl clearances.

20.2.8.3. Initial cleaning with solvents used for dissolving or suspending the explosives residues shall be done remotely (except for melt mix or slurry coating vessels).

20.2.8.4. Explosive powders and plastic bonded explosives formulations should be mixed wet in a contact operation. This can be accomplished if the wet mixture cannot be initiated with energy sources available, the viscosity is kept low, and the possibility of isolated portions of the mix becoming dry is precluded.

20.2.9. Ball or Jar Milling

20.2.9.1. Balls that are porous or contain cavities shall not be permitted in mills for grinding explosives.

20.2.9.2. Grinding media contaminated with explosives slurry shall be protected from excessive impact when emptying of the mill.

20.2.9.3. After grinding, a careful inspection shall be made to verify that the explosive is free of grinding media. Dispose of any explosives contaminated with broken media.

20.2.9.4. After separating the explosive, the grinding media shall be thoroughly cleaned and inspected before reuse or disposal.

20.2.10. Roll Milling

20.2.10.1. Positive stops should be installed on roll mills to prevent rolls from rubbing against each other.

20.2.10.2. Before starting a milling operation on a roll mill, the contact of the scraper blade with the roll should be adjusted to the minimum pressure necessary to perform the operation.

20.2.10.3. Roll gaps should be set as wide as possible while still allowing adequate working of the material. The minimum gap setting shall be 0.1 mm.

20.2.10.4. Roll rpm should be held at the minimum required to process the material adequately.

20.2.10.5. All roll mills that should be contact operated (e.g., with nonexplosive materials) shall be equipped with emergency stop devices (breaker bar or chain) within easy reach of the operator.

21. HEATING, DRYING, AND THERMAL CONDITIONING

21.1. Hazards of Heating Explosives

21.1.1. Elevated temperature may increase an explosive’s sensitivity to other stimuli such as impact, shock, friction and static electricity.

Note: A runaway chemical reaction may occur at or above the explosive’s critical temperature that can produce an explosion or fire.

21.1.2. Elevated temperature of an explosive in a sealed container may cause gas generation and pressure rupture of the containment even at temperatures below the critical temperature.

21.1.3. Chemically incompatible or reactive materials, which may be present as accidental contaminants, as components of the formulation, or in external contact with the explosive, may intensify the preceding dangers or cause them to occur at lower temperatures.

21.1.4. Non-uniform heating can cause excessively hot regions in the explosives. Causes may include inadequate agitation of fluid explosives, non-uniform heaters, and non-uniform heat conduction.

21.2. Critical Temperature and Thermal Analysis Methodology

21.2.1. Critical temperature is a system property that depends on a combination of the explosive's chemical decomposition reactions, its mass and shape, heat transfer and other thermal characteristics of the system, and the confinement or pressure of decomposition products, especially gases. Several different methods of thermal analysis may be used to determine or estimate the critical temperature. The process is typically quite complex because of the complexity of normally occurring chemical reactions.

21.2.2. For operational safety, a conservative estimate (i.e., lower limit) of the critical temperature for a heating operation shall be made (uncertainties of 18°F to 45°F (10°C to 25°C) being common).

Note: Analogy of one explosive or system to another similar system with a reliable thermal analysis should be used to determine safe heating temperatures and heating times (heating limits).

21.2.3. The differential thermal analysis (DTA), differential scanning calorimetry (DSC), or other comparable techniques may be used to measure the temperature of the onset of an exothermic reaction in an explosive. The test results may be used to rank the thermal stability of explosives and as part of a thermal analysis. Because of the complexity of chemical decomposition, however, the DTA/DSC exotherm has no systematic relationship to the critical temperature and is unreliable for estimating safe heating limits. Exotherm temperature is always considerably above critical temperature and usually increases with the heating rate of the test.

21.2.3.1. Where the DTA/DSC exotherm is specified as a standard for temperature control, the test heating rate shall not exceed 18°F (10°C) per minute.

21.2.3.2. DTA/DSC shall not be used as a sole means for establishing heating limits.

21.2.4. Each facility shall conduct or obtain thermal analysis of any explosives system before the explosive is heated in a contact operation or in association with hazardous radioactive materials as described in Section 29.4.

21.2.5. From this analysis, a heating limit for the explosives system shall be established which the EDC shall approve.

21.2.5.1. All factors in Sections 21.1 and 21.2 shall be considered.

21.2.5.2. Any significant change in the geometry or an increase in mass should be considered a new explosives system.

21.2.5.3. For a contact operation, the maximum temperature should be set at least 18°F (10°C) below the critical temperature.

21.2.5.4. For heating explosives in association with hazardous radioactive materials, the maximum temperature should be set at least 36°F (20°C) below the critical temperature.

21.2.5.5. Contractor Facility Management should approve heating to a temperature greater than the above specifications if a documented analysis of the explosive's thermal characteristics indicates that an acceptable time or temperature safety factor is still present for a specific operation.

21.2.5.6. These operations shall be conducted remotely.

21.2.6. Heating controls for each operation shall be established and specified in written operating procedures.

21.2.6.1. Specified conditions should be set at the lowest temperatures and heating times to do the job efficiently. Temperatures should not exceed the heating limit for the explosives system.

21.2.6.2. Factors to consider when establishing heating controls include:

- The heating limit and accuracy of the estimated critical temperature.
- Accuracy of the temperature control equipment.
  The likelihood of incompatible chemical contamination and other operational parameters.

21.3. **Heating and Drying Equipment**

21.3.1. Heat should be supplied by steam, hot water, friction air, electrically heated transfer fluid, or electrical resistance elements.

21.3.2. Redundant, automatic heat controls shall limit temperatures.

21.3.3. Explosives heated using electrical resistance elements shall be separated from electrical resistance elements to avoid any possible contact.

21.3.4. In systems heated by steam only, the requirements for redundant, automatic heat controls shall be satisfied if a pressure reducing valve, pressure relief valve, and thermostatic valve on the system control the steam pressure.

21.3.5. In electricity heated systems, a manual reset secondary over-temperature system consisting of a controller, failsafe sensor, and an interrupting device shall be provided to interrupt the heat supply source if the primary system fails.

21.3.5.1. The secondary interrupter shall be separate from the primary interrupter.

21.3.5.2. The upper limit of the primary controller is determined by the desired operating temperature limit.

21.3.5.3. The secondary (override) controller is set at a higher temperature but should not exceed the maximum temperature determined by the heating limit specified for the explosives system as determined in Paragraph 21.2.4.

21.3.6. Visual and/or audible alarms should be provided to alert operating personnel to abnormal temperature conditions.

21.3.6.1. The heating of explosives should be monitored at all times.

21.3.7. The air or gas used to condition exposed explosives shall not be recirculated if directly heated by electrical resistance elements.

21.3.8. Drying or heating ovens should be vented to a safe location outdoors. Water wash or filtration of the exhaust may be required.

21.3.8.1. If exhaust fans are used, they shall be interlocked with the heat source.

21.4. **Heating and Drying Operations**

21.4.1. Heating and drying shall be performed under the mildest set of conditions to accomplish the task safely and efficiently.

21.4.2. A thermal analysis shall be made and a written procedure prepared consistent with Section 21.2.

21.4.3. The operating procedure shall include controls on the mass and geometry (thickness of the layer) of the material that may be heated.

21.4.4. Except as described in Paragraph 21.4.5, drying shall be achieved by circulating a warm, dry gas—either air or inert—over or through the material.

21.4.5. Small samples may be dried by placement in desiccators or by subjecting them to vacuum.

21.4.5.1. Vacuum drying of larger items should be preceded by drying at atmospheric pressure to remove quantities of moisture or solvent before vacuum is applied to remove the final traces of moisture or solvent.

21.4.5.2. Explosives having a vapor pressure exceeding 0.013 Pa (1 x 104 mm Hg) at the drying temperature shall not be subjected to vacuum drying.

21.4.5.3. A cold trap shall be used for vacuum drying where the vapor pressure of the explosives is unknown.

21.4.6. A vapor air mixture within explosive concentration limits shall be avoided.

21.4.6.1. Such a vapor air mixture can be controlled by providing sufficient airflow to maintain a vapor concentration well below the lower flammability limit or by using an inert atmosphere.

21.4.6.2. For inert atmosphere, positive purge shall be used to preclude oxygen leakage into the unit.

21.4.6.3. If vapor concentrations approaching a flammable level are anticipated, they shall be monitored.

21.4.6.4. Airflow shall be controlled to prevent dusting.

21.4.7. When heating explosives whose vapor pressure may cause undesired condensation of explosives on equipment parts, heating shall be conducted in a manner to control condensation of the explosive material.

21.4.7.1. This control should be accomplished by heating the exhaust system or by circulating the air at a rate that shall keep the explosives concentration below the level at which condensation could occur.

21.4.8. The proper operation of heater controls shall be verified on a regular schedule established by Contractor Facility Management.

22. DRY SCREENING, BLENDING, AND MELTING

22.1. Dry Screening

22.1.1. Use of magnetic separators is often advisable to remove ferrous materials that may have passed through the screens.

22.1.2. Operations using mechanical screens shall be performed remotely.

22.1.3. Screening small samples may be performed as a contact operation in accordance with approved operating procedures.

22.1.4. Operating areas and equipment therein shall be cleaned frequently to avoid accumulation of explosives dust.

22.1.5. Operations and equipment shall be set up to minimize and control dust generation.

22.1.6. Equipment shall be designed and operations performed to avoid subjecting explosive materials to pinching, friction, or impact.

22.1.7. Precautions shall be taken to prevent metals from rubbing together when the screens vibrate.

22.1.8. Vibrating equipment shall be inspected frequently for developing cracks subject to contamination by explosives.

22.1.9. Equipment shall be electrically bonded and grounded. Resistance to ground shall be 10 ohms or less and shall be inspected as established by Contractor Facility Management.

22.1.10. Equipment used to transfer electrostatic sensitive explosives to or from screens shall be conductive and electrically bonded to the screen during transfer.

22.2. Blending

22.2.1. Dry blending of explosives shall be performed remotely.

22.2.2. Dry, hand blending of small samples may be performed as a contact operation in accordance with approved operating procedures.

22.2.3. Equipment should be designed and operations performed to minimize generation and dispersion of explosives dust.

22.2.4. Equipment shall be electrically bonded to provide a continuous path to ground.

22.2.4.1. Resistance to ground shall be 10 ohms or less and shall be inspected as established by Contractor Facility Management.

22.2.5. Equipment used to transfer electrostatic sensitive explosives to or from blenders shall be conductive and electrically bonded to the blender during transfer.

22.3. **Melting**

22.3.1. The heat for melting explosives shall be supplied by saturated steam, hot water, or another temperature controlled medium. The steam pressure shall be controlled in accordance with Paragraph 21.3.4.

22.3.2. Temperatures for contact melting of TNT based explosives (except those containing PETN (Pentaerythritol Tetranitrate), e.g., pentolite) and keeping them molten shall not exceed 249.8°F (121°C).

22.3.2.1. The temperature limit for TNT explosives containing PETN shall be 228.2°F (109°C).

22.3.3. Alarms shall be provided on the melt temperature and on melt kettle agitation when the operation shall be left unattended.

22.3.3.1. Alarms shall sound if the temperature exceeds the specifications of Paragraph 22.3.2 above, or if agitation ceases.

22.3.4. Provisions should be made for emergency emptying of melt kettles in the event of temperature control problems or power failures.

22.3.5. Feeding of the melt kettle and the melting operation shall be controlled or regulated to prevent the formation of large chunks of explosives.

22.3.6. Wherever possible, valves, piping, and threaded bolts and fasteners should be eliminated from melted explosives handling systems.

22.3.7. Melt kettles shall be constructed with corrosion resistant materials.

22.3.7.1. Construction shall not contain blind holes, threads, or cracks in areas exposed to melted explosives.

22.3.7.2. Welds shall be inspected and found free of cracks and porosity.

23. PRESSING AND EXTRUDING

23.1. Pressing

Note: Explosives pressing operations subject explosives to high pressures to achieve a physical change. Pressing of explosives formulations is done routinely to consolidate explosive materials into configurations required for test assemblies or weapon systems. Two common types of pressing operations commonly performed are isostatic/hydrostatic and punch and die. The following requirements apply to these types of pressing operations.

23.1.1. Explosives pressing operations shall be conducted remotely.

23.1.2. The correct functioning of press interlock systems shall be verified at intervals established by Contractor Facility Management.

23.1.3. Pressing mandrels, punches, and dies used in explosives operations shall be examined regularly during periods of use for evidence of structural failure.

23.1.3.1. Suitable nondestructive test methods shall be used to perform the examination.

23.1.3.2. Contractor Facility Management shall establish intervals between inspections for each tooling design before committing the tooling to use.

23.1.3.3. The inspection interval and updating should be based on experience with similar tooling designs and configurations.

23.1.4. All new or modified mandrels, punches, and dies shall be inspected before their first use.

23.1.4.1. At least one pressing cycle shall be completed with mock explosives before proceeding to explosives.

23.1.5. Pressure controllers and indicators shall be calibrated periodically to verify accurate control and monitoring of pressing operations.

23.1.6. Press parts that contact explosive materials shall be cleaned thoroughly to remove residual explosives before use with a different explosive formulation.

23.1.7. Temperature control for heated presses and dies shall comply with the requirements of Paragraphs 21.3.1 and 21.3.4.

23.1.8. All pressing assemblies shall be designed or procedural controls established to minimize or eliminate the extrusion of explosives between two mating metal surfaces during the pressing operation.

23.1.9. Operations with explosive powders should be performed in a manner that reduces the release of explosives dust and thereby reduces operator exposure and general room contamination.

23.1.9.1. For operations involving large amounts of powders, local exhaust ventilation with a dust collection system should be provided.

23.1.9.2. Respiratory protection to prevent inhalation of explosives dust may be required when adequate ventilation is not available.

23.1.10. Isostatic/Hydrostatic Pressing

23.1.10.1. Before an elastomeric container or mandrel constructed of a new material is introduced into a pressing operation (where it shall contact explosives), the material shall be evaluated for compatibility with the explosives.

23.1.10.2. All pressing vessels shall be examined for evidence of cracking or other signs of incipient structural failure at regular use intervals by suitable nondestructive test methods. Contractor Facility Management shall establish examination intervals.

23.1.10.3. Before large scale pressings of new explosives or explosives formulations, the materials shall be evaluated for thermal stability (see scaleup procedures in Chapter 19).

Note 1: “New explosives or explosives formulations” refer to those that are “new” to large scale pressing.

Note 2: Stability test results shall be used to assist in establishing safe pressing conditions for the specific pressing size.

23.1.10.4. For isostatic pressing, procedural controls shall be established to validate that:

- An acceptable vacuum can be obtained on the mandrel assembly to prevent adiabatic heating during pressing; and
- Air is bled out of the press before pressurization.

23.1.10.5. Consideration should be given to the use of fire resistant hydraulic fluids.

Note: New fluids shall be checked to verify compatibility with the explosives used.

23.1.11. Punch and Die Pressing

23.1.11.1. All pressing punches and dies shall be inspected visually for damage, deformation, and cleanliness before installation on a press.

Note: Any questionable condition shall be resolved before the pressing proceeds to verify that the operation's safety is not compromised.

23.1.11.2. All punches, dies, and press attachment fixtures shall be designed to minimize the possibility of the punch being misaligned with the die (resulting in gouging of a die surface during pressing).

Note: Press setup procedures shall provide for operator verification of proper alignment before pressing.

23.1.11.3. The responsible user of a gauging section capable of performing the necessary measurements shall control punches and dies.

Note: Punches and dies should be maintained in matched sets.

23.1.11.4. A group other than the user shall check critical punch and die dimensions before initial use and at suitable intervals thereafter.

Note: Suitable check intervals for each punch and die design should be determined as in Paragraph 23.1.4.

23.2. **Extruding**

23.2.1. Extrusion operations shall be conducted remotely.

23.2.2. Contact extrusion should be performed only when extruding nonexplosive or mock materials or when hand extruding small quantities with no metal to metal contact.

23.2.3. Precautions shall be taken to prevent personnel from being injured by the rupture of pressurized equipment.

23.2.4. The explosive shall be protected against extrusion beyond the tooling cavity.

23.2.5. Precautions shall be taken to prevent foreign material from entering the explosives.

23.2.6. New designs and significant design changes in equipment, tooling or components shall be tested by mock explosives extrusion before actual explosives extrusion.

23.2.7. Pressure controllers and indicators shall be calibrated periodically to validate that proper sealing and extrusion pressures are maintained.

23.2.8. Extrusion press parts shall be cleaned thoroughly of residual explosives remaining from the previous operation before the press is loaded with a different explosive formulation.

23.2.9. Hand loading of extrudable explosives is covered in Section 28.3.

24. MACHINING

24.1. Equipment Requirements

24.1.1. Interlocks shall be provided for wet machining operations to verify coolant flow before machine operation.

24.1.1.1. The coolant flow shall be monitored and the equipment automatically and safely shut down if loss of coolant flow is detected.

24.1.1.2. The coolant interlocks shall be protected from tampering and unauthorized disabling by physical means, or supervisory control.

24.1.2. The vacuum on vacuum chuck holding fixtures shall be monitored and interlocked with the equipment for automatic shutdown of machining in the event of vacuum loss.

24.1.3. Tool path controls (stops, limits, design patterns) shall be provided to prevent the unplanned travel path of a tool or work piece.

24.1.4. Positive means or secondary verification shall control and limit equipment speed and feed rates.

24.1.5. Pressure-relief devices should be installed on pneumatically or hydraulically powered equipment to provide for safe operation.

24.1.6. Metal chip waste from machining operations should be kept separate from explosives waste.

24.1.6.1. When this is not possible, mixed explosives and metal waste should be completely segregated from unmixed waste and held for separate disposal.

24.1.7. A cutting tool inspection and control program shall be established for explosives machining operations.

24.1.8. Dull or damaged tools shall not be used.

24.1.9. Consideration shall be given to additional safety control devices (e.g., design patterns, safety templates, chip thickness sensors, tool pressure sensors), depending on the type of machining operations, size of explosives pieces, types of explosives, and other factors.

24.1.10. The “machining over-test” shall be considered a testing operation (see Paragraph 24.4.13) and is exempt from equipment requirements.

24.2. **Contact or Remote Operations**

24.2.1. The following explosives may be contact machined if a compatible, nontoxic, noncombustible coolant is used. Explosives not listed below shall be machined remotely.

- Amatol
- Baratol
- Boracitol
- Explosive D
- Octol with no more than 75% HMX (Cyclotetramethylene Tetranitramine)
- Pentolite with no more than 50% PETN
- RDX/TNT compositions with no more than 75% RDX (Cyclotrimethylene Trinitramine). These compositions include Composition B, Composition B-3, and 75/25 Cyclotol
- TATB (Triamino Trinitrobenzene) and TATB compositions with an inert plastic binder
- TNT

24.2.2. Explosive assemblies composed of any combination of explosives listed in the Paragraph 24.2.1 and the following non-explosive materials may be contact machined if a compatible, nontoxic, noncombustible coolant is used.

- Foamed plastics
- Solid plastics
- Adhesives
- Amorphous graphite
- Calcium sulfate casting powder
- Explosives mockup

24.2.3. If an assembly contains an explosive not listed in Paragraph 24.2.1 or a nonexplosive material not listed in Paragraph 24.2.2, the assembly shall be machined remotely.

24.2.4. On any explosive, with certain exceptions for TATB and TATB/KEL-F (or equivalent) formulations and explosives machined by fluid jet (see Paragraph 24.2.6), the following operations shall be performed remotely:

- Drilling of holes smaller than 5cm in diameter (except for TATB and TATB/KEL-F (or equivalent) formulations, where drilling of holes smaller than 5 mm).
- Coring operations (except contact operations on those explosives listed in Paragraph 24.2.1, when the requirements of Section 24.6 are met and a coolant is used).
- Machining of any metal/explosives interface.
- Machining TATB and TATB/KEL-F (or equivalent) formulations subassemblies with HD 1.1 boosters installed.
- Machining of explosives in Phase II or earlier stage of scaleup (see Chapter 19).
- Dry machining

Note: TATB and TATB/Kel-F (or equivalent) formulations booster pellets may be contact machined provided a dust collection system is used.

24.2.5. Machining of primary explosives shall be avoided. Consider other methods, such as forming or pressing to final dimensions, to achieve the desired shape.

24.2.6. IHE, PBX 9404 (Plastic Bonded Explosive), and LX-10 may be contact machined by high-pressure fluid jet.

24.2.6.1. The fluid jet system pressure shall not exceed 20,000psig.

24.2.6.2. The velocity of the fluid jet shall not exceed 520m/sec (theoretical).

24.2.6.3. The jet nozzle orifice diameter shall not exceed 0.01in.

24.2.6.4. The system machining fluid shall be water and shall not contain any abrasives.

Note: See Chapter 25 for use of low-pressure fluids.

24.2.7. Concurrent contact machining operations in the same bay should not be permitted. However, concurrent TATB and TATB/KEL-F (or equivalent) formulations contact machining is permitted when other explosives are not present.

24.2.8. Provisions shall be made to monitor remote machining operations visually. Consideration should be given to video recording and audio monitoring.

24.3. Setup and Preparation Prior to Machining

24.3.1. Before setting up the explosive work piece, the equipment shall be checked for proper function and the absence of interference between stationary and moving parts.

24.3.2. An inert shape (e.g., wax, Lexan (polycarbonate), or mock explosive) should be used to test the equipment function of any operation using new tooling or new part programs.

24.3.3. The explosive component to be machined shall be inspected by radiography or other suitable nondestructive test methods for cracks, voids, and high-density foreign objects.

24.3.4. The explosive component shall be checked for proper size.

24.3.5. Caution shall be exercised during setup and adjustment to avoid pinching, dropping, crushing, or otherwise applying abnormal forces to explosives present.

24.3.6. Special care shall be given to mounting and centering a part on a vacuum chuck.

24.3.7. Special attention shall be given to the proper functioning of the vacuum system and its surface holding area.

24.3.8. Limits on machine speed, depth of cut, and feed rate shall be set before the machine is activated.

24.3.9. Interlocks shall be functional before the machine is used to machine explosives. They should be tested once per shift.

24.4. Operations Requirements

24.4.1. The minimum tool speed necessary for safe and efficient operation should be maintained. The following maximums shall apply:

- The relative velocity between the explosives surface and the cutting tool shall not exceed 65m/min;
- Work pieces or cutting tools shall not be rotated at speeds exceeding 525rpm; and
- The feed rate of the cutting tool or work piece shall not exceed 1mm per revolution.

24.4.2. The work piece, fixture, cutting tools, equipment, floor, troughs, drains, etc., should be cleaned frequently to prevent accumulation of explosive wastes.

24.4.3. Approved measures should be taken to prevent rust and minimize deterioration of precision surfaces.

24.4.4. All tools, equipment, fixtures, and parts should be cleaned before removal from the work area for storage.

24.4.5. Coolant shall be used to aid in removing heat and cutting waste for contact machining operations.

24.4.6. Coolant should be used for remote operations when practical.

24.4.7. Coolant should be used on explosives/inert assemblies.

24.4.8. When the explosives portion is included in the cut, coolant shall be used for contact machining.

24.4.9. Coolant is not required if the explosives portion of the assembly is contained (no bare explosives) and is not included in the cut, or the machining is conducted remotely.

24.4.10. Spray mist coolant may be used during machining of the explosive-containing assemblies if the explosives portion is not included in the cut.

24.4.11. All visible explosives shall be removed from the machine before maintenance or repairs.

24.4.12. No safeguards or interlocks shall be removed or made inoperative, except by authorized personnel.

24.4.13. Before submitting an explosive for contact machining approval, a machining over-test shall be conducted to identify the machinability and associated hazards.

24.4.13.1. Machining over-test should be performed in facilities set aside for this purpose.

24.4.13.2. Machining over-test shall be conducted remotely.

24.4.13.3. Operations performed during sample preparation may include gaging and assembly, but shall not include any contact cutting, scraping, or other material-removing operations on explosives specimens.

24.5. **Drilling**

24.5.1. Drilling operations should be set up to maximize the ease of achieving and maintaining proper alignment and to facilitate removal of explosives chips, fines, and powder.

24.5.2. The fluting length on the drill bit shall exceed the depth of the hole to be drilled by a minimum of 1.3cm or one-hole diameter, whichever is greater.

24.5.3. The depth of a hole shall not be extended more than 1.5 times the hole diameter (up to a maximum of 2cm) during a single insertion of the drill into the material.

Note: After each insertion, it may be advisable to withdraw the drill completely and remove loose explosives from the cavity and drill bit before reinserting.

24.5.4. Coolant flow (when used) shall be directed to the explosives/cutting edge interface.

24.5.5. Drill bits larger than 0.25in (6mm) should have a coolant channel to the tip of the drill.

Note: Bits 0.25in (6mm) or less in diameter do not need coolant channels, but should limit the depth of each pass to no more than ½ the diameter of the bit to verify that the coolant flow is capable of keeping the hole clean.

24.5.6. Pulsating pressure types of coolant supplies are recommended for drills of 0.25in (6 mm) diameter or less to remove drill fines.

24.6. **Coring**

Note: A machining operation that removes material in the form of a cylinder by cutting at the circumference to create a hole or recover the material from the center of the cut.

24.6.1. Coolant flow (when used) shall be directed at the explosives/cutting edge interface.

24.6.2. If the hole is not positioned to provide continuous breakout, the coring shall be accomplished incrementally.

24.6.3. When done in increments, no more than 1.5 times the diameter of the hole shall be cored at one time.

24.6.3.1. Before the maximum distance has been cored, the tool shall be totally retracted from the hole and cleaned.

24.6.3.2. The hole shall be flushed with coolant.

24.7. Sawing

24.7.1. The feed rate of the saw blade or work piece shall not exceed 7.5cm/min.

24.7.2. For band saws, coolant flow should be directed onto the saw blade at the cutting interface, guide rollers, and the drive wheel/saw blade interface.

24.7.3. For circular saws, the coolant flow should be directed at the explosives/cutting edge interface.

25. LOW PRESSURE FLUIDS

25.1. Use of Low Pressure Fluids

25.1.1. Low pressure fluids may be handled in explosives contact operations to aid in the following:

- Dissolution
- Rinsing
- Flushing, or
- Similar operations

25.1.2. The fluid system shall have a pressure relief device installed to prevent system over pressurization.

25.1.3. Low pressure fluid operations may be used with those explosives whose impact sensitivity is less than PETN.

Note: Such operations may be used on other explosives only after analyzing the energies involved.

25.1.4. Solvents shall be compatible with the explosive material.

Note: Controls for their use shall be specified in operating procedures.

26. LASER ABLATION

26.1. Laser Ablation Operations

26.1.1. Laser ablation shall be conducted as a Hazard Class 1 Level-of-Protection Activity.

26.1.2. During set-up, when personnel are exposed to the explosives hazard, the ablation laser beam shall not be able to reach the explosives or assembly containing explosives.

Note: Low-power alignment lasers may be used.

26.1.3. Before setting up the explosive work piece, the equipment shall be checked for proper function and the absence of interference between stationary and moving parts.

26.1.4. Caution shall be exercised during setup and adjustment to avoid pinching, dropping, crushing, or otherwise applying abnormal forces to explosives present.

26.1.5. Interlocks shall be functional before the laser is used to ablate explosives.

26.1.6. During laser ablation operations, the operator should be provided an immediate means to block the laser beam from reaching the explosives.

27. HAND CUTTING AND FINISHING

27.1. Hand-Cutting and Finishing Operations

27.1.1. Hand-cutting and finishing of explosive materials shall be performed using the mildest energy input that shall accomplish the task safely and efficiently.

27.1.2. These activities may include:

- Cutting
- Trimming
- Coring
- Lapping (surface polishing)

27.1.3. The Contractor EDC shall review and approve the safety of hand-cutting and finishing operations, which shall then be incorporated into an operating procedure before starting the operation.

28. ASSEMBLY AND DISASSEMBLY

28.1. Tools

28.1.1. Hand tools and electrical and pneumatic tools that may subject the explosives to abnormal frictional forces, pinching, or excessive pressure, or cause significant deformation, shall not be used during assembly or disassembly.

Note: Tools may be used on nonexplosive components.

28.2. Assembly Operations

28.2.1. Operators need to be alert for mismated parts and misaligned components during assembly operations.

28.2.2. Hard surfaces that contact explosives shall be precisely machined to mate with the explosives, lined with cushioning material, or otherwise configured to keep sharp corners or projections from being forced into explosives.

28.3. Loading Assemblies with Plastic or Extrudable Explosives

28.3.1. Contamination of these explosives with abrasive or foreign substances shall be avoided.

28.3.2. The assembly shall be loaded with small increments of explosives and may be tamped with suitable nonmetallic tools to eliminate air voids.

28.3.3. Plastic explosive compositions C-3 and C-4 may be softened by warming to between 69.8°F (21°C) and 100.4°F (38°C) before working.

28.3.4. Extrudable explosives LX-13 and XTX should be kept as cool as practical to prevent premature curing.

28.4. Disassembly Operations

28.4.1. Before beginning disassembly, the device’s condition shall be assessed to determine if it can be safely handled.

28.4.2. Disassembly operations shall be planned before actual disassembly. Possible problem areas caused by method of construction or physical condition shall be considered.

28.4.3. Approved operating procedures shall be used for each unique disassembly.

28.4.4. If disassembly would normally cause release of pressure or if a credible hazard exists of pressure causing components to fly apart, before beginning disassembly, pressurized units shall be thoroughly depressurized.

28.4.5. If approved for use, compressed air shall be applied cautiously during disassembly to avoid causing device components to fly apart.

28.4.5.1. This may require remote operation.

28.4.5.2. Use hydraulic pressure if possible.

28.5. Personnel Protection for Disassembly Operations

28.5.1. Operators and all other personnel shall be provided complete protection from disassembly operations involving conditions known or expected to require the use of abnormal force.

28.5.1.1. Such operations require either remote operation or the use of an operational shield.

28.5.2. When required, shielding shall be designed to protect personnel at other operations or locations from blast and fragments arising from a possible explosion.

28.5.3. When disassembly requires that the operator be protected by an operational shield, disassembly shall be defined as complete separation (threads or other connections) of component parts.

Note: For example, parts shall not be loosened or separated while the operator is unprotected.

29. TESTING

29.1. Test Planning

29.1.1. All explosives testing involving the intentional initiation of explosives materials or articles shall be considered Class 0 operations and shall comply with the requirements of Chapter 12 of this Technical Standard.

29.1.2. Proposed testing programs shall undergo a hazard analysis based upon the maximum credible event.

29.1.2.1. This shall be done with knowledge of the construction and operation of all standard and nonstandard equipment to be used, as well as the type of explosives involved.

29.1.3. Large-scale tests with the potential to propel fragments off DOE testing locations shall receive a formal risk analysis of the worst-case conditions for each test type.

29.1.3.1. Such analysis shall address the probability and potential severity of hazards with respect to injury and property damage.

29.2. **Firing Areas**

29.2.1. A secured firing area (danger zone) shall be established for each test to protect personnel from hazardous blast overpressure, firebrands (burning or hot fragment), fragments, or projectiles from an explosives shot or gun firing.

29.2.1.1. The danger zone shall be determined by the application of the principles outlined in DESR 6055.09.

29.2.2. Selected firing areas shall minimize the potential for secondary fires and adverse effects to the environment.

29.3. **Checkout of Dynamic Engineering Test Equipment for Explosive Assemblies**

29.3.1. To minimize the possibility of an incident during dynamic testing of explosive assemblies, load-bearing members of the test equipment or explosive assembly should be proof-tested and examined if:

29.3.1.1. The test equipment is new or has undergone a design modification;

29.3.1.2. Existing test equipment is to be used under unusually severe test conditions (i.e., conditions of velocity, vibration, pressure, load); or

29.3.1.3. A new or modified explosive assembly is to be tested that affects the loading characteristics of the equipment.

29.3.2. Proof-testing of the explosive assembly or test equipment should be conducted before running tests involving systems with explosives.

29.3.3. At a minimum, proof-testing should consist of the following sequence of checkouts:

29.3.3.1. Check out load-bearing members (lifting devices, hold-down mechanisms, fixtures, vehicle cases) to at least 125% of rated load using simulated loads.

29.3.3.2. “Dry run” tests of actual systems with mock materials in place of explosives and hazardous radioactive materials.

29.3.4. If a part failure occurs in either of the checkout tests in Paragraphs 29.3.3.1 or 29.3.3.2, tests involving explosives or radioactive material shall not be run until additional checkout tests have demonstrated that the cause of failure has been eliminated.

29.4. Testing of Explosives and Hazardous Radioactive Materials

29.4.1. Explosives and hazardous radioactive materials (e.g., plutonium, enriched uranium) shall not be included in the same test or operation if the test or operation is not contained and involves any of the following:

Note 1: Depleted uranium and natural thorium are not considered hazardous radioactive materials for this purpose.

Note 2: Nuclear Explosive Operations, covered by DOE Order 452.2 are exempted from this requirement.

29.4.1.1. Application of high-energy stimuli (e.g., high shock, impact, or friction levels) to the explosive.

29.4.1.2. Heating the explosive to within 18°F (10°C) of the heating limit determined for the explosive system without hazardous radioactive materials consistent with Paragraph 21.2.4.

29.4.1.3. Intimate contact of incompatible material with the explosive as determined by compatibility testing.

29.5. Heating of Explosives Test Specimens

29.5.1. Before heating an explosive, a thermal analysis shall be conducted and a written procedure prepared consistent with Section 21.1.

29.5.2. For requirements on heating equipment see Section 21.3.

29.5.3. Contact operations on explosives specimens undergoing thermal conditioning may be permitted if:

29.5.3.1. The specimen is not subjected to excessive friction, impact, or spark stimuli during normal operations or during a credible accident scenario.

29.5.3.2. The explosive involved has satisfied appropriate scale-up sensitivity and stability criteria (see Chapter 19) and has sufficient handling history to reveal any special characteristics affecting safe use.

29.5.4. If an explosives test specimen in a contact operation is discovered to have exceeded the established heating limit for the explosive system, the test shall be terminated and the specimen cooled to ambient temperature.

Note: An operating procedure should be prepared and approved for the required corrective action (i.e., disassembly or disposal).

29.6. **Instrumentation**

29.6.1. Instrumentation directly applied to explosives in a test specimen shall be physically disconnected, isolated, or grounded before personnel may enter the test cell.

29.6.1.1. Only instrumentation channels that contain devices that limit the current below the level capable of initiating the explosive are exempt.

29.6.2. Environmental control transducer leads, not attached to the test specimen and permanently installed in an approved control system, do not need to be grounded or disconnected.

29.7. **Explosives Accumulation Limits**

29.7.1. Explosives specimens shall not be permitted to accumulate in a test cell beyond the quantity required to sustain the test.

29.7.1.1. For short-term testing (less than one day), specimens present shall not exceed a 4-hr supply.

30. TEST FIRING

30.1. **General Range Standards**

30.1.1. Each DOE explosives test site shall establish procedures to verify that personnel are not exposed to firebrands (burning or hot fragment), fragments, or excessive blast overpressure from a test shot.

30.1.2. During test operations, personnel access to each test site shall be controlled.

30.1.2.1. Unattended roadblocks, gates, or doors used to prevent personnel from entering the danger zone during a test should be interlocked or locked with specially controlled keys.

Note: In locations where interlocks or locks are not practicable, appropriate barriers and signage may be applied.

30.1.3. Before test firing, all firing site personnel and visitors shall be accounted for and in a safe place.

30.1.4. A visual inspection of the danger zone shall be performed immediately before each test shot or series of shots as applicable, to verify that no transients are present.

30.1.5. The danger zone shall be free of service personnel (e.g., telephone repairmen, surveyors, road maintenance crews) during test operations.

30.1.6. The control point shall notify service personnel of the specific requirements under which they may safely work in the area when testing is not in progress.

30.1.7. The control point shall notify firing site personnel of the presence and location of service personnel in their areas.

30.1.8. Clearance for a test or test series shall be coordinated with all test sites and other areas that could be affected.

30.1.9. A warning shall be provided to every affected area to warn personnel of an impending test firing.

Note 1: This warning shall include standard audible signals.

Note 2: Detonation of very large explosive shots, numerous smaller shots, or gun firings could exceed the DOE allowable limits for impulse noise.

30.1.10. During test operations, all personnel assigned to the test area shall be continuously alert for movement of personnel, vehicles, and aircraft.

30.1.11. Test firings often create hazardous conditions for aircraft operating in the airspace near the danger zone. If this airspace is subject to air traffic, precautions shall be taken to verify that the airspace is clear of traffic at the time of firing.

30.1.12. Each firing site shall establish personnel limits based on the number of people actually needed to conduct an operation and the number of casuals that should be present. The responsible person at the firing site shall enforce these personnel limits.

30.1.13. Testing of explosives can result in personnel exposure to toxic decomposition products such as carbon monoxide, hydrogen chloride, hydrogen fluoride, hydrogen cyanide, and nitrogen oxides.

30.1.13.1. Allow the detonation cloud to disperse before leaving protective bunkers.

Note: Fragment-danger-zone distances are normally adequate to allow cloud dispersal and protect outside personnel from excessive exposure.

30.1.14. For testing that can result in abnormally long hazardous conditions following the test, the procedure shall require a suitable waiting period before personnel leave their shelter or safe haven area.

30.2. **Grass Fires**

30.2.1. Before conducting a test shot at an outside firing pad, an evaluation shall be made to determine the need to control grass fires that the test may initiate.

30.3. **Test Setup**

30.3.1. Test setup work should be done before receipt of explosives. When possible the following activities should be performed:

30.3.1.1. Firing site safety devices (at both the bunker and remote from the firing bunker) shall be checked as established by Contractor Facility Management.

Note: Safety devices include warning lights, door and gate firing circuit interlocks, emergency firing circuit cutoff switches, and grounding.

30.3.1.2. Firing pad and shot stand setup work that require power tools or other potential spark-producing devices should be completed.

Note: Special precautions and procedures shall be developed and implemented if power tools or other spark producing devices are needed after explosives are delivered to the firing pad.

30.3.1.3. The firing pad shall be cleared of all unnecessary equipment.

30.3.1.4. When possible, all diagnostic equipment shall be set up, checked, and tested in a “dry run.”

30.3.1.5. If a special structure is required, as much work as possible should be accomplished on the structure, including assembly of all materials.

30.4. **Pin Switches and Other Non-initiating Circuits**

30.4.1. Whenever pin switches and other non-initiating circuits are checked (such as for charging current or leakage) and are in contact with or in close proximity to explosives, the check should be performed remotely.

30.4.2. Other non-initiating electrical circuits include strain gauges, pressure transducers, thermocouples, etc., that may be affixed to or close to the explosives within an assembly.

30.4.2.1. A continuity-only (resistance) check may be accomplished as a contact operation with an electrical instrument approved for use with the particular explosive device.

30.4.3. When low-firing-current actuators are involved, consider conducting these tests remotely (see Section 37.4).

30.5. **Low-Energy Electro-explosive Devices**

30.5.1. Procedures shall be established to verify that Radio Frequency (RF), Frequency Modulation (FM), and television transmitters with sufficient output energy to initiate an electro-explosive devices (EED) at the test site are either restricted to a safe distance from the site or not operated.

30.5.2. Appropriate separation distances from Electromagnetic Radiation (EMR) transmitters shall be determined per Paragraph 38.1.3.

30.5.3. Low-firing-current igniters or detonators shall be kept separate from explosives at all times, except during actual test charge assembly and setup.

30.5.4. At all times, wiring systems for the explosive charge and any low-firing-current initiators shall be kept insulated from all sources of extraneous current unless the weapon components have an exposed electrical ground by design.

30.5.5. Connections made using weapon wiring connectors or cables are acceptable without further modification.

30.5.6. Shunts shall be left on low-energy initiators or lead wires until connections are made.

30.5.7. Connections shall be taped or otherwise insulated.

30.5.8. Test units containing low-firing-current actuators or detonators shall be clearly marked.

30.5.8.1. No contact operations involving electrical testing shall be permitted on this type of unit unless an electrical meter for the specific application is used.

30.6. **Explosives Storage in Firing Areas**

30.6.1. Explosives or ammunition storage at a firing area shall be located such that ignition, explosion, or detonation is improbable if a fire, unplanned explosion, or detonation occurs in the area.

30.6.2. Tests that require storage of explosives or ammunition at the firing site beyond a day's event shall conform to the requirements of Chapter 32.

30.7. **Firing Leads**

30.7.1. All detonator lead wires shall be electrically insulated.

30.7.2. During setup on the firing point, firing leads or cables of low-energy detonators for explosive assemblies shall be kept shorted.

30.8. **Unattended Test Assemblies (during off-shift hours, when necessary)**

30.8.1. If explosives are present, appropriate safety warning signs shall be displayed at all entrances to the firing pad.

30.8.2. Protective services and fire department personnel shall be notified of the explosives location.

30.8.3. This location shall be in a controlled-access or secured area.

30.8.4. If low-energy detonators are present on the assembly, their leads or cables shall be shorted.

30.9. **Firing Control Circuit Criteria**

30.9.1. The criteria in this section apply to electrical circuits used to initiate EEDs used for test firing.

Note 1: These criteria apply regardless of whether the circuit is energized using an internal or external power source.

Note 2: A Firing Circuit shall be treated as capable of firing without warning as soon as it is coupled to an EED.

Note 3: A Firing Circuit that is connected to explosives shall not be armed during contact operations.

30.9.2. Firing Control Circuits shall be documented, reviewed, and approved for safety and operational control purposes.

30.9.2.1. Documentation shall include complete wiring diagrams, electrical schematics, and cable function lists.

30.9.3. All Firing Control Circuits, including changes and modifications, shall be reviewed for safety and compliance with Section 30.9, and approved by Contractor Facility Management prior to use with explosives.

30.9.4. Firing Control Circuits not meeting the safety criteria of Section 30.9 may be used with explosives only if equivalent safety is provided as determined by a documented analysis reviewed by the Contractor Explosives Safety AHJ, and approved by Contractor Facility Management.

30.9.5. Firing Control Circuits shall include both an arm and a fire control.

30.9.5.1. For low-energy EEDs, the safe mode of the arming circuit shall interrupt the firing circuit, short-circuit the EED terminals, and should ground the EED terminals.

Note: Manual shorting and grounding is permitted.

30.9.6. Each Firing Control Circuit shall include an interlock device which prevents unauthorized or inadvertent energization of a firing circuit.

30.9.6.1. The interlock device shall be unique for its application.

30.9.6.2. If key-operated controls are used, they shall be designed to lock in the safe (Off) position when the control key is removed.

30.9.6.3. Duplicate keys, safety plugs, or other interlock devices shall not be permitted in any single test area.

30.9.6.4. During shot preparation, the key, safety plug, or other interlock device, whichever is used, shall be in the control of the lead operator at all times.

30.9.7. Each Firing Control Circuit shall be isolated from all other circuits so as to prevent inadvertent energization by other circuits.

30.9.8. Firing Control Circuits shall be failsafe. Failure of any single component shall not result in inadvertent initiation of the EED prior to arming.

30.9.9. Firing Control Circuits shall be marked clearly or otherwise distinctively identified.

30.9.10. Developmental and/or Self-Contained Firing Circuits designed to initiate EEDs shall meet the requirements of Section 30.9 before being used with explosives.

30.10 **Test Firing in Containment Apparatus (Tanks, Chambers, or Vessels)**

30.10.1. Explosives may be detonated in containment apparatus.

30.10.2. All containment components shall be capable of withstanding and confining the effects of the explosion.

30.10.3. When new firing containment apparatus are designed and put into service, a safety factor to their operational explosives weight limit shall be included during certification testing.

30.10.3.1. This over-test load should be based on a percentage of the operational explosives weight limit.

Note: For example, a certification test should be performed with an appropriate explosive material weighing at least 125% TNT equivalency of the intended operating limit.

30.10.4. The firing circuit should be interlocked with the containment apparatus access door latch so that the door shall be closed and latched before the explosive can be fired.

30.10.5. Qualified engineering personnel shall periodically inspect the containment apparatus to verify that its structural integrity is maintained after repeated detonations.

30.10.6. Test firing is often conducted inside large containment apparatus that allow personnel entry but provide a confined working space and limited egress.

30.10.6.1. The operating procedure shall include requirements for ventilating and evaluating the containment apparatus' atmosphere before personnel entry.

30.11. **Gun Firings**

30.11.1. The gun shall be rigidly mounted so that the impact area is defined and controlled.

30.11.2. The target shall have an adequate backstop.

30.11.3. Provision should be made to remotely move the gun, remotely remove the propellant charge, or remove the explosives from the line of fire if the gun misfires, unless the hazardous effects of an accidental detonation of the explosive target is contained or effectively shielded from personnel.

30.11.4. Provisions shall be made to collect and remove undetonated explosives from the chamber or area.

30.11.5. Work, adjustment, or observation shall not be permitted on a gun while a live round is in the firing chamber. The only exception is to check azimuth and elevation.

30.11.6. Precautions shall be taken to protect personnel or equipment against hazards resulting from errors in assembly or preparation of equipment and ammunition. In particular, the following areas shall be checked:

- Fluid level of hydraulic recoil mechanisms.
- Function of the firing mechanisms.
- Absence of obstructions in the bore.

30.11.7. Firing mechanisms, particularly electric firing mechanisms, shall be tested before use to verify that merely inserting a round or closing of the breech does not result in firing.

30.11.8. Test weapons other than manually-fired small arms should be equipped for remote control of the safety and for remote cocking.

Note: The safety shall not be advanced to the fire position and the weapon shall not be cocked until all personnel are in a safe location.

30.11.9. When using hydrogen gas to fire a light gas gun, the operation shall be remote while hydrogen is present in the gun pressure tanks or in the gun barrel and catch tank after firing.

30.11.9.1. The hydrogen shall be purged from the entire system with inert gas and the atmosphere checked before personnel are allowed to reenter the gun bay.

30.12. **Drop Testing**

30.12.1. After an explosives drop test, personnel shall wait a minimum of 5 minutes before leaving the control bunker to inspect the test pad.

30.12.1.1. If smoke or flame is observed at the drop test area, entry shall not be permitted until at least 30 minutes after all visual signs have disappeared.

30.13. **Post-firing Controls**

30.13.1. If the firing appears to be normal, test personnel shall remain in the protective shelter for a suitable waiting period.

30.13.1.1. The test procedure shall specify the waiting period, which shall be sufficient to verify adequate dissipation of smoke and dust.

Note: In some cases, developing and analyzing the diagnostic film for misfires may be helpful.

30.13.2. During the waiting period, all power to the firing units shall be turned off or disconnected.

30.13.2.1. Whenever possible, detonator cables should be disconnected from the firing units and shunted and grounded, and the firing unit capacitor grounded.

30.13.3. After the waiting period, one qualified person (or more, when required by a documented hazard analysis) shall physically inspect the firing pad to determine the results of the shot before other personnel leave the shelter.

30.13.3.1. When a partial detonation or a test misfire occurs or is suspected, the firing area shall be inspected for unreacted explosives (see Chapter 31).

30.13.3.2. If the inspection confirms that safe conditions exist, the lead person shall signal “all clear.”

30.13.4. Recovered explosives from a destructive test shall be placed in an explosives storage magazine as Storage Compatibility Group L unless a documented analysis determines that the explosives do not present a special risk.

30.14. **Contamination of Firing Areas**

30.14.1. A contamination zone for each firing area shall be established and permanently documented.

30.14.2. Personnel access to explosives-contaminated areas shall be controlled.

Note: Unless determined unnecessary, through documented analysis reviewed by the Contractor Explosives Safety AHJ and approved by Contractor Facility Management.

30.14.3. Service personnel shall not work in the area without the permission of testing-area management and only when supervised by a management-approved person.

Note: Unless determined unnecessary, through documented analysis reviewed by the Contractor Explosives Safety AHJ and approved by Contractor Facility Management.

31. TEST FAILURES AND MISFIRES

31.1. **Explosives Misfire**

31.1.1. If no audible detonation is heard after once pulsing the firing circuit, the firing circuitry and detonators may be checked for continuity. These checks shall be accomplished from within the control bunker or from a protected location. If the firing circuits and detonators appear operative, additional attempts to fire may be made.

31.1.2. If the shot still does not fire, the following precautions shall be taken:

31.1.2.1. Disconnect and de-energize all electrical power sources connected to the shot.

31.1.2.2. Verify that all personnel in the danger zone are aware of the misfire and that they shall remain under cover until released.

31.1.2.3. Before personnel are permitted to leave the cover of the bunker, a pre-established waiting period shall be observed.

Note: A minimum 30 minute waiting period is advised.

31.1.2.4. A carefully prepared review of the situation should be initiated in consultation with another knowledgeable person.

31.1.2.5. After an agreement has been reached and before other personnel are permitted to leave the cover of the bunker, one qualified person should carefully approach and examine the setup to verify that it is safe.

31.2. **Misfire of a Remotely Fired Gun**

31.2.1. When a misfire occurs, several more attempts to fire the gun may be made. If subsequent attempts are also unsuccessful, the following precautions should be taken:

31.2.1.1. Disconnect all electrical circuitry to the gun so the firing system cannot be energized.

31.2.1.2. Before approaching a light-gas-driven gun, verify that it is in a safe condition by venting all pressure in the gun breech.

31.2.1.3. To reduce the risk of a gas explosion if the driving gas is flammable, the gun breech shall be purged with inert gas after venting.

31.2.1.4. A minimum waiting period of 10 minutes shall be observed before permitting personnel to approach to the gun.

31.2.1.5. When approaching the gun, if there is any indication that powder is burning, personnel shall return to a safe area and observe an additional waiting period of at least 20 minutes.

31.2.1.6. The gun shall not be approached within the known recoil distance behind the breech or from the front. Approach to and work on the gun shall be from the sides.

31.2.1.7. For separate loading guns (i.e., propellant charge is loaded separate from projectiles), the propellant igniter shall be disconnected from the firing mechanism and removed from the gun before any other gun operations.

31.2.1.8. If possible, the powder chamber of the gun shall be checked for the presence of pressure and vented to the atmosphere before opening the chamber.

31.2.2. If an unforeseen failure situation arises (e.g., the explosive projectile is stuck in the bore), an emergency procedure shall be prepared and followed to resolve the situation.

32. EXPLOSIVES STORAGE

32.1. Storage Magazine Facilities

32.1.1. Permanent Facilities and Portable Magazines

32.1.1.1. New permanent explosives facilities shall comply with UFC 3-340-02, *Unified Facilities Criteria*.

Note: DOE/TIC-11268 may be used as supplemental guidance.

32.1.1.2. Legacy facilities with an approved QD site plan may continue to be used as explosives facilities (see Chapter 11).

32.1.1.3. Portable magazines should be ventilated and resistant to water, fire and theft. They may be made of any material that meets these requirements.

Note: Portable facilities that comply with 27 CFR Part 555.203, 27 CFR Part 555.207, 27 CFR Part 555.208, 27 CFR Part 555.209, 27 CFR Part 555.210, or 27 CFR Part 555.211 meet these requirements.

32.1.1.4. Portable magazines shall be sited per DESR 6055.09 as above ground magazines.

32.1.2. Placards shall be posted on or near each magazine door, specifying explosive and personnel limits and general safety precautions that should be observed during work in the magazine.

32.1.3. Vegetation around storage magazines should be controlled to minimize potential damage to the magazine (Section 40.1).

32.1.4. At least two fire extinguishers, minimum rating 2A-10BC should be provided for immediate use by personnel working around a magazine.

32.1.5. Rated telephone or other emergency communication equipment should be provided in magazine storage areas.

32.1.6. All communication equipment located outdoors should be protected from the weather.

32.1.7. Temperature control.

32.1.7.1. In general, storage magazines should not be heated unless heating is necessary to prevent damage caused by sudden temperature changes or when dimensional changes of components are undesirable.

32.1.7.2. Magazines requiring heat should be heated with steam, hot water, or electrically heated hot water.

32.1.7.3. Magazines with temperature control requirements, may require both heating and air conditioning.

32.1.7.4. Electrical systems with forced air through ducts may be allowed if the systems are located exterior to any explosive hazard.

32.1.7.5. Heating coils shall be arranged so that explosives material cannot come into contact with the coils. They shall be equipped with covers designed to prevent storage of materials on top of the coils.

32.1.7.6. Maximum and minimum temperature monitors should be provided in all heated magazines.

32.2. **Storage Magazine Operations**

32.2.1. Explosives items shall be properly packaged and stored in either DOT-approved manufacturers' containers/packages or in approved onsite containers (see Section 32.5).

32.2.2. Explosives may be stored on magazine shelves.

32.2.2.1. The bottom of the container should not be more than 2m off the floor, except as permitted by Section 32.2.3.

32.2.3. Explosives and explosives containers in storage shall be positioned safely and securely. If explosives containers are stacked, they shall be placed in stable arrays.

32.2.4. Load limits shall be established for shelving in magazines.

32.2.4.1. If overloading is possible, the loading conditions shall be posted.

32.2.5. Materials shall not be left suspended by booms, cranes, or hoists in any explosives storage facility.

32.2.6. Stacks of explosives should be arranged so that air freely circulates to all parts of the stack.

32.2.6.1. To prevent moisture accumulation, pallets or appropriate dunnage should be used so containers are not stacked directly on the magazine floor.

32.2.7. Aisles shall be wide enough to accommodate inspection, inventory, sampling, and materials handling operations of the stored explosives containers.

32.2.8. Crews shall not be permitted to work in a position that requires passing the work aisle or the position of a second crew to reach the exit.

32.2.9. Each crew working in a magazine shall have their own exit route that does not interfere with exit routes for other crews (see Chapter 41).

32.2.10. Magazines shall be locked at all times except when permissible operations are in progress or when opened for ventilation.

32.2.11. Personnel shall be present while the magazine is open for ventilation.

32.2.12. All exit doors shall be unlocked and open when personnel are working in the magazine.

32.2.13. Each magazine shall be inventoried at least annually to determine the total weight of explosives present.

Note: For the purpose of inventories, “annually” refers to the one-year anniversary of the last inventory or inspection plus or minus 30 days.

32.2.13.1. Materials that are not properly identified or labeled shall be dispositioned.

32.2.14. The liquid level in storage containers for wetted explosives shall be checked and replenished as necessary at least once a year.

32.2.14.1. A log of the checks shall be maintained.

32.2.15. Empty containers, tools, conveyors, lift trucks, skids, etc., should not be stored in a magazine containing explosives.

32.2.16. Combustible materials such as excess dunnage, packing material, and boxes shall not be stored in a magazine containing explosives.

32.2.17. Flammable liquids shall not be stored or used in explosives magazines unless the liquid is an explosive, is needed as an explosives-wetting agent, or is an integral part of an explosives device.

32.2.18. Explosives-handling operations shall not be performed when magazine entranceways are icy or do not provide adequate footing for any other reason.

32.2.19. Operations involving hazardous materials shall not be permitted in any magazine with the following exceptions:

32.2.19.1. Those operations incident to storage or removal from storage.

32.2.19.2. Inspection and surveillance sampling of compatibility Group D materials, and Group C materials consisting of bulk propellants and IHE, provided that each storage container sampled is in good condition (i.e., the container is not leaking, no evidence exists of explosives contamination at the closure or of seal failure, and the closure is mechanically sound and free of excessive corrosion).

32.2.19.3. Only one container of explosives shall be opened at one time in a magazine.

32.2.19.4. Adding liquid to adjust the liquid composition level in which a Group D explosive is stored (water and alcohol mixtures may be used). If only water is added to the explosive, the water should be distilled or de-ionized (bacteria present in untreated water may produce gas during storage).

32.3. Storage Review Program

32.3.1. Contractor Facility Management shall establish a program to review stored explosive materials. Explosives may degrade during prolonged storage, increasing the hazards of handling or use.

Note: An example storage review program is provided in Attachment A of this chapter.

32.4. Storage Compatibility

32.4.1. Explosives shall not be stored with materials or items that increase the risk of initiation or decomposition.

Note: Examples are mixed storage of explosives with flammable or combustible materials, acids, or corrosives.

32.4.2. Different types of explosives may be stored in the same magazine if they are compatible.

32.4.2.1. Explosives shall be assigned to a storage compatibility group (SCG) when they can be stored together without significantly increasing either the probability of an accident or, for a given quantity of explosive, the magnitude of such an accident.

32.4.3. Each type of explosive shall be assigned to an appropriate SCG (A through G, L, and S) for the purpose of storage at DOE facilities. The groups are defined in the following sections.

Note 1: These definitions and Table 32.1 are in accordance with the principles and tables in DESR 6055.09.

Note 2: Table 32.1 presents some examples of commonly used materials that are assigned to each storage compatibility group. This list does not enumerate all materials that may be included in each group.

32.4.3.1. Group A: Initiating explosives. Bulk initiating explosives that have the necessary sensitivity to friction, heat, or shock to make them suitable for use as initiating elements in an explosives train.

Note: Examples are lead azide, lead styphnate, mercury fulminate, and tetracene.

32.4.3.2. Group B: Detonators and similar initiating devices not containing two or more independent safety features. Items containing initiating explosives that are designed to initiate or continue the functioning of an explosives train.

Note: Examples are detonators (all types, excluding Exploding Bridge Wires (EBW) and slappers), blasting caps, small arms primers, and fuses.

32.4.3.3. Group C: Bulk propellants, propellant charges, and devices containing propellant with or without their own means of initiation. Items that shall deflagrate, explode, or detonate upon initiation.

Note: Examples are single-, double-, triple-base, and composite propellants, rocket motors (solid propellant), and ammunition with inert projectiles.

32.4.3.4. Group D: High explosives (HE) and devices containing explosives without their own means of initiation and without a propelling charge, or articles containing a primary explosives substance and containing two or more effective protective features.

Note: Example includes explosives and ammunition that can be expected to explode or detonate when any given item or component thereof is initiated.

32.4.3.5. Group E: Explosives devices without their own means of initiation and with propelling charge (other than one containing a flammable or hypergolic liquid).

Note: Examples are artillery ammunition and rockets.

32.4.3.6. Group F: Explosives devices with their own means of initiation and with or without propelling charge.

Note: Examples are offensive and fragmentation grenades.

32.4.3.7. Group G: Pyrotechnic materials and devices containing pyrotechnic materials.

Note: Examples are devices that, when functioning, result in an incendiary, illumination, lachrymatory, smoke, or sound effect.

32.4.3.8. Group H: Ammunition containing both explosives and White Phosphorus or other pyrophoric material. Ammunition in this group contains fillers, which are spontaneously flammable when exposed to the atmosphere.

Note: Examples are White Phosphorus, Plasticized White Phosphorus (PWP), or other ammunition containing pyrophoric material.

32.4.3.9. Group J: Ammunition containing both explosives and flammable liquids or gels. Ammunition in this group contains flammable liquids or gels other than those that are spontaneously flammable when exposed to water or the atmosphere.

Note: Examples are liquid or gel filled incendiary ammunition, fuel-air explosive (FAE) devices, flammable liquid fueled missiles, and torpedoes.

32.4.3.10. Group K: Ammunition containing both explosives and toxic chemical agents. Ammunition in this group contains chemicals specifically designed for incapacitating effects more severe than lachrymation.

Note: Examples are artillery or mortar ammunition (fuzed or unfuzed), grenades, and rockets or bombs filled with a lethal or incapacitating chemical agent.

32.4.3.11. Group L: Explosives or ammunition not included in other compatibility groups that present a special risk, requiring isolation of each type. This group shall include explosives or ammunition having characteristics that do not permit storage with other similar or dissimilar materials.

Note 1: Examples are damaged explosives; suspect explosives; and explosives, explosive devices, or containers that have undergone severe testing unless documented determination is made that these items do not present a special risk; fuel/air explosive devices, and water-activated devices.

Note 2: Also included are experimental explosives, explosives of temporary interest, newly synthesized compounds, new mixtures, and salvaged explosives until they have been established to be compatible with the original materials. Types presenting similar hazards may be stored together.

32.4.3.12. Group N: HD 1.6 ammunition containing only extremely insensitive detonating substances (EIDS).

Note: Examples are IHE missiles and bombs.

32.4.3.13. Group S: Explosives, explosive devices, or ammunition presenting no significant hazard. Explosives or ammunition so designed or packed that when in storage any hazardous effects from accidental functioning are limited to the extent that they do not significantly hinder firefighting.

Note: Examples include explosive switches or valves and small arms ammunition.

32.4.4. Mixing of storage compatibility groups may be permitted as indicated in Table 32.2.

32.4.4.1. When using the “Z” mixing authorized by Table 32.2, items shall be stored in approved containers and the net quantity of explosives for that location shall not exceed 1,000 lbs.

32.4.4.2. SCG B and SCG F articles shall be segregated in storage from those of other compatibility groups by means that shall prevent propagation of those articles.

32.4.5. Newly synthesized compounds and mixtures shall be stored in Group L storage facilities. After a complete evaluation, the EDC shall assign those compounds or mixtures of continuing interest (see Section 19.1) to the appropriate compatibility group, and stored according to the following considerations:

32.4.5.1. The material’s sensitivity to initiating stimuli (e.g., friction, impact, spark, shock, and thermal) is similar to that of other explosives in the group.

32.4.5.2. The material's reactions and the effects of these reactions, in the event of application of initiating stimuli, are similar to other members of the group.

32.4.5.3. The material is chemically compatible with other materials in the group. Sensitivity and compatibility testing is described in Sections 19.3 and 19.4.

32.4.6. The material shall be stored in separate cubicles in one of the following categories:

- High explosives
- Propellants
- Detonators, actuators, and similar devices
- Primary and static-sensitive explosives

Note: As an alternate to Table 32.1 and Table 32.2, samples of explosives up to 4.4 lbs. total may be stored in the same cubicle if the cubicle walls are designed to prevent propagation.

32.5. Onsite Containers

32.5.1. Explosives containers used for handling, transportation (including transportation to disposal sites), and storage shall be designed and constructed to prevent:

- Leakage or spills
- Excessive movement of contents
- Effects of external stimuli
- Contamination

32.5.2. When screw-type closures are used, the ingress of explosive substances into the threading shall be prevented.

32.5.3. Explosives containers should be constructed of, or lined with, nonabsorbent materials that are compatible with the explosive contents.

32.5.4. Use of glass containers is discouraged, except for small samples, and shall be used only when the explosive reacts with other materials or when a high degree of purity is required.

32.5.5. Metal containers for materials that are potential dust producers shall be constructed without seams or rivet heads. Seams or rivet heads can provide locations for dust accumulation.

32.5.6. Containers for cast or pressed explosives pieces that are larger than 1 ft at their greatest dimension or weigh more than 11 lbs. loaded should be provided with handles or some other type of handhold.

32.5.6.1. If the loaded container weighs more than 110lbs., provisions should be made to allow handling by mechanical handling equipment.

32.5.7. Containers shall be labeled with the applicable UN hazard classification code and clearly marked to identify the contents.

32.5.8. Whenever possible, explosive pellets and items containing small quantities of explosives (e.g., detonators) shall be packaged in containers constructed so the functioning of one item does not propagate to the remaining items in the container.

Note: When a non-propagating array is not possible, the pellets or detonators shall be stored inside a closed container and shall be labeled to indicate the total weight of the explosive contents.

32.5.9. Container closures shall be the type that shall not apply excessive pinching or rubbing forces to explosives during closing and opening.

32.5.10. The closures and surfaces of container openings shall be kept clean of explosives contamination to minimize any hazard during closing and opening.

32.5.11. Explosives and ammunition in damaged containers shall not be stored in a magazine with other explosives and ammunition.

Note: Damaged containers shall be repaired, or the contents transferred to new or undamaged containers, or the container plus contents moved to a Group L storage magazine.

32.5.12. Open containers and containers with covers not securely fastened shall not be stored in magazines.

Note: Containers that have been opened shall be properly closed before being returned to storage.

32.6. **Storage in Buildings Other Than Storage Magazines**

32.6.1. Packing and Shipping Buildings (Designed for Packing & Shipping)

32.6.1.1. Incoming shipments shall be distributed as soon as practical after receipt and shall not be allowed to accumulate.

32.6.1.2. Items for outgoing shipments should not be accumulated before receipt of orders covering each specific shipment.

32.6.1.3. Separate rooms shall be provided for the temporary storage of explosives awaiting shipment and for their preparation for shipment (i.e., assembling, crating, marking).

Note: The rooms shall be divided by walls or separated to prevent an explosion in the preparation area from propagating to the temporary storage area.

32.6.1.4. The combined total amount of explosives permitted in shipping/receiving buildings, platforms, and transportation vehicles shall be based on QD constraints.

Note: When an adequate barricade (sufficient to prevent sympathetic detonation) is in place between transportation vehicles and the adjoining building or platform, quantities on each side of the barricade may be considered individually to determine QD requirements.

32.6.1.5. If required by operational necessity, explosives and pyrotechnics that are part of the work in process within the building may be stored during non-operational hours in operating buildings provided:

- Explosives limits are not exceeded.
- Containers of bulk explosives or pyrotechnics are properly secured and covered.
- Processing equipment, such as hoppers and pipelines, is empty.

32.6.2. Service Magazines

Note: The requirements for storage magazines presented in Sections 32.1 through 32.5 of this chapter shall also apply to service magazines, except as modified below.

32.6.2.1. An explosives item should be stored for no longer than necessary in a service magazine (with a maximum of 180 days).

32.6.2.2. Service magazine inventory should be reviewed every three months.

Note: Any material that has been in the service magazine for a period approaching 180 days and is not expected to be used immediately should be disposed of or removed to an appropriate storage magazine.

32.6.2.3. When practical, store explosives in service magazines in approved containers.

32.6.2.4. A documented hazard analysis shall be performed for activities involving unpackaged explosives or explosives-containing devices, unsealed explosives containers, as well as their associated packaging and unpackaging.

32.6.2.5. Unpackaged explosives or explosives-containing devices and unsealed explosives containers shall be stored in a manner that renders them stable and unlikely to be dropped or spilled.

32.6.2.6. Packaging material shall not be stored in a service magazine.

32.6.2.7. Minimum/maximum temperature monitors are not normally required for service magazines.

32.6.3. Warehouses

32.6.3.1. HD 1.4 materials (see Paragraph 11.2.2) packaged as HD SCG 1.4S, may be stored in warehouses if they are placed in segregated and specifically designated areas.

32.6.3.2. Articles in HD SCG 1.4S are considered inert for storage purposes and are not subject to QD requirements as long as they are stored with inert items or other HD SCG 1.4S items only.

Note 1: This applies only if HD SCG 1.4S articles remain in their original packaging container or are proven to be self-contained.

Note 2: When stored with items in a storage compatibility group other than S, normal QD requirements shall be observed.

32.6.4. Service Bays

32.6.4.1. Service bays should not be used for long term storage/staging of explosives or explosives components.

32.6.4.2. If intermediate storage/staging of explosives is within an operating building containing Class II or Class I operations, the intermediate storage/staging bay shall require Class II Level-of-Protection.

32.6.4.3. Explosives items shall be properly packaged and stored/staged in either DOT-approved containers/packages or in specified onsite containers (see Section 32.5).

32.6.4.4. The storage of containers shall comply with the requirements of Paragraph 32.2.6.

32.6.4.5. An explosives item shall be stored/staged for no longer than necessary in a service bay (with a maximum of 180 days).

32.6.4.6. Any material that has been in the service bay for a period approaching 180 days and is not expected to be used immediately shall be disposed of or removed to a storage magazine.

32.6.4.7. Contractor Facility Management shall provide a method to verify the explosives limit and the 180-day limit are not exceeded.

32.6.4.8. Explosives containers shall be positioned safely and securely.

32.6.4.9. Aisles shall be wide enough to accommodate operations. Unobstructed aisles shall be maintained to permit rapid exit of personnel and to facilitate safe and efficient operations.

32.6.4.10. Along with operations incident to storage or removal from storage, the following are allowed in service bays:

- Material handling,
- Visual inspection,
- Surveillance, and
- Inventory operations.

32.6.4.11. Empty containers, tools, pallet jacks, pallets, etc., should not be stored in a service bay containing explosives.

32.6.4.12. Combustible materials such as excess dunnage, packing material, and boxes shall not be stored in a service bay containing explosives.

32.6.4.13. Flammable liquids shall not be stored or used in a service bay containing explosives.

Table 32.1 Storage Compatibility Groups for Explosives and Explosive-Containing Devices

Group A Initiating explosives.

- CP (5-Cyanotetrazolpentaamine Cobalt III Perchlorate)
- HMX (Cyclotetramethylene tetranitramine) (dry)
- Lead azide
- Lead styphnate
- Mercury fulminate
- PETN (Pentaerythritol tetranitrate) (dry)
- RDX (Cyclotrimethylene trinitamine) (dry)
- TATNB (Triaziodotrinitrobenzene)
- Tetracene

Group B Detonators and similar initiating devices.

- MDF (mild detonating fuse) detonator assemblies
- Detonators excluding EBWs and slappers
- Explosive bolts
- Fragmenting actuators
- Blasting caps
- Pressure cartridges
- Small arms primers
- Squibs

Igniters

Group C Bulk propellant, propellant charges, and devices containing propellants with or without their own means of initiation. This Group also includes some IHEs.

- Smokeless powder
- Pistol and rifle powder
- Rocket-motor solid propellants
- TATB (Triamino trinitrobenzene)
- LX-17
- PBX-9502

Group D High explosives (HE) and devices containing explosives without their own means of initiation and without a propelling charge or articles containing a primary explosive substance and containing two or more effective protective features.

- Ammonium picrate
- Baratol
- Black Powder
- Boracitol
- Compositions A, B, and C (all types)
- Cyclotols (not to exceed a maximum of 85% RDX)
- DATB (diaminotrinitrobenzene)
- Detasheet
- Detonating cord (primacord or mild detonating fuse)
- Bis-Dinitropropyl adipate
- Bis-Dinitropropyl glutarate
- Bis-Dinitropropyl maleate
- Dinitropropane
- Dinitropropanol
- Dinitropropyl acrylate monomer (DNPA)
- Dinitropropyl acrylate polymer (PDNPA)
- EBW and slapper detonators
- Elastomeric plastic bonded explosives
- Explosive D
- HMX (Cyclotetramethylene tetranitramine) (wet)
- HMX/wax (formulated w/ at least 1% wax)
- HNS (Hexanitrostilbene)
- Linear-shaped charge
- Methyl dinitorpentanoate
- Nitroguanidine
- Octol
- Pentolite
- PETN (Pentaerythritol tetranitrate) (wet)
- PETN/extrudable binder
- Plastic Bonded Explosives, PBX (a Group D explosive formulated w/ a desensitizing plastic binder)
- Potassium picrate
- RDX (Cyclotrimethylene trinitramine) (wet)
- TATB/DATB mixtures
- Tetryl
- TNT (Trinitrotoluene)

Group E Explosives devices without their own means of initiation and with propelling charge.

- Fixed Artillery ammunition
- Rockets (e.g., 66mm LAW)

Group F Explosives devices with their own means of initiation and with or without propelling charge.

- Hand Grenade, fragmentation

Table 32.1 Storage Compatibility Groups for Explosives and Explosive-Containing Devices (cont.)

Group G Pyrotechnic material and devices that produce an incendiary, illumination, lachrymatory, smoke, or sound effect. • Smoke pots • Flares • Incendiary ammunition
Group K Ammunition containing both explosives and toxic chemical agents. • Artillery or mortar ammunition (fuzed or unfuzed), grenades, and rockets or bombs filled with a lethal or incapacitating chemical agent.
Group L Explosives or ammunition not included in other compatibility groups that present a special risk requiring isolation of each type. • Damaged or suspect explosives, explosive devices or containers. • Experimental explosives, explosives of temporary interest, newly synthesized compounds, new mixtures, and some salvaged explosives.
Group N HD 1.6 articles containing only extremely insensitive detonating substances (EIDS). • IHE missiles and bombs
Group S Explosives and Ammunition that presents no significant hazard. Items are packaged or designed so that any hazardous effects from accidental functioning are limited to the extent that they do not significantly hinder firefighting. Examples include the following: • Cable cutters • Cartridge actuated valves • Linear actuators (e.g., dimple, piston, bellows motors) • Safety fuze • Small arms ammunition
Materials and Systems that need not be stored or labeled as explosives unless they are near other explosives that could initiate them. When near explosives, these materials become Group D, unless otherwise indicated. • FEFO/SOL (35% weight or less FEFO in ethyl acetate) • FEFO/solution • Group D explosives in inert solvents (explosive concentration not exceeding 25% weight) • Nitrates; treat as Group C when with other explosives • Perchlorates; treat as Group C when with other explosives • Materials received as ORM-D (Other Regulated Material-D) are to be relabeled and stored as Classification Code 1.4C in accordance with the requirements of TB 700-2. Authorized on-site classifiers may assign an alternate classification and SCG as appropriate for on-site storage and use.

Table 32.2. Storage Compatibility Mixing Chart

Groups	A	B	C	D	E	F	G	H	J	K	L	N	S
A	X	Z											
B	Z	X	Z	Z	Z	Z	Z					X	X
C		Z	X	X	X	Z	Z					X	X
D		Z	X	X	X	Z	Z					X	X
E		Z	X	X	X	Z	Z					X	X
F		Z	Z	Z	Z	X	Z					Z	X
G		Z	Z	Z	Z	Z	X					Z	X
H								X					X
J									X				X
K										Z			
L													
N		X	X	X	X	Z	Z					X	X
S		X	X	X	X	X	X	X	X			X	X

Notes:

1. An “x” in a block of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted according to the following sections.
2. A “z” in a block of the above chart indicates that when warranted by operational considerations or magazine availability, and when safety is not sacrificed, these groups may be combined in storage. Combinations that violate the principles of Paragraph 33.4.4 require justification by an exemption.
3. No mark in a block indicates that combined storage is not permitted. L compatibility group types presenting similar hazards may be stored together but not mixed with other groups.
4. K compatibility group requires not only separate storage from other groups, but also may require separate storage within the group.

Attachment A – Example Storage Review Program

1. A storage review date is assigned to each bulk explosive placed in storage. The storage review date is shown on or adjacent to the identification tag or sticker attached to every container or package of explosive in storage or listed in the inventory records.

2. Storage review intervals are based, whenever possible, on stability data. A safe storage interval is considered as that time period, at maximum anticipated storage temperature, during which an explosive material can be conservatively expected to show an acceptable level of decomposition.

3. Contractor Facility Management designates or creates an Explosives Storage Review Committee (SRC) to establish and approve storage review intervals for all explosives stored at the DOE facility. Also, the SRC prescribes for each explosive appropriate tests to evaluate the safety of handling and processing the material after it has exceeded its storage review interval. These tests are referred to as “stability tests,” although sensitivity, or other types of testing, could be included in the material evaluation program. In some cases, the SRC simply requires periodic stability testing rather than establishing a storage review interval (e.g., nitrocellulose, single- and double-base propellants).

4. To store a new explosive, to increase (or decrease) the review interval for a previously approved material, or to use different stability test data for an explosive, the following procedure could be used:

    - A responsible person should communicate the request to the SRC.
    - If the request concerns storage of a new explosive, the individual recommends a storage review interval and stability-evaluation testing.
    - Supporting data is supplied with the recommended review interval and proposed stability tests for the explosive.
    - The SRC reviews the request and supporting data and then prescribes a storage review interval and stability tests as appropriate.
    - A new explosive is assigned an interim storage review and stability test interval before Phase II scale-up (see Chapter 19).
    - The following general guidelines are offered to assist the SRC in establishing review intervals when there is insufficient stability information to predict storage life.
        - If no information is available on a new material relative to storage stability, a review interval of 90 days or less is assigned.
        - A new formulation is assigned a storage review interval not exceeding that of its least stable component.
        - If the compound or formulation is new to DOE but DoD agencies have extensive experience with it, the DoD information is used conservatively.
        - For a formulation or ingredient with a manufacturer-assigned shelf life, a review interval that exceeds the recommended shelf life is not assigned unless additional stability tests indicate such storage is warranted.

5. A storage review interval of up to 20 yrs is permissible for an explosive if a conservative evaluation of stability data indicates that such an interval is justified.

33. TRANSPORTATION

33.1. Explosives Transportation

Note 1: Onsite movements of explosives shall be in accordance with this Technical Standard, local onsite packaging, and the site's motor vehicle safety program.

Note 2: Explosives containing items transported by Federal Agents within the Office of Secure Transportation are governed by DOE Order 452.2 and DOE Order 460.1.

Note 3: Section 161.K of The Atomic Energy Act of 1954 as amended and Title 18 United States Code (USC), Chapter 40, section 845 govern security and emergency vehicles carrying explosives in support of approved contingency plans.

33.1.1. Qualified explosives handlers shall load and unload explosives (see Chapter 10).

33.1.2. When transferring explosives within facilities, open body vehicles (other than flatbed types) shall have sides and tailgates or rear doors that are strong and securely fastened to safely retain the explosives.

33.1.3. The cargo on partly or completely loaded vehicles (including flatbed types) shall be blocked, braced, chocked, tied down, or otherwise secured to prevent shifting during transit.

33.1.4. Precautions shall be taken to prevent the exhausts of motor vehicles from igniting explosive material.

33.1.4.1. When a motor vehicle approaches within 25 ft of the doors of a structure through which a shipment is to be moved, the doors shall be kept closed until the motor has been turned off, unless the vehicle is equipped with an exhaust spark arrestor or there are no explosives exposed.

Note: Explosives packaged in DOT or onsite containers are not considered exposed.

33.1.5. No explosives shall be loaded or unloaded from a motor vehicle while the motor is running unless the motor is required to provide power to vehicle accessories used in loading and unloading operations and is equipped with an exhaust spark arrestor.

33.1.6. During loading and unloading, explosives laden vehicles shall have their emergency brakes set and wheels chocked to prevent inadvertent vehicle movement.

33.2. **Onsite Shipments**

33.2.1. Hazard Division Placards are required for all shipments of HD 1.1, 1.2, and 1.3 explosives (excluding de minimis quantities) and shall be plainly visible from all directions.

33.2.2. Hazard Division Placards are required for HD 1.4, 1.5, and 1.6 explosives when the gross weight exceeds 1000 lbs.

33.2.3. Motor vehicles used to transport explosives onsite should be equipped with the following:

33.2.3.1. Adequate tie-down bolts, rings, and straps to secure the explosives load.

33.2.3.2. The cargo area where the explosives are loaded shall be void of any sharp projections.

Note: Non-sparking lining is desirable when hauling explosives in transfer containers that are not DOT approved.

33.2.3.3. A quick-disconnect switch on the battery, if explosives are left loaded on the vehicle overnight.

33.2.3.4. Two fully charged and serviceable fire extinguishers with a minimum rating of 2A-10BC, with one extinguisher mounted on the outside of the vehicle.

Note: Only one extinguisher is required for the transport of HD 1.4 explosives.

33.2.3.5. Rear view mirrors on both sides of the vehicle.

33.2.3.6. One pair of chock blocks.

33.2.4. Normal shipments of explosive materials on site shall be packaged in DOT approved containers/packages or in approved onsite containers (see Section 32.5).

33.2.5. Onsite shipments of explosive-designed systems related to experiments or tests that, by their nature, are not conducive to the

requirements of Paragraph 33.2.4 shall be governed by Section 29.1. and the following:

33.2.5.1. For shipping purposes, placards and labels shall reflect the appropriate Hazard Division as assigned by the designated onsite classification authority.

33.2.5.2. The appropriate authority shall review and approve the designed method of transport for the system.

33.2.5.3. Drivers shall be knowledgeable of the unique aspects of the system being transported or shall be accompanied by an explosives handler qualified by training and experience to handle the system.

33.2.6. After the EDC has determined that new or developmental explosives meet the necessary testing to establish that they are not forbidden explosives and are at the proper phase of development for the quantity of material being requested, onsite transport shall conform to Paragraph 33.2.4. or 33.2.5.

33.3. **Materials Handling Equipment**

33.3.1. Industrial trucks shall not be used in locations where high concentrations of dusts or sublimation of explosives occur (e.g., screening buildings, pouring bays, melt-pour units, drilling bays, consolidating bays, explosive washout facilities).

33.3.2. Gasoline-powered or diesel-powered materials-handling equipment (e.g., forklifts) should be used only in areas where all explosives are properly packaged and only if equipped in the following manner.

33.3.2.1. Backfire deflectors shall be the oil-bath or screen type (certain types of air cleaners shall serve the purpose) and shall be attached securely on the throat of the carburetor.

33.3.2.2. A tight-fitting, properly vented cap, shall be in place on the gasoline fill pipe at all times (except during refueling).

33.3.2.3. A flame arrestor shall be installed in the fill pipe.

33.3.2.4. If necessary, a deflector plate shall be installed to prevent any gasoline tank overflow from reaching the motor or the exhaust pipe.

33.3.2.5. On gravity feed systems or on pump systems where siphoning might occur, a shutoff valve shall be installed at the fuel tank or in the feed

line to permit shutting off the flow of gasoline in an emergency or a break in the fuel line or carburetor.

33.3.2.6. Provisions shall be made to prevent fuel lines from rupturing due to vibration.

33.3.3. Battery-powered handling equipment shall only be used in hazardous areas for which it is specifically rated (e.g., types E, EE, ES, EX rated).

33.4. **General Operation Requirements**

33.4.1. The operator of an explosives-transport vehicle shall have training in the general safety precautions for explosives handling.

33.4.2. Congested areas should be avoided when determining explosives routes.

33.4.3. No personnel shall ride in the cargo area. Loose items (e.g., handling gear) in the cargo compartments are prohibited.

33.4.4. No smoking is allowed in or within 25 ft of any vehicle containing explosives.

33.4.5. Matches, lighters, or other fire-, flame-, or spark-producing devices shall not be in the vehicle or carried by personnel in the vehicle containing explosives.

33.4.6. Other than when opened for inspection at an authorized location, containers of explosives shall not be opened or repaired on any transportation vehicle.

33.4.7. Refueling or maintenance shall not be performed on vehicles containing explosives.

33.4.8. Each site’s traffic rules shall address the operation of explosives-transport vehicles and the operation of other vehicles in the vicinity of explosives-transport vehicles.

33.5. **Hazardous Conditions**

33.5.1. Explosives should not be transported in hazardous conditions (e.g., storms, icy roads, or poor visibility), unless an emergency plan is in effect to provide instruction and guidelines while an explosives-transport vehicle is in transit. The plan should address the following issues:

- Parking the vehicle.

- Safeguarding the vehicle from other traffic.
- Notifying appropriate authorities of the emergency situation.
- Leaving the vehicle unattended.

33.5.2. A plan shall be prepared to address mechanical breakdowns. The plan shall address the following issues:

- Removing the vehicle from the road as far as practical.
- Posting emergency reflectors, signals, etc. (carrying flares on the vehicle is not permitted).
- Reporting the problem.
- Maintaining surveillance of the vehicle.
- If necessary, removing the vehicle load to facilitate repair of the vehicle.

33.5.3. If an explosives-carrying vehicle is involved in an accident, the following steps should be taken:

33.5.3.1. Inspect the load for evidence of fire.

Note 1: If there is a fire, but the explosives material is not presently or imminently involved, attempt to prevent the fire from spreading to the load.

- The fire may be fought using the vehicle's fire extinguishers.
- Verify the security of explosives items removed from the vehicle.

Note 2: If a fire presently or imminently involves the explosives load.

- Evacuate all personnel to a pre-established safe distance.
- Block or divert traffic from the vicinity of the accident.

Note 3: Unless the explosive cargo is imminently involved in fire, the operator is to stay with the vehicle until the cargo is properly dispositioned.

Note 4: Notify the fire department or fire brigade of the accident immediately and inform them of the general type and approximate quantity of explosives involved.

33.5.3.2. Inform the proper authorities of the accident.

34. MATERIALS RECEIPT

34.1. Motor Vehicles

34.1.1. A qualified person using an approved checklist at a designated inspection station shall carefully inspect all incoming motor vehicles loaded with explosives in HD 1.1, 1.2, and 1.3.

Note: Inspections requiring opening or moving explosives shipping containers or removing bracing or blocking shall be done at a location sited for explosives operations as specified in DESR 6055.09.

34.1.1.1. When an inspection reveals that an incoming tractor is in unsatisfactory condition, the tractor should be disconnected from the trailer at the inspection station and moved to a position where it does not endanger any other explosives.

34.1.1.2. When an inspection reveals that a trailer or its load is in an unsatisfactory condition, the trailer shall be moved to a location that is at least inhabited-building distance for the particular material involved from administration areas, hazardous locations, and the facility boundary.

Note 1: At this location, the unsatisfactory condition shall be corrected before the vehicle is moved to its destination within the facility.

Note 2: When moving from the inspection station to the isolated location, the route should be as far as possible from built-up areas and areas with high personnel concentrations.

34.1.1.3. Vehicles that cannot be immediately dispatched to points where they are to be unloaded should be moved to a location sited in accordance with Paragraph 11.2.4.

34.1.2. Vehicles shall not be backed up to a dock on which explosives are resting and could be damaged.

34.1.3. The receiving facility’s doors should be closed while the motor vehicle is in motion or the engine is running.

Note: This requirement does not apply to vehicles equipped with spark arrestors or when no exposed explosives are present.

34.1.4. Once the vehicle is in position, the engine shall be shut off, the brakes set, and the wheels chocked.

34.1.5. After unloading, the vehicle shall be inspected for loose explosives materials.

Note 1: Any spilled material shall be cleaned up after the inspection.

Note 2: Spills involving liquid explosives or explosives in solution shall be reported immediately to the building supervisor.

Note 3: Approved cleanup procedures shall be used.

34.2. **Damaged Shipments**

34.2.1. Explosives shipments shall be inspected for damage before storage.

34.2.2. Contents of a damaged or broken container shall be removed to another container. Spilled materials shall be cleaned up before continuing with loading or unloading.

34.2.3. Any shipment received in damaged condition as a result of inadequate or improper blocking and bracing or as a result of not being loaded in accordance with DOT requirements shall not be reshipped until the damage is corrected.

35. MATERIALS HANDLING

35.1. **Material Handling**

35.1.1. The distance that explosive materials can fall, if accidentally dropped during handling, shall be maintained at a minimum.

35.1.2. Hard surfaces and edges that could be accidentally struck by dropped consolidated explosives should be padded with cushioning mats or coverings when practical and needed.

Note: Protective padding includes sheet material on work surfaces, equipment, and approved floor coverings.

35.1.3. Explosives handling shall be permitted only in areas free of obstructions and where the walkway surfaces provide positive footing with no slipping or tripping hazards (i.e., snowy or icy walkways).

35.1.4. Explosives and incompatible materials shall not be handled together.

35.1.5. Detonators, actuators, EEDs, and other items normally shipped as HD 1.4 explosives should be kept in non-propagating trays or containers unless handled individually.

35.1.6. Dry explosive materials that generate dust shall be transported in closed containers.

35.1.7. Containers of explosives or explosive assemblies shall be labeled to identify contents during handling, storage, and transportation.

35.1.8. Explosives items that cannot be identified and labeled shall be stored as HD SCG 1.1L.

35.1.8.1. A material analysis shall be performed to identify the material before it is returned to inventory or disposed of in accordance with regulatory requirements.

35.1.9. Components or devices that contain explosives should not be labeled or marked “inert” or “dummy.”

35.1.10. Nonconforming items shall be labeled/tagged indicating that they contain explosives.

Note: The marking requirements of this paragraph are not applicable to items subject to the current DOE O 452 series of directives.

35.2. **Manual Handling of Bare Consolidated Explosives**

35.2.1. Operations shall be arranged to minimize the handling distance in all manual explosives handling situations.

35.2.1.1. Explosive items that cannot be securely gripped should not be manually handled.

35.2.2. Explosives should not be carried up or down stairs except when in protective containers.

35.3. **Carts or Hand Trucks**

35.3.1. Explosives that cannot be handled manually shall be moved only on suitable carts or hand trucks.

35.3.2. Carts used to handle bare explosives shall be provided with a padded surface to support the explosives.

35.3.3. The carts shall be equipped with either a lip, sides of sufficient height, or tie-down straps to prevent the explosives from sliding or rolling off the cart.

35.3.4. The cart-explosive load combination shall have a center of gravity low enough to prevent tipping if the cart suddenly stops.

35.3.5. Explosives handling carts or hand trucks should be equipped with brakes.

35.3.6. Carts containing explosives shall be positively secured (e.g., setting wheel brakes or chocking) when the cart is stationary.

35.4. Vacuum Handling

35.4.1. Any mechanical handling where a loss of vacuum would allow the explosive to drop an excessive distance shall incorporate a safety device (e.g., collar, net, or strap) to prevent dropping.

Note 1: “Excessive distance” shall be defined as a distance greater than the minimum drop height giving drop-skid “initiation” for the explosive being handled. “Initiation” in the drop-skid test refers to any indication of sample decomposition.

Note 2: An alternative method of protection can be a resilient surface under the explosives and over all items that may be struck by falling explosives.

36. ELECTRICAL

36.1. Electrical Equipment and Wiring

Note 1: The use of rated wiring, fixtures, equipment, and instrumentation provides additional safety for work with explosives materials by

- Restricting electrical ignition sources such as sparks and electrical faults (shorts, power surges),
- Controlling surface temperatures of electrical items, and
- Reducing the potential for electrically initiated fires.

Note 2: Although NFPA 70 does not specifically address explosives, NFPA 70 Article 500, Hazardous (Classified) Locations, requirements for the design and installation of electrical equipment and wiring in electrical hazard classified locations is recommended as guidance for the installation of rated equipment and fixtures where required by this chapter.

Note 3: Explosives do not normally fit the NFPA 70 definitions for groupings, classes, divisions, and area classifications. In order to apply NFPA 70 Article 500 as a guide, vapors containing explosives shall be treated as Group D (unless NFPA 70 requires a higher classification because of other components of the vapor) and dusts of explosives or solid explosives shall be treated as Group G. Maximum temperature limits shall be based on the thermal analysis of the explosives used in the operation. Division 1 items can be substituted for Division 2 items, but never Division 2 for Division 1 items.

Note 4: Electrical requirements for outdoor test areas shall be determined by hazard analysis.

36.1.1. Areas where explosives operations and activities are conducted shall be evaluated and classified.

36.1.2. Electrical equipment and wiring shall be properly classified, designed and installed to minimize the possibility of ignition.

36.1.3. Rated wiring (permanent and temporary), fixtures, equipment, and instrumentation shall be used for explosives operations and activities appropriate to the electrical hazard classification.

36.1.4. Rated wiring, equipment and instruments shall be approved for use by a Nationally Recognized Testing Laboratory.

36.1.5. Rated items shall have labels and/or clearly identifiable markings to show Class, Division, Group, and Temperature Range for which they are approved.

36.1.6. Equipment approved for one Hazard Class is not interchangeable with another Hazard Class.

36.1.7. Where rated items are required but not available, substitute items may be approved as per Paragraphs 36.4.3. and 36.4.4.

36.2. **Electrical Hazard Classification for Explosives Operations or Activities**

36.2.1. Contractor Facility Management shall assign an electrical hazard classification for all designated areas, (e.g. rooms, bays, chambers) where explosives operations or activities are conducted.

36.2.2. Area classification shall be in accordance with the recommendations of Table 36.1 or through documented analysis as described in Section 8.4.

Table 36.1 Recommended Explosives Area Electrical Hazard Classifications

Normal Operating Condition	Area Classification
1. Activities involve flammable gases or chemicals/materials expected to produce flammable vapors with explosives present.	Class I, Division 1
2. Activities are expected to produce explosives dust, or ignitable dust mixtures with explosives present, that is suspended in the air. *Examples are; screening, grinding, blending, pressing, dry machining explosives, and weighing of explosives powders.*	Class II, Division 1
3. Activities involve vapors and dust as described in numbers 1 and 2 of this table. *Examples are; synthesis, formulation, mixing, wet blending, and casting explosives, heating/drying of uncased explosives, plus any explosives processing that is expected to produce sublimation.*	Class I, Division 1 and Class II, Division 1 (dual rated)
4. Activities are expected to produce explosives dust that can accumulate on electrical equipment or apparatus. *Examples are; inspection of explosives powders and wet machining of explosives.*	Class II, Division 2 (Class II, Division 1 or dual rated equipment and wiring can be substituted)
5. Activities are not expected to produce flammable vapors or explosives dust. *Examples are; operations with fully encased explosives, explosives packaged in approved containers, and areas in explosives facilities where no explosives are present such as offices, control rooms, halls, rest rooms, and mechanical equipment rooms.*	General Purpose (See Note 1 and 2)

Note 1: General Purpose Areas may be established in explosives locations if Contractor Facility Management can determine, based on a documented analysis of the processes involved and the separation between explosives operations requiring Class I or Class II rated electrical wiring, fixtures, process equipment, and instrumentation and the General Purpose Area is established and maintained such that:

- Migration of explosive or ignitable gasses, vapors or dust mixtures into the General Purpose Area from the rated area does not occur under normal operating conditions.
- Ignition energy (arcing, sparking from General Purpose wiring, equipment, fixtures, and instrumentation) that may be developed in the General Purpose Area is not transferred to the rated area.

Note 2: Where specifically permitted in NFPA 70 Articles 501 through 503, General Purpose equipment or equipment in General Purpose enclosures shall be permitted to be installed in Division 2 locations if the equipment does not constitute a source of ignition under normal operating conditions.

36.3. Electrical Supply System

36.3.1. Mutual hazards may exist where explosives facilities are located near electrical supply lines and stepping equipment. To protect against these hazards, NFPA 70 and the following requirements apply to all new construction or major modifications, and should be considered for existing facilities.

Note 1: QD requirements are based on air blast overpressure only, and fragment distances are not considered.

Note 2: Electric supply lines that can be interrupted without loss of power (i.e., power is rerouted through existing lines and/or networks) can be separated from explosives sites in accordance with Paragraph 36.3.7.

Note 3: Electrical supply lines are classified by purpose as to transmission, distribution, or service.

36.3.2. Electrical supply lines which jointly supply power (regardless of voltage) to offsite, non-facility locations shall be considered transmission lines for QD purposes.

36.3.3. Electric transmission lines and the tower or poles supporting them shall be located no closer to explosives facilities than:

- Inhabited-building distance if the line in question is part of a grid/system serving a large, offsite area.
- Public traffic route distance if loss of the line does not create serious social or economic hardships to offsite areas.

36.3.4. Electrical distribution lines and the tower or poles supporting them shall be located no closer to explosives facilities than public traffic route distance.

36.3.5. Electrical distribution lines that exclusively support a storage/operation area and the loss of the lines is acceptable, separation is in accordance with service line criteria, Paragraph 36.3.7.

36.3.6. Unmanned privately owned or contractor-owned electrical substations (not to include building transformers and associated switch gear) shall be no closer to explosives facilities than public traffic route distances.

36.3.7. Electric service lines required to be in close proximity to a combustible constructed or uncovered explosives facility shall be no closer to that facility than the length of the lines between the poles or towers supporting the lines.

Note: An alternate effective means can be provided so that broken, energized lines cannot come into contact with the facility or its appurtenances (e.g., geographic terrain features, instantaneous circuit interrupters, cable trays, linking lines together).

36.3.8. Equivalent underground electrical service lines shall be located as specified in Paragraph 11.2.5 and Table 11.2.

36.3.9. Electrical service lines shall be installed underground from a point not less than 50 ft away from such facilities.

36.3.10. Surge arrestors or capacitors shall be provided on the supply side of the main service disconnect.

36.3.11. Lightning arrestors, surge arrestors, surge capacitors, service entrance ground, and building ground shall be interconnected outside the building.

36.4. **Electrical Equipment and Instrumentation**

36.4.1. Non-permanent process instrumentation and process equipment should be rated for the actual environment based on the explosives operation being performed (as defined in Section 36.2).

36.4.2. Group G or Group D equipment shall not have a surface temperature exceeding the lowest onset of the exotherm of the explosive.

36.4.2.1. When the thermal rating of the equipment is inadequate, additional protection shall be provided or the equipment shall be excluded from the hazardous location.

36.4.2.2. Equipment afforded additional protection shall be administratively controlled and marked accordingly.

36.4.3. When Hazard Class I or II equipment is required but not available, alternate equipment should be:

- Purged or pressurized in accordance with NFPA 496, or
- Sealed to prevent explosives contamination for Hazard Class II locations, or
- Determined intrinsically safe (without regard to voltage) in accordance with NFPA 70 Article 504/ANSI 913.

36.4.3.1. When the equipment is purged or sealed, the surface temperature shall not exceed 248°F (120°C) for normal operations, or 329°F (165°C) for overload conditions.

36.4.3.2. When the equipment is purged, the airflow shall be monitored per NFPA 496 and interlocked to the equipment, or alarmed when operator shutdown of the machine can be reliably performed immediately upon receipt of that alarm.

36.4.4. All electrical equipment or instrumentation in hazardous locations that do not meet the above requirements shall be evaluated and documented as to their suitability for use in the specific area and operation. The following are suggested areas for evaluation:

- Malfunction of electrical equipment or process instrumentation.
- Consequences of electrical initiated fire.

- Initiation of explosives by electrical current.
- Breach of containment resulting in exposed explosives or spillage of explosives.
- Ignition sources arising from physical damage to the wiring method used (e.g., crushing by forklift or other material handling equipment, frayed cords).
- Exposed electrical conductors or connectors that could make contact with leg wires or cables of explosive devices during routine handling.
- Exposed electrical conductors or connectors on which explosives dust or vapors could collect.
- Collection of explosives dust on or in the equipment.
- Sensitivity to heat and spark, and thermal stability of explosives involved.

36.4.5. Watertight equipment (that would pass a NEMA 4 hose test) should be provided in those locations where water-explosives mixtures may come in contact with the electrical equipment and wiring.

36.5. **Hand-held, Battery-Powered Lights and Instruments**

36.5.1. Hand-held, battery-operated equipment shall not come in direct or indirect contact with bare explosives, unless they are evaluated and approved by Contractor Facility Management prior to use.

36.5.2. Batteries shall not be removed or replaced in hazard rated areas.

36.5.3. Flashlights and hand lanterns powered by low-voltage dry cell batteries and “miner cap lamps” approved as permissible by the U.S. Mine Safety and Health Administration (MSHA), Underwriters Laboratory (UL), or those previously approved by the U.S. Bureau of Mines, for NEC Class I hazardous locations, are authorized for use in both Class I and Class II locations.

36.5.4. Devices that provide “cold light” through chemical action are acceptable for use in any location.

36.5.5. The following electric items powered by low voltage dry cell batteries are authorized for use in the vicinity of Hazard Class II, Division 2 rated hazardous operations and during setup of Hazard Class I or Class II, Division 1 hazardous operations:

- Hand-held instruments
- Watches
- Calculators
- Personal medical devices
- Cameras

- Self-contained flashes
- Scanners
- Communication devices

36.5.5.1. Prior to use of the above items, during Hazard Class I or Class II, Division 1 hazardous operations, they shall be evaluated as to their intrinsic safety and approved by Contractor Facility Management.

36.6. **Non-Rated Extension Lighting**

36.6.1. When it is necessary to use extension lights within 10 ft of exposed explosives, where no airborne dust exists, the following requirements shall apply:

36.6.1.1. Lights shall be positioned outside the fall-down distance to the explosives.

36.6.1.2. Lights shall be mounted on heavy tripod stands.

36.6.1.3. The lights shall be fitted with exterior globes to prevent the falling of hot sparks or particles that might ignite the explosives.

36.6.1.4. The lights shall be fitted with adequate guards to protect the globes from physical damage.

36.6.1.5. The wire providing power to the lights shall be positioned so as to prevent vehicles and personnel damaging the cord.

36.6.1.6. The light stand shall be secured to prevent tipping.

36.6.1.7. Neither the light nor the power cord shall be allowed to come in direct or indirect contact with the explosives.

37. ELECTRICAL TEST INSTRUMENTS

Note: This chapter does not address those instruments covered by DOE O 452.2E or successor document.

37.1. **Terminology Specific to this Chapter**

37.1.1. Approval: An instrument design, as designated by a manufacturer model or part number, is approved for use with explosives systems after it has been evaluated according to the requirements of this chapter.

37.1.2. Certification: A specific instrument, as designated by a serial number, is certified for use with explosives systems after the model or part number has been approved and the instrument has been inspected, calibrated, and labeled according to the requirements of this chapter.

37.1.3. 1A/1W no-fire criterion: The 1 Amp/1 Watt no-fire criterion specifies that the initiator does not fire within 5 minutes when subjected to a current of 1 amp minimum per bridge with an associated power of 1 watt minimum per bridge, whichever is most conservative.

Note: In reference to “per bridge” above, the information is based on MIL-DTL-23659F, Detail Specification: Initiators, Electric, General Design Specifications For (10 June 2010), section 3.4.3.2.1.

37.1.4. Fail-safe current: The fail-safe current of an instrument is the maximum output current through zero resistance given any single failure; at least two independent failure modes must occur before this current can be exceeded.

37.2. **Classification**

37.2.1. Test instruments shall be classified based on electrical characteristics that affect safe use with explosives systems, as noted below.

37.2.1.1. Type 1: Are used with low-energy EEDs that comply with the 1A/1W no-fire criterion, and with high-energy initiators. Other uses shall be evaluated according to Paragraph 37.4.1.3.

37.2.1.2. Type 2: Are used with high-energy initiators. Other uses shall be evaluated according to Paragraph 37.4.1.3.

37.2.1.3. Type 3: Are used on non-initiating electrical circuits. Applications shall be evaluated according to Section 37.5.

37.2.2. Test instruments not meeting the safety criteria may be used on an explosive system only if the activity is considered a remote operation and adequate personnel shielding or separation distance is provided.

37.3. **Approval and Certification**

37.3.1. Each DOE facility where electrical test instruments are used on explosives systems shall establish a formal system for approving and certifying these instruments.

37.3.2. Procedures should be established for marking instruments to show approved uses and restrictions.

37.3.3. Each test instrument used on explosives systems shall be certified.

37.3.4. Each certified test instrument shall be prominently labeled with its approved use and with a warning if its use is restricted.

37.3.5. Each DOE facility using electrical instruments to test explosives systems shall maintain records of all instrument types approved for use with initiating circuits.

37.3.5.1. These records should include type, manufacturer, model, electrical specifications, wiring diagrams, and failure mode analyses.

37.3.6. Contractor Facility Management shall notify the DOE/NNSA Explosives Safety Committee Chair in writing when new electrical instruments have been approved for use with initiating systems.

37.4. **Electrical Instruments for Use with Initiating Electrical Circuits**

37.4.1. Instruments used with electrical initiation circuits connected to EEDs are either Type 1 or Type 2. Test instruments used for this purpose shall be current limited. Before being approved for use on initiating circuits, each instrument wiring diagram and internal circuitry design shall be analyzed and examined for the following:

37.4.1.1. For Type 1 instruments, the fail-safe current shall not exceed 10 mA.

37.4.1.2. For Type 2 instruments, the fail-safe current shall not exceed 100 mA.

37.4.1.3. Where a Type 1 or Type 2 instrument cannot be used for a particular application, the maximum fail-safe current should not exceed 3% and shall not exceed 10% of the no-fire rating of the initiator being tested.

37.4.1.4. The current-limiting features of test instruments shall be internal to the instrument and shall not depend on test circuit load characteristics.

37.4.1.5. The current-limiting components should be identified and documented for reference during certification.

37.4.1.6. Circuit measurements that verify proper functioning of the current-limiting components should be documented for reference during certification.

37.4.2. An instrument is certified for use on initiating circuits when:

37.4.2.1. Its current-limiting circuitry has been inspected, measured, and found to be consistent with the approved design; and

37.4.2.2. It has been inspected, calibrated, and labeled with the instrument Type and optionally the maximum fail-safe current.

37.4.3. Certified instruments shall be inspected and calibrated at prescribed intervals or whenever the instrument is opened for servicing or repair.

37.4.3.1. Access to internal circuitry of certified instruments shall be controlled to prevent unauthorized repairs, maintenance, or alteration.

37.5. Electrical Instruments for Use with Non-Initiating Electrical Circuits

37.5.1. Instruments used with electrical circuits connected to strain gages, pin switches, pressure transducers, thermocouples, electrical components, etc., that are affixed to or within an assembly with explosives are classified as Type 3. These instruments shall meet the following requirements:

37.5.1.1. Each specific use of the instrument shall be analyzed so no credible scenario exists whereby the normal test energy from the instrument can ignite explosives charges or initiators in the test.

Note: Operational requirements are contained in Sections 30.4 and 29.6.

37.5.1.2. Where an instrument is used to make measurements on sensors directly applied to explosives (e.g., bonded strain gages or pin switches), a safe current limit and an instrument fail-safe current shall be determined and documented.

Note: The design shall be approved in accordance with Paragraphs 37.4.1.4., 37.4.1.5., and 37.4.1.6., and the instrument shall be certified in accordance with Paragraphs 37.4.2 and 37.4.3.

37.5.1.3. Instruments used with non-initiating electrical circuits shall be marked prominently with the instrument Type and any restrictions on use.

Note: Many of these instruments do not meet the requirements for use with initiating systems and shall be marked to prevent their use on this type of circuit.

38. ELECTRO-EXPLOSIVE DEVICES

38.1. Protection from Electromagnetic Radiation

38.1.1. EEDs should be left inside their containers until ready for use.

38.1.2. Shorting clips or other safety devices should not be removed until the EED is ready for use.

38.1.3. AFMAN 91-201, NAVSEAOP 3565/NAVAIR 16-1-529, or the Pantex V Curve formula should be used for establishing minimum separation distance between EMR sources and EEDs.

Note 1: EEDs are vulnerable to initiation from a variety of sources. One potential hazard associated with EEDs is the accidental initiation by stray electromagnetic energy. This hazard exists when an electromagnetic field of sufficient intensity is generated to induce or otherwise couple currents and/or voltages of magnitudes large enough to initiate EEDs or other sensitive explosive components of weapon systems, or other explosive devices. This unintended actuation could have safety (premature firing) or reliability (dudding) consequences.

Note 2: The degree to which EEDs are susceptible to unintentional initiation by exposure to the radiated fields of RF emitters depends on many variables. These variables include the ability of the leads, circuit, or installation to capture RF energy; the type and characteristics of RF energy; and methods of coupling that can introduce this energy into the EED.

Note 3: Some EEDs are initiated by low levels of electrical energy and are susceptible to unintentional initiation by many forms of direct or induced stray electrical energy, such as from lightning discharges, static electricity, or tribo-electric (friction generated) effects, and radio frequency (RF) energy.

Note 4: Lightning protection systems and requirements normally preclude the inadvertent initiation of EEDs by direct lightning strikes.

Note 5: Stray energy, such as transients and other forms of induced energy, can be imposed on circuits affecting EEDs from other subsystems by various methods. Examples are inductive or capacitive coupling; sneak ground circuits; defective components or wiring; and errors in design, modification, or maintenance.

Note 6: Emitter operating frequencies, power levels, modulation, and illumination angles are some of the factors that affect the vulnerability of EEDs to RF energy.

39. STATIC ELECTRICITY

39.1. Bonding and Grounding of Equipment

39.1.1. All equipment requiring grounding shall be interconnected if a structure is equipped with a lightning protection system.

39.1.1.1. Wires used as static ground conductors should be at least No. 10 AWG.

39.1.1.2. Static grounds shall not be made to gas, steam, or air lines; dry pipe sprinkler systems; or air terminals of lightning protection systems.

Note 1: Bonding straps may be used to bridge locations where electrical continuity can be broken by the presence of oil on bearings, paint, or rust at any contact point.

Note 2: Pressure contact alone is not adequate grounding for permanent equipment in contact with conductive floors or tabletops.

Note 3: Static grounds can be made to water pipes, ground cones, buried copper plates, or driven ground rods of lightning protection systems.

39.2. Testing Bonded Equipment Grounds

39.2.1. Grounding systems shall be tested for electrical resistance and continuity after installation has been completed and, in the case of active equipment, intervals are determined by Contractor Facility Management.

39.2.1.1. If the equipment has been inactive for more than one month, the ground system shall be visually inspected for continuity before reactivation of the system. All exposed explosives or hazardous materials shall be removed before testing.

39.2.1.2. When testing for resistance-to-ground, equipment should be considered as a unit except in the case of an electrically isolated device or a belt-driven machine.

Note: In measuring the total resistance-to-ground for belt-driven machinery resistance of the belting is to be excluded.

39.2.2. In hazardous locations (operations where a static spark discharge may be dangerous), all conductive parts of equipment shall be bonded.

39.2.2.1. In the case of grounded equipment, bonding shall be such that resistance to ground does not exceed 25 ohms, unless resistance is not to exceed 10 ohms because of a lightning protection installation.

39.2.3. For existing equipment, the rate of static generation should be considered before making changes in grounding systems.

39.3. Conductive Floors, Shoes, Mats and Wristbands

39.3.1. In areas where personnel come into the proximity of (i.e., possible contact with) static-sensitive explosives or vapors, conductive floors shall be installed except where adequate housekeeping, dust collection, ventilation, or solvent recovery methods eliminate the hazards of dust-air or flammable vapor-air mixtures.

39.3.2. Conductive floors and shoes should be used for grounding personnel in operations involving explosives (propellants, pyrotechnics, lead azide, lead styphnate, mercury fulminate, CP) that are sensitive to initiation by human electrostatic discharge.

Note: Conductive floors may also be required in areas where operations involve static sensitive EEDs.

39.3.3. Conductive floors are not required throughout an entire building or room if the hazard is localized. In such cases, conductive mats or runners may be used where required.

39.3.3.1. These mats or runners shall meet all specifications and test requirements that apply to conductive floors.

Note: Conductive wristbands may be substituted for conductive mats and footwear at fixed, grounded or bonded workstations or outdoor locations.

39.3.4. Where conductive floors and shoes are required, tabletops on which exposed explosives or dusts are encountered should be covered with a properly grounded or bonded conductive material that meets the same requirements as those for flooring.

39.4. Conductive Floor, Shoes, Work Surface, Wristband, and Rubber Hose Specifications

39.4.1. Conductive floors shall be made of non-sparking material such as conductive rubber or conductive flooring composition.

39.4.2. The flooring shall provide for electrical resistance not to exceed 1,000,000 ohms.

39.4.3. The surface of the installed floor shall be free from cracks and reasonably smooth. The material shall not slough off, wrinkle, or buckle under operating conditions.

Note: Conductive tiles are not recommended for use in areas where explosives dust can cause contamination. The large number of joints and the tendency of tiles to loosen provide areas in which explosive dust can become lodged, making normal cleanup procedures difficult.

39.4.4. Conductive floors shall be compatible with the explosive materials to be processed.

39.4.5. Conductive shoes shall provide for electrical resistance not to exceed 1,000,000 ohms.

39.4.6. Conductive wristbands shall not exceed a resistance between the wearer and ground or bonding point of 1,200,000 ohms.

39.4.7. Wristbands shall be of a design that maintains electrical contact with the wearer when used.

39.4.8. Table-top work surface mats shall have a resistance not to exceed 1,200,000 ohms.

39.4.9. The resistance of conductive rubber hose should not exceed 250,000 ohms.

39.5. **Conductive Floor, Shoes, Work Surface, and Wristband Tests**

39.5.1. Test instruments shall be used only when the room is free from exposed explosives and flammable gas mixtures.

39.5.1.1. Each electrode shall weigh 2.3kg and shall have a dry, flat, circular contact area 6.5cm in diameter, which shall comprise a surface of aluminum or tinfoil 1.3 to 2.5mm thick, backed by a layer of rubber 0.6 to 0.65cm thick and measuring between 40 and 60 durometer hardness as determined with a Shore Type A durometer (ASTM D-2240).

39.5.2. Initial tests shall be made of all conductive floors, and subsequent tests shall be made at least semi-annually.

39.5.3. Maximum floor resistance shall be measured with an ohmmeter that operates on a normal open circuit output voltage of 500 volts DC and a

short circuit current of 2.5 milliamperes with an effective internal resistance of approximately 200,000 ohms.

39.5.4. The floor shall be clean and dry. “Electrode jelly” such as brushless shaving soap or saline solution shall not be used.

39.5.5. The resistance of the floor shall be more than 5,000 ohms in areas with 110-volt service and 10,000 ohms in areas with 220-volt service, and less than 1,000,000 ohms in all areas, as measured between a permanent ground connection and an electrode placed at any point on the floor and also as measured between two electrodes placed 3 ft apart at any points on the floor.

Note: Measurements shall be made at five or more locations in each room. If the resistance changes appreciably with time during a measurement, the value observed after the voltage has been applied for about 5 seconds shall be considered as the measured value.

39.5.6. Where conductive floors and shoes are required, resistance between the ground and the wearer shall not exceed 1,000,000 ohms.

39.5.7. Conductive wristbands shall not exceed a resistance between the wearer and ground or bonding point of 1,200,000 ohms.

39.5.8. Table-top work surface mats that are not part of a total conductive system shall have a resistance not to exceed 1,200,000 ohms.

39.6. **Humidification**

39.6.1. Humidification to prevent static electricity accumulations and subsequent discharges is usually effective if the relative humidity is above 60%.

Note: Due to the possibility of spontaneous ignition, certain materials such as metallic powders and some pyrotechnic mixtures cannot be exposed to air with 60% relative humidity.

39.6.2. Where this technique is used to prevent static electricity accumulations, a daily preoperational check of the humidity levels shall be accomplished before work starts.

40. FIRE PROTECTION

40.1. Vegetation Control

40.1.1. Vegetation around storage magazines and explosives operating facilities should be controlled to minimize potential damage to the magazine or facility from erosion or grass, brush, or forest fires.

40.1.2. A firebreak at least 50 ft wide and free from combustible material should be maintained around each aboveground magazine or explosives operating facility.

40.1.2.1. If an aboveground magazine or explosive facility exterior is fire resistant, the firebreak can have vegetation, but the growth shall be controlled to prevent rapid transmission of fire to the magazine or facility.

40.1.3. Maintaining the firebreaks around earth-covered magazines and cutting grass covering these structures is only required 5 ft from ventilators to prevent transmission of a fire into a structure.

40.2. Fire Protection Criteria

40.2.1. The following fire protection criteria shall be required for all new facilities or redesign of existing facilities where changes in activities shall result in a higher hazardous classification.

40.2.1.1. Automatic fire suppression systems shall be installed in all buildings containing HE and plutonium, except storage magazines, firing chambers, or rooms used as firing chambers within explosives operating buildings.

40.2.1.2. Where fire suppression is required, each explosives bay shall have an individual feed with its controls protected outside the bay and located to enable system operation if a detonation occurs in any bay.

40.2.1.3. Transmitted fire alarms shall distinguish between explosives and non-explosives areas through the use of annunciator panels at safe locations; small non-HE areas do not need separately transmitted alarms.

41. FACILITY EGRESS

41.1. Personnel Protective Restrictions and Requirements

41.1.1. DOE occupancies containing high explosives dictate that personnel be protected from blast overpressures and fragments (and spread of plutonium in some occupancies) from an accidental detonation.

Note: Accidental detonation of explosives is usually the result of stimuli other than a fire.

41.1.2. Non-compliance with some means of egress provisions (such as those covering exit doors, exit travel distance, number and location of exits, and common path of travel to exits), is permitted where required to provide protection from blast overpressure and fragments.

Note: Justification for non-compliance shall be documented.

41.1.3. When means of egress requirements are not met, the following additional personnel-protective restrictions or requirements should be imposed:

41.1.3.1. The building and means of egress should be protected by supervised automatic sprinkler systems connected to sound evacuation alarms.

41.1.3.2. Explosives operating buildings and their means of egress should have automatic, early warning fire detection systems connected to sound evacuation alarms where such early warning might reasonably aid in prevention or mitigation of personnel injury.

Note: This requirement is not applicable to explosives storage magazines, firing chambers, or rooms used as firing chambers within explosives operating buildings.

41.1.3.3. Personnel limits within the explosives work area (bay, cell) shall be established and controlled. These should not exceed 20 for reduced hazard occupancies or 6 for high hazard occupancies.

41.2. Requirements for Existing Facilities

41.2.1. Existing facilities may deviate from current means of egress requirements in the following situations:

41.2.1.1. Code requirements are not part of the defined code-of-record.

41.2.1.2. Deviations were made to meet Level-of-Protection and design criteria.

41.2.1.3. Building construction predates both current and Level-of-Protection criteria, but a hazard analysis has shown the risk of operations to be acceptable.

41.3. Requirements for New Facilities

41.3.1. If deviations from means of egress requirements are made, the following aspects related to each explosives operation, bay, and/or workroom where a deviation exists shall be reviewed and documented (e.g., Fire Hazard Analysis, Fire Protection Facility Assessment) by a qualified Fire Protection Engineer (see DOE-STD-1066).

41.3.2. The criteria considered acceptable for the Fire Protection Engineer review are:

41.3.2.1. No obstruction shall limit the width of the pathway to less than 36 in.

41.3.2.2. Combustible and flammable material quantities shall be minimized, justified, documented, and reviewed by site fire protection personnel and approved by line management. Ignition sources shall be identified and eliminated where possible.

41.3.2.3. The total time for six people to exit the workroom or bay, including the opening of doors where necessary is 30 seconds or less.

41.3.2.4. The total time for 20 people to exit the workroom or bay is 90 seconds or less. Noncompliance with this criterion shall be evaluated and justified during the conceptual design review.

41.4. Single Exits

41.4.1. Where means of egress requires at least two exits, but provisions for personnel protection from an explosion do not permit at least two exits from a room or structure, a single exit is acceptable, provided the following are met:

41.4.1.1. The path of exit travel shall be arranged so it is not through or toward a hazardous operation.

41.4.1.2. A room containing a high hazard explosive occupancy shall not exceed 500 ft^2, and the occupant load of the room shall be restricted to two operators and two casuals.

41.4.1.3. A room containing a reduced hazard explosive occupancy shall not exceed 1,000 ft^2.

41.4.2. Explosives storage magazines may have only single exits for the purpose of maintaining integrity of design.

Note: The conditions of this chapter do not apply to these magazines.

41.5. Blast Resistant Doors

41.5.1. Blast resistant doors required to protect personnel from the effects of an accidental detonation may be located in the means of egress, provided the requirements of Sections 41.1 through 41.3 and the following are met:

41.5.1.1. Where power operated doors are required to accomplish unlatching and opening, they shall have redundant features or be capable of being opened manually (to permit exit travel) or closed where necessary to safeguard exits.

41.5.1.2. The time required to fully open or close a door shall be as short as reasonably possible.

41.5.1.3. A revolving door is acceptable if a secondary means of escape (with swinging doors) is provided at the same location.

Note: The revolving door shall be prevented from rotating at too rapid a rate to permit orderly exit of personnel.

41.5.1.4. The following exceptions to means of egress requirements are permitted with documented justification:

- Swinging doors may exceed 48 in wide.
- Swinging doors adjacent to a revolving blast door can be omitted.
- Revolving blast doors need to be designed to collapse into book fold position.
- Where fire rated doors are required, blast doors are considered to have the required fire rating.
- A vestibule with two or more doors that is intended during routine operations to prevent continuous and unobstructed passage by allowing the release of only one door at a time shall be permitted in a means of egress.

  Note: In such cases, there shall be provisions to allow for continuous and unobstructed travel during an emergency egress condition.

- Panic hardware is not required on blast doors.

41.6. **Slide Escapes**

41.6.1. Slide escapes should be provided for elevated explosives operating locations from which rapid exit may be vital and cannot be obtained by other means.

41.6.2. Slide escapes should be located on opposite sides of the explosives operation to reduce the likelihood of personnel being trapped by fire between them and a single slide.

41.6.3. Exits to slide escapes shall open onto platforms that are not less than 3 ft^2 and the platforms shall be equipped with guardrails.

41.6.4. The slides shall begin at the outside edge of the platform, not at the edge of the buildings.

41.6.5. Slide escape landings shall be located at selected places leading directly to escape routes that are free from tripping hazards, low guy lines, drains, ditches, or other obstructions.

41.6.6. Manually or automatically controlled devices (trips) that sound an alarm in the operating building shall be installed at or near the entrances to slide escapes.

Note: These devices may also actuate deluge valves and water curtains in the building or room affected. Recommended slide escape specifications:

41.6.7. Recommended slide escape specifications:

- Angle, 40 to 50 degrees horizontal.
- Slide depth, 24 in.
- Radius at bottom of slide, 12 in.
- Height at lower end of slide, not over 24 in. above the landing.

41.6.8. If necessary, the end of the slide shall have a horizontal run sufficient to prevent employee injury from exit speed without the use of landing cushions, which are unsatisfactory in cold weather.

41.6.8.1. One foot of horizontal run is required for a 15 ft. long slide.

41.6.8.2. One additional foot of horizontal run shall be provided for each additional 5 ft. of slide length.

41.6.8.3. The juncture of the two sections shall be well rounded.

41.6.8.4. Metal sheets constructing the slide shall overlap in the direction of travel.

42. LIGHTNING PROTECTION

42.1. Lightning Protection Systems

42.1.1. All explosives structures shall be protected by a lightning protection system (LPS) that is compliant with the code-of-record version of NFPA 780 unless not required as noted in this chapter.

42.1.2. Sideflash (Arcing) Protection.

42.1.2.1. NFPA 780 shall be used to determine sideflash protection for all structures other than those with a Faraday like shield LPS.

Note: For Faraday like shield structures, in general, explosives and dunnage should be in contact with no more than one interior surface, this contact surface is normally the floor, shelf, or workbench.

42.1.3. Sideflash separation distance as determined by NFPA 780, shall be applied as given below:

42.1.3.1. All sideflash separation distances shall be measured from the outermost surface of the container, packing, device or equipment holding the explosive that is nearest the structural surface, or penetration extension in question.

Note: Measure from the surface of the explosive itself only when the explosive is bare.

42.1.3.2. When sideflash separation distance from structural elements and penetrations are maintained, approved explosives storage containers provide adequate protection from effects of lightning current flow.

Note: Containers are authorized to be in direct contact with each other.

42.2. Conditions Where Lightning Protection Is Not Required

42.2.1. A documented analysis reviewed by the Contractor Explosives Safety AHJ and approved by Contractor Facility Management demonstrates that the cumulative annual risk of a lightning strike to the structure in question or to any of the metallic penetrations of that structure is low.

Note: Methods for determining cumulative annual risk can be found in NFPA 780 Annex L. Equivalent methods may also be used.

42.2.2. Explosives operations served by a local lightning warning system (LWS) where:

42.2.2.1. Contractor Facility Management accepts, in the event lightning does strike the unprotected structure or the structure's penetrations, the potential damage, the loss of use of the structure, and the impact on other explosives operations at the facility; and

42.2.2.2. Contractor Facility Management accepts the impact of pausing all operations in other structures and the area within public traffic route (remote) distance of the structure without an operable LPS during a lightning threat; and

42.2.2.3. The Facility has a local effective LWS and lightning warning plan.

42.3. Lightning Warning and Protection Plan

42.3.1. Each site's Lightning Warning and Protection Plan shall take into consideration additional hazards due to the presence of explosives as identified in this chapter.

42.4. Lightning Threat Actions

42.4.1. Each site shall establish specific documented criteria for continuation or pause of explosives operations at the receipt of lightning threat notifications.

Note: These criteria should be based on the sensitivity of operations involved and the amount of time required to safely pause operations.

42.4.2. Contractor Facility Management shall evaluate their explosives operations to determine the time required to:

42.4.2.1. Safely pause explosive operations where required.

42.4.2.2. Evacuate personnel from the areas specified in Paragraph 42.4.6 to safe locations, or

42.4.2.3. Relocate explosives to a safe sideflash separation (standoff) distance.

42.4.3. Contractor Facility Management shall determine in advance of any lightning threat those activities that shall be paused and at what threat level the pause for each identified activity shall begin.

42.4.4. For a lightning threat alert, Contractor Facility Management shall evaluate pausing the following activities:

42.4.4.1. Activities involving AC powered electrical equipment in direct or indirect contact with explosives regardless of the form of LPS installed.

42.4.4.2. Explosives operations in an unprotected building or outside (some activities may be safer to proceed to a planned detonation or to a safe mode for the explosive).

42.4.4.3. Work with exposed electrostatic discharge sensitive (0.1 joule or less) EEDs in structures not equipped with a Metallic (Faraday-Like) Cage.

42.4.4.4. Explosives work in structures not equipped with a Metallic (Faraday-Like) Cage and where any explosives are at a sideflash separation distance less than that specified above or by NFPA 780.

42.4.5. For a lightning threat warning, Contractor Facility Management shall evaluate pausing the following activities in addition to those specified in the lightning threat alert.

42.4.5.1. Outside activities involving explosives.

42.4.5.2. Activities where extensions of penetrations, bonded or not, are in direct or indirect contact with the explosives.

42.4.5.3. Positions of hoists, without non-conductive links, and other movable conductive projections into a facility that can be moved or retracted to a maximum distance from explosives or explosive devices.

42.4.5.4. Explosives operations in structures not equipped with a LPS.

42.4.6. Contractor Facility Management shall determine in advance of any lightning threat notification those structures and areas that shall be evacuated and at what threat level the evacuation should begin. Contractor Facility Management should evaluate evacuating the following areas as a minimum:

42.4.6.1. Explosives structures without an LPS.

42.4.6.2. Magazine areas.

42.4.6.3. Structures not equipped with a Faraday like shield LPSs and containing exposed electrostatic discharge sensitive (0.1 joule or less) EEDs.

42.4.6.4. Structures not equipped with a Faraday like shield LPS and containing exposed electrostatic discharge sensitive (0.1 joule or less) explosives.

42.4.6.5. Parked, explosives-laden vehicles.

42.4.6.6. All buildings and areas within public traffic route distance (based on a 2.3 psi as given in DESR 6065.09 of an explosive structure not equipped with a LPS.

42.4.7. When Contractor Facility Management determines that evacuation of personnel from and around explosives structures is required, the following shall apply:

42.4.7.1. DOE/NNSA personnel and contractor/subcontractor personnel in the identified buildings and areas shall be evacuated to at least public traffic route distance.

42.4.7.2. Other personnel shall be evacuated to at least inhabited-building distance.

42.4.7.3. The evacuation distances shall be based on the maximum operating quantities and Hazard Division of explosives approved for the structure and on applicable psi and fragment distances as given in DESR 6055.09.

42.4.7.4. In lieu of evacuation, personnel are authorized to take shelter in a room or building that provides protection from overpressures in excess of 2.3 psi, fragments, and structural collapse in event of an explosion of any adjacent structure containing explosives.

42.4.7.5. During evacuation periods, personnel are allowed, at Contractor Facility Management's discretion, to pass within the specified distance of explosives structures not equipped with a LPS if required for evacuation or to gain access to or leave other operating areas.

42.5. **Pause of Operations**

42.5.1. When operations are being paused during lightning threat notifications, the following should apply:

42.5.1.1. Process equipment containing explosives should be stopped as soon as safety permits.

42.5.1.2. If a building or bay is being evacuated, the minimum number of personnel needed to safely pause operations that cannot be paused immediately are authorized to remain at the building. As soon as operations are paused, they shall evacuate.

42.5.1.3. Explosives testing can continue as long as personnel are not required to leave the test shelter.

Note: Operations at test firing areas shall be paused during lightning threat warning when explosives are present. Completion of a test after receiving a lightning threat alert may be allowed if test preparation has progressed to the point that discontinuing testing represents a greater personnel exposure than completing testing.

42.5.1.4. Actions required to be taken by personnel transporting explosives on site should be specified.
Note: Safe parking areas should be identified.

43. BUILDING AND EQUIPMENT MAINTENANCE

43.1. Cleaning

43.1.1. To maintain safe conditions, building interiors shall be cleaned regularly to prevent the accumulation of explosives dust and waste on exposed surfaces (e.g., structural members, floors, radiators, heating coils, utility lines, equipment, electrical fixtures).

43.1.1.1. These cleaning activities should not be conducted as a concurrent operation during hazardous operations.

43.1.1.2. Floors should be cleaned with hot water or a water steam mix wherever practical. Non-abrasive sweeping compounds that are compatible with the explosives involved may be used when a water steam mix or hot water is not practical.

Note 1: Such sweeping compounds may be combustible but shall not be volatile (closed cup flash point shall not be lower than 230°F (110°C)).

Note 2: Sweeping compounds containing wax shall not be used on conductive flooring.

Note 3: Where nitrated organic explosives (which may form sensitive explosive compounds with some alkalis) are involved, the use of cleaning agents containing those alkalis is prohibited.

43.1.2. Before resuming operations following maintenance, the area shall be cleaned and approved by the Supervisor.

43.2. **Maintenance and Repair**

43.2.1. Maintenance operations involving major repairs, changes, or the use of hazardous equipment should not be performed in work areas while explosives are present.

Note 1: Before beginning such maintenance, explosives should be removed and the area prepared.

Note 2: An approved procedure shall be established to verify that the area has been inspected and is safe for these operations.

43.2.2. Non-facility personnel performing maintenance or construction operations shall be at least intraline distance from any explosives operation and should be at least intraline distance from any building containing explosives.

Note 1: This requirement does not apply to personnel making job site inspections or equipment repairs requiring less than eight hours (e.g., technical representatives, architect engineering surveyors).

Note 2: Transportation of explosives is permitted on roadways at less than intraline distance.

43.2.3. Contractor Facility Management shall determine the minimum practical distance by which non-facility personnel (e.g., technical representatives, service representatives, architect engineering surveyors) shall be separated from explosives operations while making job site inspections or equipment repairs requiring less than eight hours.

43.2.3.1. The rationale for establishing the minimum practicable distance and additional control measures taken shall be documented and maintained until operations have been completed and personnel have permanently vacated the work site.

43.2.3.2. All such personnel shall be informed of the risk of working at less than intraline distance and shall agree to accept such risk.

43.2.4. New equipment or equipment subjected to major repair or modification shall be test operated, and handling equipment shall be tested before being returned to operations.

43.3. Hot Work Permits

43.3.1. In explosives work areas, a written permit shall be completed for the temporary use of portable, heat producing equipment that generates temperatures higher than 228°F (109°C).

43.3.2. Explosives decontamination of the immediately affected work areas and explosives removal shall be required before beginning hot work operations.

44. DECONTAMINATION AND CLEANING

44.1. Cleaning Operations

44.1.1. Operating procedures shall specifically cover decontamination.

Note 1: These procedures should cover methods, inspection, marking, control, dismantling, maintenance, final disposition, etc.

Note 2: Reference TB 700-4 for decontamination methods and marking.

44.1.2. Hot water or steam may be used to clean or remove explosives contamination from equipment.

44.1.3. When required, solvents that have been tested for and are compatible with explosives can be used.

Note: Operating procedures shall specify controls for their use.

44.1.4. When cleaning or removing explosives material from equipment, work surfaces, and floors, only clean cloth rags, paper wipes, and approved non-metallic brushes or scrapers should be used in conjunction with hot water, steam, and solvents.

44.1.5. Items to be cleaned should be positioned so that water and residue shall drain directly into an approved collection system. See Chapter 47 for waste collection and Chapter 48 for waste disposal.

44.1.6. Disposal of waste generated shall be coordinated with site environmental/waste management personnel.

44.1.7. Exhaust ventilation may be required to remove toxic explosives fumes, vapors, or steam from the cleaning area.

44.2. **Cleaning Screw Threads**

44.2.1. To avoid the necessity of cleaning explosives from threads, explosives processing techniques shall be designed to prevent explosives from being deposited on threaded fasteners.

44.2.2. When screw threads are required, covering or protection (e.g., sealant, cement) over the exposed threads should be provided.

44.2.3. Threads should be cleaned using approved non-metal “picks,” solvent, hot water, or steam.

Note: Soaking in solvents and applying penetrating oil may be useful.

44.2.4. After cleaning exposed threads of screws, bolts, pipe, etc., operator protection may still be required to facilitate safe disassembly.

44.3. **Final Decontamination and Disposal of Equipment**

44.3.1. If the item to be decontaminated has only smooth, flat surfaces (i.e., no cracks, seams, voids, or other places where explosive residue may be inaccessible), hot water, steam, or solvents may be employed to accomplish decontamination.

Note: Any explosives contamination of concern shall be visible to the unaided eye and shall have dimensions (length, width, and depth).

44.3.2. If the item to be decontaminated has tight places where explosives may remain lodged following normal cleaning procedures, the item shall be subjected to final decontamination techniques that may include partial disassembly.

44.3.2.1. Before subjecting an item to final decontamination by thermal or chemical techniques, as much explosive as possible shall have been removed by approved means (hot water, steam, and approved solvents in conjunction with cloth or paper wipes and non-metallic brushes or scrapers).

44.3.2.2. Items undergoing final decontamination by thermal techniques shall be subjected to sustained heating at a temperature at least 108ºF (60°C) higher than required for decomposition of the most thermally stable explosive substance present.

Note 1: The item shall be kept at that temperature for a sufficient period so that all parts have reached the temperature and all explosives material is decomposed.

Note 2: Thermal decomposition is usually accomplished by placing the items to be decontaminated in a high-temperature sustained fire (see TB 700-4). This operation shall be conducted remotely or with operator protection.

44.3.2.3. Final decontamination also may be accomplished by immersing the item in a chemical cleaning agent.

Note 1: The period of immersion shall be sufficient so that all explosive material is chemically decomposed.

Note 2: The chemical cleaning agent shall be one that TM 9-1300-214 has approved for use.

Note 3: Chemical cleaning agents for decontamination or destruction of explosives should not be used for more than about 1 oz of explosives.
Note 4: Reference TM 9-1300-214 for decontaminating chemicals for explosives and for color tests for identification of energetic materials.

44.4. **Inspection**

44.4.1. After decontamination procedures are complete and before transfer to a nonexplosive area, the item shall be inspected.

44.4.2. The degree of decontamination shall be determined/documented and the item shall be labeled to indicate its decontaminated state.

44.4.3. Representatives of at least two departments, such as operations or safety, should accomplish the inspection.

44.5. **Identification and Control of Decontaminated Items**

44.5.1. Decontaminated items shall be marked to indicate the degree of decontamination and stored separately from non-contaminated items until final disposition is made.

44.5.2. Degrees of decontamination shall be designated and all items shall be tagged and/or marked with this designation.

44.5.3. Guidelines for establishing a system to designation degrees of decontamination are provided below.

44.5.3.1. X—A single X indicates that the facilities or equipment have been partially decontaminated. Additional decontamination processes are required before facilities or equipment are moved or any maintenance,

repair, etc., is performed. The X rating would apply to facilities, rooms, bays, or equipment that have been subjected to routine decontamination performed by an operator at the close of the workday.

44.5.3.2. XXX—Three Xs indicate that the equipment or facilities have been examined and decontaminated by approved procedures; no contamination of concern (see Note under Paragraph 44.3.1) can be detected by appropriate instrumentation, test solutions, or by visual inspection on easily accessible surfaces or in concealed housings, etc., and are considered safe for the intended use. Items decontaminated to this degree cannot be furnished to qualified DOE, DoD, or industry users or be in direct contact with an open flame (cutting, welding, high temperature heating devices), or operations which generate extreme heat, such as drilling and machining unless the following two conditions are met:

- It has been determined that decontamination to the XXXXX level shall destroy the item's usefulness.
- Decontamination to a degree less than XXXXX in combination with administrative and technical safeguards shall eliminate risk of injury. As a minimum, an approved operating procedure setting forth the specific operational limitations, precautions, and monitoring necessary to assure safety shall be available and decontamination shall be performed under the direction of the inspectors who shall certify decontamination.

44.5.3.3. XXXXX—Five Xs indicate the equipment or facilities are decontaminated, free of explosives hazards, and may be released for general use or to the general public.

44.5.3.4. 0—A zero indicates the item, although located in a contaminated area, was never directly exposed to contamination.

45. COLLECTION SYSTEMS

45.1. Vacuum Equipment

45.1.1. Precautions shall be taken to prevent explosives from entering any vacuum system not specifically designed to collect explosives.

45.1.2. All vacuum lines used for explosives operations should be labeled to warn maintenance personnel that explosive residue may be present in these lines.

Note: A suggested label is:

DANGER, MAY CONTAIN EXPLOSIVES

45.1.3. All vacuum lines that are potentially contaminated with explosives shall be disassembled according to approved operating procedures.

45.1.3.1. Disassembly should be accomplished at flanged connections or elastomeric tubing whenever practical.

45.1.3.2. No attempt should be made to disassemble a vacuum line at a threaded connection.

45.1.4. The design or installation of any new vacuum lines associated with processes capable of generating explosives contamination of concern shall not employ demountable, internal screwed, or threaded fittings or connections unless welded or fixed permanently in place.

45.1.5. Vacuum systems used to evacuate processes for explosives operations that are capable of generating explosives contamination of concern shall be equipped with primary and secondary intake line traps or filters to prevent explosives from contaminating the pump.

45.2. **Explosives Dust Exhaust Ventilation and Collection Systems**

45.2.1. Exhaust ventilation should be used to control explosives dust.

45.2.2. Exhaust ventilation used to remove explosives dust requires an approved dust collection system to prevent the release of the dust outside the building.

45.2.3. Exhaust ventilation and collection systems that control explosives dust and materials associated with explosives production shall be designed to meet minimum requirements in the American Conference of Government Industrial Hygienists (ACGIH) Ventilation Manual and this Technical Standard.

45.2.4. A “wet collector” that moistens the dust close to the point of origin and keeps it wet until the dust is removed for disposal is preferred.

Note: A “dry type collector” is permitted when authorized by an approved operating procedure.

45.2.5. Dust collectors shall be designed to prevent explosives dust from reaching any mechanical power source of the collection system.

45.2.6. All conductive portions of the collection system shall be grounded and bonded.

45.2.7. A dust collection system shall not have screw threads, recesses, or cracks that may be exposed to explosives contamination.

45.2.8. Dust collection lines should be equipped with flanged connectors and inspection ports.

45.2.9. Pipes or ducts through which explosives are conveyed shall be designed using one of the following methods:

45.2.9.1. The pipes or ducts shall be designed to avoid dead spots or propagation of detonation.

45.2.9.2. The design shall establish pipe characteristics including materials selection, diameter and turn radius in relation to the material being transferred, its ignition and detonation characteristics, and transfer rates.

45.2.9.3. The pipes and ducts shall have long radius bends with a centerline radius at least four times the diameter of the ducts or pipes.

45.2.10. Dust collectors shall be emptied and cleaned on a regular basis as system use warrants and shall be inspected periodically.

45.2.11. Wherever practical, dry type explosives dust collection chambers should be located outside operating buildings, in the open, or in buildings exclusively set aside for the purpose.

45.2.12. Stationary and portable wet type collectors may be placed in the explosives operating bays or cubicles, provided the quantity of explosives in the collectors does not exceed 2 kg.

46. DRAINS AND SUMPS

46.1. Collection

46.1.1. All drain lines handling explosive wastes shall be provided with sumps, clarifiers, weirs or basins of adequate design and capacity for removal of explosives by settling.

46.1.2. The drains shall be of adequate capacity, free of pockets, and have sufficient slope (at least ¼ in./ft.) to prevent the settling out of explosives in the line until it reaches the sump, clarifier, weir or other settling basin.

46.1.3. Drain gutters within buildings may be constructed with a slope of ⅛ in/ft.

46.1.3.1. Drain gutters shall be cleaned periodically.

46.1.4. Sumps shall be designed to prevent suspended and settleable solid explosive material from being carried in the wash waters beyond the sumps.

46.1.4.1. The design shall allow sufficient settling time on the basis of the settling rate of the material and the usual flow rate.

46.1.4.2. Sumps shall be constructed so that the overflow does not disturb any floating solids.

46.1.4.3. The design shall also permit easy removal of collected explosives and retention of those explosives that float on water (until they can be skimmed off).

46.1.5. When using settling basins to supplement sumps, they shall be cleaned periodically.

46.1.6. The following requirements apply to sumps and associated equipment:

46.1.6.1. Explosives collection trays for sumps shall be constructed of nonferrous metal.

46.1.6.2. Hoisting equipment used to lift trays shall be designed to prevent the trays from binding on the sides of the sump.

46.1.6.3. Bolted sump tanks or other types of construction that permit the explosives to settle in obscure or hidden spaces shall not be used.

46.1.7. Drains between the source of explosive and the sump shall be troughs with rounded bottoms and removable ventilated covers to facilitate inspection for accumulation of explosives.

46.1.7.1. This requirement applies to all new construction and major modifications and should be considered for existing facilities.

46.1.8. Short sections of closed pipe or trough are permitted if they can be visually inspected for blockage or explosives buildup.

46.1.9. Explosives or explosives contaminated waste liquids shall not be released into closed drains and sewers.

46.1.10. Drains shall be inspected periodically and necessary steps taken to prevent the buildup of explosive deposits.

46.2. **Effluent**

46.2.1. Drains containing explosive waste materials shall not be connected in a manner that allows such wastes to empty into the normal sewage systems carrying inert or sanitary wastes.

46.2.2. Care shall be taken to avoid the possibility of deposition of explosives from sump effluent due to drying, temperature changes, or interaction with other industrial contaminations.

46.2.3. When handling explosives that are appreciably soluble in water, sweeping and other dry collecting measures shall be used to keep such out of the drainage system.

46.2.4. The combination of sumps, settling ponds, and other systems shall remove explosives so that outflows meet environmental standards.

47. WASTE COLLECTION

47.1. **Removal of Explosives Waste**

47.1.1. Provision shall be made to remove explosives waste from areas where it is generated.

47.1.2. Removal of explosives waste may be accomplished by (see also Chapters 45 and 46):

- Collecting dust/fines or chips in a wet or dry vacuum system
- A slurry of water or nonflammable solvent
- By collecting solid waste in receptacles

47.1.3. Explosives waste shall be collected and maintained separately from conventional waste.

47.1.4. Mixing of incompatible explosive waste shall be avoided.

47.1.5. Receptacles shall be clearly labeled to indicate the type of waste permissible.

47.2. **Solid Wastes**

47.2.1. Areas where solid explosives wastes are not removed by vacuum or liquid systems shall be equipped with a seamless or lined receptacle to collect explosives wastes.

47.2.2. Explosives waste shall be removed from the collection point at an interval to keep aggregate levels within explosive weight limits.

47.2.3. Conventional waste not contaminated by explosives or containing noncombustible materials shall not be placed in an explosives waste receptacle.

47.2.4. Explosives-contaminated waste shall be segregated as combustibles and non-combustibles.

47.2.5. Before being transported, explosives waste shall be packaged to prevent spills, leaks, or exposure to initiation stimuli.

47.2.5.1. Incompatible materials shall not be packaged together.

47.2.5.2. All packages of explosives waste shall be labeled clearly to indicate the nature and approximate quantity of contents.

47.3. **Vacuum Collection of Explosives Dusts**

47.3.1. Explosives dusts should be collected by a vacuum system, preferably the wet type.

47.3.1.1. Dust in a wet vacuum should be maintained in wet form using a wetting agent that is kept close to the point of origin and kept wet in the collection system until removed for disposal.

47.3.1.2. Water-soluble explosives such as Explosive D should be collected in a dry vacuum system.

47.3.2. SCG A explosives may be collected by a wet vacuum system, provided they are maintained in a wet form using a wetting agent that is kept close to the point of intake.

47.3.2.1. Use of a vacuum system to collect these more sensitive materials should be limited to operations involving small quantities of explosives.

47.3.3. Dry-type dust collection chambers, except portable units, should be located in the open, outside operating buildings, or may be inside if adequate shielding is provided.

47.3.3.1. The quantity of explosives collected shall not exceed the capacity of the shielding to protect operating personnel.

Note: The degree of barricading and the appropriate intraline distance shall determine this limit.

47.3.4. If dry dust collection outside a building is not practical, a separate room or shielded area within the building shall be designated for this purpose.

47.3.4.1. This room or shielded area shall not contain other operations or be used as a communicating corridor or passageway between other operating locations within the building when explosives are being collected.

47.3.5. Stationary and portable wet-type collectors may be placed in the explosives operating bays or cubicles if the quantity of explosives in the collectors does not exceed 4.4 lbs.

47.3.5.1. If placed in separate cubicles, the explosive weight limits may be increased by an amount determined by the extent of the cubicle walls' capabilities to serve as operational shields.

47.3.6. Collection systems and chambers shall be designed to prevent explosives from being pinched between metal parts. See Chapter 46 for additional design information.

47.3.7. Two collection chambers shall be installed ahead of the pump or exhauster in series to prevent explosives dust from entering the vacuum producer in dry vacuum collection systems.

47.3.7.1. In addition, non-sparking fans and dust-tight motors shall be used.

47.3.8. Dry-type portable vacuum collectors shall not be located in bays or cubicles where explosives are present or in enclosed ramps, but may be positioned outside the building or in a separate cubicle.

47.3.8.1. The building or cubicle walls shall provide adequate shielding for at least 4.4 lbs. of explosives.

Note: Shielding and QD constraints shall define the explosives limits.

47.3.9. Explosives dust shall be removed from the collection chamber periodically to eliminate unnecessary and hazardous explosives concentrations.

47.3.9.1. The entire system should be cleaned at intervals established by Contractor Facility Management, dismantling the parts if necessary.

47.3.9.2. A cleaning schedule shall be established for the collection chamber and the entire system using the operating hours as a basis.

47.3.10. The entire explosives-dust collecting system shall be electrically bonded and grounded with resistance-to-ground not exceeding 10 ohms.

47.3.10.1. The grounds shall be tested at intervals established by Contractor Facility Management.

47.4. **Explosives Slurries**

47.4.1. Machine tools shall be fitted with wet boxes to catch and direct water and explosives fines to an explosives waste gutter system.

47.4.2. Wastewater that might contain explosives materials shall be kept from contaminating potable water or conventional wastewater systems.

47.4.3. Settling tanks shall be inspected regularly to monitor the waste accumulation.

47.4.3.1. Records of waste removal shall be kept.

47.4.4. When pumping settled explosives from a slurry-settling tank, the operation shall be arranged to preclude exposure of the explosive material to pinching.

47.4.5. Explosives materials in settling basins shall be kept wet until removed.

47.4.5.1. The materials shall be maintained wet until spread out for disposal.

47.4.5.2. Explosives materials containing powdered metals shall be kept sufficiently wet to prevent a dangerous temperature rise resulting from a reaction of the metal with water.

Note 1: The possibility of hydrogen generation in this situation is anticipated.

Note 2: If an explosive or flammable gas can be generated, then proper ventilation shall be supplied to prevent an explosive or flammable mixture from accumulating.

47.5. **Metal Scrap**

47.5.1. Metal scrap shall be inspected to detect explosives contamination.

47.5.2. When scrap is found to contain explosives contamination of concern, it shall be decontaminated in accordance with final decontamination procedures (see Chapter 44).

47.6. Salvaged Explosives

47.6.1. Salvaged explosives materials shall be thoroughly inspected by operating supervisors and reused, screened, reprocessed, or destroyed as the situation warrants.

47.6.2. Salvaged explosives materials shall be classified as SCG L until they have been established to be compatible with the original material.

48. WASTE DISPOSAL

48.1. Preparation for Open Burning

48.1.1. Preparations to burn or place explosives waste on a pad or in a pit shall not begin until 24 hours after the previous burn at the same burning point.

Note 1: The only exceptions are if the burn area has been thoroughly soaked with water and inspected by a qualified person(s) or the temperature of the burning tray/surface has been measured and inspected by a qualified person(s) to achieve personnel safety during subsequent burning operations.

Note 2: The burning point shall be inspected for residual embers or hot spots before loading with explosives.

48.1.2. Before beginning preparations, firing controls shall be disconnected from power sources and circuits shunted and grounded.

48.1.3. Some explosives give off toxic vapors or fumes when destroyed by burning. Refer to section 8.1.4 for hazard prevention and abatement requirements.

48.1.4. Incompatible explosives materials shall not be in the same pit or on the same pad at the same time.

48.1.5. Personnel engaged in burning explosives should be provided with non-static-producing cotton clothing.

48.1.6. Containers of explosives materials shall not be opened less than 10 ft from each other.

48.1.7. Empty explosives waste containers that are to be reused shall be situated an adequate distance from the burning point to prevent charring or damage during the destruction operation.

48.1.8. Based on past experience or analysis, a layer of excelsior or similar material may need to be placed on the bottom of the pit or pad where the explosives waste shall be placed.

48.1.9. Powdered, granular, or slurry form explosives should be placed in a layer not more than 8 cm thick.

48.1.10. Water-wet initiating explosives (SCG A) shall not be allowed to dry completely.

48.1.11. Wood, heating oil, liquid propane, or natural gas may be used to allow complete combustion of the explosives waste material.

48.1.12. The ignition train should be set up to burn upwind, except that the ignition train for burning IHE may be set to burn downwind.

48.1.13. The firing circuit shall require a key for completion. Only one copy of the firing key shall exist, and it shall be in the lead operator's possession.

48.1.14. Radio transmitters and cellular phones in the control shelter and vehicles at the burning site shall be turned off during setup and firing of low-energy electrical squibs to provide protection against radio frequency currents.

48.1.15. Precautions shall be taken to verify that extraneous electrical currents from any source do not unintentionally activate the firing system.

48.1.16 The burn shall be primed after all other preparation work is complete and with a minimum number of personnel present.

48.1.17. Ignition shall be accomplished remotely.

48.2. **Destruction by Burning or Flashing**

48.2.1. Explosives waste may be destroyed by remote burning if it can be done with little chance of detonation.

48.2.2. Explosives-contaminated waste may be burned remotely in a wire cage.

48.2.3. An open furnace or burning area for explosives should be used to destroy wet-machining cuttings and classified parts.

Note: The same furnace or burning area may also be used for flashing casings after washout of an explosive charge.

48.2.4. Explosives in closed containers or casings likely to detonate should not be burned.

48.2.5. Large pieces likely to detonate should not be burned.

48.2.6. Special attention should be given to the placement and orientation of large pieces and those in closed containers or casings.

48.2.7. Approved incinerators may be used to destroy small devices such as detonators, actuators, etc.

48.2.8. Concurrent burning operations shall not be conducted within 150 ft. of each other.

48.2.9. When several pads are burned, the downwind pad shall be ignited first, followed by the others in succession.

48.3. **Ignition System Malfunctions**

48.3.1. If the ignition system fails to fire, treat it the same as an explosives misfire (see Section 31.1).

48.3.2. If the squibs fire but fail to ignite the ignition train, remotely survey the area, and wait at least 30 minutes.

Note: When it appears safe to emerge from the control shelter, disconnect, shunt, and ground the firing circuit, and inspect the squibs, firing system, or ignition train.

48.4. **Post-burn Operations**

48.4.1. No entry should be allowed into the disposal area until eight hours have elapsed unless it can be determined visually that all explosives have been destroyed.

48.4.2. Squib firing lines shall be disconnected, shunted, and grounded before personnel can enter the burn area.

48.4.3. Unburned or partially burned explosives material remaining in the pit or pad may be moved or repositioned for further burning with the following controls:

48.4.3.1. The material shall not be raked or otherwise insulted.

48.4.3.2. The burning operation shall be repeated to destroy any remaining explosive waste.

48.4.4. At least 24 hours shall elapse before ashes are collected.

Note: The only exceptions are if the burn area has been thoroughly soaked with water and inspected by a qualified person(s) or the temperature of the burning tray/surface has been measured and inspected by a qualified person(s) to provide personnel safety.

48.5. **Disposal Area**

48.5.1. Explosives waste destruction operations shall be separated from magazines, inhabited buildings, public traffic routes, and occupied operating buildings so that personnel and facilities are not exposed to hazardous blast overpressure, fire brands, fragments, or projectiles from burning or detonation of explosives.

48.5.1.1. For destruction by open burning or flashing, the minimum separation distance from unprotected personnel and from facilities not associated with the operation shall be Hazardous Fragment Distance in DESR 6055.09, unless carried out in pits or with other aids for limiting the range of fragments and debris if an accidental detonation occurs.

48.5.1.2. Sites should be located taking into account the direction of the prevailing winds to prevent sparks from being blown toward explosives locations.

48.5.1.3. The size of the danger zone for destruction by open detonation shall be determined by one of the following formulas:

- D(ft.) = 328 W⅓
- D(m) = 131 Q⅓

48.5.1.4. Minimum separation distances shall be based on requirements outlined in DESR 6055.09 for areas used for intentional detonations.

48.5.1.5. Self-contained destruction facilities are exempt from the above requirements.

48.5.2. The maximum quantity of explosives that may be destroyed at one time shall be determined by starting with a small quantity, gradually increasing until an optimum amount, consistent with safe and efficient operation, is reached.

48.5.3. Explosives waste and ordinary rubbish shall not be destroyed in the same destruction area at the same time.

48.5.4. During destruction operations, the area within 200 ft of the destruction point shall be kept clear of dry grass, leaves, and other extraneous combustible material.

Note: This clearance may be reduced to fire brand distance if aids to limit the range of fragments and debris are provided for the destruction points used within the disposal area.

48.5.5. Explosive waste awaiting destruction shall be stored at least intraline distance from the explosives being destroyed.

48.5.6. When unloading explosives from vehicles at the burning grounds, explosives containers shall be distributed to trays or other disposal locations.

48.5.6.1. Vehicles shall be moved to a safe location as soon as explosives items have been removed.

48.5.6.2. Explosives containers shall not be opened until vehicles have been withdrawn.

48.5.7. Provisions for emergency firefighting shall be readily available at the waste disposal area.

48.5.8. The burning grounds shall be serviced with telephones or two-way radio communication.

48.6. **Destruction by Detonation**

48.6.1. Cased explosives should be removed from cases and burned or the cased item destroyed by detonation.

48.6.2. Detonators, primary explosives, and other explosives that might detonate, if burned, should be destroyed by detonation.

48.6.3. The destruction by detonation of any explosives material or article shall be considered a Class 0 operation.

48.6.4. A high-energy detonator (e.g., an EBW) or nonelectric detonator should initiate the detonation.

48.7. **Use of Solvents**

48.7.1. Solvent immersion may be used to prepare small quantities of explosives and explosive detonators for destruction.

48.7.2. Items to be destroyed shall be soaked in suitable, compatible solvents until all the explosives material is dissolved.

48.7.3. Saturated solvent solutions shall not be reused.

48.7.4. Solvent-explosives mixtures shall be destroyed by burning.

49. EMERGENCY CONTROL

49.1. Placards and Fire Symbols

49.1.1. Placards and fire symbols as specified in DESR 6055.09 shall be displayed on either buildings, work areas, or multi-building areas to warn of potential hazards from explosives and to provide information for emergency situations.

49.1.2. These placards and symbols shall be readily visible upon approach.

49.2. Emergency Plans

49.2.1. Each site's emergency plan shall take into consideration additional hazards due to the presence of explosives.

50. SECURITY RESPONSE FORCE AMMUNITION

50.1. Recommendations for security vehicles and personnel carrying HD 1.1/1.2 ammunition are included in Attachment A of this chapter.

50.2. Security Ammunition Surveillance

50.2.1. Ammunition used by the security forces, stored for contingency plans, and for other types of operations should be reviewed periodically for serviceability, safety, and any specific lot restrictions or suspensions issued by DoD, other Government agencies, or commercial sources.

50.3. Pre-positioned Storage

50.3.1. When HD 1.2 ammunition is stored inside or at less than inhabited-building distance from inhabited buildings, fragment barriers shall be provided.

Note: Minimally acceptable fragment barriers are: ¼ in of mild steel plate, one layer of sand bags, 12 in of loose sand or dirt, or other equivalent protection.

50.4. Security Working Dog Explosives Training Aids

50.4.1. Security Working Dog explosives training aids (including HD 1.1) may be transported and handled by qualified personnel in areas that provide realistic and effective training per the requirements of AFMAN 91-201 and AFI 31-202.

Attachment A – Recommendations for Security Vehicles and Personnel Carrying HD 1.1/1.2 Ammunition.

1. While performing their duties, security forces are often required to carry HD 1.1/1.2 ammunition in their vehicles and/or on their persons exempt from QD and Level-of-Protection requirements. In the case of an accident or fire, the presence of HD 1.1/1.2 ammunition present significant explosives blast and fragment hazards.

2. The following Explosives Safety recommendations are provided to assist Security Response Force Planners when preparing contingency plans involving the transportation of HD 1.1/1.2 ammunition.

3. The intent of providing these recommendations is that they be applied to routine (non-emergency) security activities when and where deemed appropriate by Security Response Force Management.

Recommendation 1: Apply the Cardinal Principle:

- Carry the minimum quantity of HD 1.1/1.2 munitions needed to support security duties and contingency plans.
- Whenever practicable, pre-position HD 1.1/1.2 ammunition in readily accessible magazines.

Recommendation 2: Additional controls for vehicles carrying HD 1.1/1.2 ammunition:

- Carry no more than 25 lbs NEW of 1.1/1.2 munitions in any individual security response force vehicle.
- Secure the ammunition in the vehicle to prevent excess movement.
- Do not use the vehicle for administrative purposes.
- When temporarily out of security service, separate the vehicle from inhabited facilities and property lines by a minimum of 125 ft.
- If the vehicle is to be parked in excess of one shift, download the ammunition to properly sited magazines or approved facilities.
- Prior to repairing or performing maintenance on the vehicle, download the ammunition into properly sited magazines or approved facilities.

Recommendation 3: Additional controls for personnel carrying HD 1.1/1.2 ammunition:

- Place ammunition temporarily removed from an individuals' uniform/load bearing equipment in approved locations.

References

1. 50 U.S.C. 2401, National Nuclear Security Administration Act.
2. Title 41, Code of Federal Regulations (CFR), Part 102-193, Creation, Maintenance, and Use of Records.
3. DOE O 226.1B, Implementation of Department of Energy Oversight Policy.
4. DOE O 251.1D, Departmental Directives Program.
5. DOE O 410.1, Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements.
6. NNSA SD 410.1A, Implementation of National Nuclear Security Administration Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements.

APPENDIX A. Acronyms

ACGIH	American Conference of Government Industrial Hygienists
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
BOE	Bureau of Explosives
CFR	Code of Federal Regulations
CP	5-Cyanotetrazolpentaamine Cobalt III Perchlorate
DDESB	Department of Defense Explosives Safety Board
DDT	Deflagration to Detonation Transition
DESR	Department of Defense Explosives Safety Regulation
DoD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DSC	Differential Scanning Calorimetry
DTA	Differential Thermal Analysis
EAA	Explosives Approval Authority
EBW	Exploding Bridge Wire
EDC	Explosives Development Committee
EED	Electro-explosive Device
EIDS	Extremely Insensitive Detonating Substance
EIS	Extremely Insensitive Substance
EMR	Electromagnetic Radiation
EOD	Explosive Ordnance Disposal

ES	Exposed site
ESC	Explosives Safety Committee
ESP	Explosives Safety Program
ESSP	Explosives Safety Site Plan
GFCI	Ground Fault Circuit Interrupters
HD	Hazard Division
HDBK	Handbook
HE	High Explosive
HEVR	High Explosive Violent Reaction
HMX	Cyclotetramethylene Tetranitramine
IHE	Insensitive High Explosive
LLNL	Lawrence Livermore National Laboratories
LPS	Lightning Protection System
LWS	Lightning Warning System
MCE	Maximum Credible Event
MSHA	Mine Safety and Health Administration
NA	Nuclear Administration
NEW	Net Explosive Weight
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
OPI	Office of Primary Interest
PBX	Plastic Bonded Explosive
PES	Potential Explosion Site

PETN	Pentaerythritol Tetranitrate
PTRD	Public Traffic Route Distance
QD	Quantity-Distance
RDX	Cyclotrimethylene Trinitramine
RF	Radiofrequency
SDT	Shock to Detonation Transition
SCG	Storage Compatibility Group
TATB	Triamino Trinitrobenzene
TNT	Trinitrotoluene
UFC	Unified Facilities Criteria
UL	Underwriters Laboratory
UN	United Nations
USC	United States Code
UXO	Unexploded Ordnance
XDT	Unknown to Detonation Transition

APPENDIX B. Definitions

ARM. A general term that implies the energizing of electronic and electrical circuitry, which in turn controls power sources or other components used to initiate explosives. The arming operation completes all steps preparatory to electrical initiation of explosives except the actual fire signal.

BARRICADE. An intervening approved barrier, natural or artificial, of such type, size, and construction as to limit in a prescribed manner the effect of an explosion on nearby buildings or personnel.

BAY. A location (e.g., room, cubicle, cell, or work area) containing a single type of explosives activity, which affords the required protection specified for appropriate hazard classification of the activity involved.

BLENDING. The mixing of solid materials (usually dry) by gravity flow, usually induced by vessel rotation.

BONDED (BONDING). Connected to establish electrical continuity and conductivity.

BOOSTER. Explosives used in an explosive train to amplify the shock output of the initiating device and cause detonation of the main explosive charge.

CARDINAL PRINCIPLE. The Cardinal Principle of Explosives Safety is to limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives, consistent with safe and efficient operations.

CASUAL. A person other than an operator who intermittently visits an explosives operation for the purpose of supervision, inspection, maintenance, etc. Casuals do not perform hands-on work with explosives but are otherwise involved with the explosives operation being performed. Casuals are accounted for in the established personnel limits for the area and are provided a Level-of-Protection consistent with the explosion hazard of operations in adjacent areas.

CLEAR ZONE. The required minimum distance for the protection of personnel and facilities from the PES.

COMPATIBILITY. The chemical property of materials to coexist without adverse reaction for an acceptable period of time. Compatibility in storage exists when storing materials together does not increase the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident. Storage compatibility groups are assigned to provide for segregated storage.

CONCURRENT OPERATIONS. Operations performed simultaneously and in close enough proximity that an incident with one operation could adversely influence the other.

CONTACT OPERATIONS. An operation in which an operator and an explosive item are both present with no operational shield.

CONTAMINATION OF CONCERN. Explosives contamination that is visible to the unaided eye and has dimensions (length, width, and depth).

CONTRACTOR EXPLOSIVES DEVELOPMENT COMMITTEE. A committee established at each DOE/NNSA facility engaged in explosives development to be the approving authority for each phase of an explosives development program.

CONTRACTOR EXPLOSIVES SAFETY AUTHORITY HAVING JURISDICTION (AHJ). An Explosives Safety Subject Matter Expert who is appointed by the M&O Contractor Facility Manager to provide day-to-day support to ongoing and planned explosives operations and activities.

CONTRACTOR EXPLOSIVES SAFETY PROGRAM MANAGER. A manager assigned by the M&O Contractor Facility Manager who assists Contractor Facility Management in implementing the requirements of this Technical Standard.

CONTRACTOR FACILITY MANAGEMENT. Management staff of the M&O contractor responsible for explosives facilities at the site.

CONTRACTOR FACILITY MANAGER. The senior M&O manager at the site.

CRITICAL TEMPERATURE. Temperature above which the self-heating of an explosive causes a runaway reaction. It is dependent on mass, geometry, and thermal boundary conditions.

DANGER ZONE. That area around a test site where personnel could be in physical jeopardy due to overpressure, fragments, or firebrands released during an explosive test.

DEFLAGRATION. A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated 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. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction, and temperature and may cause transition into a detonation.

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 propagating shock wave that is originally of

supersonic velocity. When the material is located on or near the surface of the ground, a detonation is normally characterized by a crater.

DIFFERENTIAL SCANNING CALORIMETRY (DSC). A technique in which the difference in energy inputs into a substance and a reference material is measured as a function of temperature or time while the substance and the reference material are subjected to a controlled temperature program, or are held isothermally. The record is the differential scanning calorimetry or DSC curve. The energy input is substituted for ΔT and is plotted in the same manner as a normal DTA curve.

DIFFERENTIAL THERMAL ANALYSIS (DTA). A technique in which the temperature difference between a substance and a reference material is measured as a function of temperature or time while the substance and the reference material are subjected to a controlled temperature program or are held isothermally. The record is the DTA curve. The energy input is substituted for ΔT and is plotted in the same manner as a normal DTA curve.

DIRECT CONTACT WITH EXPLOSIVES. Physical contact between an electrical instrument or equipment to bare explosives, the metallic casing of an explosive, or the firing leads of an explosive device.

DUAL RATED. Equipment and wiring which can be used for both Class I, Division 1 and Class II, Division 2 electrical hazard areas.

DRYING. The removal of volatiles from ingredients or mixtures.

ELECTRO-EXPLOSIVE DEVICE (EED). A device containing some reaction mixture (explosive or pyrotechnic) that is electrically initiated. The output of the initiation is heat, shock, or mechanical action. See also LOW-ENERGY EED.

ENERGIZED. A circuit is energized when any part of it is connected to an electrical energy source.

EXPERIMENTAL PROCEDURE. A procedure prepared for conducting a specific experiment a limited number of times under close technical supervision.

EXPLODING BRIDGEWIRE (EBW). An EED that is initiated by the discharge of a high current through the device bridgewire, causing the wire to explode and produce a shockwave. An EBW as defined herein is a device containing no primary explosive.

EXPLOSIVE. Any chemical compound or mechanical mixture that is designed to function as an explosive, or chemical compound that functions through self-reaction as an explosive, and that, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

DOE explosives may be dyed various colors except pink, which is reserved for mock explosive.

EXPLOSIVES APPROVAL AUTHORITY (EAA). NA-51 Deputy Associate Administrator for Safety fills this role.

EXPLOSIVE DECONTAMINATION. The removal of hazardous explosive material.

EXPLOSIVES FACILITY. A structure or defined area used for explosives storage or operations. Excluded are explosives presenting only localized, minimal hazards as determined by the Contractor Explosives Safety Authority Having Jurisdiction. Examples of excluded items may include user quantities of small arms ammunition, commercial distress signals, or cartridges for cartridge actuated tools, etc.

EXPLOSIVES SAFETY SITE PLAN. A formal package of explosives facility and operations safety documents to be prepared by Facility Management for DOE/NNSA approval of explosives facilities siting and operations before the operation starts. This package becomes part of the basis for explosives facility operations.

EXPLOSIVES SAFETY SUBJECT MATTER EXPERT (SME). The DOE Site or Field Office person responsible for Explosives Safety Oversight.

EXPOSED SITE. A magazine, cell, stack, truck or trailer loaded with ammunition, explosives workshop, inhabited building, assembly place or public traffic route, which is exposed to the effects of an explosion (or fire) at the PES under consideration.

EXTRUDING. Forcing a plastic-type material, under pressure, into a confined space or through a confined opening to produce a desired configuration.

FIRING CIRCUIT. A firing circuit is a component of a Firing Control Circuit. It is intended to transmit energy to an EED to reliably initiate it. A firing circuit usually includes the final energy storage device and the last switch that releases energy to the EED.

FIRING CONTROL CIRCUIT. An electrical circuit designed to reliably initiate EEDs) while preventing unintentional initiations. The firing control circuit includes everything electrically associated with the circuit providing energy to the EED being initiated, (e.g. the firing circuit, safety interlocks, diagnostic interfaces, controls and switches, power supplies, transmitters, receivers).

FIRING PAD. The prepared site where explosive items are fired for test data acquisition.

FLAMMABLE LIQUID. Any liquid having a flash point below 60°C and a vapor pressure not exceeding 280 kPa (41 psia) at 37.8°C. This is the definition as applied in this Technical Standard; it includes some materials defined as combustible liquids

by the Department of Transportation (DOT) and/or NFPA 70, Flammable and Combustible Liquids Code.

FLASH POINT. The temperature at which a liquid or volatile solid gives off a vapor sufficient to form an ignitable mixture with air near the surface of the material or within the test vessel.

FORMULATION. (1) The operation of combining ingredients to produce a mixture of a final desired composition possessing specific physical and explosive properties. (2) An explosives composition.

GROUNDING. Providing an electrical path to the earth, generally to the facility grounding electrode system.

HAZARD ANALYSIS. The identification of risks associated with the tasks being performed. It focuses on the relationship between the worker, the task, the tools, and the work environment.

HAZARDOUS FRAGMENT DISTANCE. The distance at which the areal density of hazardous fragments or debris becomes one per 600 ft^2 (55.7m^2).

HEAD OF DOE FIELD ELEMENT. Manager in charge of a DOE Site, Field Office Manager or designated Operations or Production Office Manager

HEATING LIMITS. The conditions established for safely heating an explosive system (maximum temperature, heating time, heating rate, etc.). These limits are based on the estimated critical temperature of the explosive system with a suitable margin of safety.

HEAVY-WALLED. A wall thickness to diameter ratio greater than 0.01.

HIGH-ENERGY INITIATOR. Exploding bridgewire systems, slapper detonators, and EEDs with similar energy requirements for initiation.

HOLE (as applied to machine explosives). Any cavity that is more than one-half diameter deep, being cut by any tool with the direction of feed along the axis of rotation.

HOT WORK (thermal). Any operation requiring the use of a flame-producing device, an electrically heated tool producing a temperature higher than 109°C, or a mechanical tool that can produce sparks or heat explosives or explosives contamination to provide an initiation stimulus.

HYDROSTATIC PRESSING. The operation of compacting a material that is confined in a press by a diaphragm by hydraulically applying pressure to the diaphragm.

INDIRECT CONTACT WITH EXPLOSIVES. Contact between bare explosives, the metallic casing of an explosive, or the firing leads of an explosive device and electrical instruments or equipment through electrically conductive equipment or surfaces other than the equipment leads.

INERT MATERIALS. Materials that show no exothermic decomposition when tested by DSC or DTA. Moreover, when tested by recognized compatibility tests, the inert material will not show any incompatibility with energetic material with which it may be combined. Inert material will neither alter the onset of exotherm of the DSC or DTA trace of the energetic material nor increase the rate of decomposition or gas evolution of the energetic material.

INHABITED-BUILDING DISTANCE. The minimum distance permitted between explosives locations and inhabited buildings, administrative areas, site boundaries, main power stations, and other facilities of vital or strategic nature.

INITIATION, WITH ITS OWN MEANS. Explosives or ammunition having their normal initiating device (e.g., detonators or squibs) assembled to them so that this device is considered to present a significant risk of activation during storage.

INITIATION, WITHOUT ITS OWN MEANS. Explosives or ammunition that (1) are not stored with an initiating device assembled to them; or (2) have the initiating device assembled to them, but (a) safety features preclude initiation of the explosives filler of the end item in the event of accidental functioning of the initiating device, or (b) the initiating device does not contain any primary explosives and has a high threshold of initiation (e.g., EBW or slapper detonators). The power source for the initiator should not be present within the assembly or system. If the initiator’s power source is present, two or more management-certified safety devices connected in series will be present to interrupt any flow of energy from the power source to the initiator.

INTENTIONAL INITIATION. This operation involves intentionally initiating explosives materials or articles for the purpose of testing, training, demonstration, or destruction.

INTERMAGAZINE DISTANCE. The minimum distance permitted between any two storage magazines. The distance required is determined by the type(s) of magazine and also the type and quantity of explosives stored therein.

INTRALINE DISTANCE. The minimum distance permitted between any two operating buildings or sites within an operating line, at least one of which contains, or is designed to contain, explosives.

INTRINSICALLY SAFE. An apparatus or system whose circuits are incapable of producing any spark or thermal effect capable of causing ignition of a mixture of flammable or combustible material under test conditions described in ANSI/UL 913.

ISOSTATIC PRESSING. The operation of compacting a material in a sealed flexible container. The container is submerged in a pressure vessel, and the vessel is pressurized with liquid.

LABORATORY OPERATIONS. Experimental study, testing, and analysis of small quantities of energetic materials. Manufacturing processes with small quantities of materials are not included.

LASER ABLATION. The removal of material using a laser.

LOW-ENERGY EED. All EEDs except EBW detonators and slapper detonators.

LOW PRESSURE. Gas less than 150 psig (1 MPa gauge); liquid less than 1,500 psig (10 MPa gauge).

MACHINING OVERTEST. A test to evaluate the susceptibility of an explosive material to initiation during machining.

MAXIMUM CREDIBLE EVENT (MCE). The MCE from a hypothesized accidental explosion or fire is the worst single event that is likely to occur from a given quantity and disposition of explosives or explosives devices. The event must be realistic with a reasonable probability of occurrence considering the explosive propagation, burning rate characteristics, and physical protection given to the items involved.

MELTING. Operations involving change in the physical state of explosives from solid to liquid.

MISFIRE. An explosive charge that has partially or completely failed to initiate as planned.

MIXING. A mechanical operation that combines dissimilar materials.

MOCK EXPLOSIVE. Substances bearing similar physical properties (texture, density, cohesion, etc.) to an explosive material. They are non-detonable; however, some are exothermic materials that will burn. Mock explosives are used to represent explosives for purposes such as dry run testing of equipment. DOE mock explosives are normally pink in color.

NEW (OR EXPERIMENTAL) EXPLOSIVES. Explosive, explosive mixture, or explosive and binder mixture that the EDC has not characterized.

NON-FACILITY PERSONNEL. Construction or maintenance personnel who do not have a continuing contract with DOE or NNSA or their agents at the facility/site concerned where construction or maintenance activities occur.

OCCUPIED AREA. Any work area that can be reasonably considered integral to an explosives operating area to which personnel are assigned or in which work is performed, however intermittently. Examples of areas to be considered as occupied are assembly/disassembly cells or bays, explosives operating bays, radiography control and film processing rooms, offices, break areas, and rest rooms.

OPERATIONAL SHIELD. A barricade constructed to protect personnel, material, or equipment from the effects of a possible fire or explosion occurring at a particular operation.

PENETRATION. A conductive object that passes through the zone of protection or exterior surface of an LPS.

PERMANENT WIRING. Facility wiring that includes installed electrical wiring, communications wiring, security systems wiring, and fire protection systems alarm and response wiring.

PERMANENT EQUIPMENT. Equipment that includes the installed electrical fixtures and equipment associated with permanent wiring. Permanent equipment also includes equipment such as HVAC, hoods, vacuum pumps, hydraulic pumps, etc.

POTENTIAL EXPLOSION SITE (PES). The location of a quantity of ammunition and explosives that will create a blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its contents.

PRESSING. The operation of increasing the density of explosive material by applying pressure.

PRIMARY EXPLOSIVE. A sensitive explosive that nearly always detonates by simple ignition from such means as a spark, flame, impact and other primary heat sources of appropriate magnitude. Examples are mercury fulminate, lead azide, lead styphnate, and other materials of similar sensitivities.

PROPELLANT. Explosive composition used to propel projectiles and rockets and to generate gases for powering auxiliary devices.

PUBLIC TRAFFIC ROUTE DISTANCE. The minimum separation distance required between a potential explosion site and any public street, road, highway, passenger railroad, or navigable waterway (including roads on DOE-controlled land open to public travel).

PUNCH AND DIE PRESSING. The operation of compacting a material confined by a die by forcing a punch or punches into the die and against the material.

PYROTECHNIC MATERIAL. Physical mixtures of finely divided fuels and oxidizer powders; may include various organic binders and color intensifiers. The material is

intended to produce an effect by heat, light, sound, gas or smoke, or a combination of these as the result of non-detonative, self-sustaining exothermic chemical reactions.

QUALIFIED PERSON. A person assigned by Contractor Facility Management who has the appropriate level of training and experience in the explosives operation or activity.

QUANTITY-DISTANCE (QD). The quantity of explosive material and distance separation relationships that provide defined levels of protection. The relationships are based on levels of risk considered acceptable for specific exposures and are tabulated in applicable QD tables. These separation distances do not provide absolute safety or protection. Greater distances than those in the QD tables should be used if practical.

REMOTE OPERATION. An operation performed in a manner that will protect personnel in the event of an accidental explosion. (Remote operations involve protection from accidental (not intentional) initiations. See Intentional Firing in this section and Class 0 operations in Chapter VI for operations involving intentional initiation).

RESILIENT MATERIAL. An engineered product that is manufactured using various types of flexible bouncy and elastic material (e.g., cork, linoleum, rubber, sheet vinyl, vinyl composition tile).

RESISTANCE. The property of a conductor to oppose the flow of an electric current and change electric energy into heat. For lightning protection purposes, low resistance values are desired. Resistance is measured in ohms.

SCREENING. An operation using screens to separate particles of differing sizes.

SECONDARY EXPLOSIVES. An explosive substance that is relatively insensitive (when compared to primary explosives) and is usually initiated by primary explosives with or without the aid of boosters or supplementary charges. Such explosives may react as a deflagrating or as a detonating explosive. Examples are TNT, plastic bonded formulations, and other materials of similar sensitivity.

SERVICE BAY. A designated room, area or vault within an operating building for the intermediate storage/staging of explosives or explosives components awaiting either processing performed in that facility or transportation once intermediate or final processing in that facility is complete.

SERVICE MAGAZINE. An auxiliary building or suitable designated room (vault) used for the intermediate storage of explosives materials not exceeding the minimum amount necessary for safe and efficient operation.

SHUNT. An electrical interconnection of various portions of EED circuitry to prevent the development of an electrical charge differential between the parts.

SIDEFLASH. (1) The phenomena in which lightning current will jump through a non-conductive medium to attach to improperly bonded metallic objects. (2) An electrical spark, caused by differences of potential, which occurs between conductive metal bodies or between conductive metal bodies and a component of an LPS or ground.

SLAPPER DETONATOR. An EED initiated by a rapid discharge of a high current through a metal foil. The expansion of the metal vapor causes a plastic or metal covering to be propelled across an air gap and detonate a high-density explosive pellet.

SMALL ARMS AMMUNITION. (1) Ammunition designed to be fired from a pistol, revolver, rifle, or shotgun held by the hand or to the shoulder. (2) Ammunition of caliber less than 20 mm with incendiary, solid, inert, or empty projectiles (with or without tracers) designed to be fired from machine guns or cannons. (3) Blank cartridges.

STATIC GROUND. An electrical path to ground intended to reduce the potential for static-generated sparks and arcs.

STORAGE MAGAZINE. A structure designed or specifically designated for the long-term storage of explosives or ammunition.

SYNTHESIS. The chemical operation or operations required to produce a desired chemical compound.

TARGET. The area, structure, or material into which a projectile is fired.

TNT EQUIVALENT. A measure of the blast effects from explosion of a given quantity of material expressed in terms of the weight of TNT that would produce the same blast effects when detonated.

TRANSIENT. Any person within inhabited-building distance but not inside an explosives bay or other occupied areas (offices, break areas, shops, etc.). A transient’s presence within IBD of an explosives operation is transitory in nature, or to complete a relatively short-term, non-explosives-related work assignment in an area in which personnel are not permanently assigned, such as a building corridor, access ramp, or roadway. Transients are not accounted for in established personnel limits for any explosives operating area and are afforded a Level-of-Protection only from Class I explosion hazard activities.

UNEXPLODED ORDNANCE (UXO). Explosive ordnance which has been primed, fuzed, armed, or otherwise prepared for action, and which has been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to

operations, installations, personnel, or material and remains unexploded either by malfunction, design, or for any other cause.

UNOCCUPIED AREA. Locations where occupancy is of a transitory nature such as building corridors, access ramps, and facility roads.
Note: Examples are locations such as mechanical equipment rooms, equipment/parts staging/storage areas, decontamination areas and janitor's closets, which typically have a low personnel density and an intermittent and relatively short-term duration of occupancy for assigned work but in which personnel are not normally permanently assigned.

APPENDIX C. Measurement Abbreviations

°C	degrees Celsius
cm	Centimeters
°F	Degrees Fahrenheit
ft	Feet
ft-lbs	Foot Pounds
ft^2	Square Feet
GPa	Gigapascals
g	Grams
hr	Hour
in	Inches
kg	Kilograms
kPa	Kilopascals
L	Liters
lbs	Pounds
m	Meters
µs	Microseconds
mg	Milligrams
min	Minute
mm	Millimeters
mm Hg	Millimeters of Mercury
oz	Ounces
Pa	Pascals

psi	Pounds per Square Inch
psig	Pounds per Square Inch, Gauge Pressure
rpm	Revolutions per Minute
sec	Seconds
m^2	Square Meters
yrs	Years
%	Percent

APPENDIX D. References

10 CFR Part 830: *Nuclear Safety Management*

10 CFR Part 851: *Worker Safety and Health Program*

27 CFR Part 555.203: *Bureau of Alcohol, Tobacco, Firearms, and Explosives, Department of Justice, Commerce in Explosives, Types of Magazines*

27 CFR Part 555.207: *Bureau of Alcohol, Tobacco, Firearms, and Explosives, Department of Justice, Commerce in Explosives, Construction of Type 1 Magazines*

27 CFR Part 555.208: *Bureau of Alcohol, Tobacco, Firearms, and Explosives, Department of Justice, Commerce in Explosives, Construction of Type 2 Magazines*

27 CFR Part 555.209: *Bureau of Alcohol, Tobacco, Firearms, and Explosives, Department of Justice, Commerce in Explosives, Construction of Type 3 Magazines*

27 CFR Part 555.210: *Bureau of Alcohol, Tobacco, Firearms, and Explosives, Department of Justice, Commerce in Explosives, Construction of Type 4 Magazines*

27 CFR Part 555.211: *Bureau of Alcohol, Tobacco, Firearms, and Explosives, Department of Justice, Commerce in Explosives, Construction of Type 5 Magazines*

60-Series Publications: *Explosive Ordnance Disposal Procedures*, Technical Manual (TM) (Army), Technical Order (TO) (Air Force), EOD Bulletin (Navy), Commanding Officer, Naval Explosive Ordnance Disposal Technology Division, 20008 Stump Neck Road, Indian Head, Maryland 20640-5070, (current versions)

ACGIH Ventilation Manual: *Industrial Ventilation: A Manual of Recommended Practice*,(current version); ACGIH, 1330 Kemper Meadow Drive, Cincinnati, Ohio 45240

AD 411445: *Industrial Engineering Study to Establish Safety Design Criteria for Use in Engineering of Explosives Facilities and Operations*, Process Engineering Branch, APMED Picatinny Arsenal, Dover, NJ; Defense Technical Information Center, Defense Logistics Agency, Cameron Station, Alexandria, VA 22314 (current version)

AFWL-TR-74-102: *The Air Force Manual for Design and Analysis of Hardened Structures*, Air Force Weapons Laboratory, Air Force Systems Command, Kirtland Air Force Base, NM 87117; ADB004152, Defense Technical Information Center, Defense Logistics Agency, Cameron Station, Alexandria, VA 22314, (current version)

AFMAN 91-201: *Explosives Safety Standards*, Secretary of the Air Force (current version)

AMCR 385-100: *AMC Safety Manual*, Headquarters, United States Army Material Command, 5001 Eisenhower Avenue, Alexandra, Virginia 22333, (current version).

ANSI/UL 913: *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations*, (current version)

ASCE/SEI 7-10: *Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers*, (with errata) (current version)

ASTM D-2240-68: *Standard Method for Rubber Property—Durometer Hardness, American Society for Testing and Materials*, (current version)

DDESB TP-12: *Department of Defense Explosives Safety Board Technical Paper 12: Fragment and Debris Hazards*, (current version)

DDESB TP-13: *Department of Defense Explosives Safety Board Technical Paper 13: Prediction of Building Debris for Quantity-Distance Siting*, (current version)

DDESB TP-14: *Department of Defense Explosives Safety Board Technical Paper 14: Approved Methods and Algorithms for DoD Risk-Based Explosives Siting*, (current version)

DDESB TP-15: *Department of Defense Explosives Safety Board Technical Paper 15, Approved Protective Construction*, (current version)

DDESB TP-16: *Department of Defense Explosives Safety Board Technical Paper 16, Approved Protective Construction*, (current version)

DDESB TP-17: *Department of Defense Explosives Safety Board Technical Paper 17, DDESB Blast Effects Computer*, (current version) User's Manual and Documentation, with accompanying program entitled DDESB Blast Effects Computer (BEC), (current version)

Defense Logistics Agency, Industrial Engineering Study to Establish Safety Design Criteria for Use in Engineering of Explosives Facilities and Operations, AD, 411445, Process Engineering Branch, APMED Picatinny Arsenal, Dover, NJ; Defense Technical Information Center, Defense Logistics Agency, Cameron Station, Alexandria, VA 22314

DESR 6055.09, *Defense Explosives Safety Regulation* (current version)

DoD Instruction 4140.62, *Material Potentially Presenting an Explosive Hazard*, (current version)

DOE HDBK-3010: *DOE Handbook, Airborne Release Fractions / Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, (current version)

DOE Order 252.1: *Technical Standards Program*, (current version)

DOE Order 420.1: *Facility Safety*, U. S. Department of Energy (current version)

DOE Order 430.1: *Real Property Asset Management*, U. S. Department of Energy, Office of Project and Facilities Management, (current version)

DOE Order 452.1E: *Nuclear Explosive and Weapon Surety Program*, U.S. Department of Energy, (current version)

DOE Order 452.2: *Nuclear Explosive Safety*, U. S. Department of Energy, (current version)

DOE Order 460.1: *Packaging and Transportation Safety*, U.S. Department of Energy, (current version)

DOE/TIC-11268: *A Manual for the Prediction of Blast and Fragment Loading of Structures*, U.S. Department of Energy, Albuquerque Operations, Amarillo Area Office, Facilities and Maintenance Branch, P.O. Box 30030, Amarillo, TX 79120, (current version)

FMDS 5-4/14-18: *Factory Mutual Data Sheet 5-4/14-18*, (current version)

HNDM-1110-01-2: *Suppressive Shields, Structural Design and Analysis Handbook*, U.S. Army Corps of Engineers, U.S. Army Corps of Engineering, Huntsville Division, HNDED-CS, P.O. Box 1600, Huntsville, AL 35807, (current version)

JNWPS TP-20-7: *Joint Nuclear Weapons Publication System, Technical Manual, Nuclear Safety Criteria*, (current version)

LLNL-TR-679331, LA-UR-29238: *IHE Material and IHE Subassembly Qualification Test Description and Criteria*, Maienschein, Leininger, Hooks, 2015

MHSMP-84-22: *IHE Material Qualification Tests, Description and Criteria*, Mason & Hanger-Silas Mason Publication, Rev 1, July 1985, National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

Mil Spec P-46144C: *Specification for Polycarbonate, Type I, Class 1*, (current version)

National Electrical Code: (see NFPA 70)

NAVSEAOP 3565/NAVAIR 16-1-529: *Electromagnetic Radiation Hazards (U)(Hazards to Personnel, Fuel and Other Flammable Material)* (U), Naval Sea Systems Command, Volume 1, Fifth Revision, Dated 15 July 1982, (current version)

NFPA 70: *National Electrical Code*, National Fire Protection Association, (version detailed in 10 CFR 851)

NFPA 496: *Purged and Pressurized Enclosures for Electrical Equipment*, National Fire Protection Association, (current version)

NFPA 780: *Lightning Protection Code*, National Fire Protection Association, (current version)

NUREG-1320: *U.S. Nuclear Regulatory Commission, "Nuclear Fuel Cycle Facility Accident Analysis Handbook*, (current version)

TB 700-4: *Technical Bulletin, Decontamination of Facilities and Equipment,* Department of the Army, (October 1978)

TB 700-2: *Technical Bulletin, Department of Defense Ammunition and Explosives Hazard Classification Procedures* (TB 700-2, NAVSEA INST 8020.8A, TO 11A-1-47, DLAR 8220.1), Departments of the Army, the Navy, the Air Force, and the Defense Logistics Agency, Washington, DC, (current version)

The Atomic Energy Act of 1954: 42 USC 2011, Nuclear Regulatory Legislation, Office of the General Counsel, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001

Title 18 USC: *Crimes and Criminal Procedure*, Title 18 of the United States Code

TM 9-1300-214: *Technical Manual, Military Explosives*, Department of the Army, Department of the Army, (current version)

TR-828: *Technical Report, Blast Environment from Fully and Partially Vented Explosions in Cubicles*, Keenan, W.A. and J.E. Tancreto, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, CA 93043

UFC 3-340-02: *Unified Facilities Criteria (UFC) Structures to Resist the Effects of Accidental Explosions* (formerly TM 5-1300), (current version)

UN ST/SG/AC/10/1: *Transportation of Dangerous Goods, Model Regulations*, United Nations Publications, (current version)

UN ST/SG/AC/10/11: *Transportation of Dangerous Goods, Test Manual,* United Nations Publications, (current version)