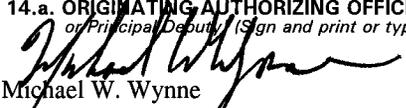


**DOD DIRECTIVES SYSTEM COORDINATION RECORD**

*(Please read instructions on back before completing form.)*

<b>1. SECURITY CLASSIFICATION</b> <i>(X one)</i>		<b>2. TYPE OF DOD ISSUANCE</b> <i>(X one)</i>		<b>3. TYPE OF ACTION</b> <i>(X one)</i>	
<input type="checkbox"/> TOP SECRET	<input type="checkbox"/> CONFIDENTIAL	<input checked="" type="checkbox"/> DOD DIRECTIVE	<input type="checkbox"/> DOD PUBLICATION	<input type="checkbox"/> NEW	<input type="checkbox"/> CHANGE
<input type="checkbox"/> SECRET	<input checked="" type="checkbox"/> UNCLASSIFIED	<input type="checkbox"/> DOD INSTRUCTION	<input type="checkbox"/> ADMINISTRATIVE INSTRUCTION	<input checked="" type="checkbox"/> REISSUANCE	<input type="checkbox"/> CANCELLATION
<b>4. DOD ISSUANCE NUMBER</b> <i>(Leave blank for new issuances)</i> DoD 4145.26-M			<b>5. COORDINATION SUSPENSE DATE</b> <i>(YYYYMMDD)</i> 8/6/04 <i>(For DoD Directives, insert a maximum of 20 working days from the date this Form is signed by the Originating Authorizing Official. For all other DoD issuances, no more than 45 working days should be required.)</i>		
<b>6. SUBJECT</b> <i>(Title of Issuance)</i> DoD Contractors' Safety Manual for Ammunition and Explosives			<b>7. PURPOSE AND REMARKS</b> <i>(Continue on back if necessary)</i> Reissuance will align DoD 4145.26-M with DoDD 5000.1, "The Defense Acquisition System: and DoDI 5000.2, "Operation of the Defense Acquisition System" criteria; eliminate obsolete guidance and provide a plain English manual; and, replace all explosives safety criteria formally contained in DoD 2145.26-M with applicable cross-reference citations to the criteria found in DoD 6055.9-STD, "DoD Ammunition and Explosives Safety Standards."		
<b>8. FEDERAL REGISTER PUBLICATION REQUIRED</b> <i>(X one)</i> <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO					
<b>9. REPORTING REQUIREMENTS</b> <i>(X all that apply)</i> <input type="checkbox"/> OMB <input type="checkbox"/> RCS <input type="checkbox"/> IRCN					
<b>10. FORMS PRESCRIBED</b> <i>(X one)</i> <input type="checkbox"/> YES <input type="checkbox"/> NO		<b>11. PRIVACY REQUIREMENTS</b> <i>(X one)</i> <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO			
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		<b>b. POSITION TITLE</b> <i>(Print or type)</i>			
<input type="checkbox"/> <b>UNDER SECRETARY OF DEFENSE FOR INTELLIGENCE</b> DIR NATIONAL SECURITY AGENCY/CHIEF, CENTRAL SECURITY SERVICE DIR DEFENSE INTELLIGENCE AGENCY DIR NATIONAL IMAGERY AND MAPPING AGENCY DIR DEFENSE SECURITY SERVICE DIR DOD COUNTERINTELLIGENCE FIELD ACTIVITY		<b>c. DATE FORM SIGNED</b>			



Draft DoD 4145.26-M

# **DOD CONTRACTORS' SAFETY MANUAL FOR AMMUNITION AND EXPLOSIVES**

*Draft* March 18, 2004

Assistant Secretary of Defense for  
Acquisition, Technology and Logistics



OFFICE OF THE SECRETARY OF DEFENSE  
THE PENTAGON  
WASHINGTON, DC

March 18, 2004

FOREWORD

This Manual is issued under the authority of and in accordance with DoD Instruction 4145.26, "DoD Contractors' Safety Requirements for Ammunition and Explosives," April 4, 1996. The Manual provides safety standards common to DoD and private industry ammunition and explosives (AE) operations and facilities. The explosives safety requirements for the Department of Defense are in DoD 6055.9-STD, "DoD Ammunition and Explosives Safety Standards," Rewrite version, Revision 4 of January 5, 2004, which serves as the primary source document for this Manual, and provides the minimum acceptable standards for quantity distances. The explosives safety requirements included in this Manual will remain consistent with DoD 6055.9-STD so that compliance by a DoD Component and a DoD contractor is essentially equal.

The application of this Manual to AE contracts is required by DFAR Supplements. Additional AE or other related safety requirements might be included within the contract by the purchasing activity as determined necessary.

This revision removes the chapter on hazard component data statements (HCDS) and updates basic principles of AE safety, and provides sufficient information to enable the contractor to make appropriate and reliable decisions affecting his or her facilities and operations. The methods of compliance are the responsibility of the contractor.

Questions on interpretation of any aspect of this Manual by the contractor shall be submitted to the contractor's assigned administrative contracting officer (ACO) for further review and processing.

This Manual applies to the Office of the Secretary of Defense (OSD), the Military Departments, the Chairman of the Joint Chiefs of Staff, Combatant Commands, and the Defense Agencies (hereafter referred to collectively as "the DoD Components").

This Manual is effective immediately, and is mandatory for use by all the DoD Components specified in DoD Instruction 4145.26.

Forward recommendations for change to this Manual to:

Chairman  
Department of Defense Explosives Safety Board  
Room 856C, Hoffman Building I  
2461 Eisenhower Avenue  
Alexandria, VA 22331-0600

This Standard is only available in electronic form. The DoD Component, other Federal Agencies, and the public may obtain copies on the worldwide web at <http://www.ddesb.pentagon.mil/ddesb/>.

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REFERENCE LIST

- (a) DoD 6055.9-STD, "DoD Ammunition and Explosives Safety Standards," December 13, 2002
- (b) Sections 651-678 of 29 U.S.C., "Occupational and Safety Health Act," 1970
- (c) Military Standard (MIL-STD)-398, "Shields, Operational for Ammunition Operations, Criteria for Design and Tests for Acceptance," November 5, 1976
- (d) National Fire Protection Association (NFPA) 70, "National Electric Code," current version
- (e) Technical Manual (TM)-5-1300, Naval Facilities Engineering Command (NAVFAC) P-397, AFM 88-2, "Structures to Resist the Effects of Accidental Explosions," November 28, 1990
- (f) National Fire Protection Association (NFPA) 101, "Life Safety Code," current version
- (g) National Fire Protection Association (NFPA) 80, "Standard for Fire Doors, Fire Windows," current version
- (h) National Fire Protection Association (NFPA) 91, "Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids," current version
- (i) National Fire Protection Association (NFPA) 780, "Standard for the Installation of Lightning Protection Systems," current version
- (j) National Fire Protection Association (NFPA) 77, "Recommended Practice on Static Electricity," current version
- (k) American Society for Testing and Materials (ASTM) D-2240-68, "Standard Test Method for Rubber Property-Durometer Hardness," current version
- (l) Institute of Electrical and Electronics Engineers (IEEE) Standard 142, "Recommended Practice for Grounding of Industrial and Commercial Power Systems," current version
- (m) National Fire Protection Association (NFPA) 99, "Standard for Health Care Facilities," current version
- (n) National Fire Protection Association (NFPA) 10, "Standard for Portable Fire Extinguishers," current version
- (o) National Fire Protection Association (NFPA) 704, "Standard for the Identification of the Fire Hazards of Materials for Emergency Response," current version
- (p) National Fire Protection Association (NFPA) 49, "Hazardous Chemicals Data," current version

- (q) National Fire Protection Association (NFPA) 325, "Guide to the Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids," current version
- (r) Section 301-312 of the Emergency Planning Community Right to Know Act, 1986
- (s) National Fire Protection Association (NFPA) 13, "Installation of Sprinkler Systems," current version
- (t) National Fire Protection Association (NFPA) 15, "Standard for Water Spray Fixed Systems for Fire Protection," current version
- (u) National Fire Protection Association (NFPA) 33, "Standard for Spray Application Using Flammable or Combustible Materials," current version
- (v) Title 14, Code of Federal Regulations, Part 77, "Objects Affecting Navigable Airspace," current edition

ABBREVIATIONS AND ACRONYMS

ACO	administrative contracting officer
AE	ammunition and explosives
AGM	aboveground magazine
AP	ammonium perchlorate
ASTM	American Society for Testing and Materials
COCO	contractor-owned, contractor-operated
DCMA	Defense Contract Management Agency
DoD	Department of Defense
ECM	earth-covered magazines
EED	electro-explosive device
EPA	Environmental Protection Agency
EPCRA	Emergency Planning Community Right to Know Act
ES	exposed sites
ESD	electrostatic discharge
GFI	ground fault interrupt
HC/D	Hazard Class/Division
HD	Hazard Division
HE	high-energy or high-explosive
HMX	high-melting-point explosive
IBD	inhabited building distance
IEEE	Institute of Electrical and Electronics Engineers
ILD	intraline distance
LPG	liquefied petroleum gas
MCE	maximum credible event
NEC	National Electric Code
NEW	net explosive weight
NFPA	National Fire Protection Association
NG	nitroglycerin
PCO	procuring contracting officers
PES	potential explosion sites
PETN	pentaerythritol tetranitrate
PTRD	public traffic route distance
Q-D	quantity-distance
RAC	Risk Assessment Code
RDX	cyclotrimethylenetrinitramine
RF	radio frequency
SOP	standard operating procedure
TNT	trinitrotoluene
UL	Underwriters Laboratories



## C1. CHAPTER 1 INTRODUCTION

### C1.1. PURPOSE

This Manual provides safety requirements, guidance and information to minimize potential mishaps which could interrupt Department of Defense (DoD) operations, delay production, damage DoD property, cause injury to DoD personnel, or endanger the public during contract work or services involving ammunition and explosives (AE). The Manual contains the minimum contractual safety requirements to support the objectives of DoD. These requirements are not a complete safety program and this Manual does not relieve a contractor from complying with federal, state and local laws and regulations.

### C1.2. APPLICABILITY

These safety requirements apply to contractors performing AE work or AE services on DoD contracts, subcontracts, purchase orders, or other procurement methods. The requirements also apply to non-DoD contractor operations to the extent necessary to protect DoD work or services.

### C1.3. MANDATORY AND ADVISORY REQUIREMENTS

C1.3.1. The Manual uses the term “shall”, or an affirmative statement, to indicate mandatory requirements. The terms “should” and “may” are advisory. When advisory provisions are not met, adverse consequences might develop and become proximate causes of AE mishaps.

### C1.4. COMPLIANCE WITH MANDATORY REQUIREMENTS

C1.4.1. The Department of Defense requires compliance with mandatory provisions of this Manual and applicable portions of DoD 6055.9-STD (reference (a)). Siting criteria for AE are provided in quantity distance (Q-D) standards contained in Chapter 9 of DoD 6055.9-STD. In order to provide consistent and current information to all DoD AE contractors, Q-D requirements of DoD 6055.9-STD are incorporated by reference in paragraph C3.17.1. of this Manual.

C1.4.2. Waivers. Procuring contracting officers (PCO) may grant contract-specific waivers to mandatory provisions of this Manual. Rationale for waiver of DoD pre-award safety surveys must be documented and provided to the cognizant ACO for transmittal to the cognizant DoD Component explosives safety office for their records. Military or commercial ammunition and explosives shall not be procured unless their use is authorized by the cognizant DoD Component explosives safety approval authority. Methods of addressing non-compliance with mandatory requirements and requests for waivers are different during the pre- and post-award phases of a contract.

C1.4.3. In the pre-award phase, the PCO will request a DoD pre-award safety survey to help determine contractor capability. During pre-award surveys, noncompliance with mandatory safety requirements normally results in a recommendation of “no award.” Any noncompliance should be resolved during the pre-award survey. Contractors may choose to correct the deficiencies immediately, may offer a letter of intent to correct the deficiencies (which will

become binding upon award of contract), or may request that the PCO accept specifically identified existing conditions of facilities (contract-specific waiver).

C1.4.4. In the post-award phase, the contractor has 30 days from the date of notification by the administrative contracting officer (ACO) to correct the noncompliance and inform the ACO of the corrective actions taken. The contracting officer may direct a different time period for the correction of any noncompliance. If the contractor refuses or fails to correct any noncompliance within the time period specified by the ACO, the Government has the right to direct the contractor to cease performance on all or part of affected contracts. When the contractor cannot comply with the mandatory safety requirements of the contract, the contractor will develop and submit a request for a waiver through the ACO to the PCO for the final determination. The request will contain complete information concerning the requirements violated, actions planned to minimize the hazard, and a proposed date for correction of the deficiency.

### C1.5. PRE-AWARD SAFETY SURVEY

C1.5.1. DoD safety personnel conduct pre-award surveys to evaluate each prospective contractor's ability to comply with contract safety requirements. The pre-award safety survey is also an opportunity for the contractor to request clarification of any safety requirement or other AE issue that may affect the contractor's ability to comply. During pre-award surveys, the contractor shall provide the following:

C1.5.1.1. Site plans conforming to paragraphs C1.8.5.1 through C1.8.5.5 below for proposed facilities to be used in contract performance;

C1.5.1.2. Evidence of implementation of a safety program containing at least mandatory requirements described in Chapter 3;

C1.5.1.3. General description of proposed contract facilities, including size, building layouts, construction details, and fire resistive capabilities;

C1.5.1.4. Fire prevention program and available firefighting resources including local agreements or other documentation demonstrating coordination;

C1.5.1.5. Copies of required licenses and permits or demonstration of the ability to obtain approvals necessary to support the proposed contract;

C1.5.1.6. A safety history including mishap experience, safety survey or audit reports by insurance carriers or federal, state, and local authorities, and any variances, exemptions or waivers of safety or fire protection requirements issued by federal, state or local authorities;

C1.5.1.7. Details of proposed operations and equipment to include process flow narrative/diagram, proposed facility or equipment changes, hazard analysis, and proposed procedures for all phases of AE operations.

#### C1.5.1.8. Subcontractor Information

C1.5.1.8.1. Identification of all subcontractors proposed for the AE work,

C1.5.1.8.2. Methods used to evaluate capability of subcontractor to comply with the requirements of this manual,

C1.5.1.8.3. Methods used to manage subcontractor compliance.

C1.6. PREOPERATIONAL SAFETY SURVEY

C1.6. The DoD reserves the right to conduct a preoperational survey after contract award of new items with limited contractor experience, after major new construction or major modifications, or after an AE mishap. When these situations occur, the contractor shall notify the ACO, sufficiently in advance, to provide the Department of Defense the opportunity to schedule and perform a preoperational survey.

C1.7. POST-AWARD CONTRACTOR RESPONSIBILITIES

The contractor shall:

C1.7.1. Comply with the requirements of this Manual and any other safety requirements contained within the contract;

C1.7.2. Develop and implement a demonstrable safety program, including operational procedures, intended to prevent AE-related mishaps;

C1.7.3. Designate qualified individuals to administer and implement this safety program.

C1.7.4. Prepare, and keep available for review, all hazard analyses used to justify alternative methods of hazards control that differ from those recommended in the Manual.

C1.7.5. Provide access to facilities and safety program documentation to Government safety representatives.

C1.7.6. Report and investigate AE mishaps in accordance with Chapter 2 of this Manual.

C1.7.7. Provide identification and location of subcontractors to the ACO for notification or approval in accordance with terms of the contract.

C1.7.8. Establish and implement management controls to ensure AE subcontractors comply with paragraphs C1.7.1 through C1.7.7, above.

C1.8. SITE AND CONSTRUCTION PLANS

C1.8.1. Contractors must prepare site and construction plans for support of the pre-award process, and for any change in layout or construction potentially affecting Q-D incident to the contract. Contractors shall also maintain a current site map depicting Q-D relationships for all AE locations within the facilities.

C1.8.2. When the place of performance of the contract is at a DoD-owned facility, site and construction plans shall be prepared and processed (content and staffing) in accordance with the requirements of DoD 6055.9-STD, as well as, appropriate military service regulations contained within the contract.

C1.8.3. For contractor-owned, contractor-operated (COCO) facilities, the contractor shall submit, through the ACO to the PCO, site and construction plans for all new construction or major modification of facilities for AE activities and for the facilities that may be exposed to AE

hazards if improperly located. The contractor shall provide sufficient copies for the review process. The contractor shall not begin construction or modification of proposed facilities until receiving site and construction plan approval from the PCO through the ACO.

C1.8.4. Minor new construction, changes, and modifications of existing AE facilities involving Hazard Class/Division (HC/D) additions and deletions or that add or remove small portable operating buildings and magazines may not require formal site plan submission. Minor applies to all changes that involve only 1.4 HC/D materials. Minor also applies to changes of other HC/D materials that do not increase the existing maximum credible event (MCE) for an AE facility or do not extend any quantity distance arcs beyond existing fragment, inhabited building, and public traffic route distance arcs for other nearby potential explosion sites (PES). When the contractor thinks a modification/change is minor, he shall notify the ACO and request a determination. The ACO shall make the final determination as to whether a formal site plan submission is necessary.

C1.8.5 Site plans shall comply with the following:

C1.8.5.1. Plans shall include maps and drawings which are legible, accurate, and of a scale which permits easy determination of essential details. For general layout of buildings, this is normally a scale of 1 inch to 400 feet (or metric equivalent) or less. Site plans may require other-scaled drawings, which provide details of construction, structure relationships within the project area, barricades, or other unique details. Plans may also include pictures to illustrate details and videotapes of MCE testing data.

C1.8.5.2. Maps and drawings shall identify distances between all PESs, all exposed sites (ESs) within the facility, the facility boundary, any additional property under contractor control, ESs on adjacent property when applicable, public railways and highways, power transmission lines and other utilities.

C1.8.5.3. Plans shall identify and briefly describe all PESs and all ESs within any applicable fragmentation distance and/or inhabitable building distance of a PES. Site plans for major new construction or modification shall also identify and briefly describe all PESs whose inhabitable building distance arc includes the proposed new or modified site.

C1.8.5.4. Plans shall include the maximum net explosive weight(s) (NEW) and the HC/Ds of all PESs and, when applicable, shall include MCE information and maximum NEW for each room or bay. Plans shall also include engineering or test data when substituting construction or shielding for distance to protect from fragmentation or overpressure.

C1.8.5.5. Plans shall include a topographical map in sufficient detail to permit evaluation, when the contractor uses natural terrain for barricading to reduce fragment distance.

C1.8.6. Construction plans for proposed facilities shall contain the information required in paragraphs C1.8.5.1 through C1.8.5.5 and construction details of dividing walls, venting surfaces, firewalls, roofs, operational shields, barricades, exits, ventilation systems and equipment, AE waste disposal systems, lightning protection systems, grounding systems, processing equipment auxiliary support structures, and, general materials of construction, as applicable.

C2. CHAPTER 2  
MISHAP INVESTIGATION AND REPORTING

C2.1. GENERAL

This chapter contains requirements for investigating and reporting mishaps involving AE.

C2.2. REPORTING CRITERIA

The contractor shall investigate and report to the ACO and cognizant Defense Contract Management Agency (DCMA) contract safety specialist all mishaps involving ammunition or explosives that result in one or more of the following:

C2.2.1. One or more fatalities;

C2.2.2. One or more lost-work day cases with days away from work as defined by the Sections 651-678 of 29 U.S.C. (reference (b));

C2.2.3. Five or more non-fatal injuries (with or without lost workdays) (reference (b));

C2.2.4. Damage to government property exceeding \$20,000;

C2.2.5. Delay in delivery schedule exceeding 24 hours. (This requirement does not constitute a waiver or amendment of any delivery schedule required by the contract.);

C2.2.6. Contractually required notifications of mishaps other than C2.2.1. through C2.2.5., above; or

C2.2.7. Any mishap that may degrade operational or production capability, or is likely to arouse media interest.

C2.3. MISHAP INVESTIGATION REQUIREMENTS

Paragraph C2.5., below, contains the elements of information which a basic investigation shall produce. Based upon the seriousness of the mishap and impact on munitions or munitions systems involved, the ACO or PCO may require an additional, more comprehensive investigation. The PCO retains the right to participate in contractor investigations, or to perform an independent DoD investigation. In the event the PCO directs DoD participation, or an independent DoD investigation, the contractor shall preserve the mishap scene, taking only those actions necessary to protect life and health, preclude further damage, or prevent access by unauthorized persons in order to preserve investigative evidence. The contractor shall obtain the PCO's permission to disturb the evidence, with the exception of paragraph C2.2.2, above. Nothing in the reporting requirements contained in this Manual relieve the contractor of making other notifications required by federal, state, or local requirements.

C2.4. TELEPHONE REPORT

The contractor shall report any mishap described in paragraph C2.2., above, by telephone to the ACO and cognizant DCMA contract safety specialist as soon as practicable, but not later than three hours after the mishap.

## C2.5. WRITTEN REPORT

C2.5.1. The contractor shall submit a written report to the ACO and cognizant DCMA contract safety specialist by the end of the second business day after mishap occurrence.

C2.5.1.1. Contractor's name and location;

C2.5.1.2. Date, local time, and plant facility/location of the mishap;

C2.5.1.3. Type of mishap (explosion, fire, loss, other);

C2.5.1.4. Contract, subcontract, or purchase order;

C2.5.1.5. Item nomenclature, hazard classification, lot number;

C2.5.1.6. Mishap narrative;

C2.5.1.7. Number of injuries, fatalities, degree of injuries;

C2.5.1.8. Description of property damage and cost;

C2.5.1.9. Quantity of energetic material involved (pounds, units, rounds);

C2.5.1.10. Probable cause(s);

C2.5.1.11. Corrective action taken or planned;

C2.5.1.12. Effect on production;

C2.5.1.13. Name, title or position, and phone number of person submitting the report;

C2.5.1.14. Remarks.

C2.5.2. The contractor shall provide to the ACO supplemental information to the initial report within 30 days of mishap occurrence.

## C2.6. SPECIAL TECHNICAL MISHAP INVESTIGATIONS AND REPORTS

When warranted by the circumstances of a mishap, the PCO may require a special technical investigation conducted by DoD personnel. The PCO may also direct the contractor to conduct a special technical investigation. In either case, the investigation report shall provide details such as fragmentation maps, photographs, more detailed description of events of the mishap, effects on adjacent operations, structural and equipment damage, Q-D drawings, detailed description of occurrence and related events, findings and conclusions. If the contractor performs the special technical mishap investigation, the contractor shall forward the report through the ACO to the PCO within 60 days of the direction by the PCO to perform the investigation. Upon determination by the PCO that a DoD investigation is required, the PCO will immediately advise the contractor.

### C3. CHAPTER 3 GENERAL SAFETY REQUIREMENTS

#### C3.1. GENERAL

This chapter provides general safety requirements for all AE operations addressed in this Manual. When these practices exceed or differ from local or national codes or requirements, the more restrictive shall apply.

#### C3.2. PERSONNEL AND MATERIAL LIMITS

C3.2.1. Control of all locations or operations presenting real or potential hazards to personnel, property, or the environment is essential for safety and efficiency. Control measures include minimizing the number of personnel exposed, minimizing the duration of the exposure, and minimizing the amount of hazardous material consistent with safe and efficient operations.

C3.2.2. All buildings, cubicles, cells, rooms, and locations containing AE shall have AE and personnel limits prominently posted. Include supervisors, production workers, and transient personnel when determining personnel limits. Posted personnel limits are not required in storage magazines, magazine areas, or transfer points.

C3.2.3. All buildings, cubicles, cells, rooms or locations containing AE shall have prominently posted limits for the quantities of AE permitted. The posted limits shall not exceed the quantity stipulated in the site plan, and shall accurately reflect current process requirements. Post AE limits in storage magazines when the limit differs from that for other magazines in the block, or when circumstances prevent the limit from being readily apparent. It is not required to express AE limits in units of weight or in the number of items. Express limits in terms of trays, boxes, racks, or other units more easily observed and controlled.

#### C3.3. STANDARD OPERATING PROCEDURES (SOP)

C3.3.1. Clearly written procedures are essential to avoid operator errors and ensure process control. Therefore, before commencing manufacturing operations involving AE, qualified personnel shall develop, review, and approve written procedures.

C3.3.2. Preparation. The contractor shall prepare and implement written procedures which provide clear instructions for safely conducting AE activities. The use of controlled tests is an acceptable method for developing and validating SOPs. SOPs shall include the following:

C3.3.2.1. The specific hazards associated with the process.

C3.3.2.2. Indicators for identifying abnormal process conditions.

C3.3.2.3. Emergency procedures for abnormal process conditions or other conditions which could affect the safety of the process.

C3.3.2.4. Personal protective clothing and equipment required by process personnel.

C3.3.2.5. Personnel and AE limits.

C3.3.2.6. Specific tools permitted for use by the process operator.

C3.3.2.7. The chronological sequence of job steps the operator is to follow in performing the work.

C3.3.2.8. Procedures for disposing of any scrap and waste AE.

C3.3.3. Dissemination. Personnel involved with AE processes, and personnel who maintain AE equipment, shall have written operating procedures readily accessible.

C3.3.4. Training. Personnel shall receive appropriate training before performing work involving exposure to AE. The training shall include emphasis on the specific safety and health hazards, emergency operations including shutdown, and safe work practices applicable to the employee's job tasks. The contractor shall ascertain that each employee involved in an AE process has received and understood the training. The contractor shall prepare a record that contains the identity of the employee, the date of training, and the means used to verify that the employee understood the training.

C3.3.5. Emergency Procedures. The contractor shall instruct employees on procedures to follow in the event of electrical storms, utility or mechanical failures, equipment failures, process abnormalities, and other emergencies occurring during the manufacturing, handling, or processing of AE.

C3.3.6. Revalidation. Qualified personnel shall review SOPs on a regular basis. The managing authority shall change and validate SOPs as often as necessary to reflect improved methods, equipment substitutions, facility modifications, or process revisions.

#### C3.4. STORAGE IN OPERATING BUILDINGS

C3.4.1. The contractor may store limited quantities of hazardous materials, other than AE materials, which are essential for current operations in an operating building.

C3.4.2. The contractor shall store AE materials that exceed minimum quantity necessary for sustained operations in a service magazine located no closer than the intraline distance (ILD) (based on the quantity in the magazine) from the operating building or area. If ILD distance is not available for a separate service magazine, the contractor may designate storage locations within the operating building. Designated storage locations shall preclude immediate propagation from the operational location to the storage location. The quantity of AE material in the internal storage location shall not exceed that needed for one half of a work shift. The contractor should consider personnel exposure, structural containment afforded, and the venting ability of the proposed storage location when determining where to locate a designated storage location. When storage containers completely contain all fragments, debris, and overpressure, AE material may be stored without regard to Q-D requirements...

C3.4.3. At the end of the workday, personnel should remove all AE material from processing equipment and store it in an appropriate magazine or designated storage location. If operationally required, personnel may store in-process AE materials in the building during non-operating hours provided the physical characteristics and stability of the AE materials are not degraded, and the AE material would not compromise the safety of the process equipment or personnel when the process is restarted.

C3.4.4. The contractor may use a separate enclosed room or bay in an operating building specifically adapted for the interim storage of production items awaiting the results of testing before final pack-out. The room or bay must afford the equivalent of service magazine distance protection to other parts of the building, and ILD to other buildings. Such a room or bay is limited to its defined and designed function and items, but is not subject to the four-hour supply limitation for the building or the ultimate pack-out operation.

### C3.5. HOUSEKEEPING IN HAZARDOUS AREAS

C3.5.1. The contractor shall keep structures containing AE clean and orderly.

C3.5.2. Explosives and explosive dusts shall not accumulate on structural members, radiators, heating coils, steam, gas, air or water supply pipes, or electrical fixtures.

C3.5.3. Written procedures shall include instructions for the removal of spilled material.

C3.5.4. Floor cleaning methods shall not create an ignition hazard or alter the conductive ability of floors in AE areas, nor should they result in an environmental contamination potential.

C3.5.5. Cleaning methods for AE processing equipment shall not result in any foreign material or AE remaining in the equipment.

### C3.6. PRECAUTIONS FOR MAINTENANCE AND REPAIRS TO EQUIPMENT AND BUILDINGS

C3.6.1. The contractor shall examine and test all new or repaired AE processing equipment prior to placing the equipment in service in order to ensure that it is safe to operate.

C3.6.2. Before proceeding with maintenance or repairs to AE processing equipment, contractor personnel shall decontaminate the equipment to the degree necessary to perform the work safely. The contractor shall protect maintenance personnel from the effects of a reaction resulting from AE material in or on other parts of the equipment. Contractor personnel shall tag AE processing equipment before proceeding with repairs. The tag shall identify the decontaminated parts of the equipment, and those parts that contain AE.

C3.6.3. The contractor shall have SOPs for maintenance personnel performing work on AE equipment or performing building maintenance, repair, or modification activities in AE areas. The SOPs shall include a provision for inspecting equipment after maintenance work to ensure no tools or foreign materials remain in AE equipment. The SOPs shall identify the specific tools required to perform work on equipment which may contain explosive residues or areas which could have an explosive atmosphere.

C3.6.4. Before performing any building repair, modification or maintenance activity, the contractor shall ensure the removal of all AE materials from areas that may pose a hazard. The contractor shall also ensure the decontamination of all places where AE material could accumulate, such as, equipment, crevices, vents, ducts, wall cavities, pipes and fittings.

### C3.7. OPERATIONAL SHIELDS

C3.7.1. The purpose of operational shields is to prevent propagation of AE material from one AE operation or location to another, protect facilities and equipment, and provide personnel protection. Shields used for these purposes require an evaluation to determine their suitability for their intended purpose. All AE operations and processes require a hazard assessment prior to work performance to determine the type of hazard involved, the level of risk associated with the AE material or item, and the corresponding level of protection required.

C3.7.2. The primary hazards that accompany explosions and deflagrations are blast overpressure, fragmentation (primary and secondary) and thermal effects. The hazard assessment shall consider these hazards and the quantity of AE materials, initiation sensitivity, heat output, rate of burning, potential ignition and initiation sources, protection capabilities of shields, various types of protective clothing, fire protection systems, and the acute and chronic health hazards of vapors and combustion products on exposed personnel.

C3.7.3. When the hazard assessment indicates an unacceptable probability of explosion or deflagration, conduct operations or processes remotely. When an analysis of the hazard assessment indicates the hazards associated with an explosion or deflagration are controllable by using operational shields, the contractor shall design, install, and use shields which effectively protect personnel from the hazards. Shields complying with MIL-STD-398 (reference (c)) are acceptable protection.

C3.7.4. The contractor shall test operational shields under conditions that simulate the operational environment. AE materials or items used in the test shall correspond to those that may be involved in a maximum credible event (MCE), plus 25 percent. The contractor shall maintain records of the test that demonstrate the shields will function as planned. Analysis rather than testing of shields may be acceptable on a case-by-case basis.

C3.7.5. When the doors of AE processing equipment function as operational shields, interlocking devices are required to prevent the operator from opening the door while the equipment is in operation.

### C3.8. PROTECTIVE CLOTHING

C3.8.1. All AE operations require a hazard assessment to determine the need for protective clothing and personal protective equipment. The assessment shall include an evaluation of all hazards and factors contained in paragraphs C3.7.2.

C3.8.2. The contractor shall provide a changing area for employees who must remove their street clothes to wear protective clothing, such as explosive plant clothing, anti-contamination clothing, impervious clothing, and so forth. To avoid exposing personnel not involved in AE operations to unnecessary risks, employees shall not wear or remove protective clothing from the premises. Employees shall not wear any static producing clothing in areas where static electricity is a hazard.

C3.8.3. Explosives plant clothing, generally referred to as powder uniforms, shall have nonmetallic fasteners and be easily removable.

C3.8.4. When sending explosives-contaminated clothing to an off-plant laundry facility, the contractor is responsible for informing the laundry of the hazards associated with the contaminants and any special laundering or disposal requirements.

### C3.9. MATERIAL HANDLING EQUIPMENT

C3.9.1. The contractor shall not refuel gasoline, diesel or liquefied petroleum gas (LPG) powered equipment inside buildings containing AE. Refueling shall take place at least 100 feet from structures or sites containing AE. Doors and windows through which vapors may enter the building shall not be open during refueling. Position refueling vehicles at least 100 feet from structures or sites containing AE during refueling.

C3.9.2. Gasoline-, diesel- or LPG-powered equipment shall not be stored in buildings, loading docks, or piers containing AE. The contractor shall store gasoline-, diesel-, and LPG-powered equipment at the appropriate fire protection distance from buildings containing AE.

C3.9.3. Gasoline, diesel, and LPG powered equipment shall have spark arrestors. The contractor shall perform and document inspections of the exhaust and electrical systems of the equipment as necessary to ensure that the systems are functioning within the manufacture's specifications. The contractor shall maintain documentation of the inspections for a period of one year.

### C3.10. PARKING OF PRIVATELY OWNED VEHICLES

C3.10.1. Control of parking of privately owned vehicles within an AE establishment minimizes fire and explosion hazards and prevents congestion in an emergency.

C3.10.2. Parking lots serving multiple PESs shall not be closer than the ILD from each PES. Parking lots serving a single PES shall not be closer than 100 feet to the associated facility to protect it from vehicle fires, and shall be at least public traffic route distance from unassociated PESs. Parking lots for administration areas shall be located at public traffic route distance from all PESs

C3.10.3. Vehicles shall not obstruct access to buildings by emergency equipment or personnel.

### C3.11. IGNITION SOURCES IN HAZARDOUS AREAS

The contractor shall not permit any nonessential ignition sources in operating buildings.

### C3.12. OPERATIONAL EXPLOSIVES CONTAINERS

C3.12.1. Containers shall be compatible with the material they contain.

C3.12.2. Containers used for intraplant transportation or storage of process explosives and energetic materials shall not leak. Because of their fragility and potential for fragmentation, glass containers are not acceptable.

### C3.13. INTRAPLANT RAIL TRANSPORTATION

C3.13.1. The contractor shall develop written procedures to ensure safe and efficient rail movement of AE. The SOPs shall include information covering the inspection of the engine, car mover, and cars, normal and emergency operating procedures for the engine and car mover, AE loading and unloading procedures, and emergency procedures including fire fighting.

C3.13.2. Railcars positioned for loading shall have their brakes engaged to prevent movement. Contractor personnel shall inspect each railcar before loading to ensure it is suitable to carry the specific AE cargo. Contractor personnel shall check the cargo to ensure it is stable and secure, and close the railcar doors before car movement. If using an engine to move railcars, the contractor shall ensure that personnel have connected the air brakes of the railcars in sequence to the engine. If moving a railcar with a car mover the contractor shall station an individual at the hand brake of the railcar.

C3.13.3. A single parked railcar shall have the hand brakes set and the wheels chocked. When more than one railcar is parked, personnel shall set hand brakes on enough railcars to ensure the cars will not move. Personnel shall set hand brakes on the downgrade end of a group of parked railcars. Do not rely on the automatic air brakes to hold parked railcars.

C3.13.4. Contractor personnel shall avoid rough handling of railcars. Personnel shall not disconnect railcars containing AE from each other or a locomotive while in motion. Personnel shall couple railcars gently in order to avoid damaging the AE cargo or shipping containers. Disconnected railcars shall not strike railcars containing AE.

C3.13.5. The contractor shall maintain all rolling stock used for intraplant transportation of AE in a safe and good working condition.

C3.13.6. Portable transmitters and railroad locomotives equipped with two-way radios shall not transmit when passing AE operating buildings where electro-explosive devices are in use. The contractor shall determine minimum safe distances based on radio frequency and power output of the transmitter.

### C3.14. INTRAPLANT MOTOR VEHICLE TRANSPORTATION OF AE

C3.14.1. The contractor shall develop written procedures for the safe transportation of AE in motor vehicles. The SOP shall include procedures for vehicle inspection, vehicle operation, loading and unloading AE materials, and emergency procedures, including fire fighting.

C3.14.2. The operator responsible for transporting AE material shall perform a daily inspection of the vehicle before transporting materials. The operator shall verify that the fire extinguisher is charged and in working order, there are no fuels or other fluid leaks, and that brakes, tires, steering, and other equipment are in good operating condition. Before transporting AE, the operator shall inspect the cargo compartment to ensure it does not contain any residual AE material or any object which could present a hazard to the cargo.

C3.14.3. When loading or unloading AE, the operator shall shutoff the vehicle's engine, unless the engine is required to provide power to equipment for loading or unloading. The operator shall engage the emergency brake and use wheel chocks when the vehicle could move during loading or unloading. The operator shall stabilize and ensure the load is secure to prevent

damage to containers or their contents. The operator shall not transport AE material in the passenger compartment of the vehicle.

C3.14.4. The vehicle operator shall understand and follow established procedures involving a vehicle fire, breakdown, accident, damaged or leaking containers, and spilled material.

C3.14.5. Transportation containers shall not allow the contents to leak or spill in transit.

C3.14.6. Non-sparking material shall cover the cargo compartment when transporting AE in containers capable of exposing their contents if damaged.

C3.14.7. Motor vehicles transporting AE within the establishment boundaries but outside the AE area shall bear at least two placards. Placards based on the fire division symbols discussed in Chapter 10, Fire Protection, are acceptable. Motor vehicles or equipment with internal combustion engines, used near explosives scrap, waste, or items contaminated with explosives, shall have exhaust system spark arresters and carburetor flame arresters (authorized air cleaners).

C3.14.8. The contractor shall maintain vehicles and material handling equipment used to load and transport AE in a safe operating condition.

C3.14.9. Batteries and wiring shall be located to prevent contact with containers of AE material.

### C3.15. INSPECTION OF AE MIXING EQUIPMENT

C3.15.1. The contractor shall establish a preventative maintenance program which includes the inspection of all AE mixing equipment on a periodic basis. The SOP for the inspection shall include criteria for inspecting the blades to bowl clearances, alignment of the blades and bowl, and detection of any distortion of the blades or bowl. The inspection procedures shall also include instructions for checking critical drive system components for wear, damage or misalignment. The procedures shall include criteria for determining that associated equipment used to control the mixer is functioning as designed. The contractor shall maintain a record of all inspections. After performing maintenance of the equipment, the contractor shall run the equipment under load to ensure it is safe to operate.

C3.15.2. The SOPs for operating mixing equipment shall include instructions for inspecting specific equipment components before each use.

### C3.16. FACILITY REQUIREMENTS

C3.16.1. Buildings. The design, construction techniques, process layout, and siting of AE buildings are important considerations in explosives safety and directly influence quantity distance (Q-D) requirements and the degree of exposure to personnel, equipment, and facilities. Construction features which limit the amount of explosives involved, attenuate the resulting blast overpressure or thermal radiation, and reduce the quantity and range of hazardous fragments and debris will help to minimize the effects of an explosion. Incorporating Q-D criteria, when locating an exposed site (ES) in relation to a potential explosive site (PES), will reduce the amount of damage and injuries in the event of an incident.

C3.16.2. Building Exteriors. The contractor should design and erect AE buildings with the ability to allow for the venting of an internal explosion without collapsing. The use of lightweight materials in exterior wall and roof sections designed to vent the effects of an explosion will help reduce the number of large fragments. Exceptions from using lightweight materials include earth-covered magazines, containment type structures, firewalls, substantial dividing walls, special roof loadings, and walls and roofs used for external overpressure protection. Non-combustible exterior wall and roof coverings of operating buildings help prevent the spread of fire from one area of a building to another and from building to building.

### C3.16.3. Interior Walls, Roofs, and Ceilings

C3.16.3.1. Non-combustible material is preferred for the interior surfaces of buildings. The contractor should treat or cover exposed combustion supporting building materials with fire retardant material.

C3.16.3.2. Where hazardous locations exist, interior surfaces shall be smooth, free from cracks, crevices and openings which may create a hazardous condition. This is important to prevent the accumulation or migration of explosive dust and vapors which could result in an incident. The National Fire Protection Association (NFPA), Standard 70 (reference (d)) provides criteria for determining if a location is hazardous.<sup>1</sup>

C3.16.3.3. The contractor should use hard gloss, easily cleanable, paint on painted surfaces.

C3.16.3.4. Periodically clean any surface where explosive dust could accumulate. Establish cleaning schedules on information obtained from the job hazard analysis.

C3.16.3.5. Do not use suspended ceilings in hazardous locations.

### C3.16.4. Floors and Work Surfaces

C3.16.4.1. Locations where exposed explosives or hazardous concentrations of flammable vapor or gas are present require non-sparking floors and work surfaces.

C3.16.4.2. Chapter 12 provides requirements for conductive non-sparking floors and work surfaces.

C3.16.4.3. Floors and work surfaces require periodic cleaning to prevent the accumulation of energetic materials. In addition, all conductive and non-sparking floors and work surfaces require preventative maintenance to ensure their functional integrity.

C3.16.5. Substantial Dividing Walls. The contractor shall design and construct substantial dividing walls to prevent simultaneous detonation of explosives on opposite sides of the wall. The design and construction shall meet the criteria contained in Army TM 5-1300, Navy NAVFAC P-397, or Air Force AFR 88-22 (different designations for the same publication, reference (e)).

### C3.16.6. Exits and Doors

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<sup>1</sup> Obtain NFPA publications from the National Fire Protection Association at <http://www.nfpa.org/catalog/home/index.asp>.

C3.16.6.1. All AE buildings require adequate exits and doors. NFPA Standard No. 101, Life Safety Code (reference (f)), provides information concerning exits and doors.

C3.16.6.2. NFPA Standard No. 80, Standard for Fire Doors, Fire Windows (reference (g)), provides information on the selection and installation of fire doors and windows.

C3.16.6.3. No AE hazards shall occupy space between an operator and an exit.

C3.16.7. Safety Chutes. Multi-storied locations where rapid egress is vital and not otherwise possible require safety chutes.

#### C3.16.8. Passageways

C3.16.8.1. Weather-protected passageways and ramps for travel between buildings or magazines should include features to help prevent fire from spreading from one building to another. Fireproof construction materials, fire stops, fire doors, and fire suppression systems aid in preventing the spread of fire.

C3.16.8.2. The incorporation of weak sections, openings, or abrupt change in direction of passageways will aid in the prevention of funneling the explosion forces from one building to another.

#### C3.16.9. Roads and Walkways

C3.16.9.1. Only roads servicing a single magazine or AE processing building, including its service facilities, may dead end at the magazine or building.

C3.16.9.2. Hard surfaced roads and walkways at the entrances to or between adjacent operating buildings containing AE will help reduce the amount of foreign material tracked into the building by personnel.

C3.16.9.3. Avoid a road system which requires personnel to pass through an AE area when traveling from one area to another.

#### C3.16.10. Windows and Skylights

C3.16.10.1. Inhabited building distances do not protect against glass breakage and the hazards of flying glass. Buildings separated by inhabited building distance should not have windows or other glass surfaces exposed to PESs.

C3.16.10.2. Minimize personnel hazards from glass breakage by means such as building orientation and/or keeping the number of exposed glass panels and panel size to a minimum. When window panels are necessary and risk assessment determines a glass hazard will be present, blast resistant windows must be used. The framing and/or sash of such panels must be of sufficient strength to retain the panel in the structure.

#### C3.16.11. Hardware

C3.16.11.1. AE operations and hazardous locations require an evaluation to determine the safest type of hardware and fasteners to use in order to reduce the risk of an accidental ignition. Consider using non-sparking hardware and fasteners if they will meet the design parameters of the intended application. Depending on the potential hazard, a locking device or some other installation technique shall retain the hardware and fasteners securely in place. This

will prevent the hardware and fasteners from becoming loose, entering process equipment and creating a spark or pinch point.

C3.16.11.2. The contractor should avoid installing hardware, pipes, ducts, and other items on blowout panels in order to prevent the materials from becoming secondary fragments. If it is necessary to install items on blowout panels, select items made of materials which will not yield heavy fragments in an explosion.

#### C3.16.12. Ventilation Systems

C3.16.12.1. Well-designed ventilation systems reduce personnel exposures to airborne contaminants and prevent the accumulation of flammable or explosive concentrations of gases, vapors or dusts. A local ventilation system, which removes the gases, vapors, or dusts at the source, is more effective than a general ventilation system.

C3.16.12.2. A ventilation system is required in areas of buildings generating potentially explosive dusts, gases or vapors. Testing, inspection, and maintenance of ventilation systems used for contaminant control require documentation.

C3.16.12.3. Exhaust fans through which combustible dust or flammable vapor pass shall have nonferrous blades or a casing lined with nonferrous material. The electrical wiring and equipment of the system should comply with provisions of NFPA Standard No. 70, National Electrical Code (reference (d)). Bonding and grounding of the entire system is required.

C3.16.12.4. A slight negative pressure is required in rooms where AE operations generate explosive dust.

C3.16.12.5. NFPA Standard No. 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids (reference (h)), provides standards for exhaust systems.

#### C3.16.13. Steam for Processing and Heating

C3.16.13.1. Steam used to heat buildings containing explosives shall not exceed 228°F (108.9°C) or have a pressure greater than 5 psi (34.48 kPa).

C3.16.13.2. Process steam shall not exceed 249.5°F (120.8°C), or exceed 15 psi (103.43 kPa). Steam pressure greater than 15 psi (103.43 kPa) requires procuring contracting officer (PCO) approval.

C3.16.13.3. The surface temperature of steam and hot water pipes in contact with combustible materials shall not exceed 160°F (71°C). Pipes with an ambient temperature greater than 160°F (71°C) shall not contact combustible materials. An insulating pipe covering capable of reducing the surface temperature of the covering to 160°F (71°C) or less is acceptable.

C3.16.13.4. In AE handling or storage locations where resistance to ground is high, ground steam and hot water lines where they enter the building.

C3.16.13.5. When using a reducing valve, consider installing a relief valve on the low-pressure piping. The throttling action of reducing valves requires a positive means to prevent the production of superheated steam.

C3.16.14. Tunnels. Tunnels between buildings that contain AE shall incorporate features that resist the shock wave of an explosion. This is important in order to minimize the possibility of an explosion in one building from affecting the operations in the other building. For further information on tunnels go to DoD 6055.9, Chapter 9.

### C3.17. QUANTITY-DISTANCE (Q-D) REQUIREMENTS

C3.17.1. Minimum Q-D requirements are contained in DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards.

C3.17.2. For AE work involving an MCE of 0.25 kg (0.55 lbs) or less of HD 1.1 materials, the use of the separation distances listed in Table C3.T1 are acceptable for meeting minimum Q-D requirements.

Table C3.T1. Minimum Q-D Requirements for Small Quantities of Hazard Division 1.1 Material

Net Explosive Weight	Inhabited Building and Fragment Distance	Public Traffic Route and Fragment Distance	Intraline and Fragment Distance
Less than 0.003 kg (0.0066 lb)	0	0	0
0.003 kg-0.01 kg (0.0066 lb-0.022 lb)	5 m (16.5 ft)	3 m (9.9 ft)	2 m (6.6ft)
0.01 kg-0.25 kg (0.022 lb-0.55 lb)	15 m (49.5 ft)	9 m (29.7 ft)	5 m (16.5 ft)

**C4. CHAPTER 4**  
**QUANTITY-DISTANCE AND SITING**

Please refer to DoD 6055.9-STD reference (a), Chapter 9 for guidance.

C5. CHAPTER 5  
HAZARD CLASSIFICATION, STORAGE PRINCIPLES, AND COMPATIBILITY GROUPS

Please refer to DoD 6055.9-STD reference (a), Chapter 3 for guidance.

## C6. CHAPTER 6 ELECTRICAL SAFETY REQUIREMENTS FOR AE FACILITIES

### C6.1. GENERAL

Initiation systems often use the controlled input of electrical energy to initiate explosive mixtures and compounds, which start an explosive train. The uncontrolled release of electrical energy in explosive atmospheres or near explosives and explosive-loaded articles can result in unintended initiation and serious mishaps. Electrical energy manifests itself in many forms (e.g., standard electrical installations, lightning, electrostatic discharge, electrical testing) and with various intensities which require special precautions. This chapter contains minimum electrical safety requirements for existing, new, or modified explosives facilities and equipment.

### C6.2. ELECTRICAL INSTALLATIONS

C6.2.1. National Fire Protection Association (NFPA) Standard No. 70 (reference (d)) and this section are minimum requirements for areas containing explosives. NFPA Standard No. 70 does not specifically address explosives, but it does establish standards for the design and installation of electrical equipment and wiring in atmospheres containing combustible dusts and flammable vapors and gasses which, in general, are comparably hazardous.

C6.2.1.1. NFPA Standard No. 70 (Article 500) defines "hazardous locations" according to the hazard presented by electrical equipment installed in environments where flammable gases or vapors, combustible dusts or flyings may exist. The presence of AE may or may not result in rating a particular location as a "hazardous location." The following exceptions shall be used by DoD contractors when applying the NFPA Standard No. 70 definitions of Class I, Division 1, and Class II, Division 1 hazardous locations:

C6.2.1.1.1. Classify areas containing explosive dusts or explosive substances which may produce dust capable of suspension in the atmosphere as Class II, Division 1 hazardous locations.

C6.2.1.1.2. Classify areas where explosive sublimation or condensation may occur as both Class I Division 1 and Class II Division 1 hazardous locations.

C6.2.2. Exceptions are extraordinarily hazardous explosive substances, such as nitroglycerin (NG), which require special consideration, including physical isolation from electric motors, devices, lighting fixtures and the like.

C6.2.3. Multiple Classifications. In some potential explosion sites (PES) (e.g., powder blending with solvents), hazards resulting from both dusts and flammable vapors may exist. In these cases, it is necessary for that area to have a dual, or multiple, classification. Use only electrical equipment listed by Underwriters Laboratories (UL) or other recognized testing laboratory as suitable for use in all classes of hazardous locations.

C6.2.3. Change of Classification. The specific processes performed in operating buildings and magazines dictate the requirements for electrical equipment installation. If functions performed in the facility change, responsible personnel shall inspect, approve, or reclassify the hazardous locations.

C6.2.4. Alternate Power Source. Facilities shall have an alternate power source for special processes and operations requiring a continuous supply of power, whenever the loss of power will result in a more hazardous condition.

C6.2.5. Portable Engine-Driven Generators. The exposed, non-current-carrying, metallic frame and parts shall be electrically grounded. In addition, observe the following requirements when supplying power to magazines or explosives operating facilities.

C6.2.5.1. Place generating units at least 50 ft (15.2 m) from magazines or hazardous (classified) locations.

C6.2.5.2. Keep the ground area between and around the generator and the NFPA Standard No. 70 hazardous (classified) location clear of debris and other combustible materials.

C6.2.5.3. The exhaust from the generator shall not impinge on grass or any other combustible material.

C6.2.5.4. Position the power cord connecting the generator to the load to prevent trucks or personnel from running over or otherwise damaging the cord.

C6.2.5.5. Do not use cable-to-cable splices within a magazine, explosive operating facility, or other NFPA Standard No. 70 hazardous (classified) location. Use only three-wire, three-prong, approved service type plugs and connectors.

C6.2.5.6. Refer to paragraph C3.9.1 for refueling procedures.

C6.2.6. Electric Supply Systems. Electrical and explosives hazards may mutually exist when PES are in close proximity to electric supply lines. To protect these hazards from each other, the following separation requirements shall apply:

C6.2.6.1. Separate overhead service lines from a PES of combustible construction or a PES in the open by the distance between the poles or towers supporting the lines, unless an effective means is provided to ensure that energized lines cannot contact the facility or its appurtenances if they are severed. Four acceptable alternatives are cable trays and messenger lines, a ground-fault circuit-interrupter which causes a disconnecting means to open all ungrounded conductors of the faulted circuit, weighted triangle line separators or similar weights which ensure broken lines fall straight down away from PES, and constructed physical barriers.

C6.2.6.2. Separate electric distribution lines carrying less than 69 kV, the tower or poles supporting those lines, and unmanned electrical substations from PES by public traffic route distance (PTRD).

C6.2.6.3. Separate electric transmission lines carrying 69 kV or more and the tower or poles supporting them from PES by:

C6.2.6.3.1. Inhabited building distance (IBD) if the line in question is part of a grid system serving a large area off the establishment.

C6.2.6.3.2. PTRD if loss of the line does not create serious social or economic hardships. (NOTE: Base PTRD and IBD on airblast overpressure only; fragment distances shall not apply.)

C6.2.6.3.3. Distances in accordance with paragraph C6.2.6.1 when the line(s) in question can be interrupted without loss of power (i.e., other lines or networks exist for rerouting power).

C6.2.6.4. Avoid locating permanent electric installations in NFPA Standard No. 70 Class I or Class II hazardous locations. When practical operating reasons prevent locating permanent electrical installations outside of hazardous locations, or require the use of portable electrical equipment (e.g., lighting equipment) in hazardous locations, contractors shall only install or use electrical equipment approved for the National Electric Code (NEC) defined "hazardous location" and listed by Underwriters Laboratories (UL) or other nationally recognized testing agencies.

### C6.3. PRIMARY ELECTRIC SUPPLY

The primary electric supply to an entire explosives area should be arranged to allow cutting off the supply by remote switches located at one or more central points away from the area.

### C6.4. VENTILATION

Equip exhaust fans, through which combustible dust or flammable vapor pass, with nonferrous blades, or line the casing with nonferrous material. Motors shall meet the proper NEC class for the hazard (NFPA Standard No. 70 (reference (d))). Clean and service exhaust systems on a regular schedule. Bond and ground the entire system.

### C6.5. LIGHTNING PROTECTION

When lightning protection systems are installed, the installation, inspection, and maintenance shall comply with the NFPA Standard No. 780 (reference (i)), at a minimum. Typically, six month visual tests and 24-month electrical tests of installed systems are acceptable.

### C6.6. STATIC ELECTRICITY AND GROUNDING

C6.6.1. Two unlike materials (at least one of which is non-conductive) produce static electricity due to contact and separation. Contact creates a redistribution of charge across the area of contact and establishes an attractive force. Separation of the materials overcomes these attractive forces and sets up an electrostatic field between the two surfaces. If no conducting path is available to allow the charges to equalize on the surfaces, the voltage difference between the surfaces can easily reach several thousand volts as they separate.

C6.6.2. The potential hazard of static electricity arises when an accumulated electrical charge subsequently discharges as a spark in the presence of hazardous atmospheres, flammable vapors, dusts, exposed sensitive explosives, or electro-explosive device (EED). Electrostatic discharge (ESD) does not present a substantial hazard during the handling of most bulk explosive substances if the explosives are in approved containers. It also does not present a hazard near explosives totally contained and unexposed within loaded articles. It is not possible to prevent the generation of static electricity entirely. Elimination of potential ESD hazards requires proper grounding to dissipate static charges before they accumulate to dangerous levels. The NFPA, UL

and the U.S. Department of Commerce publish detailed discussions of the hazards of static electricity and ways of reducing it. Where static spark discharge may be hazardous, NFPA Standard No. 77 (reference (j)), shall apply, except as otherwise specified.

C6.6.3. Static Ground System. A static ground system consists of one or more electrodes in contact with the earth and a conductor (i.e., metal wire) bonded to the electrode and routed throughout the protected facility. The static ground system may use building structural steel (unless structural steel is used as lightning protection down conductor), metallic water pipes, ground cones, buried copper plates, and rods driven into the earth as electrodes. The ground system shall not use gas, steam, or air lines, dry pipe sprinkler systems, or air terminals and down conductors of lightning protection systems as earth electrodes. A static ground system provides a conductive path to earth from conductive floors, conductive work surfaces, and AE equipment and allows any generated static charges to dissipate.

C6.6.4. Testing Equipment Grounds. Trained personnel shall test ground systems after installation, after repairs, and at locally determined intervals and shall keep all records. Remove all exposed explosive or hazardous materials from the room or area before testing. The resistance of the electrode to earth shall not exceed 25 ohms. The electrical resistance from any point on the conductor to the electrode shall not exceed 1 ohm. The ground system design shall provide for interconnecting all ground electrodes of structures equipped with a lightning protection system.

C6.6.5. Grounding of Equipment. Contractor maintenance personnel shall bond all AE equipment (e.g., mixers, grinding mills, screening and sifting devices, assembly and disassembly machines, conveyors, elevators, steel work tables, presses, hoppers) to the ground system wherever ESD presents an ignition hazard. The resistance of the AE equipment to the grounding system shall not exceed 1 ohm. Trained personnel shall test this resistance initially at installation and at least semiannually thereafter, and shall keep all records. Exclude the resistance of conductive belting when testing for resistance of belt-driven machinery to the ground system. Bonding straps shall bridge contact points where oil, paint, or rust could disrupt electrical continuity. Permanent equipment in contact with conductive floors or tabletops does not meet the bonding requirement to the ground system. Maintain compatibility of metallic bonding and grounding cables, straps, or clamps with the explosives involved in the process.

C6.6.6. Belts. Use conductive belting wherever ESD is an ignition hazard. The resistance of conductive conveyor belts shall not exceed one million ohms as measured between two electrodes placed on the belt and as measured between an electrode placed on the conductive conveyor belt and an electrode attached to the ground system. Do not use static combs to drain off static charges generated from belts or pulleys used in hazardous locations.

## C6.7. CONDUCTIVE FLOORS, TABLETOPS, AND FOOTWEAR

Contractors shall use conductive tabletops and, shall use conductive floors and conductive shoes for grounding personnel at operations involving exposed explosives with electrostatic sensitivity of 0.1 J or less (e.g., primer, initiator, detonator, igniter, tracer, and incendiary mixtures). Bonding wires or straps shall connect the tabletops and floors to the static ground system. Materials sensitive to initiation by ESD sparks include lead styphnate, lead azide, mercury

fulminate, tetrazene, diazodinitrophenol, potassium chlorate-lead styphanate mixtures, igniter compositions, grade B magnesium powder, and exposed layers of black powder dust. Dust from solid propellants can be ignited from spark energy, making conductive floors and shoes necessary where such dust is present. Air and dust mixtures of ammonium picrate, tetryl, tetrytol, and solid propellants are also sensitive to initiation by ESD. Testing indicates mixtures of air with vapors from many flammable liquids (e.g., ethyl ether, ethyl alcohol, ethyl acetate, acetone, and gasoline) may ignite by ESD from the human body. Therefore, contractors shall equip areas where personnel might contact these kinds of explosives or with conductive floors and tabletops, except when hazard analysis indicates adequate housekeeping, dust collection, ventilation, or solvent recovery methods eliminate the ignition hazard.

C6.7.1. Unless hazard analyses indicate otherwise, conductive tabletops, floors, and shoes shall also protect operations involving the following:

- C6.7.1.1. Unpackaged detonators and primers and electro-explosive devices;
- C6.7.1.2. Electrically initiated items, such as rockets, with exposed circuitry; and
- C6.7.1.3. Hazardous materials capable of initiation by ESD from the human body.

C6.7.2. When a hazard remains localized, the contractor may use conductive mats or runners instead of conductive floors throughout an entire building or room. These mats and runners shall meet all the specifications and test requirements that apply to conductive floors. When justified by hazard analysis, contractors may use conductive wrist straps in place of conductive floors and shoes for grounding personnel at small scale and isolated operations. When using wrist straps, operators shall test wrist straps before each use (whenever removed and re-worn) and record test results. The resistance of the wrist strap while the operator is wearing the strap shall fall within a range of 25,000 ohms (minimum) and 1,200,000 ohms (maximum) when measured from opposite hand to ground. Use test equipment capable of testing 1,200,000 ohms  $\pm$  10%. (Note: Operators with dry skin may use special contact creams to decrease the resistance to the required value.)

C6.7.3. Conductive Floor and Tabletop Specifications. Conductive floors and tabletops, made of, or covered with non-sparking materials such as lead, conductive rubber, or conductive compositions, shall meet the following requirements:

- C6.7.3.1. Provide a continuous electrical path to the static ground system and the electrical resistance shall not to exceed the limits specified in paragraph C6.7.5.1;
- C6.7.3.2. Provide a reasonably smooth surface which is free from cracks; and
- C6.7.3.3. Maintain compatibility of conductive floor and tabletop materials with the energetic materials present.

C6.7.4. Conductive Footwear. Operators shall wear conductive shoes in areas requiring conductive mats, floors, or runners. Personnel visiting such areas shall wear conductive shoes, ankle straps, or similar devices, one on each leg. Prominent markings should identify conductive shoes to help supervisors ensure personnel compliance. Personnel required to work on electrical equipment in areas where conductive floors are installed shall not wear conductive shoes and shall not begin work until operators remove all AE.

### C6.7.5. Testing Conductive Footwear, Floors, and Tabletops

C6.7.5.1. Test Criteria. The maximum resistance of a body, plus the resistance of the conductive shoes, plus the resistance of the floor to the ground system shall not exceed 1 million ohms total. That is, if 500,000 ohms is the maximum resistance allowed from the floor to the ground system, then 500,000 ohms is the maximum combined resistance allowed for the person's body plus the resistance of the conductive shoes (i.e.,  $500,000 + 500,000$  does not exceed 1 million). The contractor can set the maximum resistance limits for the floor to the ground system and for the combined resistance of a person's body plus the shoes, as long as the total resistance does not exceed 1 million ohms.

C6.7.5.2. To protect against electrocution, the minimum resistance of the floor to the ground system and the minimum resistance of the tabletop to the ground system shall exceed 11,000 ohms in areas with 110 volts service and 22,000 ohms in areas with 220 volts service. A ground fault interrupt (GFI) circuit also meets this requirement.

C6.7.5.3. Tabletop Test Criteria. The maximum resistance of conductive tabletops to the ground system shall not exceed 1 million ohms.

C6.7.5.4. Conductive Footwear. All personnel shall test conductive footwear daily before use to ensure that the combined resistance of the person's body and the conductive shoes do not exceed the limit specified in paragraph C6.7.5.1.. Supervisors shall keep documentation of all test results, including calibration of test equipment. The test voltage of the shoe tester shall not exceed 500 volts. The short circuit current across the shoe tester electrodes (plates) should be limited between 0.5 ma and 2.0 ma. The design of the test instrument shall include built-in safeguards to prevent the test subject from experiencing electric shock. Personnel shall not test shoes in rooms or areas with exposed explosives or flammable gas mixtures. Personnel shall not wear static generating stockings such as silk, wool, and synthetics; and shall not use foot powders, which have a drying action which can increase resistance. Dirt and grit increase resistance of conductive shoes. Personnel should avoid wearing conductive shoes outdoors and shall keep shoes clean.

C6.7.5.5. Trained personnel shall test conductive floors and tabletops upon installation and at least annually thereafter using test equipment specifically designed for this purpose and shall keep records of all test results for at least five years. Testing shall proceed only when the room or area is free from exposed explosives and flammable gas mixtures. The test procedure shall measure the resistance of the floor between an electrode attached to the ground system and an electrode placed at any point on the floor or tabletop and also as measured between two electrodes placed 3 ft (1 m) apart at any points on the floor or tabletop. Each electrode shall weigh 5 lb (2.3 kg) and shall have a dry, flat, circular contact area diameter of 2.5 in (64 mm). The contact area shall have a surface of aluminum or tin foil which is 0.0005 in to 0.001 in (0.013 mm to 0.025 mm) thick and is backed by a layer of rubber 0.25 in (6.4 mm) thick. The surface hardness shall measure between 40 and 60 Shore A when measured by a Shore Type A Durometer (see American Society for Testing and Materials (ASTM) D-2240-68 (reference (k)), Institute of Electrical and Electronics Engineers (IEEE) Standard 142 (reference (l)) and NFPA Standard No. 99 (reference (m))). Make both electrode-to-electrode and electrode-to-ground system measurements at five or more locations in each room with at least two of the points in

heavily trafficked areas. If the resistance measurement changes appreciably with time, record the resistance at the 5-second interval. To prevent biased measurements, locate the electrodes for both the electrode-to-electrode and electrode-to-ground measurements a minimum of 3 ft (1 m) away from an earth ground or other grounded items such as a door frame, ordnance handling equipment, or any grounded item resting on a conductive floor. (Note: The size of the floor or tabletop may make it impractical to conduct five surface resistance (electrode-to-electrode) or resistance-to-ground measurements and still remain 3 ft (1 m) away from all grounded items. In such cases, take enough measurements to ensure adequate testing of all parts of the conductive surface and document the justification for a reduced number of electrode-to-electrode or electrode-to-ground measurements in the grounding system test plan.) Only trained personnel shall operate and maintain test instruments.

#### C6.8. HANDLING LOW-ENERGY INITIATORS

Supplement typical precautions, such as shielding and safety glasses, with the following measures, as appropriate, when manufacturing, processing, using, or testing low-energy initiators initiated by 0.1 J of energy or less.

C6.8.1. Electrically bond and ground all metal parts of equipment.

C6.8.2. Ensure personnel wear clothing which prevents generation of static electricity. Test conductive shoes with a resistance meter before entering an area where low-energy initiators are being processed.

C6.8.3. When low-energy initiators are being handled, ground personnel directly by wrist straps. The acceptable resistance reading, taken once daily when the operator is wearing the strap, shall be between 250,000 and one million ohms when measured from opposite hand to ground. Special contact creams may be used to decrease the resistance to the required value.

C6.8.4. Periodically coat glass, acrylic, or polycarbonate materials required for transparent shielding with an anti-static material to prevent buildup of static electricity, when static sensitivity is indicated to be a hazard.

C6.8.5. The sounding of a static electricity alarm, installed with the setting best able to provide ample warning, signals a work stoppage until the problem has been located and corrective action taken.

C6.8.6. Check relative humidity and temperature before starting operations and throughout the workday where such conditions are used to mitigate or prevent safety problems (i.e., hygroscopicity or static control).

C6.8.7. Do not paint metal surfaces subjected to rubbing or friction. If a lubricant is necessary, use a composition which allows the metal's surface resistance to remain at or below 25 ohms.

C6.8.8. Work on or with low-energy initiators only in areas equipped with conductive floors and table tops. Exceptions may be made when the initiators are in their original packaging, or are part of a finished metallic end item affording them complete protection from electromagnetic or electrostatic energy.

C6.8.9. Do not work in the vicinity of actual or potential electromagnetic or electrostatic fields (e.g., radio transmission, electrical storms, transformer stations, high voltage transmission lines, improperly grounded electric circuitry, rotating equipment, belts, etc.). Establish adequate lightning protection and grounding and adequate resistances for fixed sources of energy for locations with low-energy initiator operations. Shield these areas to afford protection against local mobile radio transmission.

C6.8.10. Locate electrical equipment out of the range of an operator working with a low-energy initiator. With soldering irons, it may be advisable to ground and limit energy to levels below initiating thresholds.

C6.8.11. When not part of an end item or end item subassembly, transport initiators only when packed according to the latest packing specifications for low-energy initiators.

#### C6.9. ELECTRICAL TEST EQUIPMENT

Use the lowest possible power source for all electrical and electronics test equipment. When possible, use batteries in lieu of 110 Vac power sources. During testing, do not use power sources capable of initiating the AE. When test specifications require using electrical energy at or above the initiating threshold level of explosive devices, use test chambers or provide shielding capable of containing all hazards and apply energy remotely. Provide safeguards against the possibility of human error.

#### C6.10. HUMIDIFICATION AND IONIZATION

C6.10.1. Humidification which maintains relative humidity above 60 percent effectively prevents static electricity accumulations and subsequent discharges. This technique involves pre-operational checks and regular monitoring of the humidity levels throughout the day. Do not use humidification with metallic powders unless hazard analysis indicates the powders are not susceptible to spontaneous ignition in air with 60 percent relative humidity.

C6.10.2. Ionization is electrical neutralization and serves as an effective method of removing static charges from certain processes and operations. Methods of application can be found in NFPA Standard 77 (reference (j)).

C6.10.3. Contractors may use ionization or humidification to augment their ESD control program but, may not use them in lieu of conductive floors and footwear (where required).

C7. CHAPTER 7  
ENERGETIC (PROPELLANT) LIQUIDS

Please refer to DoD 6055.9-STD reference (a), Section 9.5, for guidance.

C8. CHAPTER 8  
SAFETY REQUIREMENTS FOR MANUFACTURING  
AND PROCESSING PYROTECHNICS

C8.1. GENERAL

C8.1.1. Pyrotechnics, as well as propellants and explosives, are chemical mixtures which release large amounts of energy. The amount of energy released, the speed of reaction, and the form of the output energy are the characteristics that distinguish between pyrotechnics and other forms of high-energy (HE) mixtures, and between types of pyrotechnics. The safety precautions for manufacturing and processing pyrotechnics parallel those of many types of explosives and propellants. However, incident mitigation techniques must recognize the unique characteristics of the particular mixtures, and not rely on techniques appropriate to other types of explosive substances (e.g., HE). Rates of reaction of pyrotechnic mixtures vary greatly, from mixtures with very low rates of reaction to rates equivalent to high explosives. Energy output also varies from very low to very great. Process variables, such as ingredient particle size, can affect reaction rate and output to the extent that a change in process variables can negate protective measures. Complicating safety in pyrotechnics operations is the variety of highly flammable solvents often used as processing aides.

C8.1.2. Pyrotechnics are mixtures of fuels and oxidizers, typically held together by binders. Pyrotechnics display many different characteristics, because they are formulated for different purposes. General categories of pyrotechnics are: initiators (igniters); illuminants; smokes; gas generators; sound generators; heat producers; and timing compositions. Each has its own characteristics and attendant processing requirements.

C8.2. PROPERTIES OF PYROTECHNIC MATERIALS AND MIXTURES

Knowledge of the various pyrotechnic properties is critical to the establishment of proper hazard controls.

C8.2.1. Oxidizers. Oxidizers are oxygen rich substances which decompose to liberate oxygen gas, or substances which act as oxidizers with active metal fuels. Typical inorganic oxidizers are nitrates, chlorates, perchlorates, oxides, chromates, and dichromates. Fluorine and chlorine, as in hexachloroethane and Teflon (brand of fluorine containing compound) are examples of organic compounds used as oxidizers. All oxidizers, if not well controlled, tend to increase the risk of undesired reactions, particularly in the presence of organic materials (including wood). Potassium chlorate compositions are particularly susceptible to accidental ignition. Impurities in process materials, or introduced by poor process control (e.g., oils, lubricants) can readily increase the sensitivity of mixtures or result in ignition. Some oxidizers with trace impurities, or by themselves (i.e., ammonium perchlorate (AP)), can detonate when subjected to severe stimuli such as an adjacent explosion or thermal energy. Safety requires absolute control of oxidizers to prevent contamination, uncontrolled moisture absorption (many are hygroscopic), fires or explosions from accidental mixing with fuels.

C8.2.2. Fuels. Fuels react with the oxidizers to produce heat and an oxidized product. It is the proper pairing of the fuel with an appropriate oxidizer that determines the reaction

characteristics, and the use for the mixtures. Metals, such as magnesium or aluminum, create high heat or light output. Fuels include an almost unlimited variety of organic (sugars and red gum) and a more limited variety of inorganic materials (e.g., sulfur boron, phosphorus, and sulfides). Although generally more stable than oxidizers, fuels also have unique characteristics that contribute to risk. These include the liberation of hydrogen from magnesium and aluminum powders which become wetted. Again, storage and handling of fuels requires tight process controls which respect the characteristics of the specific materials and prevent contamination which may result in a reaction.

C8.2.3. Binders. Homogeneity of the mixtures governs the effectiveness of pyrotechnic compositions. Some pyrotechnics (e.g., black powder) are self-bound by the manufacturing process to maintain the charcoal, sulfur, and potassium nitrate in the correct, proportionate, intimate mixture needed. Other mixtures, because of differences in particle size or weight of ingredients, require the use of a binder to retain the homogeneous blend. Other binders include lacquers, epoxies, and a variety of polymers activated by heat or solvents. Some solvents are similar in composition to fuels, and the binder may also be a fuel or burn rate modifier. Some binders are flammable, others require the use of a highly flammable solvent, and thus the ignition characteristics of these materials are important risk factors.

C8.2.4. Types of Pyrotechnic Compositions. Pyrotechnic compositions are usually grouped by the function of the end item. There is no universal single grouping, but typical major groupings are: heat and delay compositions (e.g., ignition, delay, heat, and propellant), color and light compositions, smoke (e.g., obscuring and signal smokes, noise). The range of sensitivity to initiation and the rate/amount of output energy varies greatly both within and between groups.

C8.2.4.1. Heat and Delay Compositions. Pyrotechnic fuzes, electric matches, first fires, primers, igniters, delay compositions are all members of this group. The end products must function with very little stimulus, and thus the mixtures, as well as individual ingredients, are sensitive to initiation. First fire, igniter and primer mixtures are generally the most sensitive to initiation stimuli (i.e., heat, friction, impact, static electricity). (Note: Primer mixes containing initiating explosives such as lead azide or lead styphnate are properly classed as explosives.) These mixtures often use black powder or potassium chlorate/metal combinations or potassium chlorate/phosphorous mixtures. This group also contains mixtures with high heat outputs for such purposes as document destroyers and welding. These high heat producers are generally metallic fuels and metallic oxidizers, as in the iron oxide/aluminum powder formulations for Thermite. Black powder, when used to launch or expel items is a propellant and is included in this group.

C8.2.4.2. Color or Light Producing Compositions. There are a wide variety of mixes and compositions which produce light, color, or both. Illuminant candles, photoflash, decoy flares all are part of this very broad category. Many of the compositions, notably the photoflash and decoy flare compositions, are characterized by very rapid reactions, and extreme temperature outputs. Both have resulted in fatal accidents. Metallic fuels are characteristic of the high light (visible, IR) output mixtures. Output temperatures exceeding 2000°F (1093°C) characterize many of the items in this category. Accidental initiation of large mix batches of some compositions may have a significant pressurization effect in addition to the heat, with resultant structural damage.

C8.2.4.3. Smoke and Noise Producing Compositions. Obscurants, colored markers, weapons simulators and weapons effects simulators comprise this category. Smoke compositions are characteristically slow burning in finished form, but must burn at a temperature high enough to vaporize the dye compound (usually organic). Chlorates are often the oxidizer in colored smoke mixes. "Flash-bang compositions" used in weapons simulators and weapons effects simulators are actually explosives in most instances, and will detonate with adequate stimulus in unconfined bulk form. "Flash-bang" compositions, particularly in display or commercial fireworks, but also in military items, were the cause of many injury-producing accidents. Similarly, "whistle" compositions are very sensitive to ignition and can detonate.

### C8.3. PROCESS REQUIREMENTS

Pyrotechnic operations, because of the sensitive nature of the ingredients and compositions, the dangerous effects of contamination, including cross contamination of oxidizers and fuels, and the amount of open or exposed ingredients and mixtures, require stringent housekeeping and cleanliness. Materials control and cleanliness are mandatory not only to reduce the likelihood of accidental initiations, but also to minimize the effects of a mishap.

C8.3.1. Do not allow ingredient or composition dusts to accumulate, whether on the exterior work surfaces or the interior of process equipment and ventilation systems. (Note: Accident investigations frequently identify dust buildups as the source of initiation when items are dropped on, or scraped across them.) Dust accumulations also provide a propagation path, which can follow from initiation to a significant source of material, causing an accident.

C8.3.2. Similarly, where flammable solvents are part of the process, positive vapor control is mandatory to prevent initiation of a solvent vapor cloud, which may be injurious in itself, or may be the propagation path which ignites a mixture. Just as dusts in ventilation systems may provide a propagation path for an event, solvent vapors in ventilation systems, hallways, conduits, or pipes may also provide a propagation path.

C8.3.3. As many pyrotechnic ingredients, mixtures or the solvents used in their production are highly susceptible to initiation by static electricity, static control systems (i.e., conductive floors/mats, shoes, wrist straps, grounding of equipment, etc.) are mandatory where hazard analysis indicates a need for static control.

C8.3.4. For all pyrotechnic operations, a documented hazard analysis and risk assessment is mandatory to validate the layout of operations, selection of materials and equipment, and process control parameters. See Chapter 11.

C8.3.5. Weighing Raw Materials. Positive means of separation of fuels and oxidizers is mandatory. The scale of the operation will dictate whether separate rooms, cubicles, areas, or other means for separation are required. It is important that equipment (e.g., containers, hand tools, scale pans, etc.) used for weighing fuels or oxidizers are not interchanged or shared among incompatible operations, unless thoroughly cleaned between fuel and oxidizer use, particularly where distance rather than physical barriers separates these areas. A hazard analysis shall determine appropriate personnel protective equipment for personnel weighing or handling exposed oxidizers or fuels.

C8.3.6. Drying Materials. Drying materials may result in the generation of flammable vapors or dust which have the potential to create an explosive atmosphere. The dust settling out of the atmosphere may increase in sensitivity. Operational hazard analysis must address these possibilities and the possibility of initiation by over-temperature or extended heating. Use the minimum temperature necessary for drying component and pyrotechnic materials. Dust and residue control is very important in drying operations, as elevated temperatures frequently results in increased sensitivity of materials. The requirements for drying apparatus are described in section C13.6.

C8.3.7. Mixing and Blending. Mixing, blending, and cleanup of pyrotechnic compositions from equipment apparatus require attention because of the high potential for mishaps during these operations. As compositions vary, no single type of mixer or blender can be the exclusively approved equipment for pyrotechnic mixing and blending operations.

C8.3.7.1. Select the mixing equipment and methods appropriate for each composition. Hazard analysis or test shall determine the type of mixer or blender and batch size. Devices using a tumbling action eliminate many of the problems associated with rotating blade mixers, plows and scrapers. Rotating blade type mixers create points where frictional heat may develop or where accidentally introduced foreign material can create hot spots through friction or crushing of the composition. Equip enclosed mixers and blenders with pressure relief, to preclude a transition from burning to detonation. Minimize personnel exposure when charging and emptying mixers and blenders. Unless hazard analysis indicates otherwise, charge, operate and empty mixers and blenders remotely. Use appropriate interlocks, clutch brakes, and similar devices to preclude personnel exposure during mixer or blender operation, and to preclude the movement of mixer or blender parts during periods when operators are present.

C8.3.7.2. Mixing and blending operations often present a high risk of explosion. Facility construction and procedural controls, guided by hazard analysis or test, must reflect this risk. Prevention of propagation, protection of production capability and personnel require separation and isolation of these operations. At least one wall or equivalent panel area in each bay shall be frangible to provide pressure relief in case of an incident. Preclude personnel exposure to pressure relief areas.

C8.3.7.3. Flammable solvents used in mixing operations present a potential fire or explosion vapor hazard. When flammable solvents are used, install ventilation equipment, interlocked to the mixers. Design interlocks to preclude mixer operation without ventilation. Ventilation systems must operate in the presence of solvent vapors. Vapor sensors provide warning of flammable vapor levels approaching the lower explosive limit. Design ventilation systems to prevent propagation of an incident from one bay to others served by the same system.

C8.3.7.4. Prohibit direct viewing of blender or mixer operations. Use remote means such as television or mirrors, or interpose transparent shields.

C8.3.7.5. Prohibit manual mixing, blending or scraping of pyrotechnic composition.

C8.3.7.6. The following are the minimum criteria for rotating-blade mixing operations:

C8.3.7.6.1. Assure the stability of mixers, and platforms, to prevent distortion during operation and resultant contact between the bowl and blade.

C8.3.7.6.2. Provide positive controls to physically block or stop bowl or blender head movement in case of malfunction to assure maintenance of clearances between mixer bowl and blades.

C8.3.7.6.3. Mixer blades and shaft shall be rigid and structurally strong to ensure minimum flex from weight of the mix and speed of the shaft.

C8.3.7.6.4. All mixer electrical components shall meet the appropriate NFPA Standard No. 70 (reference (d)) electrical classification.

C8.3.7.6.5. The mixer blade shaft shall include adequate and compatible seals or packing glands to prevent migration of mix or solvent vapor into bearings. Submerged bearings and packing glands should be avoided. If used, periodically test packing glands and bearings for contamination and clean them as necessary.

C8.3.7.6.6. Establish a maintenance program to monitor wear in the mixer blade shaft and bearings to avoid excess play. Maintain a record of such checks, mixer blade adjustments, and any damage to the mixer blades and bowls. Perform operational checks of blade/plow and bowl clearances prior to the introduction of materials.

C8.3.7.6.7. Procedures must exclude dry mixing. Starting the mix with dry pockets of materials has been the cause of several serious accidents. Unless adequate amounts of solvent are added in an appropriate sequence with dry ingredients, pockets of dry mix may remain after solvent addition.

C8.3.7.6.8. Interlock power to mixers with fire protection system controls so that the mixer cannot start when the fire protection system is inoperative.

C8.3.7.6.9. Maintain grounding during charging or discharging of mixes.

C8.3.7.6.10. Maintain torque limits or amperage overload protection.

C8.3.7.6.11. Maintain appropriate solvent traps for vacuum mixing.

#### C.8.3.8. Pressing, Extruding, and Pelleting

C8.3.8.1. Few pressing, extruding, or pelleting operations are sufficiently safe to operate without personnel and facility protective features. Omit protective features only when documented hazard analysis supports direct personnel involvement. Use substantial dividing walls, barricades, operational shields or intraline distance (ILD) to protect personnel from pressing, extruding or pelleting operations. (Note: ILD alone does not provide adequate personnel protection. For personnel protection by separation alone, use public traffic route distance (PTRD).) When it is necessary to repair, adjust, or otherwise clear a jam on a press or extruder, remove the pyrotechnic material from the hopper and the bay or press room before making such repairs or adjustments. Only those adjustments of ram speed or conveyor speed routinely controlled by the operator may proceed with material in the bay. Under no circumstances shall repair or adjustment require the use of tools with pyrotechnic material in the bay.

C8.3.8.2. Limit the quantity of composition at the pressing location behind the barricade to that required for the components undergoing the pressing operation. Separate all other quantities in the bay to prevent propagation from an event in the press. The quantity of

composition in the remainder of the building at any one time shall not exceed the minimum required for a safe, efficient operation.

C8.3.8.3. Each individual press, extruder, or loading device shall be located in a separate building, room, or cubicle, and be designed to limit an incident to that area and protect operators. Tests or a hazard analysis may be used to demonstrate that multiple operations in a bay or cubicle do not jeopardize personnel or the facility. Due to the difficulty in positively excluding propagation to feed hoppers or similar feeds to the equipment, designs for pressure relief in case of an incident must include the quantities in such hoppers when present.

C8.3.9. Assembly Operations. Cleanliness and isolation are important safety requirements for assembly operations. Keep individual assembly operations separate from other assembly, mixing, blending, and consolidation operations. Use separate cubicles, bays, or buildings as dictated by hazard analysis. To reduce the possibility of accidental initiation, keep pyrotechnic compositions (including fuels and oxidizers) in closed or covered containers at all times, except during physical processing (i.e., requiring access to the material). This is especially important when materials are accumulating or in transit between operations. Limit quantities of pyrotechnics, including those in components to the smallest quantity necessary for safe and efficient operations.

C8.3.10. Granulation, Grinding and Screening. Operations which reduce particle size are particularly hazardous due to the energy imparted to a material with an increasing surface area, including dusts. The materials are often in their most sensitive form during these operations.

C8.3.10.1. Remove foreign materials using mechanical or magnetic screening from compositions reduced in particle size both before and after the size reduction operation.

C8.3.10.2. Provide positive personnel protection for the operation of ball mills, hammer mills, granulators, or screeners. It is highly desirable to fill and discharge grinding, granulating, and screening equipment remotely. Hazard analysis may dictate that the cleaning of such devices also requires operator protection.

C8.3.10.3. Bond and ground working surfaces, containers, and hand tools.

C8.3.11. Transportation. Transport pyrotechnic compositions in closed containers only. Fabricate individual containers and the transport vehicle (e.g., handcart, hand truck, etc.) of the lightest materials compatible with the composition and having the requisite strength. This minimizes fragment generation if an incident occurs. "Dead man" brakes are often desirable on transport vehicles. Transport vehicles require protection from the weather when loading or unloading. Provide racks or other support, suited to the size and shape of composition containers, to stabilize them in transport.

C8.3.12. Rebowling. These operations transfer materials, typically sensitive and in small quantities, from one container to another, to recover remains of small quantities of materials, or to subdivide large masses for processing. Rebowling of dry pyrotechnics compositions with characteristics similar to initiating explosives require operational shields to protect operators.

C8.3.13. Machining of Pyrotechnic Material

C8.3.13.1. Conduct machining of pyrotechnic materials remotely.

C8.3.13.2. Drilling and facing operations must be done to minimize friction and heat build-up. Hazard analysis should address factors including feed rate, type of composition and tooling.

C8.3.13.3. Perform hand trimming and cutting of pyrotechnic candles only when supported by results of a hazard analysis specific to that composition and candle configuration.

C8.3.13.4. Sawing operations require particular care to prevent work from plunging into the saw blade, and to ensure chip removal from saw teeth before subsequent cutting passes. Plunging can occur when thin sections are force fed into coarse pitch saw blades. To prevent this, the work feed rate shall be controlled. Chip accumulation in the saw teeth is a function of the material being sawed, rate of feed, blade speed, tooth design, and flushing arrangement.

#### C8.4. SPILL CONTROL

Spills of pyrotechnic composition and energetic ingredients pose potential hazards. Notify the responsible supervisor before any action to clean or contain the spills. SOP for pyrotechnic operations shall cover spill cleanup, either as part of the various operations detailed or as a separate procedure. The procedures shall specify which actions are to be taken by whom and in what order. The procedures shall also address recovery of the spilled material and decontamination of the area.

#### C8.5. MANAGEMENT OF PYROTECHNIC SCRAP AND REJECTS

C8.5.1. At regular intervals, remove all pyrotechnic reject materials and scraps from all operating areas. Segregate such materials by type and compatibility, and keep it separate from common wastes. Use positive identification systems for containers of these materials. Place filled containers at designated collection points.

C8.5.2. To prevent undesired reactions, use special care to preclude the mixing of water with powdered or finely granulated metals. Plastic liners for waste containers facilitate cleaning. Liners should be conductive when contents are subject to initiation by static electrical discharge.

#### C8.6. CLEANING OF PYROTECHNIC PROCESSING EQUIPMENT

C8.6.1. Since pyrotechnic materials are sensitive to friction, impact, or static discharge, cleaning equipment contaminated with pyrotechnic materials poses hazards. Because personnel are near the equipment being cleaned, risks may exceed those of processing. Therefore, cleaning shall receive the same planning and SOP coverage as production.

C8.6.2. Cleaning procedures must satisfy environmental and safety concerns. The use of flammable solvent solutions for flushing may require remote control. Minimize the quantity of solvents used. Control possible run-off from cleaning operations to preclude the spread of contamination.

C8.6.3. Select personal protective equipment based on hazard analysis and test data. Protective equipment must withstand the maximum credible event (MCE) when personnel perform cleaning in the vicinity of equipment and contamination.

## C8.7. PERSONAL PROTECTIVE EQUIPMENT

C8.7.1. Engineering controls remain the primary and preferred means of providing personnel protection. Unattended operations, remote controls, substitution of less hazardous materials, and reduced quantities are all more effective than personal protective equipment or apparel. Personal protective equipment shall not be relied upon as the primary means of operator protection. Operational shields and high-speed deluge systems may offer supplemental protection. Operators must use only the protective equipment and apparel prescribed by the SOP, and that apparel or equipment must be that prescribed by hazard analysis.

C8.7.2. The minimum protective apparel for personnel exposed to open containers of pyrotechnic or energetic raw materials shall consist of the following:

- C8.7.2.1. Cotton socks,
- C8.7.2.2. Conductive-soled safety shoes,
- C8.7.2.3. Flame-retardant coveralls, and
- C8.7.2.4. Hair coverings.

C8.7.3. All employees exposed to hazardous quantities of pyrotechnic compositions shall wear:

- C8.7.3.1. Aluminized, thermally protective suit with hood and faceplate;
- C8.7.3.2. Aluminized, thermally protective trousers; and
- C8.7.3.3. Aluminized, thermally protective gloves or equivalent.

(Note: The definition of hazardous quantities will depend on the composition's energy output and sensitivity (as determined by hazard analysis or tests) and the nature of the operation.)

C8.7.4. Required levels of protective apparel shall be specified in appropriate SOP steps.

C8.7.5. When the protective clothing described in paragraph C8.7.2 and C8.7.3 is required, the design and wearing shall ensure no exposure of any area of the body. Use appropriate seals or joints to preclude flame intrusion where apparel items overlap or join. Give particular attention to possible gaps in coverage provided by the hood in order to prevent flame or hot gas impingement on the face, head, or neck. Protection of the employee's throat and lungs may require use of a self-contained breathing apparatus or supplied-air respirator from the effects of a fireball.

## C8.8. REWORKING PYROTECHNIC COMPONENTS

C8.8.1. Perform all repair, reassembly, or similar operations on loaded pyrotechnic compositions in a separate bay used only for that purpose.

C8.8.2. Reworking and reusing pyrotechnic material is desirable from both an economic and environmental basis; however, all rework and reuse concepts require careful analysis to assure safety. Manage all unused materials in accordance with local, state and federal requirement.

### **C8.9. FIRE PROTECTION**

When compatible with process materials, use deluge systems for the protection of mixing and blending operations, screening, granulation, drying, and pressing or extrusion operations. Select the response time of the deluge system to minimize the damage to process equipment and facilities. Hazard analysis of the operation may dictate other applications.

## C9. CHAPTER 9 STORAGE OF AMMUNITION AND EXPLOSIVES

### C9.1. GENERAL

A properly sited storage area is mandatory for AE. Earth-covered magazines (ECM) offer the greatest protection for the stored AE, and provide some mitigation of fragments and over pressures from internal explosions. Such magazines are preferred for the storage of all AE.

### C9.2. MAGAZINE OPERATIONAL REGULATIONS

C9.2.1. Do not store unpackaged AE and ammunition components, packing materials, conveyors, skids, empty boxes, or other such items in magazines containing AE. Limited dunnage lumber may be stored in the magazines, if it does not block exits or aisles.

C9.2.2. All AE containers shall be marked with a DoD hazard classification/division, storage compatibility group and item nomenclature.

C9.2.3. While crews are working inside magazines, keep doors unlocked to permit rapid egress.

C9.2.4. Do not store flammable liquids in magazines containing AE, except as the chemical filler of ammunition, or as a prepackaged storable liquid propellant.

### C9.3. STACKING

C9.3.1. Store AE in original shipping containers or equivalent. When stacking, group and identify AE according to lots, if practicable.

C9.3.2. Use dunnage to provide ventilation to all parts of the stack.

C9.3.3. Maintain aisles between each stack to allow inspection, inventory, and removal for shipment or surveillance tests. Block storage configuration is permitted, provided ventilation of stacks exists. Maintain unobstructed aisles to permit rapid egress.

C9.3.4. Avoid more than one light (partially filled) box or pallet per lot in storage. Stack light units to be readily visible and immediately accessible. Conspicuously mark incomplete boxes to identify contents and quantities.

### C9.4. UNPACKAGED AE ITEMS AND DAMAGED CONTAINERS

C9.4.1. When necessary, store unpackaged AE items in separate magazines.

C9.4.2. Do not store damaged containers of AE in a magazine with serviceable containers of AE. Repair such containers or transfer the contents to new or serviceable containers. Close and securely fasten covers on containers of AE allowed in magazines. Close containers that have been opened before storing them again. Keep stored containers free from loose dust and grit.

C9.4.3. Do not permit loose powder, grains, powder dust, or particles of explosive substances from broken AE or explosive substance containers in magazines. In addition, clean up any spilled explosive substance as soon as possible and suspend all other work in the

magazine until accomplished. (NOTE: Manage explosive residue as a waste in accordance with Chapter 15.)

#### C9.5. MAINTENANCE AND REPAIRS TO MAGAZINES

Perform and document a hazard analysis, and implement the recommendations resulting to support the plans for maintenance and repairs of magazines containing AE.

#### C9.6. OPEN STORAGE (OUTDOORS)

Do not store AE outdoors.

#### C9.7. STORAGE OF BULK INITIATING EXPLOSIVES

Bulk initiating explosives must neither be stored dry nor exposed to the direct rays of the sun. Containers of ample size to hold the double bag of explosives are used for normal storage. Types of AE range from highly sensitive, bulk explosive substances (e.g., pyrotechnics, propellants and explosives) to less sensitive, metal-cased AE (e.g., bombs, torpedoes and artillery projectiles). For appropriate guidance, refer to DoD 6055.9-STD (reference (a)) or industry standards for specific storage requirements applicable to the various types of AE.

#### C9.8. HAZARDS OF LONG-TERM STORAGE

C9.8.1. AE may deteriorate in storage. The method of packaging, extremes of temperature and humidity during storage, the length of time the AE is stored, the nature of the deterioration, and the explosive substance compositions used are factors in the rate and criticality of the deterioration. Any deterioration that decreases the stability of the AE increases the risk of auto-ignition or a handling mishap due to friction, impact or electrostatic discharge. The longer that AE remains in storage, the greater the likelihood that stocks of AE for issue or use will deteriorate. Older unstable AE material should be tracked, identified and prioritized in the contractor inventory management programs.

C9.8.2. Dispose of unstable AE stock material in accordance with the procedures and requirements of Chapter 15, Collection and Destruction Requirements for AE. Disposition of unserviceable AE will be under local procedures based on the latest available technical data. Unstable AE includes substances with totally depleted stabilizer, misfired ordnance, explosive devices rendered safe by explosive ordnance disposal and any similar items. Unstable AE material is incompatible with all other AE material in storage. When available store different types of unstable AE material in separate magazines.

C9.8.3. Treat AE with unknown stability as unstable. Examples of AE to treat as unstable include non-stock material, dropped or damaged material, material in substandard packaging, unidentified material and material not receipt inspected.

C10. CHAPTER 10  
FIRE PROTECTION

C10.1. GENERAL

This chapter provides:

C10.1.1. General requirements for developing and implementing AE fire protection and prevention programs, and

C10.1.2. Standard fire fighting hazard identification measures to ensure a minimum practicable risk in fighting fires involving AE.

C10.2. FIRE PLAN

C10.2.1. A written fire plan shall be prepared which itemizes the emergency functions of each department or outside agency and indicates responsible individuals and alternates.

C10.2.2. When the contractor has an internal fire department or brigade, plant officials have the responsibility for firefighting procedures, training of firefighting personnel, the use and maintenance of firefighting equipment and vehicles, the provision of water supply and alarm systems and first aid measures required in firefighting.

C10.2.3. Firefighting Agreements. Voluntary and mutual agreements with local municipalities or industrial centers shall include AE firefighting guidelines (see paragraph C10.6). Contractor officials are responsible for informing the firefighters of AE hazards.

C10.2.4. Smoking. Smoking may take place only in safe, specifically designated and posted "smoking locations." Personnel shall not wear clothing contaminated with explosives or other dangerous material in smoking locations.

C10.2.5. Hot Work Permits. A written permit shall be required for the temporary use of heat-producing equipment or devices when explosives or highly flammable materials are involved.

C10.2.6. Portable Fire Extinguishers. Hand extinguishers within buildings can extinguish fires before major damage is done. Portable equipment may prove similarly valuable outside aboveground magazines (AGM) and other buildings with AE. Portable fire extinguishers will be maintained in accordance with NFPA Standard No. 10 (reference (n)).

C10.3. FIRE HAZARD IDENTIFICATION SYSTEM

C10.3.1. The contractor shall establish a fire hazard identification system. This system shall assess the relative dangers, up to the most hazardous material stored. The system must include placards on AE buildings.

C10.3.2. One such system is the DoD Fire Identification System, which consists of six fire divisions (1 - 6) which correspond to Hazard Division (HD) 1.1 through HD 1.6.

C10.3.2.1. Fire Division 1 indicates the greatest hazard. The hazard decreases with ascending fire division numbers from 1 to 4. Fire Divisions 5 and 6 refer to explosion hazards from less sensitive substances and extremely insensitive articles.

### C10.3.3. Fire Division Symbols

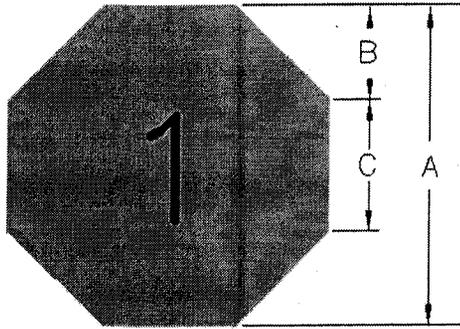
C10.3.3.1. The six fire divisions are indicated by four distinctive symbols (see Table C10.T1 and Figure C10.F1) in order to be visually recognized by the firefighting personnel from a distance. The number is shown on each symbol indicating the type of AE present. Reflecting or luminous symbols should be used. For application on doors or lockers inside buildings, half-sized symbols may be used.

C10.3.3.2. The symbols are orange and each number identifying the fire division is black.

Table C10.T1. Fire Division Markings

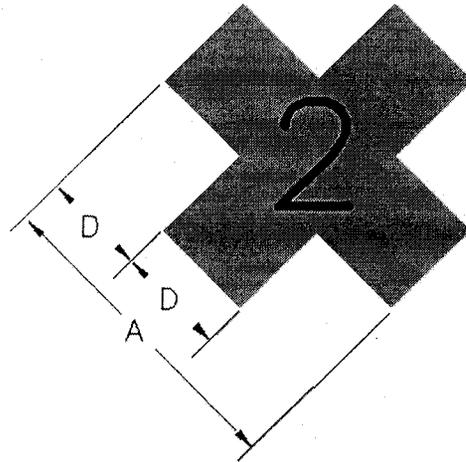
Fire Division	Hazard Involved	Shape
1	Mass detonation	Octagon
2	Explosion with fragment hazard	Cross
3	Mass fire	Inverted triangle
4	Moderate fire	Diamond
5	Mass Explosion (blasting agents)	Octagon
6	Nonmass explosion (EIDS article)	Cross

Figure C10.F1. Fire Division Symbols



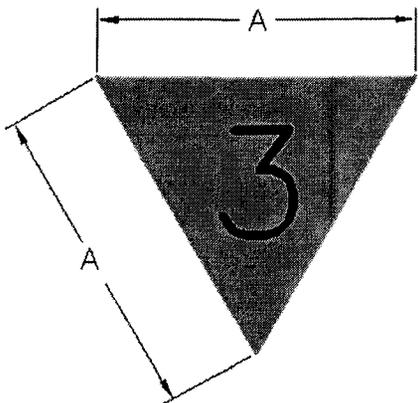
Fire Division 1 or 5

24-inch: NSN 7690-01-082-0290  
12-inch: NSN 7690-01-081-9581



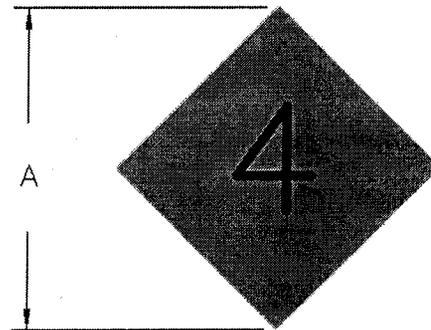
Fire Division 2 or 6

24-inch: NSN 7690-01-082-0289  
12-inch: NSN 7690-01-087-7340



Fire Division 3

24-inch: NSN 7690-01-081-9583  
12-inch: NSN 7690-01-081-9582



Fire Division 4

24-inch: NSN 7690-01-082-6709  
12-inch: NSN 7690-01-081-9584

Dimensions	Large Symbol		Small Symbol	
	inches	metric (mm)	inches	metric (mm)
A	24	610	12	305
B	7	178	3.5	89
C	10	254	5	127
D	8	203	4	102
Letters (height)	10	254	5	127
Letters (thickness)	2	51	1	25

COLORS (per Federal Standard 595A or GSA Catalog):

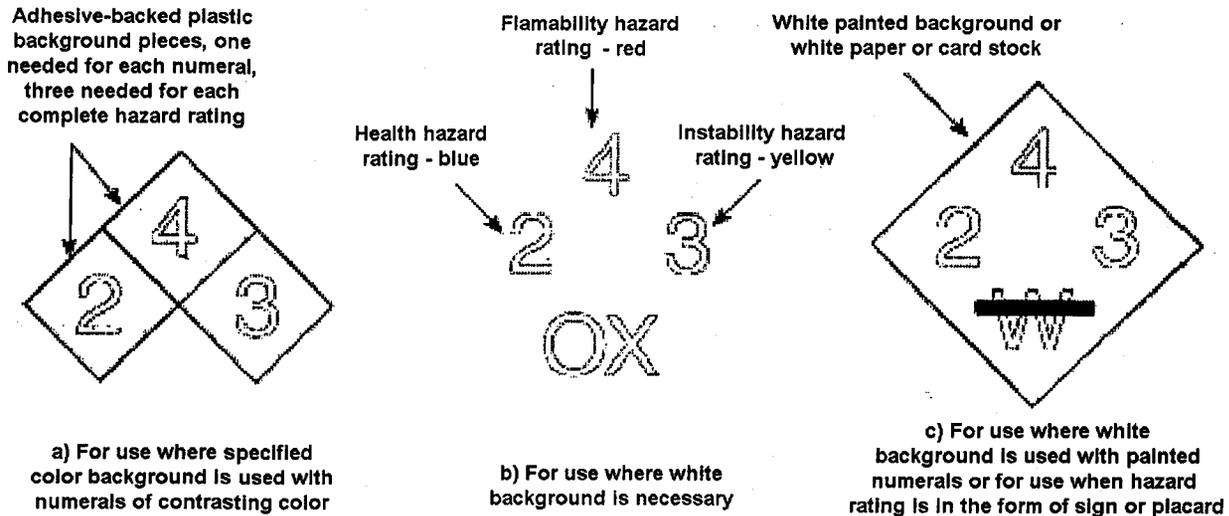
Background: Orange #12246  
Letters: Black #17038

**C10.4. NFPA STANDARD NO. 704 STANDARD SYSTEM FOR THE IDENTIFICATION OF THE HAZARDS OF MATERIALS FOR EMERGENCY RESPONSE**

NFPA Standard No. 704 (reference (o)) provides a simple, readily recognized and understood system of marking which many fire departments prefer for response. This system identifies the hazard and severity of materials and may be used in lieu of the DoD fire hazard symbols.

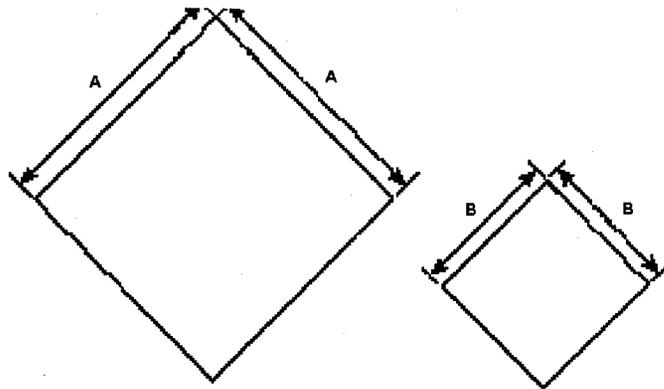
C10.4.1. The system identifies the hazards of a material in terms of three categories: health, flammability and stability. This system indicates the degree of severity by a numerical rating which ranges from four (4), indicating severe hazard, to zero (0), indicating minimal hazard. The system is based on relative rather than absolute values. For assignment of hazards, see NFPA Standard No. 49 (reference (p)) and NFPA Standard No. 325 (reference (q)).<sup>2</sup> Figures C10.F2 through C10.F4 present an overview of the NFPA marking system.

Figure C10.F2. Alternate Arrangements for Display of NFPA Hazard Identification System



<sup>2</sup> NFPA Standard No. 704, NFPA Standard No. 49 and NFPA Standard No. 325 are all contained in "Fire Protection Guide to Hazardous Materials," 2001 Edition, ISBN# 0877654735, available at <http://www.nfpa.org/catalog/home/index.asp>.

Figure C10.F3. Dimensions of NFPA Standard No. 704 Placards and Numerals

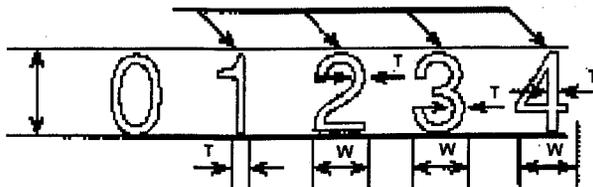


When painted (use same dimensions for sign or placard)

When made from adhesive-backed plastic (one for each numeral, three necessary for each complete hazard rating)

Color of numerals 1, 2, 3, 4 should be as indicated

Note: Style of numerals shown is optional.



Minimum dimensions of white background for hazard ratings (white background is optional)

Size of hazard ratings (in (mm))				
H	W	T	A	B
1 (25)	0.7 (18)	5/32 (4)	2.5 (64)	1.25 (32)
2 (51)	1.4 (36)	5/16 (8)	5 (127)	2.5 (64)
3 (76)	2.1 (53)	15/32 (12)	7.5 (191)	3.75 (95)
4 (102)	2.8 (71)	5/8 (16)	10 (254)	5 (127)
6 (152)	4.2 (107)	15/16 (24)	15 (381)	7.5 (191)

Exception: For containers with a capacity of one gallon or less, symbols may be reduced in size, provided:

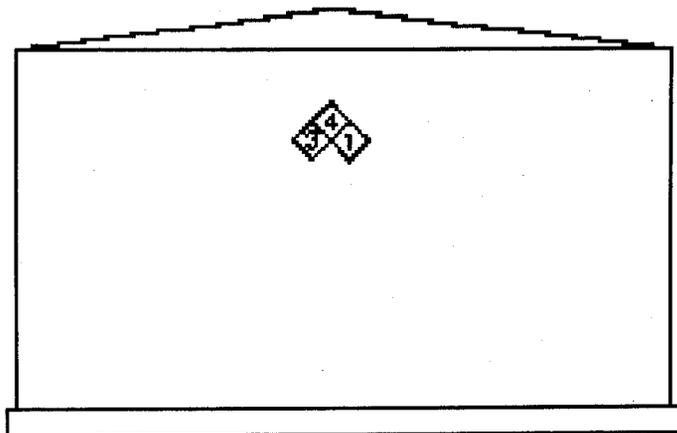
1. This reduction is proportional.
2. The color-coding is retained.
3. The vertical and horizontal dimensions of the diamond are not less than 1 in (25 mm).
4. The individual numbers are no smaller than 1/8 in (3 mm).

Figure C10.F4. Minimum Size of Numerals and Legibility at Distance

Arrangement and order of hazard ratings  
– optional form of application

Distance at which hazard ratings must be legible (ft (m))	Minimum size of hazard ratings required (in (mm))
50 (15)	1 (25)
75 (23)	2 (51)
100 (30)	3 (76)
200 (61)	4 (10)
300 (91)	6 (152)

Note: This shows the correct spatial arrangement and order of hazard ratings used for identification of materials by hazard.



## C10.5. FIREFIGHTING PROCEDURES

### C10.5.1. General

C10.5.1.1. Firefighters of AE fires must have a thorough knowledge of the specific reactions of AE exposed to heat or to fire. The firefighting forces and other essential personnel shall be briefed before approaching the scene of the fire. They shall be informed of the known hazards and conditions existing at the scene of the fire before proceeding to its location.

C10.5.1.2. Fire involving AE shall be fought according to the appropriate response for hazard or fire division and the stage of the fire.

C10.5.1.3. All fires starting in the vicinity of AE should be reported and should be fought immediately with all available means. However, if the fire involves explosive substance, is supplying heat to them, or if the fire is so large that it cannot be extinguished with the equipment at hand, the personnel involved shall evacuate and seek safety.

C10.5.1.4. Emergency withdrawal distances for non-essential personnel are intended for application in emergency situations only and not facility siting. Emergency withdrawal distances depend on fire involvement and on whether fire division and net explosive weight (NEW) are known. Emergency authorities shall determine the withdrawal distance for essential personnel at the fire. Emergency authorities shall determine who are essential personnel.

C10.5.1.5. If a fire involves explosive substance, the initial withdrawal distance applied shall be at least to the inhabited building distance (IBD). See Table C10.T2. If fire does not involve explosive substances, emergency authorities shall determine the withdrawal distance based on the situation at hand.

C10.5.1.6. Structures or protected locations offering equivalent protection for the distances listed in Table C10.T2 may be used in lieu of relocating personnel from the structure and/or location to the specified emergency withdrawal distance.

C10.5.1.7. Contractors should develop evacuation plans for their facilities which reference the appropriate withdrawal distances as part of the emergency response plan. Contractor personnel are responsible for alerting local authorities of any imminent explosive accident on the facility which may affect the local community and for providing local authorities with the appropriate emergency withdrawal distances.

### C10.5.2. Specific

C10.5.2.1. Contractors shall train operational personnel on the characteristics of explosive substances, including their reactions to heat and fire, as well as what to do in case of fire. Personnel shall not attempt to fight fires involving Hazard Division (HD) 1.1 and HD 1.2 AE. These AE detonate with a fragmentation hazard, and personnel shall evacuate immediately, using protective cover where available and activating deluge systems and fire alarms while escaping. Individuals remain in danger until they reach shelter, although reaching IBD in the open affords some safety. Exit drills should be conducted annually and during exit drills, employees shall be advised of the safest escape routes and evacuation points.

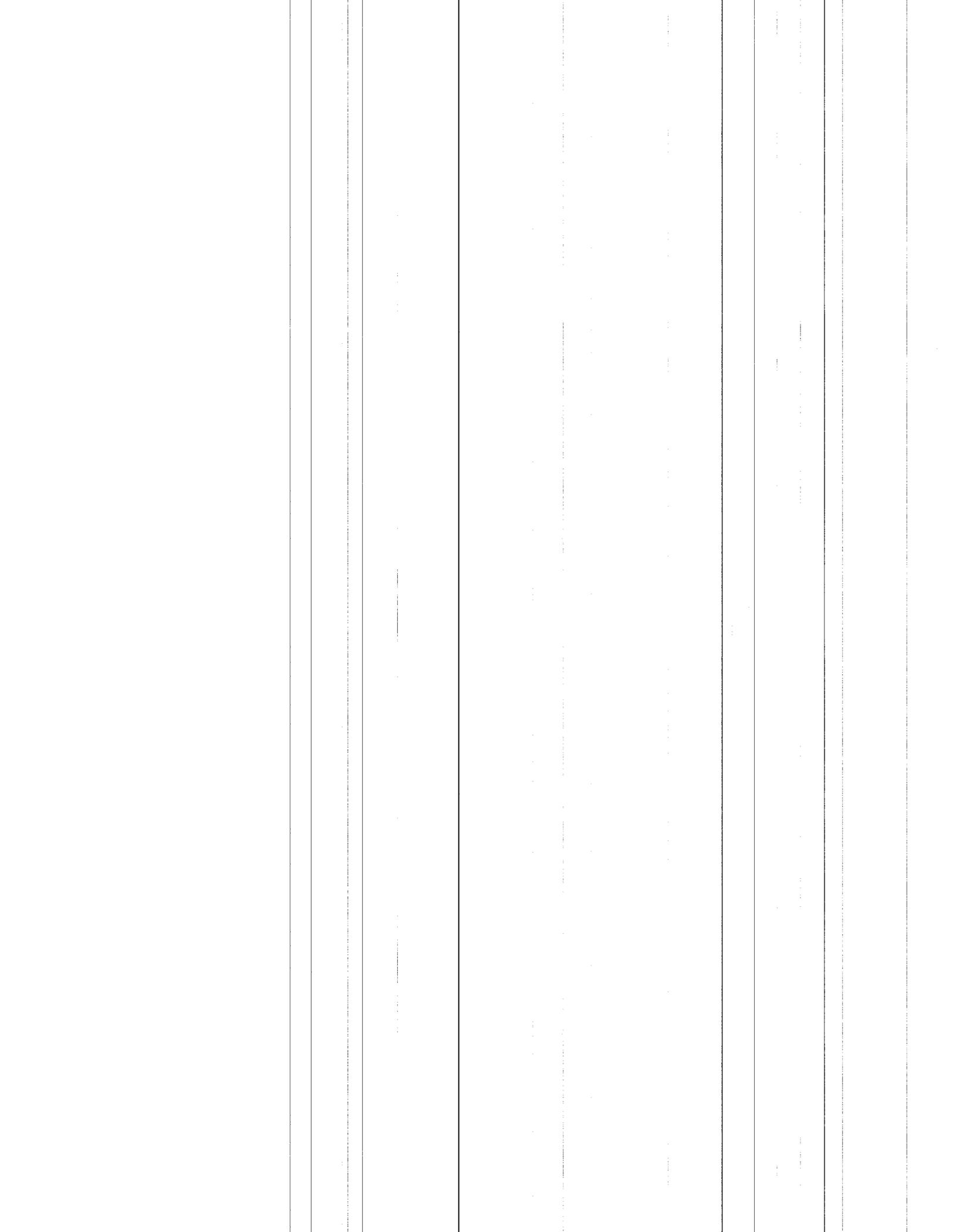


Table C10.T2. Emergency Withdrawal Distances for Nonessential Personnel

Hazard Division		Unknown Quantity	Known Quantity
Unknown, located in facility, truck and or tractor trailer		4,000 ft (1,220 m)	4,000 ft (1,220 m)
Unknown, located in railcar		5,000 ft (1,524 m)	5,000 ft (1,524 m)
1.1 and 1.5 <small>Note 1</small>	Same as unknown facility, truck trailer or railcar as appropriate	<p>For transportation, use 2,500 ft (762 m) minimum distance for 500 lb (227 kg) and below. Above 500 lb (227 kg), for rail cars use 5,000 ft (1,524 m) minimum distance; otherwise use 4,000 ft (1,220 m) minimum distance. Use 4,000 ft (1,220 m) minimum distance for bombs and projectiles with caliber 5 in (127 mm) or greater.</p> <p>For facilities, use 2,500 ft (762 m) minimum distance for 15,000 lb (6,804 kg) and below. Use 4,000 ft (1,220 m) minimum distance for net explosive weights above 15,000 lb (6,804 kg) and less than or equal to 50,000 lb (22,680 kg). Above 50,000 lb (22,680 kg), use <math>d = 105 W^{1/3}</math> <small>Note 3</small></p>	
1.2 (1.2.1, 1.2.2, and 1.2.3) 1.6 <small>Note 1</small>	2,500 ft (762 m)	2,500 ft (762 m)	
1.3 <small>Note 2</small>	600 ft (183 m)	Twice the IBD (Table C9.T10.) with a 600 ft (183 m) minimum range.	
1.4	300 ft (91 m)	300 ft (91 m)	

**Notes:**

- For HD 1.1 and HE 1.2 AE, if known, the maximum range fragments and debris will be thrown (including the interaction effects of stacks of items, but excluding lugs, strongbacks, or nose and tail plates) may be used to replace the minimum range.
- For accidents involving propulsion units, it is not required to specify emergency withdrawal distances based upon the potential flight ranges of these items.
- This is the quantity-distance formula. 105 is the K-factor, a constant, and represents the degree of damage which is acceptable in this situation. The distance  $d$  is in feet and  $W$  is the net explosive weight in pounds.

C10.5.2.2. If the fire in a HD 1.1 or HD 1.2 building does not directly involve explosive substances and is small or in a segregated container, an attempt should be made to extinguish the fire. After summoning firefighters, responsible contractor personnel shall meet them as they approach the facility to brief them. When HD 1.1 or HD 1.2 AE is directly involved, firefighting forces should maintain IBD from the fire. The safety of personnel fighting a HD 1.1 or HD 1.2 fire depends on the accuracy of the information made available to all firefighting forces. No person shall re-enter a burning building containing HD 1.1 or HD 1.2 AE.

C10.5.2.3. Personnel in the immediate vicinity of HD 1.3 AE should activate deluge systems and alarms. Unless the fire is minor, involves no explosive, and appears controllable, firefighters shall confine their efforts to prevent it from spreading to other buildings. Fire in HD 1.3 AE creates a wide area of intense radiant heat, dangerous to personnel and equipment. The firefighters should exercise extreme caution.

C10.5.2.4. HD 1.4 AE presents a moderate fire hazard. Fires involving this material shall be fought until extinguished unless emergency authorities determine to evacuate.

#### C10.6. EMERGENCY PLANNING

Contractors shall develop procedures or plans to provide safety, security, and environmental protection. Plans shall be coordinated with the applicable Federal, state, and local emergency response authorities (e.g., law enforcement, fire departments, and hospitals, etc.). At a minimum, those procedures or plans shall include provisions for complying with Section 301-312 of the Emergency Planning Community Right to Know Act (EPCRA) (reference (r)).

#### C10.7. AUTOMATIC SPRINKLER SYSTEMS

Properly installed and maintained automatic sprinklers reduce fire losses. They are particularly useful for load lines, AE manufacturing, receiving, shipping, inspection, and workshops, and demilitarization.

#### C10.8. DELUGE SYSTEMS

C10.8.1. Contractors may use deluge systems to supplement sprinklers, when the hazards are high, such as in powder hoppers and cutters. Rate of rise, light actuating, ultraviolet, or other quick-action devices for automatic control of deluge systems are recommended. Manual controls should serve as backup.

C10.8.2. To ensure immediate drenching of AE material, the distribution outlets (nozzles, sprays, heads, etc.) should be as near the explosive's exposed surface as permitted by the outlet discharge pattern. When explosives are under tight hoods or covers inside machines, distributing outlets belong inside the enclosed space.

C10.8.3. Nonmetallic, internally-spring-held caps should protect outlets exposed to explosive vapors, gases, or dust. Upon exertion of pressure within the outlet, the cap shall immediately pop. Caps should be attached to outlets to prevent their dropping into equipment during a deluge.

C10.8.4. Water flow and pressure should be determined for the hazard.

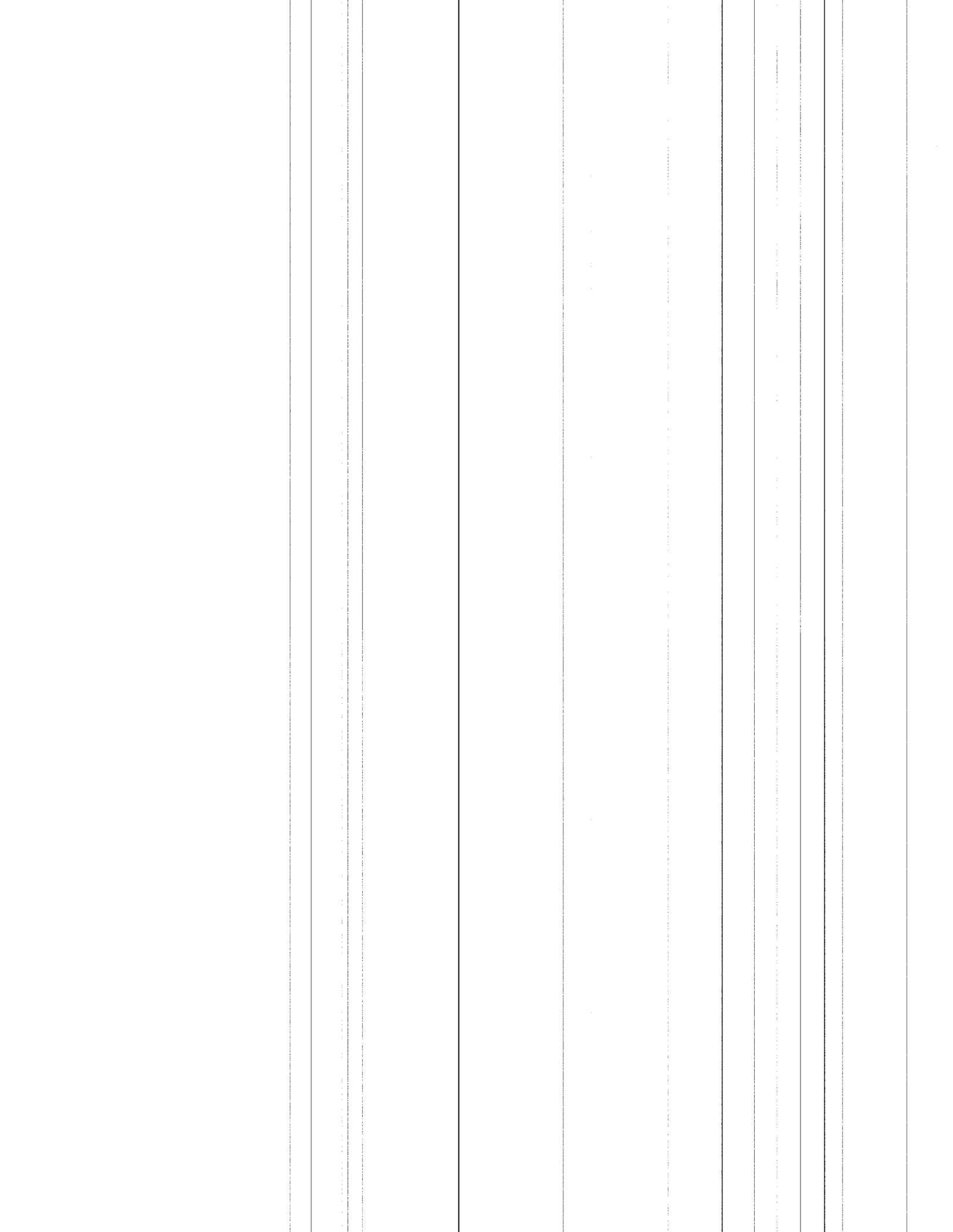
C10.8.5. Periodic inspections of deluge systems shall ensure that they are in proper operating condition.

C10.8.6. The deluge valve should allow for automatic and manual activation. Manual activation devices shall be placed at the operator station or at exits in explosive operating buildings as determine by a hazard analysis.

C10.8.7. NFPA Standard No. 13 (reference (s)) and NFPA Standard No. 15 (reference (t)) contain basic installation rules.

### C10.9. FIREBREAKS

A firebreak is an area of bare ground or vegetation intended to limit the probability of fires causing a hazard to AE areas. A firebreak, at least 50 ft (15 m) wide shall be maintained in all directions around magazine and AE operating buildings or locations. Barricades and other sloping ground, within the firebreak area, should retain enough vegetation to prevent significant erosion. Growth of vegetation within a firebreak shall be controlled to prevent rapid transmission of fire. Relatively long vegetation of 6 to 8 in (152 to 203 mm) in length, which is green or sparsely spread, is acceptable. Do not allow vegetation to become dry or dense; this could allow rapid transmission of fire.



C11. CHAPTER 11  
RISK IDENTIFICATION AND MANAGEMENT

C11.1. GENERAL

AE operations involve many hazards and risks. These include the type of hazards associated with any industrial enterprise (e.g., lifting, slipping, tool use, toxic chemicals, potential exposures to environmental extremes, etc.).

C11.1.1. The evaluation of hazards and risk of mishap addressed in this chapter relate to processes not end products. The safety of operations is a contractor responsibility. Only the Government can accept risk for the AE it acquires and uses.

C11.1.2. A basic risk identification and management system is a necessary element of a comprehensive AE safety program. The purpose of this chapter is to address risk identification and management for all AE operations.

C11.2. RISK MANAGEMENT SYSTEM

Contractors shall have a risk identification and management system, which, as a minimum, results in the analysis of materials, equipment, and personnel capabilities. This analysis will aide in the development of a written SOP for AE contract operations. The contractor shall document the analysis and keep it as long as the SOP is active. The analysis shall include such factors as: initiation sensitivity, quantity of materials, heat output, rate of burning, potential ignition and initiation sources, protection capabilities of shields, various types of clothing, fire protection systems, and personnel exposure with special considerations (such as toxic or corrosive chemicals).

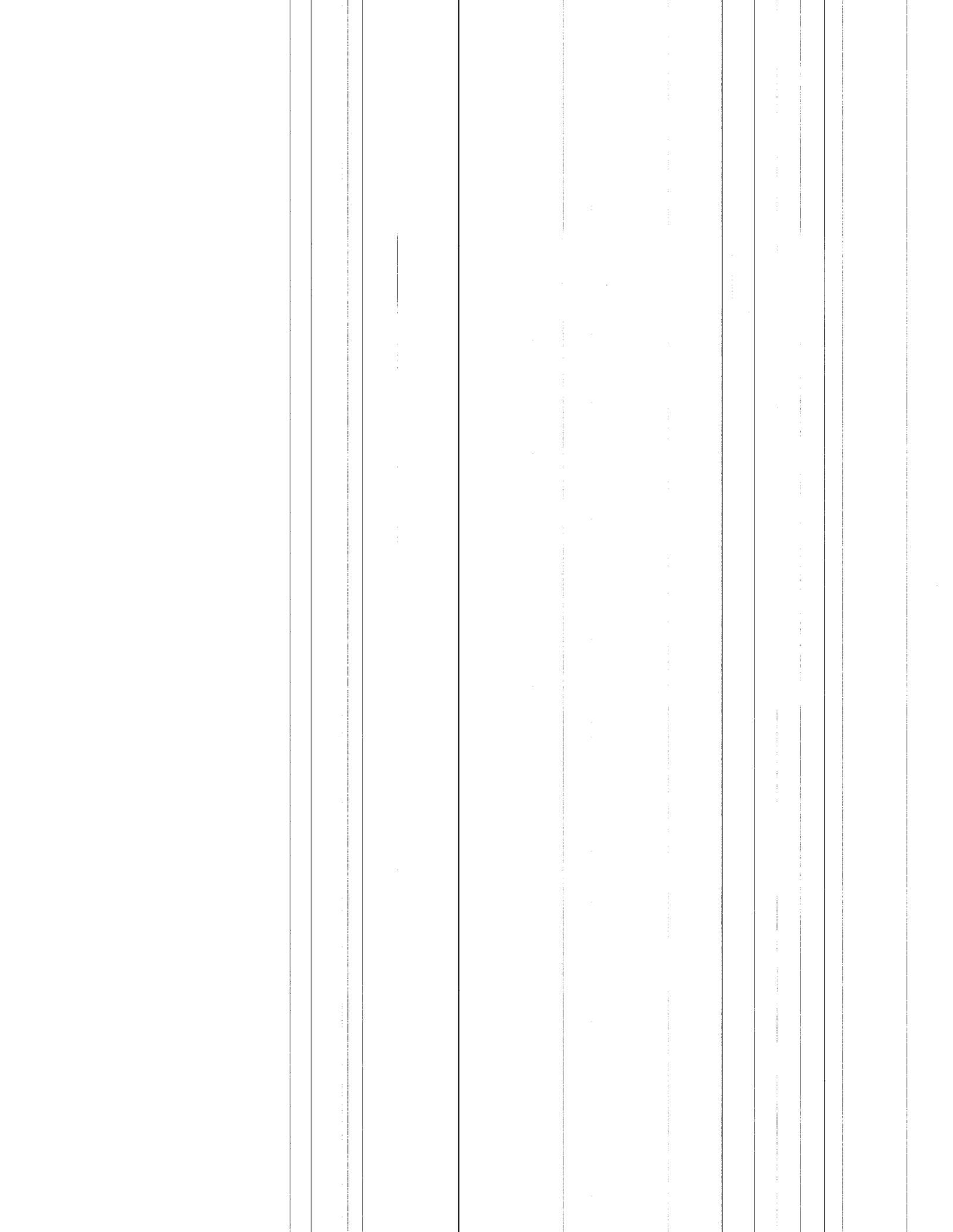
C11.2.1. The contractor shall perform risk analysis using personnel knowledgeable in the process, materials, equipment and relevant safety requirements.

C11.2.2. Hazard and Risk

C11.2.2.1. A hazard is any condition, which, by itself or by interacting with other variables, may result in death or injury to personnel or damage to property. Controls only reduce the likelihood or severity of hazards. They do not eliminate them..

C11.2.2.2. After identifying a hazard, qualified contractor personnel shall determine the associated risk. The risk analysis shall address both the severity of a resulting mishap and the probability of occurrence of a mishap. A risk deals with the mishap which arises from a hazard, considering both the severity of its potential consequences, and its likelihood of occurrence over time.

C11.2.2.3. Evaluation of the hazard provides information useful for ranking the degree of risk associated with a hazard. The degree of risk indicates which hazardous conditions should receive priority for corrective action when compared to other hazardous conditions. One technique for ranking hazardous conditions is the assignment of a Risk Assessment Code (RAC). Table C11.T1 is an example of a risk matrix. The evaluation of the hazard results in the assignment of a narrative or numerical risk assessment such which management can judge the



seriousness of the risk before and after action is taken to control it. Table C11.T1 shows one risk matrix used by the DoD. Definitions of the code numbers and letters are contained in Table C11.T2.

Table C11.T1. Sample Risk Matrix Format

Mishap Severity	Mishap Probability			
	A	B	C	D
I	1	1	2	4
II	1	2	3	4
III	2	3	4	5
IV	4	4	5	5

Table C11.T2. Risk Assessment Definitions

Mishap Severity		Mishap Probability		Risk Assessment Codes (RAC)	
I	A mishap which could result in the death or permanent disability, or result in the inability to deliver the contract item.	A	Likely to occur immediately	1	Critical
II	A mishap which could result in permanent partial disability or temporary total disability, in excess of three months, or result in late delivery, 30 days or more, of the contract item.	B	Probably will occur in time	2	Serious
III	A mishap which could result in lost workdays or compensation for employees, or result in the late delivery, less than 30 days, of the contract item.	C	Possible to occur in time	3	Moderate
IV	A mishap which could result in first aid or minor supportive medical treatment, or damage to process equipment or product but would not affect the delivery of the contract item.	D	Unlikely to occur	4	Minor
				5	Negligible

### C11.3. ANALYTICAL METHODS

There are a number of analytical methods or approaches to the performance of hazard/risk analyses. The complexity of the process involved, the number of variables, and the severity of the consequences of failure should determine the level and methodology of the analysis used. The contractor shall select the level and best method for performing the analysis.

C11.3.1. As a minimum, contractors shall break the total process into successive steps and assess the hazards and risks for each process step. A sample format for conducting such an analysis is contained in Table C11.T1. Any format, which provides essentially the same information, is acceptable.

C11.3.2. A significant percentage of accidents occur during intermittent operations such as setup, startup, maintenance, repair, response to out-of-tolerance operation, and shut down/clean-up. Therefore analyses must consider intermittent operations as well as normal operations.

C11.3.3. Risk decisions must not only consider the severity and probability of a process change failure, but also recognize the criticality of operations (e.g., dollar value, lead time to procure, significance to end item or process, etc.).

#### **C11.4. INFORMATION FOR ANALYSIS**

C11.4.1. Contractors shall develop and use a methodology to address any change to an AE operation which may present a new hazard or increase the risk of a present hazard before incorporating the change into an operation.

C11.4.2. Before introducing a change to an AE operation, contractors shall perform a hazard analysis. Contractors shall maintain documentation explaining how they will control the hazard or hazards if the analysis indicates the change will result in any new hazards, or increase the risk of present hazards. Contractors shall validate the hazard controls for the changed operation, and maintain documentation of the validation.

C11.4.3. Contractors shall use the information acquired from the hazard analysis and validation process to revise SOPs and retrain employees.

C12. CHAPTER 12  
AE BUILDING DESIGN AND LAYOUT

C12.1. GENERAL

The design and layout of AE buildings are critical considerations in explosive safety and directly impact Q-D requirements and hazardous exposures to operating personnel and valuable equipment. Preplanning and proper design can significantly reduce risk of injury and property loss.

C12.2. BUILDING EXTERIORS

Fire, fragment generation, venting, and evacuation are critical design parameters. Exterior wall and roof coverings of AE operating buildings shall be designed with noncombustible and, whenever possible, frangible (breakaway) construction. AE buildings should be one story, except to meet process requirements. Basements should not be used, since they expose personnel above and make evacuation difficult.

C12.3. INTERIOR WALLS, ROOFS AND CEILINGS

Roofs and walls of AE buildings shall be as light as practicable to vent an internal explosion and produce the smallest number of fragments. Firewalls and dividing walls constitute exceptions. AE buildings which might house loose, finely divided explosive substances require smooth, fire resistive walls and ceilings which are free from cracks and crevices. When appropriate, paint walls and ceilings with high gloss paint to minimize dust accumulation and facilitate cleaning. Avoid ledges that collect dust. Bevel and keep clean all existing ledges. Seal all wall joints and openings for wiring and plumbing against dust. Do not install suspended ceilings or construct hollow walls in Class II Hazardous Locations as defined by the NFPA Standard No. 70 (reference (d)). Install insulation and covering directly on the underside of the roof deck.

C12.4. FLOORS AND WORK SURFACES

Construct and finish floors and work surfaces to facilitate cleaning, with no cracks or crevices in which explosives could lodge and no exposed nails, screws, or bolts. Cove bases at the junctions of walls and floors should be used. All locations where exposed explosives or hazardous concentrations of flammable vapor or gas are present require non-sparking floors and work surfaces.

C12.5. SUBSTANTIAL DIVIDING WALL

C12.4.1. Substantial dividing walls, constructed in accordance with the requirements of Army TM 5-1300, Navy NAVFAC P-397, or Air Force AFR 88-22 (different designations for the same publication) (reference (e)), separate independent quantities of HE so they do not need to be added when determining Q-D requirements.

C12.4.2. Avoid openings in dividing walls for conveyors, pass-through boxes, or other uses when possible. When operationally necessary, design closures with equivalent wall-strength characteristics.

#### C12.6. EXITS AND DOORS

Facility design and operational flow shall eliminate all explosive hazards between an operator and an exit. AE building design should include casement-type exit doors glazed with non-shattering plastic material. All interior doors should open in the direction of the flow of material through the building and should open onto unobstructed passageways.

#### C12.7. EMERGENCY EGRESS

When hazard analysis determines that standard exits and fire escapes are inadequate from work levels above the ground floor, other means of emergency egress (e.g., safety chutes) shall aid evacuation.

#### C12.8. PASSAGEWAYS

Design of weather-protected passageways between buildings or magazines should include noncombustible construction and fire stops.

#### C12.9. ROADS AND WALKWAYS

The road system should provide alternate routes between inert locations without entering AE areas. Roads in AE areas shall not dead end unless they dead end at, and serve a single AE location. Facility design should provide hard-surface walkways and roads at the entrance to or between AE buildings to prevent employees from tracking such potential hazards as stones, grit, and other foreign material into operating buildings.

#### C12.10. WINDOWS AND SKYLIGHTS

The use of conventional glass in areas with a potential blast overpressure hazard creates a serious secondary fragmentation hazard. Use safety glass or non-shattering plastic materials (e.g., Lexan, Plexiglas) when practical. When glazing with conventional glass is used, properly fixed plastic or wire mesh screening may reduce the hazard.

#### C12.11. DRAINS AND SUMPS

C12.11.1. All drain lines handling explosive wastes shall have sumps or basins of sufficient capacity for the removal of explosives by settling. The drains shall have adequate capacity; be free of pockets; and have slopes of at least 0.25 in/ft (21 mm/m) to prevent explosives settling-out in the drain line. Design of sumps shall prevent suspended and settleable solid explosive material from passing beyond the sumps in the wash water, and prevent overflow from disturbing any floating solids. The settling rate of the material and the usual rate of flow shall determine the sump capacity. The design shall also permit easy removal of collected explosives, and shall allow for retention of those that float on water until they can be removed. Sump tanks or other

types of construction (e.g., bolted) that permit the explosives to settle in obscure or hidden spaces are not acceptable.

C12.11.2. Care shall be taken to preclude deposition of explosives from sump effluent due to drying, temperature changes, or interaction with other industrial contaminations. Sweeping and other dry collecting measures should be used to keep appreciably water-soluble explosives out of the drainage system.

C12.11.3. Drains between the source of explosive and the sump shall have troughs with rounded bottoms and with removable ventilated covers to facilitate inspection for accumulation of explosives. Waste liquids shall not run into closed drains and sewers. Inspect and clean out drains periodically to prevent the excessive buildup of explosives. Drains and sewers containing explosive waste materials shall not connect into the normal sewage systems.

#### C12.12. HARDWARE

C12.12.1. Facility design shall provide for non-sparking hardware in AE areas when hazard analyses determine sparks provide sufficient energy to initiate exposed explosive materials, explosive dusts, or flammable vapors. Avoid installing hardware (e.g., piping and ducts) on blowout panels or walls

C12.12.2. Some fasteners (e.g., nuts and bolts) on or near operating equipment can fall into explosives or explosive constituents and cause friction, heat, and initiation. Operating personnel shall secure such fasteners using safety wire or other methods.

#### C12.13. VENTILATION

Exhaust fans through which combustible dust or flammable vapor pass shall use nonferrous blades, or a casting lined with nonferrous material. Motors shall meet NFPA Standard No. 70 (reference (d)) rating for the hazard classification of its location. Maintenance personnel shall electrically bond and ground the entire exhaust system and clean and service it on a regular schedule.

#### C12.14. STEAM FOR PROCESSING AND HEATING

Process steam is that which is in direct contact with explosives, used directly in their manufacture; or which, in case of equipment failure, would exhaust directly into contact with explosives or explosive fumes. Avoid steam or hot water pipes contacting wood, paper, or other combustible materials.

C12.14.1. Steam Temperature. The exterior of pipes shall not exceed 160°F (71°C). Maximum steam temperature should not exceed 228°F (109°C). When steam temperature must exceed 228°F (109°C) in hazardous locations, cover and paint the steam lines with an impervious material or otherwise protect them against contact with explosives.

C12.14.2. Steam Pressure. Steam used for heating AE operating buildings should have a maximum pressure of 5 psi (34.5 kPa). Steam pressure shall not exceed 15 psi (103.4 kPa). When a reducing valve is used, never bypass the relief valve in a manner permitting

circumvention of the pressure reduction equipment. Positive means shall prevent the production of superheated steam caused by the throttling action of reducing valves. The use of a "water leg" or water column is recommend to control steam pressure of 5 psi (34.5 kPa) or less. When close control of steam temperature is necessary, install indicating and recording pressure or temperature gauges. Maintenance personnel should test such devices periodically and record the test results. When electrical resistance to ground is high, properly ground steam lines where they enter buildings.

#### C12.15. TUNNELS

The design and construction of tunnels between AE buildings requires special consideration due to possible communication of an explosion by shockwave and blast.

C13. CHAPTER 13  
SAFETY REQUIREMENTS FOR SPECIFIC AE AND AE OPERATIONS

C13.1. GENERAL

This chapter provides the minimum safety requirements necessary for the prevention of mishaps involving specific AE and AE operations. The contractor is responsible for analyzing each operation and developing procedures to control or eliminate hazards.

C13.2. PROPERTIES OF EXPLOSIVES

Knowledge of properties of specific types of explosives is critical to the establishment of proper hazard controls.

C13.2.1. Primary (Initiating) Explosives. Initiating explosives include lead azide, lead styphnate, and tetracene. They are extremely sensitive to friction, heat, electrostatic discharge and impact. When involved in a fire, they may detonate.

C13.2.1.1. In storage, initiating explosives shall be kept wet with water or water/alcohol mixtures to reduce sensitivity. Take every precaution to prevent the liquid from freezing since this increases sensitivity. Handling of frozen initiating explosives is prohibited. Assure the water used for storage is free of bacteria forming impurities which could react to form gases and rupture containers.

C13.2.1.2. Operators shall keep work areas and equipment clean and maintain good housekeeping to prevent contamination of these explosives with foreign, particularly gritty, material markedly increases their sensitivity.

C13.2.1.3. Do not allow lead azide to contact copper, zinc, or alloys containing any concentration of such metals because of the likely formation of other azides that are more sensitive than the original. Similar hazards exist for other explosives.

C13.2.2. Secondary (Boostering and Bursting) Explosives. Boostering and bursting explosives include tetryl, RDX, PETN, HMX and compositions manufactured with these explosives. These explosives have sensitivities between initiating explosives and those of explosives used as main charges such as TNT. They may be ignited by heat, friction, or impact and may detonate when burned in large quantities or at too great a depth. Some of these materials are toxic when taken internally or by skin contact and special precautions are necessary to protect personnel. Use local exhaust ventilation, enclosed process systems, automatic handling systems, etc., to minimize dust in the employee's breathing zone.

C13.2.3. Main Charge Explosives. Main charge explosives include TNT, tritonal, RDX, HMX, CL-20, and compositions manufactured with these explosives. Use process hazard analysis to evaluate the safety of the processing methodology, (e.g., melt-cast, extrusion, press and machine, and mix-cast-cure versus sensitivity characteristics). Do not permit alkaline cleaning agents or other alkaline products in buildings where large quantities of these explosives are handled.

C13.2.4. Other Explosives. Other common military explosives encountered include black powder and nitroglycerin (NG). Black powder is a mixture of potassium or sodium nitrate, charcoal, and sulfur, which is highly sensitive to friction, heat, and impact. It deteriorates rapidly after absorption of moisture, but retains its explosive properties indefinitely if kept dry. NG's extreme sensitivity to impact and friction is such that it is manufactured only as needed. Frozen nitroglycerin, while less sensitive than liquid, may undergo internal changes upon thawing and, if enough heat is generated, may detonate.

C13.2.5. Research of Additional Properties. Contractors must investigate pertinent properties before handling other explosive substances. Sensitivity data for the same characteristic, generated on different types of equipment, are not necessarily comparable. Contractors must thoroughly understand the sensitivity test method employed, the unit of measure in which data are presented, and the relative ranking of the explosive verses other similar explosives.

### C13.3. LABORATORY OPERATIONS

C13.3.1. Research and development laboratories and testing facilities constitute a separate category involving guidance, restrictions, and relief from certain requirements prescribed in this manual.

C13.3.2. Review each operation at facilities designed for blast and fragment confinement to ensure that the explosives limits are within the laboratory or test area capability. Decrease explosives limits and increase safe separation distances as the capability to confine fragment and blast decreases.

C13.3.3. Inspect a total confinement facility after a detonation to ensure structural integrity. It may become necessary to reduce the explosives limits to prevent future blasts from exceeding the retention capability.

C13.3.4. Review each proposed program for the laboratory or test facility to determine all potential hazards including the following considerations:

- C13.3.4.1. Structural limitations of the facility;
- C13.3.4.2. Remote control viewing and operating equipment, if required;
- C13.3.4.3. Special safety precautions for personnel elsewhere in the building;
- C13.3.4.4. Safe separation distances;
- C13.3.4.5. Required deviations from other sections of this manual;
- C13.3.4.6. SOP, which shall, at a minimum, include the following:
  - C13.3.4.6.1. Protective clothing,
  - C13.3.4.6.2. Warning signals,
  - C13.3.4.6.3. Fire and other emergency procedures,
  - C13.3.4.6.4. Special testing of equipment needed before operations (e.g., stray voltage and calibration checks),

C13.3.4.6.5. Removal of all explosives not needed for the operation,

C13.3.4.6.6. Arrangements for overnight storage of necessary explosives,

C13.3.4.6.7. Inspection and cleanup procedures after a test or detonation.

C13.3.5. Use no more explosives than absolutely required for a given operation. Perform particularly hazardous laboratory operations involving new or relatively unknown explosives by remote control. Use operational shields in these operations and in new or untested applications of explosives.

C13.3.6. When laboratories and testing facilities are shielded properly to prevent the release of fragments, the minimum incremental safe separation distances shown in Table C13.T1 apply to operations, facilities, and personnel.

C13.3.7. If the proposed storage facilities will confine the blast and fragments, or if the incremental safe separation distances are as indicated in paragraph C13.3.6, up to 15 lbs (6.8 kg) of explosive substance may be stored without consideration of storage compatibility. Review the operation to determine all potential hazards prior to use as outlined in paragraph C13.3.4.

Table C13.T1. Laboratory Q-D Requirements

Hazard Division 1.1					Hazard Division 1.3				
Quantity (lbs)		Distance (ft) <sup>1</sup>			Quantity (lbs)		Distance (ft)		
Over	Not over	IBD	PTRD	ILD	Over	Not over	IBD	PTRD	ILD
0	1	40	25	20	0	5	10	10	10
1	2	50	30	25	5	10	15	15	15
2	5	70	40	30	10	20	20	20	20
5	10	90	55	35	20	30	25	25	25
10	20	110	65	45	30	50	30	30	30
20	30	125	75	50	50	80	35	35	35
30	40	140	85	55	80	100	40	40	40
40	50	150	90	60	100	150	45	45	45
Note 1. The distance above may be used only when structures, blast mats, and so forth, can completely contain fragments and debris. If fragments cannot be contained or the quantity of high explosives exceeds 50 pounds, then the distances shall be obtained from the Q/D tables of DoD 6055.9 (reference (a)).					150	200	50	50	50

**C13.4. HEAT CONDITIONING OF AE**

C13.4.1. All ovens, conditioning chambers, dry houses and other devices and facilities which are capable, in ordinary service, of heating AE to temperatures in excess of 90°F (32°C) are heat-conditioning devices. Provide heat-conditioning devices with dual independent fail-safe heat controls. For devices or facilities heated by steam only, the requirement for dual heat

controls is satisfied if the steam pressure is controlled by a reducing valve (maximum pressure of 5 psi, (34.45 kPa), unless otherwise authorized) on the main building steam supply, and a thermostat.

C13.4.2. Ensure heat-conditioning devices are able to discharge overpressure from an internal explosion. Use barriers or catching devices to restrain blowout panels, doors, and other venting apparatus and prevent excessive displacement during an accidental explosion.

C13.4.3. Heat-conditioning devices must be vented to allow any gases produced to escape.

C13.4.4. Steam heat conditioning devices are preferred; however, when using electrical heating elements, locate them where there is no possibility of contact with explosives or flammable materials.

C13.4.5. Ensure the blades of a fan in a heat-conditioning device are non-sparking and install its electric motor externally. Do not re-circulate the air if the heating surfaces exceed 228°F (109°C) or if the air contains materials which could collect on the heating coils.

C13.4.6. Permit only electrical equipment and fixtures approved for use in the hazardous atmosphere in question in or on a heat-conditioning device used for explosives or flammable material.

C13.4.7. Ensure the interior of a heat-conditioning device is free of crevices, openings, and other protuberances not easily cleaned, where dust or flammable material could lodge.

C13.4.8. Interconnect and electrically ground all non-current-carrying metal parts of a heat-conditioning device.

C13.4.9. Install heat-conditioning devices in isolated locations, set up to give personnel maximum protection from the effects of an explosion. Use operational shields and other personnel protection measures when warranted.

C13.4.10. Safe separation distances or protective construction ensures against an explosives accident in one heat-conditioning device from propagating to others. Do not place hazardous materials in a room or cubicle containing a heat-conditioning device, unless it can be shown that a mishap in the conditioning device would not involve the other materials.

C13.4.11. Operating procedures for heat-conditioning devices must:

C13.4.11.1. Limit the explosive materials in the device to the type and quantity authorized for the specific device.

C13.4.11.2. Address the critical parameters of explosives compositions before processing in a heat-conditioning device. Ensure the device does not exceed limits established for the hazardous composition being conditioned.

C13.4.11.3. Check heat-conditioning device temperatures at specified intervals during operation.

C13.4.11.4. Clean the conditioning devices, ducts, vacuum lines, and other parts of the equipment subject to contamination by hazardous materials, before introducing a different item or composition for conditioning.

### C13.5. SPRAY PAINTING

C13.5.1. Do not electrostatically spray paint loaded AE.

C13.5.2. Use water wash or dry filter-type spray booths for loaded AE.

C13.5.3. Interlock controls for ventilating fan motors for spray painting booths with the controls for the paint sprayer. With this arrangement, failure of the ventilating system will shut off power to the paint sprayer.

C13.5.4. Install high-voltage, electrically-powered, paint-spraying equipment in accordance with the requirements of NFPA Standard No. 33 (reference (u)) as applicable.

C13.5.5. Ensure conventional equipment used for spray painting in standard spray booths meets the requirements of NFPA Standard No. 33. Electrically ground the nozzles of all spray guns to suppress static electricity.

### C13.6. DRYING AE

Use ovens which comply with the NFPA Standard No. 70 (reference (d)) to dry loaded AE. Other requirements include the following:

C13.6.1. Ensure automatic thermostatic controls regulate temperatures once they reach a maximum determined by the AE involved.

C13.6.2. Equip each oven with automatic internal sprinkler systems which conform with NFPA Standard No. 13 (reference (s)). Approved electrical heat actuated devices, installed as required for NFPA Standard No. 70, Class I, Division 1, Group D, hazardous locations (reference (d)) may be used for automatic operation of the system.

C13.6.3. Hot air or other means may supply heat, provided AE does not contact coils, radiators, and heating elements.

C13.6.4. In case of power failure, the heat supply for any conveyor system must automatically stop.

C13.6.5. Design electric drying units not approved for use in Class I hazardous locations so that solvent vapor concentration in the oven is kept below 25% of its lower explosive limit.

### C13.7. REWORK, DISASSEMBLY, RENOVATION, AND MAINTENANCE

C13.7.1. Avoid conducting AE rework and disassembly operations with other AE or inert operations. When concurrent scheduling cannot be avoided, operations shall be sufficiently separated from one another to protect adjacent personnel and equipment, and prevent propagation to adjacent AE. Separation may be accomplished with Q-D, operational shielding, or the remote control of operations.

C13.7.2. Protect the worker and all other personnel from possible initiation when the force applied during rework or disassembly is known or expected to exceed assembly force.

C13.7.3. Personnel protection required during assembly operations is normally also required during disassembly or rework operations. Use lesser protection only if fully supported by a risk

assessment. Verify that assembly was within specification, the surfaces are not corroded and whether sealant is present.

C13.7.4. Request specific safety guidance through contract channels when renovation or maintenance is not adequately addressed in the contract.

## C13.8. AE LOADING AND ASSOCIATED OPERATIONS

C13.8.1. Screening and Blending HE. Screen or visually inspect and pass over a magnetic separator bulk HE intended for processing to detect extraneous material. Do not subject HE to pinching, friction or impact in screening equipment. Thoroughly clean HE screening units without exhaust ventilation as necessary and after every shift, to prevent hazardous accumulations of explosives dusts.

C13.8.2. Screening and Blending Initiating Explosives. Provide suitable operational shields for screening and blending operations involving initiating explosives. As an alternative, locate operators at barricaded ILD from screening and blending facilities.

### C13.8.3. Explosives Melting

C13.8.3.1. Do not exceed 228°F (109°F) when melting explosives and keeping explosives molten. It is permissible to use steam pressures up to 15 psi (103.35 kPa) (250°F (121°C)) to melt or maintain TNT-based explosives in a molten state.

C13.8.3.2. Construct and maintain melt unit valves and melt mix draw-off or other lines carrying molten explosives to prevent friction or impact capable of igniting the explosives. Disassemble and regularly inspect diaphragm type valves. Replace damaged or old diaphragms before cracks develop to prevent metal-to-metal contact. Construct draw-off lines to prevent exposure of threads, fastening screws, and bolts, both outside and between the flanges. Use a sealing compound to prevent explosives seepage or vapor condensation on the contacting surfaces of the bolts, flanges, screws, and nuts. Electrically bond melt mix kettle draw-off pipes to items being filled during draw-off operations. Individually ground AE unless tests indicate that contact ground is adequate.

C13.8.3.3. Wet-type collectors remove dust and vapors from exhausted air, and are effective for melt mix exhausting systems. Do not re-circulate water in the wet collector unless the system removes hazardous suspensions. Discharge water retaining explosives to a containment unit designed to keep them wet. Regularly inspect and flush the exhaust and collecting equipment of explosives accumulations. Equip each kettle with a complete dust and vapor collection system when protective construction prevents propagation of a detonation between melt kettles.

C13.8.4. Agitation. Equip agitation nitrators, washers, and other machines with at least two means of agitation, each operating from an independent power source. A loss of power if using only one power source could result in material decomposition.

### C13.8.5. Explosives Machining

Awareness of the friction sensitivity of explosives to be machined is required. Friction sensitivity values of explosives listed in paragraphs C13.8.5.2 and C13.8.5.3 are available for comparison. Compare sensitivity values only for identical test, methods and equipment.

C13.8.5.1. HE, cased or uncased, may be machined without special personnel protection and without coolant, if no metal-to-metal contact is involved, include: TNT, composition B with RDX at or below 60 %, RDX compositions containing 60% or less RDX and HMX compositions containing 60% or less HMX.

C13.8.5.2. HE, cased or uncased, may be machined without special personnel protection provided a coolant is directed on the tool and explosives at their point of contact and no metal-to-metal contact is involved, include: Octol, Pentolite (50-50 and 10-90), HMX compositions with greater than 60% HMX, Cyclotols, Composition B and RDX compositions with concentrations of RDX greater than 60%.

C13.8.5.3. Machine other HE by remote control, and protect the operators by a suitable operational shield. Do not machine primary explosives if you can obtain desired shapes or sizes by other means (e.g., forming).

C13.8.5.4. Use only a single drill bit with a diameter greater than 0.25 in (0.064 cm) when an unprotected operator is involved in drilling.

C13.8.5.5. Permit machining of cased explosives in an operation requiring removal of metal before or after tool contact with the explosives filler. Protect operators with operational shields and machine by remote control.

C13.8.5.6. Where wet machining is performed, use automatic interlocking devices to prevent machining unless coolant is flowing. Establish controls capable of stopping the machining if the coolant flow is interrupted. When coolant flow must stop for adjustment of machining tools, provide positive means to ensure that flow of coolant is restored and all automatic control devices are operating before machining resumes.

C13.8.5.7. Maintain the lineal and rotational speeds of tools used for the machining of explosives at the minimum required to perform the operation safely and efficiently. The rate of feed should be consistent with the hazard analysis.

C13.8.5.8. Use pneumatically- or hydraulically-driven machine tools whenever possible for machining operations on HE. Install control mechanisms for hydraulic and pneumatic equipment to prevent unauthorized personnel from tampering with speeds.

C13.8.5.9. In all machining operations on cased or uncased HE, ensure tool adjustments prevent contact between moving parts of the machining equipment and metallic parts of the case or holding fixtures.

C13.8.5.10. Use machining tools compatible with the HE being processed. Remove dull or damaged tools from HE machining operations.

C13.8.5.11. Remove explosives products resulting from machining operations with an exhaust system meeting NFPA Standard No. 70 (reference (d)) requirements or by immersion in a stream of water flowing away from the operation.

C13.8.5.12. Machine HE with unknown physical or chemical characteristics, by remote control with operators protected by operational shields during AE operations.

C13.8.6. Assembly and Crimping of Complete Rounds. Separate each assembly and crimping operation from other operations by structures or shielding sufficient to contain any fragments produced by an accidental detonation.

C13.8.7. Pressing Explosives

C13.8.7.1. Conduct each pelleting operation involving black powder, tetryl, TNT, or other explosives of similar sensitivity and each operation involving the pressing or reconsolidation of explosives in a separate room or cubicle having walls of sufficient strength to withstand an explosion of all explosives present.

C13.8.7.2. Perform pressing or reconsolidating of explosives in small caliber rounds, tracer bodies, tetryl lead-ins, detonators, and similar items on machines having consolidating stations designed to preclude propagation between stations and provide adequate operator protection. Ensure operators stay behind tested protective barriers during such operations.

C13.8.7.3. Only use punches and dies in matched sets which have passed inspection and are calibrated. Regularly inspect and test by magnaflux, X-ray or similar means, all punches and dies used in explosives pressing operations.

C13.8.8. Protection of Primers. Design equipment, transportation, and operations to protect loose primers or primers in components from accidental impact or pressure. When feasible, use a protecting cap to cover the primer.

C13.8.9. Explosives Washout and Flashing Facilities. Separate washout operations in operating buildings or other locations from other operations by operational shields or proper distances. Inspect AE subjected to washout operations to ensure against residual explosives contamination. When contamination is confirmed, decontaminate prior to disposal.

C13.8.10. Heat-Sealing Equipment. Separate electric heat-sealing machines from other operations. Establish temperature limits for heat-sealing equipment with a safety factor below the ignition temperature of the explosives, propellants, or pyrotechnics involved.

C.13.8.11. Rebowling Operations. Perform rebowling operations involving primary explosives or primer mixes by remote control, with the operator protected by an operational shield.

C13.8.12. Thread Cleaning

C13.8.12.1. Use nonferrous picks for thread cleaning. Stainless steel brushes are acceptable or use to clean threads of explosives-loaded projectiles if a fuze seat liner separates the thread cleaning operation from the explosive charge. Operators may use operational shields or quantity distance separation to protect them from unrelated operations.

C13.8.12.2. Power-actuated, thread-chasing tools may be used to clean loaded projectiles when threads are imperfect because of previously applied sealers; however, the operation must be performed within a separate cubicle and by remote control. Hand-operated thread-chasing tools may be used when no explosives are present in the threads.

C13.8.12.3. Do not cut threads or correct cross threads on projectiles containing explosives. Straightening crossed threads is considered thread cutting.

C13.8.13. Profile and Alignment Gaging Operations

C13.8.13.1. Use operational shields to enclose each profile and alignment gauging operation, excluding small arms ammunition, to protect adjacent operations. Develop the layout of equipment and operational procedures to minimize personnel injury and property damage in case of an accident.

C13.8.13.2. When chamber gauging large caliber fixed ammunition, point the gauge toward a dividing wall or other barrier. Use the same operator to insert and remove each round. Never leave a round in the gauge. Gauge rounds of mortar ammunition before attaching propellant increments and, unless prohibited by the design characteristics, before assembly of the ignition system.

## C14. CHAPTER 14 TEST AND TESTING REQUIREMENTS

### C14.4. GENERAL

The contractor is responsible for the safety of testing programs. Test programs include any and all tests, evaluations, quality assurance functions tests, or similar situations where AE response to stimulus is the objective.

### C14.2. BASIC PRINCIPLES FOR TEST OPERATIONS

The following safety precautions apply where pertinent:

C14.2.1. Conduct all test operations in accordance with procedures developed in accordance with paragraph C3.3, and paragraph C6.9 of this Manual, using a hazard analysis as the basis for the procedures.

C14.2.2. Wherever possible, substitute inert materials for live AE. When only live AE will meet test objectives, protect test personnel. Use remote control of operations, barricades, shields, remote methods of shutting down the test operation, or other appropriate methods of eliminating exposure to personnel. By definition, all tests involve some level of uncertainty. Therefore test methods and procedures must address all credible malfunctions, or non-function potentials and the appropriate reaction to them.

C14.2.3. Assembly and testing requirements specific to each ammunition and weapon system are contained in the appropriate technical manual and end-item specifications which should be incorporated into procedures. The hazard analysis process should identify specific hazards of assembly and test. It is particularly important to develop procedures for the guidance of unique tests (e.g., fuze function, fragmentation, thermal effects, barricade test) which do not duplicate assembly, disassembly, or test requirements described in technical manuals or other government publications. Include disposal procedures for damaged energetic materials and ordnance items. The following are general assembly and testing safety requirements.

C14.2.4. Do not allow test conditions to compromise basic AE safety considerations, for example, compatibility of materials, quantity control, quantity distance, exposure of personnel to blast (including hazardous noise levels), fragments and thermal effects, bonding and grounding, and personal protective equipment.

C14.2.5. Recognize and plan for the mitigation of overpressure (including sound), fumes, dust, fragments, thermal effects and catastrophic failure of test equipment or barricades which can occur during or as the result of testing.

C14.2.6. Clearly identify expended ordnance contaminated with residual energetic or other hazardous materials. Include decontamination steps in the test operations procedure.

C14.2.7. Some testing, such as electrical continuity, built-in-test, or weapon functionality on components or all-up-rounds will require remote operations. Perform this testing with approved test equipment at a facility site-approved for the operation. When this is the case, the following requirements apply:

C14.2.7.1. Do not expose any test personnel to operations that have a high probability of resulting in a detonation, or to test operations that involve intentional detonations. Protecting personnel from all fragments, and from overpressures exceeding 2.3 psi (overpressure at k24) meets that requirement. Distance, operational shields (see paragraph C3.7 of this Manual), or structural design of buildings and bays involved, or a combination of these, can provide this protection.

C14.2.7.2. Protection by distance must include consideration of fragments as well as overpressure. For many test operations involving relatively small quantities of explosives, the distance at which the blast over pressure drops to the 2.3-psi level is less than the minimum fragment distance. When this occurs, the minimum distance between the operation and any personnel is the fragmentation distance. Use of barricades, earth covered shelters, or structural elements to control the fragmentation hazard are acceptable when it is possible to demonstrate this protection by test or engineering design. Tests normally require an overcharge of 25% NEW greater than the maximum expected charge weight for testing, when testing is the sole proof of protection.

C14.2.7.3. Provision of protection by structural design, whether by itself or in conjunction with distance, requires specialized structural designs. Army TM 5-1300, Navy NAVFAC P-397, or Air Force AFR 88-22 (different designations for the same publication (reference (e))), provides assistance for these designs. When using this publication, Protection Category 1 is the level of design for personnel protection. Designs based on lesser levels of protection are acceptable, depending upon the level of risk to contract performance deemed acceptable by the PCO when personnel exposure is not an issue.

C14.2.7.4. Spalling and other phenomena of structural failure are part of the design considerations when using the referenced manual for protection. Spalling is the ejection of material from the back face of a slab or beam as the result of an explosion adjacent to the front face. When not using the manual for structural designs, spalling protection must be part of the design and test of structural elements. When test cell walls do not extend through the ceiling of the structure, it is possible for overpressure and debris from an explosion to escape over the top of the cell and injure personnel near the cells. Designs must provide protection from such an eventuality. Similarly, when cell walls extend through ceilings and roofs, these structural elements must be strong enough to resist the effects of overpressure and fragments, protecting personnel below.

C14.2.7.5. Install interlocks to prevent operator exposure to operations when doors on any equipment or cells used for explosives processing function as operational shields. Do not install door closure controls within cells. Design cell door release devices to prevent personnel from being stuck by a closing door and to allow egress from the cell. These may require designs to become inoperative to prevent the overpressure of an explosion from opening the door. Ensure that any pass-throughs between cells prevent the transmission of fragments or damaging overpressures. Typically, such pass-throughs have doors interconnected so that only one door can open at a time.

C14.2.7.6. Establish a warning system of flags, lights or sound signals during testing operations. Provide personnel who are not familiar with the warning system in test areas, and

equipped test areas with a telephone and/or radio to permit communication during testing operations.

C15. CHAPTER 15  
COLLECTION AND DESTRUCTION REQUIREMENTS FOR AE

C15.1. GENERAL

This chapter provides safety requirements for the collection and destruction of AE. It contains more detailed information than other portions of this manual due to the higher risks of these operations. The Environmental Protection Agency (EPA) has developed regulations which apply to contractors and may impose requirements beyond those in this Manual. Contractors shall avoid compromising explosive safety for environmental considerations.

C15.2. PROTECTION DURING DISPOSAL OPERATIONS

C15.2.1. Operational shields or special clothing shall protect personnel during disposal operations.. Fragmentation hazards require, at a minimum, overhead and frontal protection for personnel. Contractors detonating AE may locate personnel shelters at the appropriate IBD for the AE NEW. Personnel shall use protective structures when destroying AE by detonation and when burning AE that may detonate. Personnel shall not approach the burning site, but shall observe an appropriate waiting period after the fire is out.

C15.2.2. Personnel shall never work alone during disposal and destruction operations. Warning signs or lights, roadblocks, or other effective means shall restrict the area. One person, available in an emergency, should observe from a safe distance while another performs the operations.

C15.3. COLLECTION OF AE

C15.3.1. Water-Soluble Materials. Use sufficient water to neutralize ammonium picrate (Explosive D), black powder, and other soluble materials to ensure their complete dissolution. Dissolve as little material as practicable at one time. Sweeping floors before washing them down reduces the amount of dissolved material in the wash water. Consult experts when uncertainty exists concerning the purity and composition of wash water.

C15.3.2. Solid Wastes. Collect explosives-contaminated solid waste material, place in closed containers, and promptly deliver to buildings for treatment or holding, or to the burning ground for destruction.

C15.3.3. Explosives Dusts

C15.3.3.1. The contractor may use a vacuum system to remove HE dusts such as TNT, tetryl, Explosive D, Composition B, and Pentolite. The preferred removal method for explosives is a "wet collector" which moistens the dust near the point of intake and keeps it wet until disposal. Collect Explosive D in a dry system.

C15.3.3.2. The contractor may collect more sensitive explosives such as black powder, lead azide, lead styphnate,, tracer, igniter, incendiary compositions, and pyrotechnic materials by vacuum, provided they are kept wet close to the point of intake. Collect each type representing a different hazard separately so that black powder, for example, cannot mix with lead azide. The

vacuum system should release any build up of gases. Confine the use of vacuum systems for collection of sensitive explosive substances to operations involving small quantities of explosives, that is, operations with fuzes, detonators, small-arms ammunition, and black powder igniters. To minimize the fire and explosion hazard, collect scrap pyrotechnic, tracer, flare, and similar mixtures in No. 10 mineral oil or equivalent. Collect dry explosive dust in an oil-filled receptacle available at each operation throughout the shift. The oil level shall maintained at least 1 inch above the level of any pyrotechnic mixture in the container. Some pyrotechnic compositions float on oil. If it occurs use a wooden plunger to submerge the material.. Remove containers of scrap explosive for disposal from the operating buildings at least once per shift. When using oil, use the appropriate rated Class B firefighting equipment.

#### C15.4. DESIGN AND OPERATION OF COLLECTION SYSTEMS

C15.4.1. Design collection systems and chambers to prevent pinching thin layers of explosives or explosives dust between metal parts. Pipes or ducts used to convey dusts require flanged, welded, or rubber connections. The contractor shall not use threaded connections. The system shall prevent explosive dusts from accumulating in parts outside the collection chamber. Pipes or ducts conveying high explosives shall have long radius bends. Systems for propellant powder may use short radius bends, provided they are stainless steel, with polished interiors. Minimize the number of vacuum application points. Use wet primary collectors when possible. The design of the vacuum collection system should provide a separate exhaust line to the primary collection chamber from each room. If this is not possible, a common header shall service no more than two bays. Keep short lengths of vacuum lines from the application points to the wet collectors. A single secondary collector shall service as few primary collectors as possible. The contractor shall connect not more than two dry primary collectors to a single secondary collector (wet or dry type). Vacuum systems that are permanently attached to the explosive dust-producing machine may increase the likelihood of detonation propagation through the collection system. Recommend using manually operated vacuum systems unless dust concentrations pose an explosion or health hazard. Manually operated hose connections to explosive dust-producing machines should not interconnect.

C15.4.2. Install two collection chambers in series ahead of the pump or exhauster to prevent explosives dust from entering the vacuum producer in a dry vacuum collection system.

C15.4.3. There shall be no metal-to-metal contact on slide valves for vacuum collection systems. An aluminum slide operating between two ebonite spacer bars or similar compatible materials will eliminate unacceptable metal-to-metal contact.

C15.4.4. Install dry-type portable vacuum collectors, limited to 5 lbs (2.3 kg) of explosives, in a separate cubicle having substantial dividing walls, or outside the building. Never install type of collector in the bay or cubicle with the explosives. The contractor may use wet-type portable vacuum collectors in explosives operating bays or cubicles, provided limited quantities of explosives in the collector meet the requirements of paragraphs C.15.5.1 through C15.5.3. For dry collection over 5 lbs (2.3 kg) or wet collection over 8 lbs (3.64 kg) of explosives, the provisions of paragraphs C.15.5.1 through C.15.5.3 also apply.

C15.4.5. The design of wet collectors shall provide for:

C15.4.5.1. Proper immersion of explosives,

C15.4.5.2. Breaking up of air bubbles to prevent release of airborne particles, and

C15.4.5.3. Prevent moistened particles of explosives from entering the small piping between the collector and the exhaustor or pump

C15.4.6. At least once every shift, remove the explosives dust from the collection chamber to eliminate unnecessary and hazardous concentrations of explosives. Clean entire system on a regular basis to remove residual contamination, with parts dismantled as necessary.

C15.4.7. Electrically bond the entire explosives dust collection system to the grounding system. Test the electrical bonding/grounding system in accordance with paragraph C 6.6.5.

C15.4.8. Shield personnel workstations from vacuum systems.

### C15.5. LOCATION OF COLLECTION CHAMBERS

C15.5.1. Whenever practicable, locate dry-type explosives dust collection chambers, except portable units, in the open, outside operating buildings, or in buildings set-aside for that purpose. Provide a barricade or operational shield appropriate for the NEW involved to protect operating personnel from blast (2.3 psi) and fragments from the collection chamber. At least 3 ft (1 m) should separate the collection chamber from the barricade or operational shield.

C15.5.2. When locating dry-type collection chambers outside the operating building is not feasible, set aside a separate room for this purpose in the building. The contractor shall not allow personnel to work or pass through the dry-type collection chamber room. Walls separating the room from other portions of the operating building shall meet the requirements for operational shields for the NEW in the collection chamber. Subdivide rooms with multiple collection chambers into cubicles with only one collection chamber per cubicle.

C15.5.3. Stationary and portable wet-type collectors in operating bays or cubicles shall not exceed 5 lbs (2.3 kg) NEW. When placed in separate cubicles, quantities may increase to 8 lbs (3.64 kg). See paragraphs C.15.5.1 and 15.5.2 for location requirements of wet collectors, containing more than 8 lbs (3.64 kg),

### C15.6. AE AWAITING DESTRUCTION

Maintain IBD from AE destruction sites and explosives stored in the open. If adequately protected from frontal and overhead hazards, IBD separation between AE material awaiting destruction and AE destruction sites is acceptable. Protect all AE awaiting destruction from accidental ignition or explosion from fragments, grass fires, burning embers, or blast originating from the destruction site.

### C15.7. CONTAINERS FOR WASTE EXPLOSIVES

Use appropriate containers for AE waste to prevent leakage and spillage of contents. The contractor shall not pinch or rub explosives during container closing and opening. Clearly mark containers to identify contents. Do not use containers constructed of spark-producing or easily ignited material.

## C15.8. DESTRUCTION SITES

### C15.8.1. Site Criteria

C15.8.1.1. Locate AE destruction sites as far as possible from magazines, inhabited buildings, public highways, runways, taxiways, and operating buildings. The minimum separation distance is 1,250 ft (381 m) or the applicable fragmentation distance, unless pits or similar aids (e.g., natural barricades) limit the range of fragments. Since burning explosives may detonate, contractor shall use appropriate protective barriers or separation distances for the safety of personnel and property. To prevent secondary fragments, do not burn or detonate AE on concrete, or in areas having large stones or crevices.

C15.8.1.2. For separation distances less than 1250 ft (381m), use DoD approved documentation to determine fragment and debris throw in calculating the appropriate IBD based on the maximum NEW of AE present.

C15.8.1.3. Recommend keeping firefighting equipment available to extinguish grass fires and to wet down the area between burnings and at the close of operations.

C15.8.1.4. The contractor should not dispose of ordinary combustible rubbish near AE and AE-contaminated material destruction sites.

### C15.8.2. Materials and Equipment for Detonating Explosives

C15.8.2.1. Contractor should initiate detonations of AE with electric blasting caps and blasting machines or permanently installed electric circuits energized by storage batteries or conventional power lines. When covering AE for disposal with earth, do not bury the blasting cap. Prime the initiating explosives with sufficient primacord to allow connecting the blasting cap above ground level.

C15.8.2.2. Special requirements for using electric blasting caps and electric blasting circuits follow.

C15.8.2.2.1. Never hold a blasting cap at the explosive (output) end. Hold the wire lead end of the cap between the thumb and the index finger. Whenever possible, point the explosive end of a hand-held cap down, away from the body, and to the rear.

C15.8.2.2.2. Do not remove the shunt from the lead wires of the blasting cap until ready to connect them to the blasting circuit, except during electrical continuity test of the blasting cap and lead wires.

C15.8.2.2.3. Carefully hold the lead wires so that there is no tension where they connect to the cap and manually straighten the lead wires. Do not throw, wave through the air, or uncoil by snapping as a whip.

C15.8.2.2.4. Use blasting circuit wires in twisted pairs. Operators shall keep blasting circuit wires twisted together and connected to ground at the power source and twisted at the opposite end at all times except when actually firing the charge or testing circuit for continuity and extraneous electricity. Never connect the blasting cap to the blasting circuit wires unless the blasting circuit wires are shorted and grounded power source.

C15.8.2.2.5. Maintain safe distances between radio frequency (RF) energy transmitters and electric blasting, demolition operations, and unshielded electric blasting caps.

C15.8.2.2.6. Transport blasting caps in closed metal boxes wherever exposure to RF energy and extraneous electricity is possible (i.e., vehicles equipped with two-way radios).

C 15.8.2.2.7. Operators should follow these procedures when connecting electric blasting cap lead wires to the blasting circuit wires.

C15.8.2.2.7.1. Test the blasting circuit wires for electrical continuity.

C15.8.2.2.7.2. Test the blasting circuit for extraneous electricity. To test, arrange a dummy test circuit similar to the actual blasting circuit, except substitute a radio pilot lamp of suitable voltage for the blasting cap. If the pilot lamp glows, indicating potentially dangerous amounts of RF energy, stop blasting operations using electric blasting caps. Blasting operations may resume using non-electric blasting caps and safety fuse. The contractor may substitute other test instruments (e.g. the DuPont "Dectect-A-Meter" or "Voltohmeter,") for the radio pilot lamp. If the potential source of extraneous electricity is radar, television, or microwave transmitters, test the actual blasting circuit, including the blasting cap but without other explosives, for extraneous electricity. Protect personnel performing such tests from the effects of an exploding blasting cap.

C15.8.2.2.7.3. Test the blasting cap and its lead wires for electrical continuity. The individual who removes the shunt should ground himself or herself by grasping the blasting circuit wire prior to performing the operation in order to prevent accumulated static electricity from firing the blasting cap

C15.8.2.2.7.4. Assure the blasting circuit wires are shorted and grounded at the power source and connect the blasting cap lead wires to the blasting circuit wires..

C15.8.2.2.7.5. Evacuate all but two persons from the area. One person shall partially retreat and act as safety observer. The other person shall maintain physical possession of a safety device that locks out the blasting circuit (e.g., plug, key, pigtail, etc.) and shall place blasting cap onto charge. Both persons will then retreat to personnel shelter.

C15.8.2.2.7.6. Untwist blasting circuit wires at power source and test for continuity. A galvanometer shall be used to test the firing circuit for electric continuity before connection to the blasting machine.

C15.8.2.2.7.7. The individual assigned to make the connections shall confirm that everyone in the vicinity is in a safe place before connecting the blasting circuit wires to the power source and signaling for detonation. This individual shall not leave the blasting machine or its actuating device for any reason; and when using a panel, shall lock the switch in the open position until ready to fire, retaining the only key. Connect blasting circuit wires to power source and fire the charge.

C15.8.2.2.7.8. After firing, disconnect blasting circuit wires from power source, twist the wires together, and connect to ground.

C15.8.2.2.7.9. Suspend blasting and demolition operations when electrical storms are in the vicinity. At the first sign of an electrical storm, short-circuit the blasting cap lead wires

and the blasting circuit wires, and evacuate all personnel from the demolition area to a safe location.

C15.8.2.2.8. Use non-electric blasting caps and safety fuses when conditions prevent the use of electrical initiators for detonation. At the beginning of each day's operation and whenever using a new coil, test the safety fuse's burning rate. The fuse shall be long enough for personnel to evacuate to a safe distance. Under no circumstances shall the fuse length be less than that required for a 2-minute burn time. Use appropriately designed crimpers to affix fuses to detonators. Use only fuses small enough in diameter to enter the blasting cap without forcing. All personnel, except the fuse-actuator, shall move to the personnel shelter or leave the demolition area before ignition.

#### C15.8.3. Servicing of Destruction Site

C15.8.3.1. Vehicles transporting AE to burning or demolition grounds shall meet the requirements of this Manual. See Section C3.14 and paragraph C8.3.1. No more than two persons shall ride in the cab. No one shall ride in the truck bed.

C15.8.3.2. The contractor should unload vehicles immediately then move the vehicle from the burning or demolition area until completion of destruction operations. The contractor should not open AE containers before the vehicle departs.

C15.8.3.3. The contractor shall place and open all AE containers set for destruction at least 10 ft (3.1 m) from each other and from explosives material previously set out to prevent rapid transmission of fire if premature ignition occurs.

C15.8.3.4. Close and move empty containers to prevent charring or damage during destruction of AE. Delivery vehicles shall pick up and remove empty containers on the next trip.

### C15.9. DESTRUCTION BY BURNING

C15.9.1. No mixing of an explosive with extraneous material, other explosives, metal powders, detonators, or similar items shall occur without authorization.

C15.9.2. Because of the danger of detonation, do not burn AE in large quantities or in containers.

#### C15.9.3. Beds for Burning Explosives

C15.9.3.1. A bed of easily combustible material at least two inches thick should be positioned under the explosive bed to ensure complete consumption of wet explosives. The combustible material should extend at least two inches beyond the edges of the explosive bed. If necessary, the thickness and extent of the combustible material may be adjusted, based on actual experience at the site.

C15.9.3.2. The explosive bed shall be no more than 3 in (76 mm) deep.

C15.9.3.3. The ignition train of combustible material leading to the explosives bed shall be positioned so that both it and the explosive bed can burn in a controlled fashion and not propagate to any other explosive treatment areas.

C15.9.3.4. No burning shall take place when wind velocity exceeds 15 mph (24 km/h).

C15.9.3.5. For direct ignition of a combustible train, use either a safety fuse long enough to permit personnel to reach protective shelter or a black powder squib initiated by an electric current controlled from a distance or protective structure. Tying two or more squibs together may be necessary to ensure ignition of the combustible train.

C15.9.3.6. Burning solid propellants ignited by squibs do not require combustible materials.

C15.9.3.7. Evacuate sites of misfires for at least 30 minutes, after which two qualified persons shall approach the position of the explosives. One shall examine the misfire and the other shall act as backup. The backup shall watch the examination from a safe distance, behind natural or artificial barriers or other obstructions for protection. The backup shall follow contractor procedures should an accident occur.

C15.9.4. Burn loose, dry explosives without combustible material, if the ground can remain uncontaminated. Check the ground for residual unburned explosive for the safety of personnel and operations. Do not pour volatile flammable liquids, at any stage, over explosives or the underlying combustible material to accelerate burning.

C15.9.5. Always burn wet explosives on beds of non-explosive materials.

C15.9.6. Burn explosive powders (e.g., RDX, HMX, etc.) in desensitized form to promote safe handling and prevent detonation.

C15.9.7. Empty oil-covered pyrotechnic materials from containers into shallow metal pans before burning. The contractor may burn explosives in the open containers.

C15.9.8. Prepare separate parallel beds of explosives for burning by not less than 150 ft (46 m). Take care to prevent material igniting from smoldering residue or from heat retained in the ground from previous burning operations. Saturate a burned-over plot with water, then check for hot spots, or allow 24 hours to elapse before the next burn.

#### C15.10. DESTRUCTION BY DETONATION

C15.10.1. Detonation of AE should occur in a pit of at least 4 ft (1.3 m) deep and be covered by at least of 2 ft (0.6 m) of earth. Place the components on their sides or in a fashion to enhance complete destruction. Place demolition blocks on top of the AE and secure them with earth packed over them. Under certain circumstances, the contractor may substitute bangalore torpedoes or bulk HE for the demolition blocks. (Note: Detonations do not require a pit at remote demolition areas.)

C15.10.2. Local regulations, atmospheric conditions, earth strata, etc. shall dictate quantities destroyed at one time, both in pits and open sites. Considering these variables, determine the acceptable NEW based on criteria in Chapter 9, DoD 6055.9-STD (reference (a)). The contractor should use this procedure for destruction of fragmentation grenades, HE projectiles, mines, mortar shells, bombs, photoflash munitions, and HE rocket heads separated from their motors.

C15.10.3. Search the surrounding area for unexploded AE after each detonation.

C15.10.4. In cases of misfires, follow established procedures. Wait a minimum of 30 minutes before approaching the site.

### C15.11. DESTRUCTION BY NEUTRALIZATION

Methods of neutralization include dissolving in water-soluble material or chemical decomposition. The contractor is responsible for investigating which of these is most appropriate. The contractor shall comply with all applicable local, state, and Federal requirements.

### C15.12. DESTRUCTION CHAMBERS AND INCINERATORS

C15.12.1. General. The contractor should destroy small, loaded AE components (e.g., primers, fuzes, boosters, detonators, activators, relays, delays, and all types of small-arms ammunition) in destruction chambers or deactivation furnaces. The contractor should use explosives scrap incinerators for burning tracer and igniter compositions, small quantities of solid propellant, magnesium powder, sump cleanings, absorbent cleaning materials, and similar materials. The contractor should equip destruction chambers and incinerators with suitable pollution control devices (e.g., multiple chamber incinerators with thermal incinerator afterburners) and concrete barricades. The final incineration should take place at 1400°F (760°C), minimum.

#### C15.12.2. Operation of Incinerators

C15.12.2.1. The contractor shall not operate the feeding conveyor until the incinerator temperature is high enough to ensure complete destruction. The contractor should install temperature recording devices.

C15.12.2.2. To remove accumulated residue, shut down and thoroughly cool the incinerators. Make repairs only during shutdown. Personnel entering the incinerator to clean it shall wear respiratory protection to prevent inhalation of toxic dusts or fumes (e.g., mercury from tracers or lead from small-arms ammunition).

#### C15.12.3. Operation of Destruction Chambers and Deactivation Furnaces

C15.12.3.1. Operation of destruction chambers and deactivation furnaces requires remote control.

C15.12.3.2. Operators shall not approach the unprotected side of the concrete barricade, for any other reason, until enough time has elapsed for explosives in the chamber to react. Perform regular inspections to keep the feed-pipe chute or conveyor obstruction free.

C15.12.3.3. Feed components into the chamber a few at a time. Post the exact number permitted at one time for each type of component in a place easily seen from the operator's working position.

C15.12.3.4. Install guards on conveyor-feeding mechanisms to facilitate feeding and to prevent items from jamming or falling.

### C15.13. SUPPORT IN DISPOSAL OF WASTE

The contractor shall request instructions from the responsible ACO if, at end of contract, there is excess or residual Government-owned AE and the contract does not address disposition. A

contractor having difficulty safely disposing of residual (scrap) AE related to contractual operations may request help from the ACO.

**C16. CHAPTER 16**  
**CONSTRUCTION AND SITING CRITERIA**

Please refer to DoD 6055.9-STD reference (a), Chapter 5 for guidance on facilities construction and siting.

AP1. APPENDIX 1  
GLOSSARY

This appendix defines terms and phrases used in this Manual, which are associated with ammunition, explosives, and other dangerous materials. For those terms that are not found in this glossary please refer to DOD 6055.9-STD for Q-D terminology. Because of contractual reasons some terms of this manual may be define differently.

AP1.1. Aboveground Magazine. Any open area or any structure not meeting the requirements of an ECM which is used for explosives storage.

AP1.2. Administration Area. The area encompassing administrative buildings which serve the entire installation. This excludes offices located near and directly serving explosives storage and operating areas.

AP1.3. Aircraft Passenger Transport Operations. Passenger transport operations for the purpose of applying explosives Q-D tables are defined as follows: Passenger transport traffic involving military dependents and civilians other than those employed or working directly for DoD Components. The following are not considered passenger transport operations.

AP1.3. 1. Infrequent flights of base and command administrative aircraft that may on occasion, provide some space available travel to authorized personnel.

AP1.3.2. Travel of direct hire appropriated funds personnel employed by any DoD Component.

AP1.4. Ammunition and Explosives. Includes (but is not necessarily limited to) all items of U.S.-titled (owned by the U.S. Government through DoD Components) ammunition: propellants, liquid and solid; pyrotechnics; high explosives; guided missiles; warheads; devices; devices, and chemical agent substances and components presenting real or potential hazards to life, property and the environment. Excluded are wholly inert items and nuclear warheads and devices, except for considerations of storage and stowage compatibility, blast, fire, and non-nuclear fragment hazards associated with the explosives.

AP1.5. Ammunition and Explosives Aircraft Cargo Area. Any area specifically designated for:

AP1.5.1. Aircraft loading or unloading of transportation configured ammunition and explosives.

AP1.5.2. Parking aircraft loaded with transportation configured ammunition and explosives.

AP1.6. Ammunition and Explosives Area. An area specifically designated and set aside from other portions of an installation for the development, manufacture, testing, maintenance, storage or handling of ammunition and explosives.

AP1.7. Auxiliary Building. Any building accessory to or maintained and operated to serve an operating building line, plant, or pier area. Explosive materials are not present in an auxiliary building, such as powerplants, change houses, paint and solvent lockers, and similar facilities.

AP1.8. Barricade. An intervening 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 exposures.

AP1.9. Blast Impulse. The product of the overpressure from the blast wave of an explosion and the time during which it acts at a given point (that is, the area under the positive phase of the overpressure-time curve).

AP1.10. Blast Overpressure. The pressure, exceeding the ambient pressure, manifested in the shock wave of an explosion.

AP1.11. Cavern Storage Site. A natural cavern or former mining excavation adapted for the storage of ammunition and explosives.

AP1.12. Chamber Storage Site. An excavated chamber or series of excavated chambers especially suited to the storage of ammunition and explosives. A cavern may be subdivided or otherwise structurally modified for use as a chamber storage site.

AP1.13. Change House. A building provide with facilities for employees to change to and from work clothes. Such buildings may be provided with sanitary facilities, drinking fountains, lockers and eating facilities.

AP1.14. Classification Yard. A railroad yard used for receiving, dispatching, classifying, and switching of cars.

AP1.15. Closure Block. A protective constructive feature designed to seal the entrance tunnel to an underground storage chamber in the event of an explosion within the chamber. Magae blocks are passive closures that are driven by the blast from a normally open to a closed position. Klotz blocks are active closures, operated by a hydraulic system to move from normally closed to an open position (for access).

AP1.16. Compatibility. Ammunition or explosives which may be stored or transported together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such as accident.

AP1.17. Debris. Any solid particle thrown by an explosion or other strong energetic reaction. For aboveground detonations, debris usually refers to secondary fragments, which are transported by a strong flow of detonation gasses.

AP1.18. Debris Trap. A protective construction feature in an underground storage facility which is designed to capture fragments and debris from a detonation within the facility. This usually accomplished by using the inertia of the material to separate from the detonation gas stream. (illustrated in Figure C9.F3).

AP1.19. Deflagration. A rapid chemical reaction in which the output of heat is enough 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.

AP1.20. Demilitarize. Any disarming, neutralizing, and any other action rendering ammunition and explosives innocuous or ineffectual for military use.

AP1.21. Detonation. A violent chemical reaction with a chemical compound or mechanical mixture evolving heat and pressure. A detonation which 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 which is initially of supersonic velocity. A detonation, when the material is located on or near the surface of the found, is characterized normally by a crater.

AP1.22. Dividing Wall. A wall designed to prevent, control, or delay propagation of an explosion between quantities of explosives on opposite sides of the wall.

AP1.23. DoD Mishap. An unplanned event or series of events which results in damage to DoD property, occupational illness to DoD military or civilian personnel, injury to DoD military personnel on or off duty, injury to on-duty civilian personnel; damage to public and private property, or injury and illness to non-DoD personnel as a result of DoD operations.

AP1.24. Donor/Acceptor. A total quantity of stored ammunition may be subdivided into separate storage units in order to reduce the MCE, and, consequently, the Q-D of an accidental detonation. The separation distances, with or without an intervening barrier, should be sufficient to ensure that a detonation does not propagate from one unit to another. For convenience, the storage unit, which detonates, is termed the donor; and nearby units, which may be endangered, are termed acceptors. The locations of the donor and acceptor define the PES and ES, respectively.

AP 1.1.25. Earth-Covered Magazine (ECM). Any earth-covered structure that meets soil cover depth and soil requirements of DoD 6055.9-STD (reference (a)). ECM has three possible structural strength designations ("7-Bar", "3-Bar", or "Undefined"). The strength of an ECM's headwall and door(s) determines its designation.

AP1.26. Energetic Liquid. A liquid, slurry, or gel, consisting of or containing an explosive, oxidizer, fuel, or combination of the above, that may undergo, contribute to, or cause rapid exothermic decomposition, deflagration, or detonation.

AP1.27. Engineering Controls. Regulation of facility operations through the use of prudent engineering principles, such as facility design, operation sequencing, equipment selection, and process limitations.

AP1.28. Expansion Chambers. A protective construction feature in an underground storage facility which is designed to reduce the blast shock and overpressure exiting the facility by increasing the total volume of the complex. It may also function as a operating area within the underground facility, as well as a debris trap. (Illustrated in Figure C9.F3)

AP1.29. Explosion. A reaction of any chemical compound or mechanical mixture, which, when initiated, undergoes a very rapid combustion or decomposition releasing large volumes of highly heated gases that exert pressure on the surrounding medium. In addition, a mechanical reaction in which failure of the container causes the sudden release of pressure from within a pressure vessel, for example, pressure rupture of a steam boiler. Depending on the rate of energy release, an explosion can be categorized as a deflagration, a detonation, or pressure rupture.

AP1. 1.30. Explosive. Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases which exert pressures in the surrounding medium. The term applies to materials which either detonate or deflagrate.

AP1.31. Explosives Facility. Any structure or location containing ammunition and explosives excluding combat aircraft parking areas or ammunition and explosives aircraft cargo areas.

AP1.32. Exposed Site (ES). A location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential site (PES). The distance to a PES and the level of protection required for an ES determine the quantity of ammunition or explosives permitted in a PES.

AP1.33. Firebrand. A projected burning or hot fragment whose thermal energy is transferred to a receptor.

AP1.34. Fire-resistive. Combustible materials or structures that have been treated or have surface coverings designed to retard ignition of fire spread.

AP1.35. Flame-Resistant. Combustible materials, such as clothing, which have been treated or coated to decrease their burning characteristics.

AP1.36. Flammable. A material which ignites easily and burns readily.

AP1.37. Fragmentation. The breaking up of the confining material of a chemical compound or mechanical mixture when an explosion takes place. Fragments may be complete items, subassemblies, pieces thereof, or pieces of equipment or buildings containing items.

AP1.38. General Public. Persons not associated with the DoD installation's mission or operations such as visitors, to include guests of personnel assigned to the installation, or persons not employed or contracted by DoD or the installation.

AP1.39. Hazardous Fragment. A hazardous fragment is one having an impact energy of 58 ft-lb or greater.

AP1.40. Hazardous Fragment Density. A density of hazardous fragments exceeding one per 600 sq ft.

AP1.41. High Explosive Equivalent or Explosive Equivalent. The amount of a standard explosive that, when detonated, will produce a blast effect comparable to that which results at the same distances from the detonation or explosion of a given amount of the material or which performance is being evaluated. It usually is expressed as a percentage of the total net weight of all reactive materials contained in the item or systems. For the purpose of these standards, TNT is used for comparison.

AP1.42. Hazard Analysis. The logical, systematic examination of an item, process, condition, facility, or system to identify and analyze the probability, causes, and consequences of potential or real hazards.

AP1.43. Holding Yard. A location for groups of railcars, trucks, or trailers used to hold ammunition, explosives, and dangerous materials for interim periods before storage or shipment.

AP1.44. Hybrid Propellants. A propellant charge using a combination of physically separated solid and liquid (or jelled) substances as fuel and oxidizer.

AP1.45. Hygroscopic. A tendency of material to absorb moisture from its surroundings.

AP1.46. Hypergolic. A property of various combinations of chemical to self-ignite upon contact with each other without a spark or other external initiation.

AP1.47. Inhabited Buildings. Buildings or structures, other than operating buildings occupied in whole or in part by human beings, both within and outside DoD establishments. They include but are not limited to schools, churches, residences (quarters), service clubs, aircraft passenger terminals, stores, shops, factories, hospitals, theaters, mess halls, post offices, and post exchanges.

AP1.48. Inspection Station. A designated location at which trucks and railcars containing ammunition and explosives are inspected.

AP1.49. Installation Related Personnel. Military personnel (to include family members), DoD employees, DoD contractor personnel, and other personnel having either a direct operational (military or other Federal personnel undergoing training at an installation) or logistical support (e.g., vendors) relationship with installation activities.

AP1.50. Interchange Yard. An area set aside for the exchange of railroad cars or vehicles between the common carrier and DoD activities.

AP1.51. Intraline Distance. The distance to be maintained between any two operating buildings and sites within an operating line, of which at least one contains or is designed to contain explosives, except that the distance from a service magazine for the line to the nearest operating building may be not be less than the intraline distance required for the quantity of explosives contained in the service magazine.

AP1.52. K-Factor. The factor in the formula  $D = kW^{1/3}$  used in quantity-distance determinations where D represents distance in feet and W is the net explosive weight in pounds. The K-factor is a constant and represents the degree of damage that is acceptable. Typical constants range from 1.25 to 50; the lower the factor, the greater the damage that is accepted.

AP1.53. Launch Pads. The load-bearing base, apron, or platform upon which a rocket, missile, or space vehicle and its launcher rest during launching.

AP1.54. Liquid Propellants. Substances in fluid form (including cryogenics) used for propulsion for operating power for missiles, rockets, ammunition and other related devices (See DoD Standard 6055.9 (reference (a))). For purposes of this Manual, liquid fuels and oxidizers are considered propellants even when stored and handled separately.

AP1.55. Loading Density. Quantity of explosive per unit volume usually expressed as either pounds per cubic foot (lbs/ft<sup>3</sup>). As applied to underground storage facilities, there are two types of loading densities used in Q-D calculations:

AP1.55.1. Chamber loading density is based on the NEW within an individual storage chamber and the volume of the chamber ( $V_{ch}$ ).

AP1.55.2. The calculations of air blast peak pressures and IBD's for explosions in underground storage facilities is based on the shock-engulfed volume ( $V_e$ ) of the facility. This is the total volume filled by the expanding gases at the time the blast front reaches the point of interest (e.g., the entrance to an adjacent chamber). It includes volumes in any direction that the gases can enter, to a distance from the explosion source that equals the distance from the source to the point of interest. For IBD, the point of interest is the tunnel opening.

AP1.56. Loading Docks. Facilities, structures, or paved areas, designed and installed for transferring ammunition and explosives between any two modes of transportation.

AP1.57. Lunchrooms. Facilities where food is prepared or brought for distribution by food service personnel. It may serve more than one PES. A breakroom in an operating building may be used by personnel assigned to the PES to eat meals.

AP1.58. Magazine. Any building or structure, except an operating building, used for the storage of ammunition and explosives.

AP1.59. Mass-Detonating Explosives. HE, black powder, certain propellants, certain pyrotechnics, and other similar explosives, alone or in combination, or loaded into various types of ammunition or containers, most of the entire quantity of which can be expected to explode virtually instantaneously when a small portion is subjected to fire, to severe concussion or impact, to the impulse of an initiating agent, or to the effect of a considerable discharge of energy from without. Such an explosion normally will cause severe structural damage to adjacent objects. Explosion propagation may occur immediately to other items of ammunition and explosives stored sufficiently close to and not adequately protected from the initially exploding pile with a time interval short enough so that two or more quantities must be considered as one for Q-D purposes.

AP1.60. Maximum Credible Event (MCE). In hazards evaluation, the MCE from a hypothesized accidental explosion, fire, or agent release is the worst single event that is likely to occur from a quantity and disposition of ammunition and explosives. The event must be realistic with a reasonable probability of occurrence considering the explosion propagation, burning rate characteristics, and physical protection given to the involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

AP1.61. Module. A barricaded area comprised of a series of connected cells with hard surface storage pads separated from each other by barricades.

AP1.62. Military Munitions. All ammunition products and components produced or used by for the U.S. Department of Defense or the U.S. Armed Services for national defense and security, including military munitions under the control of the Department of Defense, the U.S. Coast Guard, the U.S. Department. of Energy, and the National Guard personnel. The term "military munitions" includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, incendiaries used by the DoD Components, including bulk explosives and chemical warfare, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. "Military munitions" do not include wholly inert items, improvised explosive devices, and nuclear weapons, nuclear devices, and nuclear components thereof. However, that term does include non-nuclear components of

nuclear devices, managed under the DoE's nuclear weapons program, after all required sanitizing operations under the "Atomic Energy Act of 1954," as amended, have been completed (40 CFR Section 260.10< reference (d)).

AP1.63. Navigable Streams. Those parts of streams, channels, or canals capable of being used in their ordinary or maintained condition as highways of commerce over which trade and travel are or may be conducted in the customary modes, not including streams that are not capable of navigation by barges, tugboats, and other large vessels unless they are used extensively and regularly for the operation of pleasure boats.

AP1.64. NEQ. Net explosive quantity expressed in kilograms.

AP1.65. NEW. Net explosive weight expressed in pounds.

AP1.66. Nitrogen Padding (or Blanket). Used to fill the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical contained therein and to avoid formation of a flammable mixture, or to maintain a nitrogen atmosphere in or around an operation of piece of equipment.

AP1.67. Non-combustible. Not burnable.

AP1.68. Non-DoD Components. Any entity (government, private, or corporate) that is not a part of the Department of Defense.

AP1.69. Operating Building. Any structure, except a magazine, in which operations pertaining to manufacturing, processing, handling, loading, or assembling of ammunition and explosives are performed.

AP1.70. Operating Line. A group of buildings, facilities or related work stations so arranged as to permit performance of the consecutive steps in the manufacture of an explosive, or in the loading, assembly, modification, and maintenance of ammunition. Parallel operating lines are adjacent buildings or other facilities that process the same or comparable ammunition or explosives, presenting parallel operating lines but may require physical separation or other control measures to ensure inventory control and management of explosives limits.

AP1.71. Operational Shield. A barrier constructed at a particular location or around a particular machine or operating station to protect personnel, material, or equipment from the effects of a possible localized fire or explosion.

AP1.72. Parallel Operating Lines. Adjacent buildings or other facilities that process the same or comparable ammunition. or explosives presenting the same or comparable hazards and using the same or comparable process methods. Such ammunition or explosives processed at related work stations in the same building or facility are not parallel operating lines but may require physical separation or other control measures to ensure inventory control and management of explosives limits.

AP1.73. Passenger Railroad. Any steam, diesel, electric, or other railroad which carries passengers for hire.

AP1.74. Potential Explosive Site (PES). The location of a quantity of explosives that will create a blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its

contents. Quantity limits for ammunition and explosives at a PES are determined by the distance to an ES.

AP1.75. Prohibited Area. A specifically designated area at airfields, seadromes, or heliports in which all ammunition and explosives facilities are prohibited.

AP1.76. Propellant. Explosives compositions used for propelling projectiles and rockets and to generate gases for powering auxiliary devices.

AP1.77. Public Highway. Any street, road, or highway used by the general public for any type of vehicular travel.

AP1.78. Public Traffic Route. Any public street, road, highway, navigable stream, or passenger railroad (includes roads on a military reservation that are used routinely by the general public for through traffic).

AP1.79. Pyrotechnic Material. The explosive or chemical ingredients, including powdered metals, used in the manufacture of military pyrotechnics.

AP1.80. Quantity-Distance (Q-D). The quantity of explosive material and distance separation relationships that provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Q-D tables. Separation distances are not absolute safe distances but are relative protective or safe distances. Greater distances than those shown in the tables shall be used whenever practicable. Tables are contained in DoD 6055.9-STD (reference (a)) and form a part of this Manual.

AP1.81. Ready Ammunition Storage. A location where ammunition is stored for near-term tactical or training use. Generally, ready ammunition storage will supply one or more armament pads.

AP1.82. Renovation. The work performed on ammunition, missiles, or rockets to restore them to a completely serviceable condition; this usually involves the replacement of unserviceable or outmoded parts.

AP1.83. Risk. The product of the probability or frequency an accident will occur within a certain time and the accident's consequences to people, property or the environment.

AP1.84. Robust Munitions. These are munitions that meet two of the following three criteria: (1) have a ratio of the explosive weight to empty case weight less than 1.00, (2) have a normal wall thickness of at least 0.4 inches, and (3) have a case thickness/NEW<sup>1/3</sup>>0.05 in/lb<sup>1/3</sup>. The following cartridges are by definition, robust:

20mm, 25mm, and 30mm. Other examples of robust ammunition include MK 80 series bombs, M107 projectiles, Tomahawk and Harpoon penetration warheads. (Changed at 319<sup>th</sup> Board Meeting)

AP1.85. Rock Strength. Strong, moderately strong, and weak rock are designators which provide a general classification of a rock body into one of these rankings is based on the rock impedance factor:

Rock impedance factor = p.c.10-6

and  $p = \gamma/g$

where

- y. is the rock density, lbs/ft<sup>3</sup>
- g. is the gravitational acceleration, ft/sec<sup>2</sup>
- p. is mass density of the rock, lbs-sec<sup>2</sup>/ft<sup>4</sup>
- c. seismic velocity of the rock, ft/sec.

AP1.85.1. The rock impedance factor will be 0.75 or more for strong rock; Between 0.75 and 0.5 for moderately strong rock; and less than 0.5 for weak rock.

AP1.85.2. Values of these parameters can usually be estimated based on examinations of exposed rock outcrops or core samples from an exploratory drill hole. For the detailed design of an underground storage facility (maximum) span width, rock reinforcement, etc.), standard rock mechanics classification systems should be used.

AP1.86. Runway. Any surface on land designated for aircraft takeoff and landing operations, or a designated lane of water for takeoff and landing operations of seaplanes.

AP1.87. Secure Explosives Holding Area. An area designated for the temporary parking of commercial carriers' motor vehicles transporting DoD-owned Arms, Ammunition, Explosives (AA&E).

AP1.88. Secure Non-explosives Holding Area. An area designated for the temporary parking of commercial carriers' motor vehicles transporting Categorized DoD Arms, classified (SECRET or CONFIDENTIAL) materials, and Controlled Cryptographic Items (CCI).

AP1.89. Service Magazine. A building of an operating line used for the intermediate storage of explosives materials.

AP1.90. Single-Chamber Storage Site. An excavated chamber with its own access to the natural ground surface, not connected to any other storage chamber.

AP1.91. Spall. Pieces of a material (and the process by which they are formed) that are broken loose from the surface of a parent body by tensile forces created when a compression shock wave travels through the body and reflects from the surface. For underground storage, spall normally refers to the rock broken loose from the wall of an acceptor chamber by the shock wave transmitted through the rock from an explosion in a nearby donor chamber.

AP1.92. Static Missile Battery. Deployed ground-based missiles meant to be employed in a non-mobile mission for offensive or defensive purposes.

AP1.93. Static Test Stand. Locations on which liquid propellant engines or solid propellant motors are tested in place.

AP1.94. Substantial Dividing Wall. An interior wall designed to prevent simultaneous detonation of explosives on opposite sides of the wall; however, such walls may not prevent propagation (depending on quantities and types of explosives involved).

AP1.94.1. Substantial dividing walls are one way of separating explosives into smaller groups to minimize the results of an explosion and allow a reduction in Q-D. These walls do not protect personnel near the wall from high explosives because the spalling of wall surface opposite the explosion source may form dangerous secondary fragments.

AP1.94.2. Reinforced concrete-type walls may vary in thickness, but will be at least 12 in (305 mm) thick. At a minimum, both will be reinforced with rods at ½ in (12.7 mm) in diameter. The rods will be spaced not more than 12 in (305 mm) on centers horizontally and vertically, interlocked with footing rods and secured to prevent overturning. Rods on one face will be staggered with regard to rods on the opposite face and should be approximately 2 in (50.8 mm) from each face. Concrete should have a design compressive strength on 2,500 psi (17.24 MPa) or more. The capability to prevent simultaneous detonation is based on a limit of 425 net lb (193 kg) of mass-detonating explosives. All storage plans and Q-D calculations shall be based on the total quantity of mass-detonating explosives on both sides of a dividing wall when the quantity of either side exceeds 425 lb (193 kg). Explosives should be 3 ft (0.91 m) or more from the wall.

AP1.94.3. Retaining walls filled with earth or sand must be at least 5 ft (1.5 m) wide, with earth or sand packed between concrete, masonry, or wooden retaining walls.

AP1.95. Support Facilities. Ammunition and explosives storage or operations that support solely the functions of tactical or using units as distinguished from storage depots or manufacturing facilities.

AP1.96. Suspect Truck and Car Site. A designated location for placing trucks and railcars containing ammunition and explosives that are suspected of being in a hazardous condition. These sites area also used for trucks and railcars that may be in a condition that is hazardous to their contents.

AP1.97. Taxiway or Taxilane. Any surface designated as such in the basic airfield clearance criteria specified by a DoD Component publication or Federal Aviation Regulation (reference (v)).

AP1.98. Toxic Area. A defined area in which CG K or Class 6 chemical agents are handled or stored.

AP1.99. Ufer Ground. A Ufer Ground is an earth electrode system which consists of solid conductors encased along the bottom of a concrete foundation footing or floor indirect contact with the earth.

AP1.100. Unexploded Ordnance. 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 manner as to constitute a hazard to operations, installations, personnel or material and remains unexploded either by malfunction or design for any other cause.

AP1.101. Unit Risk. The risk to personnel and/or facilities that is associated with debris, fragment and/or blast hazards that is result of the detonation of a single round of ammunition.

AP1.102. Waste Military Munitions. Military munitions are waste when they are solid or hazardous waste under the regulations (42 U.S.C. 9601, et seq., reference (ff) implementing the

Resource Conservation and Recovery Act (RCRA) Subpart EE of Part 264 of 40 CFR, reference (dd), or defined as a waste under a DoD Component's written procedures. Waste military munitions are defined in Section 266.202 of 40 CFR, reference (dd). (Note: Decision about whether specific munitions are or are not waste should be made with reference to Section 260.10 and Sections 266.200 through 266.206 of 40 CFR, reference (dd)).

AP1.102.1. An unused military munition is a solid waste when any of the following occurs:

AP1.102.1.1. The munition is abandoned by being disposed of, burned, detonated (except during intended use), incinerated, or treated before disposal;

AP1.102.1.2. The munition is removed from storage in a military magazine or other storage area for the purpose of being disposed of, burned, or incinerated, or treated prior to disposal;

AP1.102.1.3. The munition is deteriorated or damaged (e.g., the integrity of the munition is compromised by cracks, leaks, or other damage) to the point that it cannot be put into serviceable condition, and cannot reasonably be recycled or used for other purposes; or,

AP1.102.1.4. An authorized military official has declared the munition a solid waste. (Note: Declaration by an "authorized military official" that munitions are waste (Section 266.202(b)(4) of 40 CFR, reference (dd)) has a very limited meaning and applicability. The only example is a declaration by the Army in 1984 that M55 rockets are waste. The environmental Protection Agency expects that such a declaration would be in writing. A decision that munitions are unserviceable, or that they are to be transferred into a demilitarization account does not, by itself, constitute a decision that the munitions are solid waste).

AP1.102.2. A used or fired military munition is a solid waste, it follows:

AP1.102.2.1. When transported off range or from the site of use, where the site of use is not a range, for the purposes of storage, reclamation, treatment, disposal, or treatment before disposal; or,

AP1.102.2.2. If recovered, collected, and then disposed of by burial, or land filling either on or off a range.

AP1.102.2.3. For the RCRA (section 1004(27) of reference (dd)), a used or fired military munition is a solid waste, and therefore, is potentially subject to RCRA corrective action authorities under Section 3004(u) and 3004(v), and 3008(h) of reference (dd), the munition lands off-range and is not promptly rendered safe and/or retrieved. Any imminent and substantial threats associated with any remaining material must be addressed. If remedial action is not possible, the operator of the range must maintain a record of the event for as long as any threat remains. The record must include the type of munition and its location (to the extent the location is known). (For further clarification see 40 CFR Section 266.202 of reference (dd) under "Definition of Solid Waste.").

AP1.103. Waiver. A written authority that provides a temporary exception, permitting deviation from mandatory requirements of this Manual. It generally is granted for short periods

of time pending cancellation as a result of termination of scheduled work commitment or correction of the waived conditions.

AP1.104. Wharf. A landing place or platform built into the water or along the shore for the berthing of vessels.

AP1.105. Wharf Yard. A yard that is close to piers or wharves in which railcars or trucks are held for short periods of time before delivery to the piers or wharves.