DOD 4145.26-M

DEPARTMENT OF DEFENSE

DOD CONTRACTORS' SAFETY MANUAL FOR AMMUNITION AND EXPLOSIVES

July 1997

Under Secretary of Defense
Acquisition and Technology

UNDERSECRETARY OF DEFENSE
FOR ACQUISITION AND TECHNOLOGY
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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 (A&E) operations and facilities. The explosives safety requirements for the Department of Defense are in DoD 6055.9-STD, "DoD Amunitionand Explosives Safety Standards," October 1992, 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 A&E contracts is required by DoD FAR Supplements. Additional A&E or other related safety requirements may be included within the contract by the purchasing activity as determined necessary.

This revision adds chapters on manufacturing propellants and hazardous component safety data statements, updates basic principles of A&E 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 or recommendations for revisions 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 recommended changes to this Manual through appropriate channels to:

Commander
US Army Armament, Munitions, and Chemical Command
ATTN: AMSMC-JS
Rock Island, IL 61299-6000

The DoD Components may obtain copies of this Manual through their own publications channels. Other Federal Agencies and the public may obtain copies from the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

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REFERENCES

(a) MIL-STD 398, "Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance"

(b) Title 14, Code of Federal Regulations, Part 77, "Federal Aviation Administration Regulation, Objects Affecting Navigable Airspace"

(c) DoD Directive 6055.9, "DoD Explosives Safety Board (DDESB) and DoD Component Explosives Safety Responsibilities," July 29, 1996

(d) "Blue Book", Occupational Safety and Health Administration (OSHA)

(e) TB 700-2, NAVSEA Instruction 8020.8, T011A-1-47, Defense Logistics Agency Regulation (DLAR) 8220.1, "Explosives Hazard Classification Procedures," December 1989, current edition

(f) TM 5-1300, AFM 88-22, and NAVFAC P-397, "Structures to Resist the Effects of Accidental Explosions," November 1990

(g) Title 49, Code of Federal Regulations, Parts 100 through 199, "Transportation"

(h) National Fire Protection Association 491M, "Hazardous Chemical Reactions," 1986

(i) National Fire Protection Association Standard No. 13, "Installation of Sprinkler Systems," 1989

(j) National Fire Protection Association Standard No. 15, "Water Spray Fixed Systems," 1985

(k) National Fire Protection Association Standard No. 70, "National Electric Code®," 1989

(l) National Fire Protection Association Standard No. 78, "Lightning Protection Code," 1989

(m) National Fire Protection Association Standard No. 77, "Static Electricity," 1988

(n) National Fire Protection Association Standard No 33, "Spray Application Using Flammable & Combustible Materials," 1989

(o) "Federal Aviation Administration Handbook"

(p) Title 29 Code of Federal Regulations, Part 1910, "Occupational Safety and Health Standards"

(q) Federal Standard (FED-STD-) 313, "Material Safety Data, Transportation Data and Disposal Data for Hazardous Materials Furnished to Government Activities"

(r) Defense Federal Acquisition Regulation Supplement (DFARS) 252.223-7002, "Safety Precautions for Ammunition and Explosives"

(s) Defense Federal Acquisition Regulation Supplement (DFARS) 252.223-7003, "Change in Place of Performance – Ammunition and Explosives"

DEFINITIONS

The following are descriptions of terms and phrases commonly used in conjunction with ammunition, explosives, and other dangerous materials. These are listed to provide a degree of uniformity of description in the use of technical information throughout these standards.

1. Aboveground Magazines. Any type of magazines above ground other than standard or nonstandard earth-covered types of magazines.

2. Administration Area. The area in which administrative buildings that function for the installation as a whole are located, excluding those offices located near and directly serving components of explosives storage and operating areas.

3. Aircraft Parking Area. Any area set aside for parking aircraft not containing explosives.

4. Ammunition and Explosives. As used herein, includes (but is not necessarily limited to) all items of ammunition; propellants, liquid and solid; high explosives; guided missiles; warheads; devices; pyrotechnics; components thereof; and substances associated therewith presenting real or potential hazards to life and property.

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

a. Aircraft loading or unloading of transportation configured ammunition and explosives.

b. Parking aircraft loaded with transportation configured ammunition and explosives.

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.

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 (examples: power plants and change houses, paint and solvent lockers, and similar facilities).

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.

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 vs. time curve).

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

11. Change House. A building provided 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.

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

13. Compatibility. Ammunition and explosives are considered compatible if they 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 an accident.

14. Deflagration. A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without input of heat from another source. Deflagration is a surface phenomenon with the reaction products flowing away from the unreacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction and temperature, and may cause transition into a detonation.

15. Demilitarize. To disarm, neutralize, and accomplish any other action required to render ammunition and explosives innocuous or ineffectual for military use.

16. Detonation. A violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure. A detonation is a reaction that proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium forming a propagating shock wave that is originally of supersonic velocity. A detonation, when the material is located on or near the surface of the ground, normally is characterized by a crater.

17. Dud. Explosive munition that is not armed as intended, or that has failed to function after being armed.

18. Establishment. Any plant, works, facility, installation, or other activity.

19. Explosion. A chemical reaction of any chemical compound or mechanical mixture that, when initiated, undergoes a very rapid combustion or decomposition releasing large volumes of highly heated gases that exert pressure on the surrounding medium. Also, 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 a pressure rupture.

20. 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 that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

21. Explosives Facility. Any structure or location containing ammunition and explosives.

22. Exposed Site (ES). A location exposed to the potential hazardous effects (blast, fragments, debris, and heat flux) from an explosion at a potential explosion 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.

23. Fire-Resistive. Applies to generally combustible materials or structures that have been treated or have surface coverings designed to retard ignition or fire spread.

24. Firebrand. A projected burning or hot fragment from which thermal energy is transferred to a receptor.

25. Firewall. A wall of fire-resistive construction designed to prevent the spread of fire from one side to the other. A firewall also may be termed a "fire division wall".

26. Flame-Resistant. Applies to combustible materials, such as clothing, which have been treated or coated to decrease their burning characteristics.

27. Flammable. Combustible. A flammable material is one that is ignited easily and burns readily.

28. Fragmentation. 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 the items.

29. Hangfire. Temporary failure or delay in the action of a primer, igniter, or propelling charge.

30. 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.

31. High Explosive Equivalent or Explosive Equivalent. The ratio of the weight of TNT to that of another explosive when both quantities produce equivalent blast effects at the same distance from their detonations. The ratio is expressed as a percent.

32. Holding Yard. A location for groups of rail cars, trucks, or trailers used to hold ammunition and explosives for interim periods before storage or shipment.

33. Hypergolic. The term used to describe the self-ignition of certain fuels and oxidizers upon contact with each other.

34. Inhabited Building Distance. That separation between potential explosive sites (PES) and non-associated exposed sites (ES) requiring a high degree of protection from an accidental explosion. Such exposed sites include facility boundaries, wholly inert administrative facilities, the public, etc.

35. Inhabited Building. A building or structure, other than an operating building, occupied in whole or part by human beings; or a building or structure where people customarily assemble, such as a church, schoolhouse, railroad station and similar transportation facilities, store, theater, or factory, inside or outside the establishment.

36. Inspection Station. A designated location at which trucks and rail cars containing ammunition and explosives are inspected.

37. Interchange Yard. An area set aside for the exchange of railroad cars or vehicles between the common carrier and establishment.

38. Intraline Distance. The distance to be maintained between any two operating buildings and sites within an operating line, at least one of which contains or is designed to contain explosives.

39. Launch Pads. The load-bearing base, apron, or platform upon which the rocket, missile, or space vehicle and its launcher are positioned.

40. Liquid Propellant(s). Liquid and gaseous substances (fuels, oxidizers, or monopropellants) used for propulsion or operation of missiles, rockets, and related devices.

41. Loading Docks. Facilities structure, or paved areas, designed and installed for transferring ammunition and explosives.

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

43. Magazine. Any building or structure, except an operating building, used for the storage of ammunition and explosives. The types and general specifications of various magazines for ammunition and explosives follow:

a. Reinforced concrete, arch-type, earth-covered magazines whose construction is at least equivalent in strength to the requirements of The Office of Chief of Engineers (OCE), Department of the Army, drawings 652-686 through 652-693, December 27, 1941, as revised March 14, 1942, 33-15-06, 33-15-58 (atomic blast resistant), 33-15-61, and 33-15-74. For new construction use drawings 33-15-74.[1]

b. Magazines constructed according to Navy drawings 357428 through 357430, August 9, 1944, and modified in accordance with NAVFAC drawing 626739, March 19, 1954; and NAVFAC drawings 627954 through 627957, 764597, 658384 through 658388, 724368, 751861, 764596, 793746, and 793747.[2]

c. Box-type A magazines constructed according to NAVFAC drawings 1404000 through 1404007; box-type B magazines constructed according to NAVFAC drawings 1404018 through 1404025; box-type C magazines constructed according to NAVFAC drawings 1404430 through 1404440, dated 20 September 1985; box-type D magazines constructed according to NAVFAC drawings 1404464 through 1404478, dated 20 September 1985; box-type E magazines constructed according to NAVFAC drawings 1404523 through 1404535, dated 23 April 1987; and box-type F magazines constructed according to NAVFAC drawings 1404541 through 1404555, dated 23 April 1987.

d. Earth-covered, corrugated steel, arch-type magazines at least equivalent in strength to those shown on Army OCE drawings numbered AW 33-15-63, March 5, 1963; AW 33-15-64, May 10, 1963; 33-15-65, January 10, 1963; and NAVFAC drawings numbered 1059128-30, 1059132, 1069906, and 1355460-61. OCE 33-15-73 (oval 1-ga steel arch) is no longer approved for new construction; however, existing magazines are considered “standard. “ For new

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[1] Copies available from U. S. Army, Chief of Engineers, Pulaski Building, 20 Massachusetts Ave. NW, Washington DC 20001.

[2] Copies available from Commander, Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA 22332-2300.

construction of large magazines of this type use the earth-covered steel, semi-circular-arch magazine design shown on Army OCE drawing number 421-80-01, and for new construction of smaller magazines of this type use OCE drawing number AW 33-15-65 addressed above.

44. Mass Detonating Explosives. High explosives, 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 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 explosive will normally cause severe structural damage to adjacent objects. Explosive 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 shall be considered as one for quantity-distance (Q-D) purposes.

45. 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 given quantity and disposition of ammunition and explosives. Event shall be realistic with a reasonable probability of occurrence, considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

46. Military Pyrotechnics. Ammunition manufactured specifically for use as signals, illuminants, and like items.

47. Misfire. Failure of a component to fire or explode as intended.

48. Navigable Streams. Those parts of streams, channels, or canals capable of being used as highways of commerce over which trade and travel are or may be conducted, excluding streams that are not navigable by barges, tugboats, and other large vessels, unless they are used extensively and regularly for the operation of pleasure boats.

49. Net Explosive Weight (NEW). Net Explosive Weight, expressed in pounds. The TNT equivalence of the explosive material may be used where known. If TNT equivalence is not known then the total weight net explosive weight must be used to express the NEW.

50. Nitrogen Padding (or blanket). Filling the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical therein and to avoid formation of a flammable atmosphere above the liquid. Nitrogen padding (or blanket) also means maintaining a nitrogen atmosphere in or around an operation, piece of equipment, etc.

51. Noncombustible. Not burnable.

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

53. 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.

54. 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. Operational shields, when designed in accordance with MIL-STD-398 (reference (a)) should protect personnel and assets from thermal, pressure, and fragmentation hazards resulting from an accidental or intentional detonation and deflagration of ammunition or explosives. Existing reinforced concrete walls built to resist the effects of accidental explosions and designed and built in accordance with requirements applicable at the time of construction may be used as operational shields, with the following guidance as a minimum requirement:

a. A 12-inch reinforced concrete wall (see definition "substantial dividing wall") provides adequate protection for operations involving an item containing 15 pounds TNT equivalent or less of high explosives when the nearest part of the item is at least 3 feet from the wall and the item is 2 feet from the floor. Care shall be taken to use appropriate equivalence data for close-in effects. Explosives characterized by greater brisance than that of TNT may have very high equivalencies at small distances from the explosives. When equivalence data is not available, existing 12-inch reinforced concrete walls may be used for operational shields for protection from items containing not more than 6 pounds of high explosives.

b. A 30-inch reinforced concrete wall provides adequate protection against the effects of an item containing not more than 50 pounds TNT equivalent of high explosives. The same separation distance as stated in paragraph 54. a., above, of this definition applies. When equivalence data is not available, a 30-inch wall may be used for an operational shield for protection from items containing not more than 20 pounds of high explosives.

c. A 36-inch reinforced concrete wall provides adequate protection against the effects of an item containing not more than 70 pounds TNT-equivalency of high explosives. The separation distance as stated in definition "operational shield," paragraph 54. a., above, applies. When equivalence data is not available, a 36-inch wall may be used for an operational shield for protection from items containing not more than 28 pounds of high explosives.

55. 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.

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

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

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

59. Public Traffic Route. Any public street, road (including any on an establishment or military reservation), highway, navigable stream, or passenger railroad that is routinely used for through traffic by the general public.

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

61. Quantity-Distance (Q-D). The quantity of explosives material and distance separation relationships providing 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 afford less than absolute safety.

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

63. Restricted Area. Any area, normally fenced, from which personnel, aircraft, or vehicles, other than those required for operations, are excluded for reasons of safety.

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

65. Service Magazine. A building in an operating line used for the intermediate storage of explosives materials. The amount of explosives normally is limited to a minimum consistent with safe, efficient production.

66. Standard Earth-Covered Magazine (Igloo). An earth-covered, arch-type magazine, with or without a separate door barricade, constructed according to an approved standard drawing. These magazines are approved for all quantities of explosives up to 500,000 lbs (226,798 kg) net explosive weight.

67. Static Test Stand. Locations whereon liquid propellant engines or solid propellant motors are tested in place.

68. 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).

a. 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.

b. Reinforced concrete-type walls may vary in thickness, but shall be at least 12 inches thick. At a minimum, both faces shall be reinforced with rods at least 1/2 inch in diameter. The rods shall be spaced not more than 12 inches on centers horizontally and vertically, interlocked with the footing rods and secured to prevent overturning. Rods on one face shall be staggered with regard to rods on the opposite face and should be approximately 2 inches from each face. Concrete should have a design compressive strength of 2,500 psi or more. The capability to prevent simultaneous detonation is based on a limit of 425 net pounds 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 pounds. Explosives should be 3 feet or more from the wall.

c. Retaining walls filled with earth or sand shall be at least 5 feet wide, with earth or sand packed between concrete, masonry, or wooden retaining walls.

69. Suspect Vehicle and Rail Car Site. A designated location for placing trucks and rail cars containing ammunition or explosives that are suspected of being in hazardous condition. These sites also are used for trucks and rail cars that may be in a condition that is hazardous to their contents.

70. Taxiway/Taxilane. Any surface designated as such in the basic airfield clearance criteria specified by Title 14 Code of Federal Regulations, Part 77, current edition (reference (b)).[3]

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

72. Waiver. 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 commitments or correction of the waived conditions.

[3] Copies may be obtained from Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.

GLOSSARY OF ACRONYMS

A&E	ammunition and explosives
ACO	administrative contracting officer
AIT	auto-ignition temperature
CBU	cluster bomb unit
CFR	Code of Federal Regulations
COCO	contractor-owned, contractor-operated
DFARS	Defense Federal Acquisition Regulation Supplement
DNT	dinitrotoluene
DoD	Department of Defense
DODIC	Department of Defense Identification Code
DOT	Department of Transportation
DTA	differential thermal analysis
EIDS	extremely insensitive detonating substances
ES	exposed site
FAA	Federal Aviation Administration
FAE	fuel air explosive
FAR	Federal Acquisition Regulation
H/D	hazard division
HC	hexachloroethane
HCSDS	Hazardous Component Safety Data Statement
HE	high explosive
IBD	inhabited building distance
ILD	intraline distance
IMD	intermagazine distance
IMO	International Maritime Organization
IR	Infrared
JHCS	Joint Hazard Classification System
LP	liquified petroleum
MCE	maximum credible event
MILVANS	military vans/tractor vans (i.e., 8’x8’x20’ container)
MK	Mark
MOD	Model
NATO	North Atlantic Treaty Organization
NAVFAC	Naval Facilities Engineering Command
NEC	National Electrical Code
NEW	net explosive weight
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NSN	national stock number
OCE	Office of Chief of Engineers
OSHA	Occupational Safety and Health Administration

GLOSSARY OF ACRONYMS (continued)

PCO	procuring contracting officer
PES	potential explosive site
PETN	pentaerythritol tetranitrate
POPO	privately owned-privately operated
PSI	pounds per square inch
PSIG	pounds per square inch gauge
PTR	public traffic route
PWP	plasticized white phosphorous
Q-D	quantity-distance
RDX	dyclorotrimethylenetrinitramine (cyclonite)
RF	radio frequency
SCG	storage compatibility group
SOP	standard operating procedure
TDP	technical data package
TEA	triethylaluminum
TNT	trinitrotoluene
TP	target practice
TPA	thickened TEA
UL	Underwriters' Laboratories
UN	United Nations
UNO	United Nations Organization
UV	ultraviolet
WP	white phosphorus

CHAPTER 1

INTRODUCTION

A. Purpose

This Manual provides reasonable, standardized safety principles, methods, practices, requirements, and information for contractual work or services involving ammunition and explosives (A&E). Understanding and compliance with the applicable requirements of this Manual and additional safety requirements of the contract, if any, are intended to minimize the potential for mishaps that could interrupt Department of Defense (DoD) operations or delay production, damage or destroy DoD material, cause injury to DoD personnel, or endanger the general public. Adherence to the Manual's requirements and principles are intended to support DoD mission, provide a safe environment, and foster cooperation between contractor and DoD personnel.

B. Applicability

The requirements of this Manual apply to contractors performing work or services on DoD contracts, subcontracts, purchase orders, or other purchasing methods for ammunition or explosives. These requirements also apply to other contractor operations to the extent they impact DoD work or services.

C. Mandatory and advisory requirement

The term "shall" is used in this Manual to indicate mandatory requirements. Waivers to these requirements may be authorized by the procuring contracting officer (PCO) as explained in Subsections E.1 and E.2. The terms "should" and "may" are advisory. When advisory provisions are not met, adverse consequences could develop, becoming proximate causes of A&E mishaps.

D. Responsibilities

The contractor shall:

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

2. Develop and implement a demonstrable safety program, including operational procedures, intended to prevent A&E-related mishaps;

3. Designate qualified individuals to administer and implement this safety program;

4. Provide information to the administrative contracting officer (ACO) pertaining to subcontractors retained for A&E work;

5. Require A&E subcontractors to comply with D.1 through D.3 above; and

6. Conduct mishap investigations in accordance with, but not limited to, provisions of this Manual.

E. Compliance with mandatory requirements

1. During pre-award safety surveys, violations of mandatory requirements contained in this Manual shall be resolved. The contractor may choose to correct the deficiencies immediately, submit a written letter of intent to correct the deficiencies (which will become binding if awarded the contract), or request acceptance of specifically identified existing conditions or facilities by the purchasing activity.

2. When the contractor cannot comply with the mandatory safety provisions of the contract, the contractor shall develop and submit a request for a waiver through the ACO to the PCO for final determination. The request shall contain complete information concerning the requirements violated, actions planned to minimize the hazard, and a proposed date for correction of the deficiency.

F. Site and construction plans

1. Development and submission of site plans, modifications, construction, and utility drawings pertaining to DoD-owned facilities shall be processed in accordance with the requirements of DoD Directive 6055.9 (reference (c)),[1] as implemented by the applicable military service requirements.

2. 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 A&E activities and for the facilities that may be exposed to A&E 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 acceptance from the PCO through the ACO.

3. Modification or rehabilitation plans for existing facilities that are essentially minor, introduce no new hazards, and do not increase the net explosive capacity for which the facility was designed or sited, need not be submitted. The ACO shall make the final determination as to whether a site plan is necessary.

4. Site plans shall comply with the following specifications:

a. Drawings shall be drawn to a scale of 1 inch to 400 feet or less. Other-scale drawings may sometimes be necessary to reflect certain distance and structure relationships within the area surrounding a given project. In such instances, changes in scale are acceptable.

b. Drawings shall identify distances between the facility or location proposed for siting and other establishment facilities, the establishment boundary, public railways and highways, power transmission and other utility lines.

c. All other facilities within the inhabited building distance (IBD) of the proposed facility shall be identified by a brief description of their function and occupancy.

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[1] Copies may be obtained, at cost, from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

d. A&E items or energetic materials to be stored or processed in the facilities shall be described. This includes items such as bombs, rockets, artillery ammunition, liquid propellants, or other items regulated by this Manual.

e. Site plans shall provide the net explosives weight (NEW), number of units and hazard class(es) of ammunition, explosives, liquid and solid propellants and other hazardous materials for the proposed facility, including a breakdown by room or bay.

f. Site plans shall provide the NEW, number of units and hazard class(es) of ammunition, explosives, liquid and solid propellants and other hazardous materials stored or handled in facilities located within inhabited distance of the proposed facility.

g. All facilities whose inhabited building distance arcs include the facility under consideration shall be identified.

h. Site plans shall provide a topographical map with appropriate contours when terrain features are considered to constitute natural barricading, or when topography otherwise influences the layout.

5. Construction plans for the proposed facility shall contain the information in paragraphs F.4.a through F.4.h, above, and the following:

a. Show the personnel limits for the new or modified facility, including a breakdown by room or bay, when appropriate.

b. Give general details regarding dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, A&E waste disposal systems, lightning protection systems, static grounding systems, process equipment, and auxiliary support structures, as well as general materials of construction.

c. Include information relative to the types and arrangement of explosive operations or chemical processing equipment.

d. Explain any deviations from pertinent safety requirements due to local conditions.

G. Pre-award safety survey

1. When A&E materials and operations are involved in a solicitation, mishaps could adversely affect production capability, assets or schedules essential to DoD program milestones. Therefore, the contractor's capability and preparedness shall be evaluated. Pre-award safety surveys shall be conducted by DoD safety personnel.

2. During the pre-award safety survey, the contractor, as a minimum, shall provide the following for review:

a. Site plans conforming to the requirements of paragraphs F.4.a through F.4.h, above;

b. Safety program, organization, and training;

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

d. Description of facilities, including size, construction design and materials, fire resistive capability, utilities, and current compliance with existing building regulations and codes;

e. Operational compliance with applicable Federal, State, and local requirements;

f. Required licenses or capability to obtain those required to perform proposed contract work;

g. Past safety history, including reports of safety surveys by Federal, State, or local safety, fire prevention, insurance, or other authorities; current status of waivers or exemptions issued by Federal, state, or local authorities; and mishap experience;

h. A&E collection and disposal systems and procedures (The contractor may wish to request specific clarification of A&E residue/reject item disposition at this time.); and

I. Hazard analysis, as appropriate.

H. Pre-operational survey

After contract award, a significant mishap or completion of new construction or major modifications, DoD review and evaluation of the facilities and operations may be necessary before startup of production or services. The contractor shall contact the ACO to offer an opportunity for a pre-operational review by authorized DoD personnel.

CHAPTER 2

MISHAP INVESTIGATION AND REPORTING

A. General

This chapter sets forth requirements to be followed for mishaps involving ammunition and explosives.

B. Reporting criteria

All mishaps involving ammunition and explosives that result in one or more of the following shall be investigated by the contractor and reported to the ACO.

1. One or more fatalities;

2. One or more lost-workday cases (Refer to the Occupational Safety and Health Administration (OSHA) *Blue Book* lost-workday injury case guidelines.) (reference (d));[1]

3. Ten or more nonfatal injuries without lost workdays (reference (d));

4. Damage to Government property exceeding $10,000;

5. Delay in delivery schedule exceeding 24 hours (This requirement is not to be construed as a waiver of any delivery schedules mandated by the contract.);

6. Mishaps that are reportable in accordance with specific contractual requirements other than B.1 through B.5, above; or

7. Any mishap that may degrade operational or production capability or is likely to arouse unusual media interest because of exceptional circumstances.

NOTE: Based upon the seriousness of the mishap and the criticality of the munitions or explosives involved, the ACO may determine that an additional, more comprehensive mishap investigation and report is desired.

C. Mishap scene

In the event of an ammunition or explosives mishap, the contractor shall implement emergency procedures, such as controlling the spread of fire and attending to the injured. The contractor shall also secure the scene of the mishap, preventing unauthorized persons from entering the area in order to preserve evidence for an investigation.

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1 Copies may be obtained from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

D. Telephone report

The contractor shall report any mishap described in Section B, above, by telephone to the ACO as soon as practicable, but not later than 3 hours after the incident. The format provided for the written report, section E., below, will serve as a guide for the telephone report.

E. Written report

1. The contractor shall submit to the ACO a written mishap report by the end of the second working day after the mishap occurrence. At a minimum, this written report shall include the following:

   a. Contractor's name and location;

   b. Date, local time, and plant/facility location of the accident;

   c. Category of accident (explosion, fire, and so forth);

   d. Contract, subcontract, or purchase order;

   e. Item nomenclature, hazard classification, lot number;

   f. Narrative (or abstract) of events pertaining to the mishap;

   g. Number of injuries/fatalities, degree of injuries;

   h. Description of property damage and approximate damage cost;

   i. Quantity of explosives involved (pounds, units, rounds);

   j. Probable cause(s);

   k. Corrective action taken or planned;

   l. Effect on production;

   m. Name, title or position, and phone number of person submitting report; and

   n. Remarks.

2. Follow-up information to the initial written report shall be provided to the ACO within 30 days of the mishap.

F. On-site government assistance

To help determine the cause or causes of the mishap, DoD representatives may monitor the contractor's on-site mishap investigation. Additional investigation or reporting may be required by the PCO.

G. Technical mishap investigation and report

If determined by the PCO, a technical mishap investigation may be conducted by a panel chaired by DoD personnel. Otherwise, the contractor will conduct the investigation at the PCO's request. In either case, a document will be produced that provides details such as missile fragmentation maps, photographs, description of mishap, effects on adjacent operations, structural and equipment damage, quantity-distance (Q-D) drawings, detailed description of occurrence,

findings, and conclusions. The technical mishap investigation report shall be forwarded to the PCO through the ACO within 60 days of the official establishment of the investigative panel or, in the case of the contractor's investigation, from the date of the accident. The contractor will be informed immediately upon determination that the Department of Defense will form a panel to go on-site for an accident investigation.

CHAPTER 3

SAFE PRACTICES

A. General

This chapter provides general safe practices for all A&E operations addressed in this manual. When these practices exceed or differ from local or national codes or requirements, the more restrictive shall apply.

B. Personnel and materials limits

1. The cardinal rule to be observed in any location or operation involving explosives, ammunition, severe fire hazards, or toxic materials is to limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of the hazardous material consistent with safe and efficient operations. All operations shall be examined to devise methods for reducing the number of people exposed, the time of exposure, and the quantity of material subject to a single incident. Determination of personnel limits requires that jobs not essential to a particular hazardous operation be performed elsewhere; that no unnecessary personnel visit the location; and that frequent, consecutive operations not be permitted in the same room or building without adequate dividing walls, firewalls, or operational shields, depending upon the nature of the hazard. Personnel limits should allow for necessary supervision, workers, and transient workers.

2. Determination of limits for hazardous materials requires a careful analysis of all facts including normal operation times, intraplant transportation methods, size of the items, and the chemical and physical characteristics of the material. Lower limits are required for more sensitive or hazardous materials. Ensure no worker exceeds the established limit. Limits need not be expressed in units of weight or in the number of items. They may be given in terms of trays, boxes, racks, or other units more easily observed and controlled. Limits shall not be based on the maximum quantity of explosives allowed by the existing Q-D separations when lesser quantities of explosives will suffice for the operations.

3. The maximum number of personnel and quantity of explosives permitted at any one time shall be prominently displayed in all buildings, cubicles, cells, and rooms containing A&E. These limits shall be kept current, and enforced by the supervisor, foreman, or worker in charge. The personnel and explosives limits for all operations shall be recorded in the applicable standard operating procedure (SOP). Personnel limits need not be posted in storage magazines, magazine areas, or transfer points. Explosives limits need only be posted in storage magazines for which the limit differs from that for other magazines in the block, or when unusual circumstances prevent the limit from being readily apparent.

C. Standard Operating Procedures (SOPs)

Before starting any operation involving hazardous materials, qualified personnel shall develop, review, and approve written procedures. The procedures shall be clearly written to avoid confusion and ensure process control at all times.

1. **Preparation**. All aspects of an SOP shall be examined to determine a safe and orderly course of action for accomplishing the work. Controlled tests may be necessary in order to establish SOPs for certain operations. The SOPs shall include, at a minimum, such items as safety requirements; specific emergency SOPs; personal protective clothing and equipment; personnel and explosives limits for each operation; equipment designation; location and sequence of operations; the particulars regarding how, when, where, and by whom each task of the operation shall be performed; and spill cleanup.

2. **Dissemination**. Supervisors shall be responsible for explaining duties prescribed by the SOP to all personnel involved in an A&E operation.

3. **Posting**. Those portions of the SOPs necessary to facilitate operations shall be posted in a spot convenient to all workers at stations involved in the operation. SOPs do not have to be posted at work stations if their presence could distract workers and cause and accident. Supervisory personnel shall be responsible for enforcing provisions in the SOP; and should maintain copies of the entire document.

4. **Emergency procedures**. Action to be taken in the event of electrical storms, utility or mechanical failures and the like, occurring during the manufacturing, handling, or processing of A&E and other hazardous materials, shall be set forth in the SOPs as described in the preceding paragraphs, or shall be set forth in separate SOPs prepared specifically for such purposes.

5. **Recertification**. SOPs shall be reviewed on a regular basis by qualified personnel, changed and recertified by the managing authority as often as necessary to reflect improved methods, equipment substitutions, facility modification, or process revisions.

6. **Training**. Operator training shall cover SOPs, hazardous materials information, safety and warning devices, personal protective clothing and equipment, and emergency equipment. Operator training shall be documented as having been conducted.

D. Storage in operating buildings

1. Only those quantities of hazardous materials (excluding explosives, propellant and pyrotechnic materials) essential for current operations shall be stored within an operating building. Explosive materials exceeding work requirements shall be stored in a separate service magazine area located at the appropriate intraline distance from the operating building or area, based on the quantity of explosives stored in the service magazine.

2. If storage is required by operational necessity, and intraline distance is not available for a separate storage magazine, contractors may designate in-process holding containers or structures within the operating building, provided the following apply:

a. Those containers or structures would preclude propagation from the operational location to the holding site if an explosives mishap should occur at the operational site.

b. Consideration is given to the structural containment afforded, venting, and the use of non-propagating packaging within the temporary holding site.

c. Quantities of A&E in these holding sites are kept as low as possible, not exceeding amounts required for one half of a work shift.

d. Procedures have been developed to minimize exposure during transfer operations.

e. Plant managers review documented test results that confirm non-propagation characteristics.

3. If operationally required, A&E that are a part of the work in process within the building may be stored in operating buildings during non-operational hours, providing the following requirements are strictly observed:

a. Explosives limits are not exceeded.

b. Containers of bulk explosives or propellants are secured and covered.

c. Processing equipment, such as powder hoppers and pipelines, is empty.

4. Before an operation in a building shuts down for longer than a weekend or normal holiday period, all hazardous materials should be processed through the facility. If this is not possible, as much of the in-process material as possible should be processed and transferred to an approved storage area before shutdown; no new material should be introduced. The additional precautions listed in subsection D.3., above, shall apply. All supervisory personnel at A&E sites shall be familiar with these conditions for weekend and holiday storage and shall ensure that workers comply with them.

E. Housekeeping in hazardous areas

1. Structures containing explosives shall be kept clean and orderly.

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

3. Spillage of explosives and other hazardous materials shall be prevented by proper design of equipment, training of employees, and other provisions such as catch pans. For example, hoppers should be large enough to comfortably accommodate the size of charges used. A painted stripe on the inside of the hopper may serve as a reminder of the proper filling height. Catch pans or splash pans should be provided beneath draw-off pipes and trinitrotoluene (TNT) flakers, around transfer piping, and beneath powder bags on small arms ammunition charging machines, and so forth. Spillage shall be promptly removed.

4. A regular program of cleaning shall be conducted to maintain safe conditions. General cleaning shall not be conducted while hazardous operations are being performed.

5. Hot water, steam or other cleaning methods that do not create ignition hazards for the material being removed shall be used for cleaning floors in buildings containing explosives. When these methods are impractical, sweeping compounds that are nonabrasive and compatible with the explosives involved may be used. Such compounds may be combustible, but not volatile (closed cup flash point shall not be less than 230°F). Sweeping compounds containing wax shall not be used on conductive flooring. Because nitrated organic explosives can form sensitive explosive compounds with caustic alkalies, cleaning agents containing such alkalies shall not be used around them.

6. Nonferrous wire brushes may be used in cleaning explosives-processing equipment only when other methods of cleaning are ineffective; a thorough inspection should follow such cleaning

to ensure that no wire bristles remain in the equipment. This applies also to cleaning magnesium ingot molds and molds for any other metal used in an explosive. Substituting fiber brushes for hair brushes is recommended to reduce generation of static.

7. All loose explosives swept up from floors of operating buildings shall be destroyed. Explosives recovered from sources other than ammunition breakdown operations and equipment shall be thoroughly inspected to determine disposition. It may be reused, screened, reprocessed, or destroyed, as the situation warrants.

F. Explosives waste in operating areas

1. At this writing, the Environmental Protection Agency (EPA) is developing regulations which will also apply to each contractor and may impose requirements beyond those in this Manual. Explosive safety should not be compromised while meeting environmental considerations.

2. All waste material generated in an explosives area shall require analysis to determine appropriate methods for safe handling and disposition. All explosives waste and contaminated materials shall be kept in covered containers marked to indicate their contents, preferably located in isolated bays or outside the buildings.

3. Containers for scrap black powder and smokeless powders shall contain water. Certain pyrotechnic, tracer, flare and similar compositions shall be totally immersed in mineral oil or fuel oil in the waste containers. Waste initiating explosives shall be kept to a minimum, usually under water or other selected media, and shall be handled with great care. Explosives waste materials should not be left in operating buildings overnight during normal periods of shutdown or over weekends and holidays.

4. Workers shall transport explosives wastes in designated vehicles (see Section T) to storage locations specifically assigned for that purpose. Explosives waste shall not be stored with serviceable explosives. A minimum of magazine distance shall be maintained between locations where explosives wastes are stored and those used for serviceable A&E.

G. Procedure before electrical storms

1. When an electrical storm approaches, all personnel shall evacuate locations where lightning could initiate explosions. Such locations include:

a. Operating buildings or facilities containing explosives or explosives-loaded ammunition, not equipped with lightning protection systems, and locations within unbarricaded intraline distance of such facilities;

b. Buildings containing explosives dust or vapors, whether or not equipped with lightning protection systems, and locations within unbarricaded intraline distance of such buildings;

c. Magazines, open storage sites, or loading docks, not equipped with lightning protection systems; and

d. Locations, with or without lightning protection, where operations involving unprotected electro-explosive devices or circuitry are being performed.

2. Qualified supervisory personnel in authority should make final decisions about evacuation. When special warning is required for shutdown, volunteer observers or a lightning detection system may be used.

3. All personnel shall evacuate to locations identified in the SOP. These locations shall be at unbarricaded intraline distance or greater, or in a shelter providing equivalent protection.

H. Explosives in process during shutdown

When electrical storms cause evacuation of explosives buildings, operations requiring constant attention shall be manned by the minimum number of personnel consistent with safety requirements. Once the process has reached a condition that can be left safely, the building shall be completely evacuated. Explosives processes requiring constant attention should not be started when an electrical storm threatens.

I. Maintenance and repairs to equipment and buildings

1. All new or newly repaired explosives processing equipment shall be examined and tested to ensure that it is in safe working condition before being placed in service.

2. Before repairs can proceed on equipment exposed to explosives, a decontamination tag, signed by supervisory personnel, shall be placed on the equipment. The tag shall certify all explosives have been removed from the equipment or identify parts that could not be cleaned, and shall provide maintenance personnel with instructions on safe handling.

3. Major repairs or changes shall not be undertaken in a building during regular operations until the hazardous material has been removed and the employee in charge of the building informed.

4. Repairs cannot start in an explosives location until all explosives have been removed from equipment, crevices, vents and dust or fume collection systems, areas beneath floors, within walls and pipes, and under fittings where explosives could be ignited. The entire area should be wetted or washed down thoroughly. An inspection of the immediate vicinity shall assure no explosives remain.

5. After repairing, maintaining or adjusting machines and equipment, an inspection shall be made to assure all tools used for the work are removed. Before work resumes, operators should check their own equipment to ensure its safe operating condition.

6. Electricians shall not wear conductive shoes while working on electrical equipment. Exposed explosives and other static-sensitive hazardous material shall be removed before work begins.

7. Safe practices specified elsewhere in this Manual shall also apply to maintenance employees.

8. Maintenance and tool rooms in an operating line should be separated from explosives by intraline distance. Protection equivalent to that afforded by a suitable barrier shall be provided when this proves impractical.

J. Safety hand-tools

1. Hand tools constructed of wood or non-sparking metals such as bronze, lead, and "K" Monel shall be used for work in locations that contain exposed explosives or hazardous concentrations of flammable dusts, gases, or vapors. The nonferrous metals used in so-called non-sparking tools may produce sparks.

2. If their strength makes the use of ferrous metal hand tools necessary, exposed explosives and other highly combustible materials shall be removed from the area as required in Subsections I.2 through I.4, above.

K. Operational shields

1. The purpose of operational shields is to prevent propagation of explosions from one explosives operation or location to another, to protect facilities and equipment and to provide personnel protection. Therefore, all A&E operations and processes shall be assessed prior to work performance to determine the type of hazard involved, the level of risk associated with the A&E material or item, and the corresponding level of protection normally provided.

2. The primary hazards that accompany explosions and deflagrations are potential blast overpressure, fragmentation (primary and secondary) and thermal effects. These hazards and the following factors shall be considered, as a minimum, during the assessment specified in K.1.:

a. Initiation sensitivity,

b. Potential ignition sources,

c. Quantity of A&E,

d. Rate of burning,

e. A&E and personnel resource exposures, and

f. Protection capabilities of shields.

3. When analysis of these factors indicates an unacceptable probability of explosion or deflagration, additional resources shall be provided for personnel and equipment. If operational shields are selected for this purpose, they shall be tested prior to installation to assure compliance with the following criteria:

a. Prevent propagation due to blast overpressure.

b. Contain all fragmentation or direct fragments (primary and secondary) away from areas requiring protection.

c. Contain thermal effects to prevent propagation.

4. Operational shields shall be tested under conditions that simulate the operational environment. A&E materials or items used in the test shall correspond to those that may be involved in a maximum credible event (MCE), plus a 25 percent overcharge. Test methods, recording instrumentation and written documentation shall clearly demonstrate that the above protection criteria are met before the operational shield is used. Shields meeting the requirements of MIL-STD-398, (reference (a)), are acceptable. Analysis rather than testing of shields may be acceptable on a case-by-case basis. When the doors of explosives processing equipment function

as operational shields, interlocking devices shall be installed to prevent the operator from opening the door while the equipment is in operation.

L. Special clothing

1. A changing area shall be established for employees who must remove their street clothes to wear special clothing (explosives plant clothing, anticontamination clothing, impervious clothing, and so forth). To avoid exposing people not involved in A&E operations to unnecessary risks, special clothing worn during A&E operations shall not be worn or taken away from the premises. Special clothing should not be altered. Cotton undergarments, including socks, shall be worn whenever static electricity is a hazard.

2. Explosives plant clothing, generally referred to as powder uniforms, shall be fastened with nonmetallic fasteners and easily removable. Pockets should be of the lattice type. Pants and sleeves should be tapered and without cuffs, and pants should extend over the tops of footwear. These garments should be flame resistant or made of flame retardant material. Each plant should have laundering facilities available for removing contaminants from explosives plant clothing. Hazardous waste procedures should be established for the laundry. Regular testing shall verify the effectiveness of the laundering operations.

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

M. Conductive footwear

1. When conductive mats, floors, or runners are required, operators shall wear conductive shoes. Personnel visiting any such area shall wear conductive shoes, ankle straps, or similar devices, one on each leg.

2. Tests of conductive shoes or their equivalent shall be made initially and daily thereafter to ensure that the resistance from the person through the conductive shoes is less than or equal to one million ohms. Supervisors shall keep documentation of all testing, including calibration of test equipment. The test voltage shall not exceed 500 volts. The short circuit current across the electrodes (plates) shall not exceed 2.0 milliamperes (0.5 milliamperes is preferred). The instruments shall have built-in safeguards preventing the test subject from experiencing electric shock. Tests shall not be performed in rooms with exposed explosives. Shoes should be tested first without cleaning the soles and heels; if the resistance does not exceed allowed levels, the shoes may be worn. If resistance exceeds 450,000 ohms per shoe, the pair shall be cleaned and retested. Sandpaper, solvents, or other agents affecting the structure or conductivity of the sole materials should not be used. Separating or removing the conductive sock liner from the conductive plug or depressing the conductive plugs below the surface of the insole of the shoe can cause high resistance. Nonconductive stockings such as silk, wool, and synthetics; and foot powders, which have a drying action, shall be avoided. Conductive shoes should be clearly identifiable as such.

N. Materials handling equipment

1. Gasoline-, diesel-, and LP-powered equipment shall not be used inside warehouses or similar buildings containing A&E. If the fuel supply is exhausted while the equipment is inside a building, the equipment shall be towed outside to a safe location for refueling: at least 20 feet from inert buildings and inert loading docks and 90 feet from explosives locations or buildings. Doors and windows through which vapors may enter the building shall be closed during refueling. Refueling trucks shall not be located close to explosives buildings during refueling operations, but shall be parked as far as practicable from these buildings, in accordance with the above requirements.

2. Gasoline-, diesel-, and LP-powered equipment shall not be stored in buildings containing explosives or ammunition or on explosives loading docks or piers when A&E is present. A central storage location for gasoline-, diesel-, and liquefied petroleum (LP)-powered equipment is preferred. Such a building should be located at least 50 feet from other buildings to avoid a fire hazard.

3. Gasoline, diesel-, and LP-powered equipment shall receive periodic inspections of exhaust and electrical systems with the results documented. Spark arresters shall be required on exhaust systems.

O. Parking of privately owned vehicles

Controlled parking of privately owned vehicles within an establishment minimizes fire and explosion hazards and prevents congestion in an emergency. Vehicles should be parked in designated areas only, at intraline distance and outside of restricted areas. Vehicles shall not be parked so close to an explosives building or structure that fire could spread from them to the building, or that they could impede firefighters.

P. Prohibited articles in hazardous areas

Except as authorized, personnel shall not carry matches, cigarette lighters, or other flame-producing devices into explosives areas. Personal articles that increase existing hazards are also prohibited.

Q. Photographic materials in hazardous areas

Photoflash bulbs or electronic flash attachments shall not be used around exposed explosives, explosive dusts, flammable gases, or vapors. Only lighting equipment approved by a nationally recognized testing laboratory shall be used.

R. Operational explosives containers

1. Containers used for intraplant transportation or temporary storage of process explosives and energetic materials shall be designed to prevent leakage. These containers should be equipped with covers (lids) and constructed of materials in the following order of precedence:

    a. Conductive rubber or conductive plastic,

b. Nonferrous metal-lined boxes without seams or rivet heads under which explosive dusts could accumulate,

c. Paper-lined wooden boxes, or

d. Fiber drums.

2. These containers should be marked with the type of explosive or hazard involved.

3. Because of their fragility and potential for fragmentation, glass containers shall not be used.

S. Intraplant rail transportation

This section addresses intraplant transportation of explosives and may exceed national requirements because of material characteristics and operational hazards. When construction or major modification of transportation, packaging, or loading facilities is planned, the A&E contractor is responsible for ensuring that applicable Federal, state, and local requirements and those contained within this manual are met. The applicable requirements promulgated by Department of Transportation (DoT) and other Federal or local regulatory agencies concerning preparation, marking, and shipment of ammunition and explosives should be incorporated by reference in the contract.

1. **Operating rules**. Local procedures to ensure safe and efficient rail movement of A&E shall be developed, and shall include the following minimum requirements:

a. Movements in the classification yards are considered switch movements. All others are considered transfer movements. Before cars containing A&E move, air hoses shall be coupled, air brakes cut-in and in proper working order, and the car doors closed. Cars should remain coupled while in motion. Safety precautions shall be observed when breaking air hose connections.

b. When single explosives-loaded cars are spotted, the hand brakes shall be set and the wheels properly chocked. When more than one car is spotted and its engine detached, the hand brakes shall be set on enough cars to ensure sufficient braking. Hand brakes shall be set on the downgrade end of the cut of rail cars. Reliance should not be placed on the automatic air brakes to hold spotted cars.

c. A person should be stationed at the hand brake of a car mover when in use.

d. During transfer movements within establishments, full or partial loads in rail cars shall be blocked and braced so they cannot shift position.

e. Empty rail cars shall remain in warehouses, magazines, buildings, or loading docks until all warning placards have been removed or reversed, as appropriate.

f. Special care shall be taken to avoid rough handling of cars containing A&E. These cars shall not be “sent off” while in motion and shall be carefully coupled to avoid unnecessary shocks. Other cars shall not be “cut off” and allowed to strike a car containing explosives.

g. A buffer car should separate rail cars containing explosives and the switching engine when in motion.

h. Flags or signals at both ends of a rail car or cut of cars shall protect personnel working in, on, or under the cars. During these periods, cars shall not be coupled or moved.

I. Portable transmitters and railroad locomotives equipped with two-way radios shall not transmit when passing explosives operating buildings where electro-explosive devices are in use. The contractor shall determine minimum safe distances based on radio frequency (RF), frequency modulation (FM), and amplitude modulation (AM) of the transmitter.

2. **Pre-loading rail car inspections**

a. Qualified personnel shall inspect empty rail cars intended to transport A&E upon arrival, verifying that the carrier has complied with DOT requirements.

b. Before loading, the brakes shall be set on cars spotted for loading, and bridge plates equipped with side boards and stops shall be provided.

3. **Loaded incoming rail car inspections**

a. Railroad cars with A&E should, upon arrival, be inspected at remote sites. If no problems are found, rail cars may be opened for interior inspection or moved to the designated unloading point.

b. A&E-loaded cars on which foreign and suspicious articles have been attached outside or underneath the car, or that have a defect which could affect the safety of the establishment or the contents of the car, shall be moved to the suspect car site for disposition.

c. Cars should be inspected after unloading A&E to ensure that they are clean and free from loose explosives and flammable materials, and that placards and car certificates have been removed. Explosives swept from the floors shall be disposed of properly.

T. Intraplant motor vehicle transportation

1. **Operating rules**. Procedures for safe transportation of A&E in motor vehicles shall be developed locally, and should include the following:

a. Brakes shall be set and the wheels chocked while loading and unloading.

b. A&E shall not be loaded or unloaded when a motor vehicle's engine is running, unless the engine is providing power to accessories used in the loading and unloading, such as mechanical handling equipment.

c. Vehicles, including, partly or completely loaded flatbeds, shall have the load blocked and braced to prevent shifting during transit.

2. **Vehicle inspections**. All motor vehicles used to transport A&E shall be inspected before loading to ensure the following:

a. Batteries and wiring shall not come into contact with containers of A&E.

b. Exposed ferrous metal in the interior of the vehicle body shall be covered with nonsparking material when scrap and bulk explosives are being transported in containers that could be damaged, or when explosives could otherwise become exposed.

c. A portable fire extinguisher of the appropriate class shall be carried on motor vehicles used for transporting A&E.

d. Motor vehicles transporting A&E within the establishment but outside the explosives area, shall bear at least two appropriate placards. These placards should be removed or covered whenever the vehicle is not loaded. Reflectorized placards are preferred.

e. 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). They should be inspected and cleaned to prevent accumulation of carbon.

3. **Loaded incoming vehicle inspections**

a. Vehicles with A&E should, upon arrival, be inspected at remote sites. If no problems are found, vehicles may be opened for interior inspection or moved to the designated unloading point.

b. A&E-loaded vehicles on which foreign and suspicious articles have been attached outside or underneath the vehicle, or that have a defect which could affect the safety of the establishment or the contents of the vehicle, shall be moved to the suspect car site for disposition.

c. Vehicles should be inspected after unloading A&E to ensure that they are clean and free from loose explosives and flammable materials, and that placards and vehicle certificates have been removed. Explosives swept from the floors shall be disposed of properly.

U. Inspection of pyrotechnic, propellant and explosive mixers

Mixers used for manufacturing pyrotechnics, propellants and explosives shall have an initial inspection prior to use and shall be on a periodic inspection schedule during operating life.

1. The initial inspection shall, as a minimum, require radiographic and dye penetrant inspection of the blades and blade to shaft areas, blade to bowl clearances, allowable tolerances, testing for proper function of operating systems such as bowl positioning mechanisms, safety interlocks, fire detection and prevention and test of computer controller software self-check.

2. Periodic inspection shall be provided during the operating life of the mixer. The inspection program shall be based on manufacturer’s recommendations, operating history of like mixers, and any items identified in hazards analysis of the particular mixer and its operation. The inspection program shall include:

a. Tests and visual inspection criteria to be performed prior to each use to include associated equipment which might come loose and fall into the mixer.

b. Periodic inspections of clearances between blades and bowl at sufficient points to detect any distortion of the bowl or kettle.

c. Inspection and test for drive system wear, bearings condition and gear alignment with loading to establish operation within tolerances when applicable.

d. Inspection and test of proper function of operating subsystems such as bowl handling, safety and fire and control, including computer software self-check.

3. It is recommended that large (over 80 gallon) vertical blade mixers in high torque applications have a dye penetrant check of the blades annually or after every 300 hours of operation. Melt-cast kettles are not considered high torque mixers. Also, it is recommended that an inspection of clearances and operating systems be performed after any maintenance, or unusual events such as severe weather exposure, mishandling of bowl or mixer, or long idle period.

4. A log of the maintenance and inspection shall be maintained. Trend analysis of clearances should be used to detect wear which might become hazardous.

CHAPTER 4

PRINCIPLES AND APPLICATION OF QUANTITY-DISTANCE (Q-D), STANDARD EXPLOSIVES FACILITIES, AND SITING REQUIREMENTS

A. General

Explosives classes and divisions identified in this chapter are defined in TB 700-2,[1] *Explosives Hazard Classification Procedures* (reference (e)), and more fully explained in Chapter 6 . Chapter 4 sets forth the following:

1. Rules for establishing quantities of explosives;

2. Computations and determinations of quantity distance;

3. Assessment of the explosion effects, such as facility damage and personnel injury expected at specific scaled distances for Hazard Division 1.1, explosives;

4. Recommended methods for controlling the effects of Hazard Division 1.1, explosions;

5. Acceptable exposures at specific scaled distances;

6. Types and general specifications of various ammunition and explosives facilities; and

7. Siting requirements for specific facilities.

B. Quantity-distance (Q-D)

1. Quantity distances are determined by establishing a NEW at a point and measuring from that point to an exposure. The source of a Q-D measurement is called a potential explosive site, or PES. For Q-D purposes, one considers the total NEW that will be involved in an accidental explosion at the PES. A PES may be a round of ammunition, a vehicle, an operating building, or simply a location where explosives are stacked.

2. Any building, vehicle, location, or ammunition that is to be protected from an accidental explosion at another source, is called the exposed site, or ES. An ES may contain explosives requiring protection from a second explosive source located a distance away. An ES may also be a home, stadium, a high-rise apartment, a public highway or any other facility or location requiring protection from an accidental explosion.

C. Establishment of quantity of explosives and distances

1. **Quantity of explosives.** The Q-D tables are used to provide appropriate distances from potential explosion sites (PES). The hazard classification of the A&E and the weight of

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1 Copies may be obtained from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

explosives involved are primary characteristics governing the use of Q-D tables. The definitions and methods for determining hazard classifications are in Chapter 6. Methods for determining the NEW is explained in the following:

a. **Mass-detonating explosives (Hazard Division 1.1).** The total weight of explosives (NEW).

b. **Nonmass-detonating explosives.**

(1) **Propellants (Hazard Division 1.3).** The total weight of the propellants alone is the net propellant weight.

(2) **Pyrotechnic items (Hazard Division 1.1 and Hazard Division 1.3).** The sum of the net weights of the pyrotechnic composition and the explosives involved.

(3) **Bulk metal powder and pyrotechnic compositions.** The sum of the net weights of metal powders and pyrotechnic compositions in the containers.

(4) **Other ammunition.** The net weight of high explosives (Hazard Division 1.1), plus any blast contribution determined by test, if any, from propellant, pyrotechnic components, or expelling charges (percent of Hazard Division 1.3).

c. **Combinations of mass-detonating and nonmass-detonating A&E (excluding Hazard Division 1.4).**

(1) When Hazard/Division 1.1 and 1.2 are located in the same site, determine the distances for the total quantity considered first as 1.1 and then as 1.2. The required distance is the greater of the two. When the 1.1 requirements are controlling and the high explosive (HE) equivalence of the 1.2 is known, the HE equivalent weight of the 1.2 items may be added to the total explosive weight of 1.1 items to determine the NEW for 1.1 distance determination.

(2) When Hazard/Division 1.1 and 1.3 are located in the same site, determine the distances for the total quantity considered first as 1.1 and then as 1.3. The required distance is the greater of the two. When 1.1 requirements are controlling and the high explosive (HE) equivalence of the 1.3 is known, the HE equivalent weight of the 1.3 items may be added to the total explosive weight of 1.1 items to determine the NEW for 1.1 distance determinations.

(3) When Hazard/Division 1.1, 1.2, and 1.3 are located in the same site, determine the distances for the total quantity considered first as 1.1, next as 1.2, and finally as 1.3. The required distance is the greatest of the three. As permitted by Paragraphs C.1.c (1 and 2) above, HE equivalent weights for 1.2 and 1.3 items may be used in NEW determinations for Q-D purposes.

Note: For each of the above, when using composite propellants in the presence of HD 1.1 explosives, a TNT equivalency of 50% may be considered for the composites.

d. **Combinations of nonmass-detonating ammunition and explosives of different class 1 divisions shall be treated as follows:**

(1) Determine the required separation for each division.

(2) Use the greatest separation of those determined.

2. **Q-D computations and determinations.**

a. Throughout these requirements, NEW is used to calculate distance by means of formula $D = KW^{1/3}$, where D is the distance in feet, K is the appropriate risk factor and W is the NEW in pounds. Distance requirements are sometimes expressed by the value of K, such as K9, K11, and K18 to signify K = 9, K = 11, K = 18, respectively.

b. The quantity of explosives in a magazine, operating building, or other explosives site shall be the net weight of all the explosives contained therein. Q-D shall be based on the hazard division (H/D) requiring the greatest separation, unless the NEW is divided by walls or shields for that purpose.

(1) When dividing a quantity of mass-detonating explosives into smaller stacks, a suitable barrier or adequate separation distance shall prevent propagation from one stack to another. Barriers designed and constructed in accordance with TM 5-1300/AFM 88-22/NAVFAC P-397,[2] *Structures to Resist the Effects of Accidental Explosions* (reference (f)), satisfy this requirement. In such cases, the explosives content of the stack requiring the greatest distance shall govern. Otherwise Q-D computations shall be based on the sum of the mass-detonating explosives in all of the stacks.

(2) Blast waves coalesce when two or more stacks of mass-detonating explosives detonate within short time intervals (that is, when the time in milliseconds is less than 4 times the cube root of the explosive weight in pounds for lateral target positions and less than 5.6 times the cube root of the explosive weight in pounds for axial target positions). The resultant shock wave shall be that of a single detonation of a charge equal to the sum of the several stacks. The actual separation time between successive detonations is influenced by the spatial separation, geometry, and distribution of explosives; the character of the dividing wall or other barrier; and the sensitivity of the explosives.

c. The quantity of explosives permitted in each of two or more locations shall be determined by considering each location as a PES. The quantity of explosives permitted in each of these locations shall be the amount permitted by the distance specified in the appropriate Q-D tables considering each as a potential target site in turn, except for service magazines (see paragraphs D.1.g and D.2.f), below.

d. Q-D tables are in Chapter 6. The formulae specified in Tables 6-1 through 6-4 may be used to interpolate exact distances for Hazard Division 1.1 explosives. The notes to Table 6-11 provide distance formulae for Hazard Division 1.3 distances.

e. It is impractical to specify Q-D separations large enough to allow for the designed flight range of propulsive units (rockets, missile motors, and catapults) that properly belong in Hazard Divisions 1.1, 1.2 or 1.3. Therefore, maximum flight ranges for self-propelling munitions shall be disregarded. The distance required to afford protection from fragments in credible accident situations, however, shall be established in accordance with the principles in Chapter 6, subsection B.6.

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[2] Tri-service document. Copies may be obtained from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

f. Separation distances for Q-D purposes shall be measured from the nearest part of an exposed structure or site to the nearest wall of the controlling subdivision or structure containing explosives, as appropriate. Separation distances are measured along straight lines. See B.3.

g. Where railroad cars or motor vehicles containing ammunition and explosives are not separated from operating buildings, magazines, or open A&E storage sites in a manner precluding their mass detonation, the separation distance shall be based on the total quantity of explosives and measured from the outside wall of the building, railcar, vehicle, or edge of open stack closest to the target. If the explosives are separated into smaller units so that mass detonation of the explosives in the railcars and motor vehicles and inside unit or units shall not occur, the separation distance shall be measured from the controlling explosives unit, railcar, or vehicle closest to an ES.

3. **Hazard Division 1.1, explosion effects, exposure controls, and degrees of safety afforded.** Facility damage and personnel injury from Hazard Division 1.1 A&E principally depend on blast overpressure and impulse, although for limited quantities fragment hazards may control Q-D. For general purposes, peak incident overpressure is the blast parameter defining maximum permissible levels of exposure. However, in specific instances the physical characteristics of exposed structures (such as mass, stiffness, ductility, and so forth) can make blast impulse the principal damage-causing factor.

a. Separation distances for earth covered magazines (see Tables 6-4 and 6-5) provide virtually complete protection against propagation of explosions among earth-covered magazines by blast, fragments, or fire. Some cracking of concrete barrels and rear walls, spalling and severe cracking of front walls, and damage to doors and ventilators may, however, occur.

b. Above ground magazine distances (see columns 10 and 12 of Table 6-4) provide considerable protection against propagation of explosions among above-ground magazines by blast. Depending on explosive type, however, there is a risk of delayed propagation by fragments or of fire spreading from one magazine to another. Properly designed and placed barricades reduce the risk of communicating explosion through high-velocity, low-angle fragments. Without barricades, this risk is high.

(1) The above ground magazine separation distance of $6W^{1/3}$ feet corresponds to a peak overpressure level of 27 psi (1.8 bars) (1 bar = 14.5 psi) when the explosion source is in the open. Neither the overpressure nor any other pertinent blast parameter, such as impulse, are significantly reduced by an ordinary storage building of conventional unstrengthened industrial construction at the explosion site, or by the barricade required between aboveground magazines at this distance. Conventional unstrengthened buildings exposed at this distance are destroyed, vehicles overturned and crushed, and all occupants killed.

(2) The unbarricaded aboveground magazine separation distance of $11W^{1/3}$ feet corresponds to a peak overpressure level of 8 psi (0.5 bars) from an explosion source in the open. Blast observed at this distance is suppressed only slightly by a storage building of conventional construction at the explosion site. Conventional unstrengthened buildings exposed at this distance are destroyed. Blast will seriously injure eardrums and lungs of any survivor, as will being blown down or struck by fragments or building debris. Vehicles will be severely damaged by blast and may be inoperable.

c At blast overpressure of 12 psi (0.7 bars) occurring at scaled distance of $9W^{1/3}$ feet (see Tables 6-2 and 6-3):

(1) Unstrengthened buildings will suffer severe structural damage approaching total destruction.

(2) People at the exposed site will be killed or severely injured by being thrown about by blast or by building collapse.

(3) Aircraft will be damaged beyond repair. If the aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires.

(4) Transport vehicles will be heavily damaged, probably to the extent of total loss.

(5) Direct propagation of explosion between two explosives locations is unlikely when barricades between them intercept high-velocity, low-angle fragments (see Subsection D.1), below.

(6) Improperly designed barricades or structures increase the hazard from flying debris; further, their probable collapse threatens personnel and equipment.

(7) Exposed structures housing personnel or containing equipment that is monetarily valuable or critically important to the mission, may require hardening.

d. At blast overpressure of 3.5 psi (0.24 bars) occurring at scaled distance of $18W^{1/3}$ (see Table 6-2):

(1) Direct propagation of explosion is not expected.

(2) Delayed communication of explosion from fires, or equipment failure at the exposed site (ES), is possible.

(3) Unstrengthened buildings will sustain serious damage, approximating 50 percent of the total replacement cost.

(4) Personnel will be critically injured or killed by fragments, debris, firebrands, and so forth.

(5) There is a 1 percent chance of eardrum damage to personnel.

(6) Aircraft will be severely damaged from blast, fragments, and debris.

(7) Transport vehicles' body panels will be dished and shatter-resistant window glass will crack. Though extensive, this damage will not prevent the vehicles from operating.

(8) Overpressure control by suppressive construction at the PES, or by protective construction at the ES, is recommended if it is more economical than distance alone, or if distance cannot suffice.

e. At blast overpressure of 2.3 psi (0.16 bars) occurring at scaled distance of $24W^{1/3}$ (for quantities up to 100,000 pounds, see column 8 of Table 6-1).

(1) Unstrengthened buildings will sustain damage approximating 20 percent of their replacement cost.

(2) Occupants of exposed structures may suffer temporary hearing loss or be injured by such blast effects as building debris and being bodily thrown about.

(3) Personnel in the open should not be seriously injured by the blast itself. Fragments and debris could, however, cause injuries, depending on the PES structure and the fragmentation characteristics and amount of ammunition or explosive within.

(4) Vehicles on the road should not be damaged unless hit by fragments or the operator loses control during the blast wave.

(5) Aircraft appendages and sheet metal skin could be damaged by blast and possibly fragment penetrations, but should be operational after minor repairs.

(6) Barricading at the PES reduces injury and damage from fragments from limited quantities of explosives. Suppressive construction at the PES or protective construction at the ES are practical ways of controlling blast over-pressure.

f. At blast overpressure of between 2.3 psi (0.16 bars) and 1.7 psi (0.1 bars) effects and controls are intermediate between those described in paragraphs C.3.e, above and C.3.g, below (for quantities between 100,000 and 250,000 pounds, see column 8 of Table 6-1).

g. At blast overpressure of 1.7 psi (0.1 bars) occurring at scaled distance of $30W^{1/3}$ (for quantities over 250,000 pounds, see column 8 of Table 6-1):

(1) Unstrengthened buildings will sustain damage approximating 10 percent of their replacement cost.

(2) Occupants of exposed unstrengthened structures may suffer injury from secondary effects, such as building debris.

(3) Aircraft landing and taking off could lose control and crash.

(4) Parked military and commercial aircraft, with minor damage due to blast, should remain airworthy.

(5) Personnel in the open should not be seriously injured by the blast itself. Depending largely upon the PES structure and the fragmentation characteristics and amount of ammunition or explosive within, however, fragments and debris could cause injuries.

(6) Barricading at the PES or application of minimum fragment distance requirements may reduce injury or damage due to fragments from limited quantities of explosives.

h. At blast overpressure of 1.2 - 0.90 psi (0.08 - 0.06 bars) occurring at scaled distance of $40W^{1/3}$ - $50W^{1/3}$ (see column 5 of Table 6-1):

(1) Unstrengthened buildings will sustain damage approximating 5 percent of their replacement cost.

(2) Personnel injuries are principally caused by glass breakage and building debris.

(3) Personnel in the open should not be seriously injured by the blast itself. Depending largely upon the PES structure and the fragmentation characteristics and amount of ammunition or explosive within, however, fragments and debris could cause injuries.

(4) Both orientation and limiting the surface area of exposed glass panels can reduce breakage and structural damage.

D. Permissible exposures to blast overpressure

1. At sites exposed to potential blast overpressure of 12 psi (0.7 bars) occurring at $9W^{1/3}$ (see column 3 of Table 6-2 and Table 6-3), a barricade is required unless otherwise indicated (see subparagraph C.3.c (7)), above, the following facilities or operations are permitted:

a. Buildings housing successive steps of a single production, renovation, or maintenance operation.

b. Breakrooms and change houses, if part of an operating line and used exclusively by personnel employed in operations of the line.

c. Temporary holding areas for trucks or railcars containing explosives to service production or maintenance facilities.

d. Field operations in magazine areas, when performing minor maintenance, preservation, packaging, or surveillance inspection.

e. Unmanned auxiliary power facilities, transformer stations, water treatment and pollution abatement facilities, and other utility installations that serve the PES but are not integral, the loss of which would not create an immediate secondary hazard. These do not need barricades. However, unmanned auxiliary power generating or converting facilities supplying power exclusively to the explosives storage area and security fence lighting may be located as close as fire distance from explosives facilities (50 feet for fire resistant structures and 100 feet for non-fire resistant structures).

f. Dunnage preparation and similar support structures housing non-explosives operations, if used only by PES employees.

g. Service magazines that are a part of operating lines. Distances are based on the quantity/type of ammunition or explosives in the service magazine(s), not in the operating building.

h. Exposures as indicated in subsection D.2, below, if blast suppression, structure hardening, and so forth, provides comparable protection for the personnel and equipment involved.

2. At sites exposed to potential blast overpressure of 3.5 psi (0.24 bars) occurring at $18W^{1/3}$ (see column 4 of Table 6-2 and Table 6-3), the following facilities or operations are permitted:

a. Construction workers in the vicinity of ammunition production areas, waterfront areas where ammunition is being handled, or areas for loading explosives onto aircraft.

b. Surveillance, maintenance, and inspection buildings; and labor-intensive operations closely related to the PES.

c. Comfort, safety, and convenience buildings exclusively supporting PES, including lunchrooms, motor pools, area offices, auxiliary fire stations, transportation dispatch points, and shipping and receiving buildings (not magazine area loading docks).

d. Operations and training functions manned or attended only by personnel operating the PES.

e. Service magazines that are part of operating lines. Distances are based on quantity/type of ammunition or explosives in the service magazine(s), not in the operating building.

f. Container stuffing and unstuffing operations that are routine support of the PES. This applies to main support functions set aside for support of manufacturing operations. Container stuffing and unstuffing in magazine areas are permitted at intermagazine distances.

3. At sites exposed to potential blast overpressure of 2.3 psi (0.16 bars) occurring at $24W^{1/3}$ (see column 8 of Table 6-1), the following facilities or operations are permitted:

a. Public traffic routes for NEW under 100,000 pounds.

b. Personnel exposed to remotely controlled operations. NOTE: Personnel at control stations less than $24W^{1/3}$ from the PES, though provided with blast-attenuating and fragment-defeating shields, shall not be exposed to overpressure greater than 2.3 psi (0.16 bars).

c. Open-air recreation facilities exposed to PES containing NEW of up to 100,000 pounds, such as baseball diamonds, volleyball courts, and so forth, used by personnel assigned to the facility, where structures are not involved.

4. At sites exposed to potential blast overpressure of 1.7 psi (0.1 bars) occurring at $30W^{1/3}$, the following facilities or operations are permitted:

a. Public traffic routes.

b. Private vehicle parking in administrative areas. Minimum fragment distance should be applied.

5. At sites exposed to potential blast overpressure of 1.2 - 0.90 psi (0.08 - 0.06 bars) occurring at $40W^{1/3}$ to $50W^{1/3}$ (see column 5 of Table 6-1), the following facilities or operations are permitted:

a. Inhabited buildings; administrative and housing areas.

b. Plant boundaries and magazines servicing the establishment in general (see Subsection F.10).

c. Athletic fields and other recreation areas when structures are present.

d. Flight line passenger service facilities.

e. Utilities providing power to most of an establishment.

f. Storehouses and shops having strategically or intrinsically valuable contents which shall not be jeopardized.

g. Functions which, if momentarily out of action, would cause an immediate secondary hazard.

E. Ammunition and explosives facilities

This section identifies the types, general specifications, and siting requirements of various magazines for ammunition, explosives, and other dangerous materials.

1. Barricades and earth cover for magazines

a. **General**. Both constructed barricades and undisturbed earth can protect ammunition and explosives, structures, and operations against high-velocity, low-angle fragments, although the barricades may be destroyed in the process. However, barricades provide limited protection against blast in their immediate vicinity, provide no protection against high-angle fragments, and are ineffective in reducing the blast pressure in the far field (inhabited building or public traffic route distance).

b. **Barricade requirements.** Protection is considered effective when barricades meet the following minimum requirements:

(1) The slope of a barricade will not be steeper than 2/3 (rise/run). To reduce erosion and facilitate maintenance operations, future constructions should have a slope of 1/2.

(2) The earth barricade shall consist of material described in Paragraph E.1.d.

(3) Barricade height and length shall be determined as follows:

(a) **Heights.** Establish a reference point at the top of the far edge of one of the two stacks that the barricade is to separate. If the tops of the stacks are at different elevations, this reference point shall be on the lower stack. Draw a line from the reference point to the top of the other stack. Draw a second line from the reference point to form a 2 degree angle above the first line. To limit barricade height, each should be as close as possible to the stack that served as the reference point. See Figures 4-1 and 4-2.

(b) **Lengths.** The length of the barricade shall be determined as shown in Figure 4-3.

(4) Earth barricades meeting the previously identified requirements may be modified by substituting a retaining wall, preferably of concrete, for the slope on one side. The other side shall have slope and thickness sufficient to ensure that the width of earth required for the top is held firmly in place.

(5) Other barriers, such as earth-filled steel bin barricades for explosives-loaded aircraft, may also be used.

c. **Location of barricades.** The distance between the foot of the barricade and the stack of ammunition or explosives or the buildings containing explosives represents a compromise. The shorter the distance, the shorter the height and length required for the barricade. However, it may be necessary to extend the distance to provide access for maintenance and vehicles. If it is impracticable to locate the barricades near the stack of ammunition or explosives or building containing explosives, barricades may be located adjacent to the facility to be protected.

d. **Earth cover for magazines and barricades**

(1) Earth cover material for magazines and barricades shall be relatively cohesive (solid or wet clay and similar types of soil are too cohesive and should not be used), free from unsanitary organic matter, trash, debris, and stones heavier than 10 pounds or larger than 6 inches in diameter. The larger stones should be limited to the lower center of fill and never used for earth cover over magazines. Compaction and surface preparation shall be provided, as necessary, to maintain structural integrity and avoid erosion. Where cohesive material cannot be used, as in sandy soil, the barricade or the earth cover over magazines should be finished with a suitable material to ensure structural integrity.

(2) The earth fill or earth cover between earth-covered magazines may be either solid or sloped, in accordance with the requirements of other construction features, but a minimum of 2 feet of earth cover shall be maintained over the top of each magazine and a minimum slope of 2/3 (rise/run) starting directly above the spring line of each arch shall be maintained. To reduce erosion and facilitate maintenance operations, future constructions should have a slope of 2 horizontal to 1 vertical.

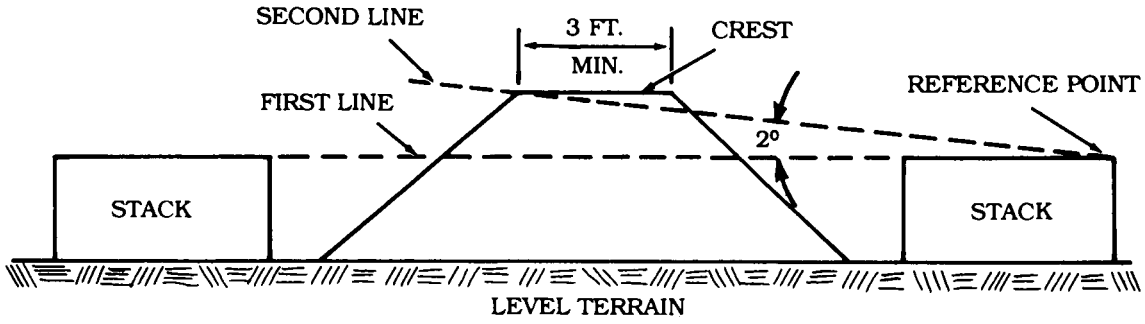

Figure 4-1. Determination of Barricade Height (Level Terrain).

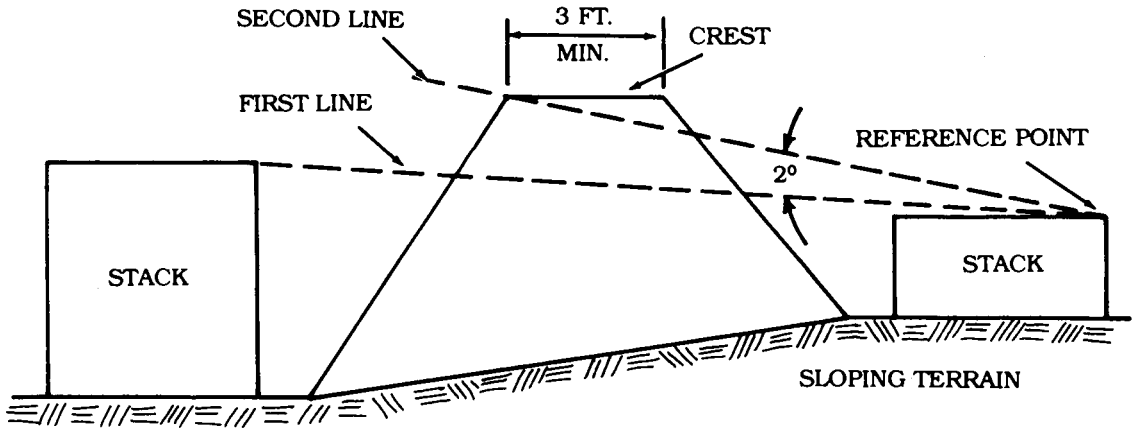

Figure 4-2. Determination of Barricade Height (Sloping Terrain).

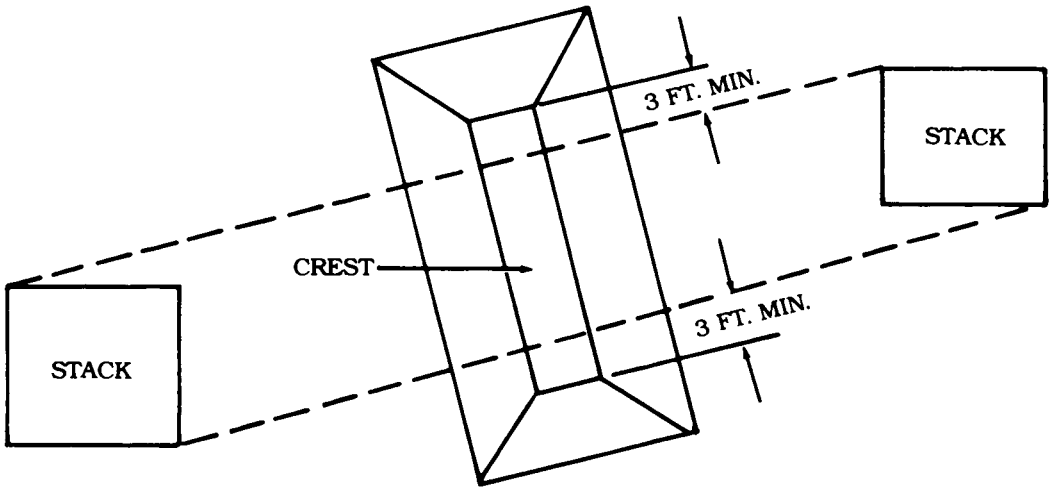

Figure 4-3. Determination of Barricade Length

2. **Application of Q-D to earth-covered magazines**

a. For application of Q-Ds, magazines shall not have been structurally weakened to the extent that they could not be expected to prevent propagation of explosives. The specified thickness and slope of the earth cover shall be maintained.

b. Normally, earth-covered magazines shall not be constructed to face door-to-door. They should face in the same direction with the long axes parallel to each other. In special cases where topographic or other important considerations would result in different orientations, they shall be sited in accordance with Chapter 6, section D.

3. **Policy on protective construction.** The present "state of the art" in protective construction is such as to permit any calculated level of protection from explosion communication between adjacent bays or buildings, personnel protection against death or serious injury from incidents in adjacent bays or buildings, and protection of vital and expensive equipment installations. Therefore, the major objectives in facility planning should be:

a. Protection against explosion communication between adjacent bays or buildings and protection of personnel against death or serious injury from incidents in adjacent bays or buildings. In situations where the protection of personnel and facilities would be greatly enhanced or costs significantly reduced by having separate buildings to limit explosion propagation rather than using protective construction and separation of explosive units within one building, planning should reflect this fact.

b. Provision of protection for vital and expensive equipment, if the additional cost is warranted.

c. When an appropriate degree of protection can be provided either by hardening a target building or constructing a source building to suppress/explosion effects, these factors may be taken into account and the distances required by the standard Q-D tables reduced. The rationale or test results justifying the reduction shall accompany A&E site and general construction plans

proposing reduced distances based on protective construction, when submitted through the ACO for PCO approval.

F. Specific siting requirements

1. **Rail and truck holding yards**

a. Generally, rail holding yards should be laid out on a unit car/group basis with each unit car/group separated by the applicable aboveground magazine distance.

b. If the rail holding yard is formed by two parallel ladder tracks connected by diagonal spurs, the parallel tracks and the diagonal spurs shall be separated by applicable aboveground magazine distances for the unit/group/quantities of high explosives.

c. If the rail holding yard is a “Christmas tree” arrangement, consisting of a ladder track with diagonal dead-end spurs projecting from each side at alternate intervals, the spurs should be separated by the applicable aboveground magazine distance for the net quantity of HE in the cars on the spurs.

d. Generally, truck holding yards should be laid out on a unit truck/group basis with each group separated by the applicable aboveground magazine distances.

e. Both rail and truck holding yards shall be separated from other facilities by the applicable Q-D criteria.

f. In addition to the temporary parking of railcars, trucks or trailers containing ammunition and explosives, holding yards also may be used to interchange truck trailers or railcars between commercial carrier and the contractor and to conduct visual inspections.

2. **Classification yards**

a. To protect the classification yard from external explosions,separation distances shall, at least, be the applicable magazine distance.

b. Specific Q-D separation is not required from the classification yard to targets other than explosive locations when the classification yard is used exclusively for the following:

(1) Receiving, dispatching, classifying, and switching of cars.

(2) Interchanging of trucks, trailers, railcars, or military vans (MILVANS)/tractor vans between the common carrier and the establishment.

(3) Conducting external inspection of motor vehicles and railcars, or opening of free-rolling doors of railcars for the purpose of removing documents and making a visual inspection of the cargo.

c. If the yard is used at any time for any purpose other than listed in Paragraph F.2.b, such as placing or removal of dunnage or explosive items into or from cars, Q-D tables apply. See Paragraphs C.2.a through C.2.g, above.

3. **Railcar and motor vehicle inspection stations**

a. Specific Q-D separations are not required for inspection stations; however, they should be as remote as practicable from hazardous or populated areas. The following activities

may be performed at the inspection station after railcars or motor vehicles containing ammunition and explosives are received from the delivering carrier, before further routing within the installation:

(1) Visual inspection of railcar and motor vehicle exteriors.

(2) Visual inspection of the cargo in vehicles (trucks, trailers, railcars, MILVANS, and so forth) that have passed the external inspection previously indicated.

(3) Interchange of trucks, trailers, railcars, or MILVANS between the common carrier and the establishment.

b. If any activities, other than those previously listed, are conducted at the inspection station, Q-D tables apply.

c. Any cars or trucks suspected of being hazardous shall be isolated consistent with applicable Q-D separation for the hazard class and explosives quantity involved. This shall be accomplished before any subsequent action.

4. **Administration, industrial, and convenience areas**

a. Administration and industrial areas shall be separated from PES's by inhabited building distances.

b. Auxiliary facilities such as heating plants, line offices, break areas, briefing rooms for daily work schedules or site safety matters, joiner shops, security posts, and similar functions that are required to be at explosives operations and servicing only one building or operation shall be so located and constructed as to provide prudent fire protection.

5. **Underground tanks or pipelines.** These should be separated from buildings or stacks containing A&E of Hazard Divisions 1.2 through 1.4 by a minimum distance of 80 feet. The separation for Hazard Division 1.1, should correspond to the formula $D = 3W^{1/3}$ with a minimum distance of 80 feet, unless the donor building is designed to contain the effects of an explosion.

6. **Storage tanks built on or above the surface of the ground**

If protection of above-ground storage tanks is required, the distances in column 5 of Table 6-1 shall apply.

7. **Recreational, training, and other such areas.** Open areas between explosives storage and handling sites and between these sites and non-explosives buildings and structures, should be carefully controlled, when used as employee recreation or training facilities. The severe fragment hazard will usually extend from the explosion site to approximately the public traffic route distances. Accordingly, exposed recreation and training facilities where employees are in the open shall be sited at not less than public traffic route distances and as close to inhabited building distances as practicable. When structures, including bleachers, are included as part of these facilities, they shall be sited at not less than inhabited building distances.

8. **Demolition or burning areas.** Sites for demolition and burning of explosives shall be separated from other facilities based on the hazards associated with the quantity and type of material to be destroyed. See Chapter 15, Section D for specific requirements.

9. **Adjacent operating lines.** These shall be separated from one another by no less than unbarricaded intraline distance ($18W^{1/3}$) for the hazard class and explosive quantities involved, whether or not barricaded, and provided that ammunition and explosives involved in each operating line present similar hazards. The criticality of survivability of one or more of the operating lines may require that each line be given an inhabited building distance level of protection.

10. **A&E storage magazines.** A&E storage locations that service the establishment in general shall be separated by appropriate inhabited building distance (blast overpressure or fragmentation, whichever applies) from A&E operating lines/locations, inert areas (warehouses, shops, administrative facilities, and so forth) and property boundaries.

11. **Spacing for movement of ammunition and explosives within operating lines.** Items or groups of items of ammunition and explosives that are transported from one operating building to another, or from bay to bay within an operating building, shall be separated to preclude the establishment of a path for the propagation of an explosion or fire between the buildings or bays. For this purpose, the minimum spacing between items, or groups of items, in transport shall be intraline distance unless reduced distances have been approved by the PCO.

CHAPTER 5

STORAGE COMPATIBILITY SYSTEM

A. General

1. Storage of A&E is based on the compatibility requirements of this chapter and the hazard classification requirements of Chapter 6.

2. Compatibility groups (CGs) and hazard classification for DoD A&E items and materials are listed in the Joint Hazard Classification System (JHCS) (see TB 700-2, *Explosive Hazard Classification Procedures* (reference (e)). Additional information may be available from the procuring activity in the form of Hazardous Component Safety Data Statements (HCSDS) for intermediate materials and items. When the solicitation or contract lacks such information, it may be requested through contract channels.

3. Compatibility and hazard classification information relating to other hazardous materials, including A&E, not contained within the JHCS, can be derived from references such as those cited below.

a. Title 49, Code of Federal Regulations, Transportation, Parts 100 - 199 (reference (g)).

b. National Fire Protection Association, Manual 491M (reference (h)).[1]

c. Data sheets developed by the National Safety Council.

d. Data sheets developed by the Chemical Manufacturers Association.

e. Manuals and books providing information on the properties of hazardous materials. There are a number of competent guides to the safety precautions required when handling potentially hazardous materials. These guides typically provide basic precautions, specific hazardous reactions, and industrial hygiene information. Additional guidance for industrial hygiene and industrial medicine is available from the American Council of Governmental and Industrial Hygienists, Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH).

4. The previous guidance is applicable for storage and transportation only and is not intended for in-process applications. For in-process application, refer to Chapter 6.

B. Compatibility groups (CGs)

1. **Storage principles**

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[1] Copies may be obtained from the National Fire Protection Association, Batterymarch Park, Attn: National Fire Codes Subscription - Service Department, Quincy, MA 02269.

a. The highest degree of safety in A&E storage could be assured if each item or division were stored separately. However, such ideal storage is not generally feasible. A proper balance of safety and other factors frequently requires mixing of several types of ammunition and explosives in storage.

b. A&E shall not be stored with dissimilar materials or items that present hazards to the munitions. Examples are mixed storage of A&E with flammable or combustible materials, acids, or corrosives.

c. Different types of A&E may be mixed in storage, by item and division, provided they are compatible. A&E are assigned to a CG when they can be stored together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

d. A&E should be mixed in storage only when such mixing will facilitate safe operations and promote overall storage efficiency.

e. As used in these requirements, the term "with its own means of initiation" indicates that the ammunition has its normal initiating device assembled to it and this device is considered to present a significant risk during storage. However, the term does not apply when the initiating device is packaged in a manner that eliminates the risk of detonating the ammunition if the initiating device should accidentally function, or when fuzed end items are configured and packaged to prevent their inadvertent arming. The initiating device may even be assembled to the ammunition, provided its safety features preclude initiation or detonation of the explosives filler of the end item if the initiating device should accidentally function.

2. **Compatible ammunition and explosives**

a. Different kinds of A&E within one compatibility group are compatible and may be stored together, except for some items in CG K and L (see Table 5-1).

b. Ammunition and explosives in substandard or damaged packaging, in a suspect condition, or with characteristics that increase the risk in storage are not compatible with other A&E and shall be stored separately.

3. **CGs.** A&E are assigned to one of thirteen CGs, designated A through H, J, K, L, N, and S:

a. **Group A - initiating explosives.** Bulk initiating explosives that have the sensitivity to heat, friction, or percussion necessary for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, and dry PETN.

b. **Group B.** Detonators and similar initiating devices not containing two or more independent safety features. Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and fuzes.

c. **Group C.** Bulk propellants, propelling charges, and devices containing propellant with or without their own means of ignition. Items that upon initiation will deflagrate, explode, or detonate. Examples are single-, double-, triple-base, and composite propellants; rocket motors (solid propellant); and ammunition with inert projectiles. Liquid propellants are not included.

d. **Group D.** Black powder, high explosives (HE), and ammunition containing HE without its own means of initiation and without propelling charge and fuzes with two or more safety features. A&E that can be expected to explode or detonate when any given item/component thereof is initiated (except for fuzes with two or more safety features). Examples are bulk TNT, composition B, wet RDX or PETN, bombs, and CBU's.

e. **Group E.** A&E containing HE without its own means of initiation and with propelling charge. Examples are artillery ammunition, rockets, and guided missiles.

f. **Group F.** Ammunition containing HE with its own means of initiation, not meeting requirements of paragraph B.1.e, above, and with or without propelling charge. HE ammunition or devices (fuzed), with or without propelling charges. Examples are grenades, sounding devices, and similar items having an in-line explosive train in the initiator.

g. **Group G.** Fireworks; illuminating, incendiary, smoke (including HC), or tear-producing munitions other than those munitions that are water-activated or contain white phosphorus or flammable liquid or gel.

h. **Group H.** Ammunition containing both explosives and white phosphorus (WP) or other pyrophoric material. Ammunition in this group contains fillers which are spontaneously flammable when exposed to the atmosphere.

I. **Group J.** Ammunition containing explosives and flammable liquids or gels, with or without explosives. Ammunition in this group contains flammable liquids or gels other than those that are spontaneously flammable when exposed to water or the atmosphere. Examples are liquid- or gel-filled incendiary ammunition; FAE devices; flammable, liquid-fueled missiles; and torpedoes.

j. **Group K.** Ammunition containing both explosives and toxic chemical agents. Ammunition in this group contains chemicals specifically designed for incapacitating effects more severe than lachrymation. Examples are artillery or mortar ammunition, fuzed or unfuzed, grenades, and rockets or bombs filled with a lethal or incapacitating chemical agent (see note 8 of Table 5-1).

k. **Group L.** Ammunition not included in other compatibility groups, having characteristics that do not permit storage with other types of ammunition or kinds of explosives. Examples are water-activated devices; prepackaged, hypergolic liquid-fueled rocket engines; TPA (thickened TEA); and damaged or suspect ammunition of any group. Types presenting similar hazards (that is, oxidizers with oxidizers, fuels with fuels, etc.) may be stored together but not mixed with other groups.

l. **Group N.** Ammunition containing only extremely insensitive detonating substance (EIDS); examples are bombs and warheads.

m. **Group S.** Ammunition presenting no significant hazard. All hazardous explosive effects are confined and self-contained within the item or package. An incident may destroy all items in a single pack but must not communicate to other packs. Examples are thermal batteries, explosive switches or valves, and other ammunition items packaged to meet this criterion.

4. **Mixed storage**

a. Mixing of CG's is permitted as indicated in Table 5-1. For purposes of mixing, all items shall be packaged in approved storage containers.

b. Items from CG's C, D, E, F, G, J, and S may be combined in storage, provided the net quantity of explosives in the items or in bulk does not exceed 1000 pounds per storage site.

c. In addition to paragraph B.4.b, above, items assigned to Hazard Division 1.4, CG C, G, or S, may be combined in storage without regard to explosives quantity limitations.

C. Explosives hazard classification procedures

TB 700-2/NAVSEAINST 8020.8/TO 11A-1-47/DLAR 8220, *DoD Explosives Hazard Classification Procedures* (reference (e)), shall be used as a basis for assignment of hazard class/division to all ammunition and explosives.

Table 5-1. Storage Compatibility Mixing Chart.

Group	A	B	C	D	E	F	G	H	J	K	L	N	S
A	X	Z											
B	Z	X	Z	Z	Z	Z	Z					X	X
C		Z	X	X	X	Z	Z					X	X
D		Z	X	X	X	Z	Z					X	X
E		Z	X	X	X	Z	Z					X	X
F		Z	Z	Z	Z	X	Z					X	X
G		Z	Z	Z	Z	Z	X					X	X
H								X					X
J									X				X
K										Z			
L													
N		X	X	X	X	X	X					X	X
S		X	X	X	X	X	X	X	X			X	X

Notes:

1. An "X" indicates that the intersecting groups may be combined in storage.Otherwise, mixing is either prohibited or restricted per note 2.
2. A "Z" indicates that, when warranted by operational considerations or magazine nonavailability, and when safety is not sacrificed, the intersecting groups may be combined in storage. Operational considerations include conditions that waste resources such as money, manpower, and energy, or compromise security, readiness, or the ability to accomplish the installation mission. Storage personnel, after consultation with safety personnel, should determine when operational considerations exist that warrant "Z" storage compatibility mixing. Examples of acceptable combinations of class 1 follow:
   a. Division 1, group C, bulk propellants with division 1, group G, fireworks.
   b. Division 1, group C, rocket motors with division 1, group F, ammunition with its own means of initiation.
   c. Group C rocket motors with group B detonators and similar initiating items.
3. Equal numbers of separately packaged components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled round; that is, WP filler in group H, HE filler in group D, E, or F, as appropriate.

4. See Subsection B.5 for permissible mixed storage of quantities of 1000 pounds or less.
5. Ammunition designated “practice” or “target practice” by national stock number and nomenclature may be stored with the fully loaded ammunition it simulated (for example, 2.75 inch TP rockets with WP rockets).
6. Ammunition items without explosives containing substances more suited to another hazard division may be assigned to the same compatibility group as items containing explosives and the same substances, and be stored with them.
7. Articles of Compatibility Group B and F shall each be segregated in storage from articles of other compatibility groups by means which are effective in the prevention of propagation to those articles.
8. Group K requires not only separate storage from other groups, but also may require separate storage for different items within the group. Before storage of mixed items in Group K, PCO approval shall be obtained.
9. If dissimilar Hazard Division 1.6, Group N munitions, such as Mk 82 and Mk 84 Bombs, are mixed together and have not been tested to assure non-propagation; the mixed munitions are considered to be Hazard Division 1.2, Compatibility Group D for purposes of transportation and storage.

CHAPTER 6

HAZARD CLASSIFICATION AND QUANTITY-DISTANCE (Q-D) CRITERIA

A. General

1. This chapter outlines Q-D requirements applicable to storage, processing, and handling of A&E. The maximum amount of explosives permitted at any location is determined by the distance from that location to other exposed sites and the hazard classification assigned to the A&E involved. The applicable Q-D table in this chapter shall be used to determine this distance. Greater distances than those shown in the tables should be used when practicable.

2. Distances required in the standard Q-D tables may be reduced if structural data or engineering demonstrate that explosion effects will be reduced or eliminated through containment, direction or suppression shields or building volume. The rationale or test results justifying the proposed distance reduction shall accompany A&E site and general construction plans when submitted through the ACO for the PCO's approval. See Chapter 1, Section F.

B. Hazard classes and class divisions

1. The United Nations Organization (UNO) classification system consists of nine hazard classes, with ammunition and explosives included in Class 1; however, some items containing explosives components may be included in other classes based upon the "predominant hazard" of that item (flammable liquids or compressed gas). Thirteen compatibility groups (CGs) are included for segregating ammunition and explosives on the basis of similar characteristics, properties, and potential accident effects.

2. The A&E hazard classes are further subdivided into "divisions" according to the associate hazards, including the potential for causing personnel casualties or property damage as shown:

Hazard Class and Division Designator	Hazards
1.1	mass detonating
1.2	nonmass-detonating fragment producing
1.3	mass fire
1.4	moderate fire, no blast
1.5	extremely insensitive detonating substances (EIDS)
1.6	EIDS loaded items

3. DoD Explosives Hazard Classification Procedures (TB 700-2, NAVSEAINST 8020.8, TO llA-l-47 and DLAR 8220.1 (reference (e)) shall be used as a basis for assignment of hazard divisions to all DoD ammunition and explosives. These classifications pertain to A&E packaged for transportation and storage. However, such hazard classification information may not be valid when applied to the hazards associated with manufacturing or loading processes. For such processes, the materials and processes shall be analyzed on a case-by-case basis. Sources of

information to support this process of analysis are available from service research and development organizations through contract channels, and other sources. Chapter 16, Section B for propellants is an example of an acceptable approach. Chapter 8, Sections C through K provide examples of processes requiring analysis to determine the hazards.

4. The separation of the A&E hazard classes into the several divisions does not necessarily mean that the different items in a division may be stored together. Also, some items may appear in more than one division, depending upon factors such as the degree of confinement or separation, type of packaging, storage configuration, or state of assembly.

5. The maximum amount of explosives permitted in any location is limited by the Q-D criteria. Explosives limits shall be established in amounts no greater than those consistent with safe and efficient operations.

6. A numerical figure (in parentheses) is used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands when distance alone is relied on for such protection. This number shall be placed to the left of the division designators 1.1 through 1.3, such as (18)1.1, (08)1.2, and (06)1.3. The following apply to minimum fragment distances:

a. A hazardous fragment is one having an impact energy of at least 58 ft-lb and a hazardous fragment density is constituted by at least one hazardous fragment impacting in an area of 600 square feet or less. Fragment distances do not indicate the maximum range to which fragments may be projected.

b. For divisions 1.1 and 1.3, a minimum distance number shall be used where the ranges of hazardous fragments and firebrands EXCEED the distances specified for inhabited buildings in the applicable Q-D table.

c. Minimum fragment distance protects personnel in the open; minimum firebrand distance primarily protects facilities.

d. Examples where minimum fragment and firebrand distances for Hazard/Divisions 1.1 and 1.3 need not be applied follow:

(1) Recreation or training facilities, if these facilities are for the exclusive use of personnel assigned to the PES.

(2) Between PES and relatively static inert storage areas.

(3) Between facilities in an operating line, between facilities and holding sites in an operating line, between operating lines, and between operating lines and storage locations normally separated by inhabited building distances (IBD) to protect workers and ensure against interruption of production.

e. The minimum distance for protection from hazardous fragments shall be based on the debris producing characteristics of the PES and the population density of the ES. For populous locations, the minimum distance shall be that distance at which fragments, including debris from structural elements of the facility or process equipment, shall not exceed a hazardous fragment density of one hazardous fragment per 600 square feet ($56m^2$). If this distance is not known, the following shall apply:

(1) For all Hazard Division 1.1 A&E, the minimum distance to exposures shall be 670 feet for 100 pounds NEW or less. In quantities of 101 to 30,000 pounds NEW, the minimum distance shall be 1,250 feet. These distances may be reduced when it can be shown by test data that reductions are warranted or when other alternatives, as described in Paragraphs B.6.f through B.6.i are used. For items that have been evaluated adequately, different minimum distances may be used. (Facilities sited at 1,235 or 1,245 feet in accordance with past requirements shall be considered to be in compliance with the 1,250 foot minimum requirement.)

(2) For public traffic routes (PTR) that are not probable sites for future construction, and for other exposures permitted at public traffic route distances from PES, fragment and firebrand minimum distances for Hazard Divisions 1.1 and 1.3 may be reduced to 60 percent of these requisite distances.

f. For sparsely populated locations on or off the establishment, the minimum fragment distance can be reduced to 900 ft. if certain specific conditions exist as follows:

(1) No more than 25 persons are located in any sector bounded by the sides of a 45 degree angle, with the vertex at the PES, and the 900 ft. and 1,250 ft. arcs from the PES, and

(2) The NEW of the PES does not exceed 11,400 pounds.

g. Minimum fragment distances may extend onto uninhabited areas such as wildlife preserve, desert, prairie, swamp, forest or agricultural land, adjacent to contractor facilities but not within control of the contractor. However, without a restrictive easement in effect, construction of inhabited buildings or other exposures in these areas, would reimpose minimum fragment distance.

h. In lieu of the minimum fragment distances prescribed, other alternatives, which reduce or eliminate the fragment hazard, may be used for requirements compliance, per subsection A.2, above. Examples include:

(1) Use distance demonstrated by testing, accident experience or engineering studies.

(2) Use protective structures.

(3) Use containment facilities or suppressive shields or other fragment control devices.

(4) Design/locate equipment to reduce fragment generation or to control the direction of fragmentation.

(5) Use barricades or terrain where possible to stop low angle, high velocity fragments.

i. Fragment distance need not be applied when it is demonstrated by structural analysis, shielding test or other documentation that building construction and volume shall confine fragments and debris resulting from an explosives accident.

7. In the application of inhabited building and public traffic route distances, the property boundary shall be treated as the governing target. In interpreting application to navigable waterways as public traffic routes, occasional small fishing and pleasure boats may be ignored.

C. Hazard Division 1.1 - mass detonating

1. Entire quantities of items in this division can detonate almost instantaneously. Some examples: bulk explosives, some propellants, mines, bombs, demolition charges, torpedo and missile warheads, rockets, palletized projectiles loaded with TNT or Composition B, 8-inch and larger high-capacity projectiles loaded with Explosive D, mass-detonating CBU's, and mass-detonating ammunition components.

2. Use Table 6-1 to determine inhabited building and public traffic route distances, Tables 6-2 and 6-3 for intraline distance, Table 6-4 for intermagazine distance and Tables 6-5 and 6-6 for fragment distances.

D. Application of intermagazine distances for Hazard Division 1.1 only

1. In applying the intermagazine distances given in Table 6-4, consideration shall be given to magazine construction and orientation. For earth-covered magazine separation distances, the following conditions apply:

a. When standard earth-covered magazines containing Hazard Division 1.1 ammunition are sited so that any one is in the forward section, 60 degrees either side of the centerline of another, the two shall be separated by distances greater than the minimum permitted for side-to-side orientations. The greater distances primarily protect door and headwall structures against blast from a potential explosion site forward of the exposed magazine. When a blast wave is reflected from a surface at other than grazing incidence (side-on orientation), the overpressure may be increased substantially over the free-field value. High reflected pressure impulse can damage doors and headwalls and propel the debris into the earth-covered magazine, communicating the explosion to the contents on impact. Some examples of the application of these rules follow:

(1) If headwalls of both A and B are outside the 120-degree sector (60 degrees either side of the centerline), they may be separated by the column 4 distances based on the largest quantity of Hazard Division 1.1 stored in either. This is considered the equivalent of standard side-to-side separation with the optimum orientation -- all earth-covered magazines facing the same direction and axes parallel. See Figure 6-1 (a) and (b).

(2) If headwall of A is outside the 120-degree sector of B, but headwall of B is inside the 120 degree sector of A, separation distance between these two earth-covered magazines is determined by column 6, based on the largest quantity of Hazard Division 1.1 in either earth-covered magazine. However, if the quantity in B were reduced to less than 1/10 of that in A, or if the storage in B is not class 1, division 1, earth-covered magazine A would control as a potential explosion site. Then, in accordance with Chapter 4, Section C, the distance shall be taken from column 4, based on the quantity in A; that is, the quantity in A would not need to be reduced. See Figure 6-1 (c).

(3) If headwalls of A and B are within the 120-degree sector of each other and are not provided with a separate door barricade, Table 6-4, Hazard Factor 11 column, distances shall be used to separate them. If a door barricade is present (meeting requirements of Chapter 4, Subsection E.1) such as A to C, then Hazard Factor 6 column distances may be used to determine separation distances. See Figure 6-1 (d).

(4) Although no separate barricade is shown between A and B, more detailed analysis of a specific storage condition of this type might show that the distribution of explosives within A and B is such that the earth fill of one or the other or both meets the specifications of an effective barricade according to Chapter 4, Subsection E.1. In such a case, column 10 distances would apply between A and B. See Figure 6-1 (d).

(5) Two additional standard earth-covered magazine orientations warrant analysis:

(a) Earth-covered magazines A and B significantly differ in length (Figure 6-1 (f)) or are "canted" in such a manner that one of them is within the 120- degree sector off the headwall of the other, even though a straight line between headwall A and earth-covered magazine B does pass through the earth cover of B. See Figure 6-1 (e).

(b) If B is the potential explosion site and A is the exposed site, the limit for B would be determined by column 7. With A as the potential explosion site, however, the limit for A would be based upon column 4.

(6) For future construction when standard earth-covered magazines containing Hazard Division 1.1 ammunition are sited so that any one is in the forward sector of another, the two shall be separated by distances greater than the minimum permitted for side-to-side orientations. The forward sector, or 'front', for earth-covered magazines is the area 60 degrees either side of the magazine centerline with the vertex of the angle placed so that the sides of the angle pass through the intersection of the headwall and side walls. The greater distances are required primarily for the protection of door and headwall structures against blast from a PES forward of the exposed magazine, and to a lesser extent due to the directionality of effects from the source. When a blast wave is reflected from a surface at other than grazing incidence (side-on orientation), the overpressure may be increased substantially over the free-field value. High reflected pressure and impulse can damage doors and headwalls and propel the debris into the earth-covered magazine so that explosion is communicated by impact of such debris upon the contents.

b. When considering relationships between standard earth-covered magazines and aboveground magazines or facilities requiring intraline distances, each containing class 1, division 1, ammunition or explosives, the question regarding the use of barricaded or unbarricaded distances arises. The following criteria shall apply:

(1) Aboveground magazines or facilities requiring intraline distances within the 120-degree sector in front of a standard earth-covered magazine shall be provided unbarricaded distances, unless a separate effective intervening barricade meeting requirements of Chapter 4, Paragraph E.1.b is present, in which case barricaded distances may be applied. See Figure 6-1 (g).

(2) Aboveground magazines or facilities requiring intraline distances outside of the 120-degree sector in front of a standard earth-covered magazine shall be provided with barricaded distances whether or not a separate intervening barricade is present. See Figure 6-1 (g).

2. Distances in column 4 apply to nonstandard, earth-covered magazines oriented so that all straight lines between the side and rear walls of two magazines pass through an earth-covered surface of each; similarly, column 10 distances apply to all orientations in which every straight line between two magazines passes through the earth cover of one and only one of them. If the above conditions cannot be met, column 12 distances apply. The earth cover of nonstandard magazines shall be equal to or greater than that required for standard earth-covered, arch-type magazines.

3. Other factors limiting earth-covered magazine storage are as follows:

a. Earth-covered magazines that are equivalent in strength to those specified under the definition of "standard magazine" in the definitions section of this manual are limited to 500,000 pounds NEW. Earth-covered magazines, not equivalent in strength to those, are limited to 250,000 pounds NEW.

b. Quantities above 500,000 pounds NEW in one storage location are not authorized except for liquid propellants.

c. The distance given for 0 to 100 pounds NEW constitutes the minimum magazine spacing permitted.

4. Examples given in subparagraphs D.1.a (1) through (5), above, apply only to the storage of Hazard Division 1.1, ammunition and explosives. Existing earth-covered magazines, regardless of orientation, meeting the construction and barricading requirements of Chapter 4 and consistent with the definition of "magazine" in definitions section of this manual (and sited for any quantity of class 1, division 1), may be used to their physical capacity for the storage of Hazard Division 1.2, 1.3 and 1.4, A&E.

E. Hazard Division 1.2 - nonmass-detonating, fragment-producing

1. Items in this division are those for which the principal hazards are fragment and blast, either individually or in combination, depending on such factors as storage configuration, type of packing, and quantity. The designated minimum distances are based on the limiting range of fragments for which protection by distance is provided and shall be used for inhabited building and public traffic route distances.

2. The fragment hazard from items within a specified minimum distance category varies with existing conditions, but is essentially the same for one as for many items or components. For these items, the required separation distances are influenced heavily by packing, state of assembly, charge/weight ratio, and caliber. Items in this division usually explode progressively when involved in a fire or otherwise initiated. Therefore, the distances prescribed shall not be lessened if the quantity to be stored is less than the maximum quantity specified by the appropriate table. Use Tables 6-7 through 6-10 for determining quantity/distance for Hazard Division 1.2.

F. Hazard Division 1.3 - mass fire

Items in this division burn vigorously with little chance of being extinguished in storage. Explosions shall normally be confined to pressure ruptures of containers and shall not produce propagating shock waves or damaging blast overpressure beyond the magazine distance specified in Table 6-11. A severe hazard of the spread of fire may result from burning container materials, propellant, or other flaming debris being tossed about by the force of pressure ruptures.

G. Hazard Division 1.4 - moderate fire, no blast

Items in this division present a fire hazard with no blast hazard and virtually no fragmentation hazard beyond the fire hazard clearance ordinarily specified for high risk materials. Separate facilities for storage and handling of this division should not be less than 100 feet from other facilities, except those of fire-resistive construction, which may be 50 feet from each other providing both are fire resistant. The Q-D's for Hazard Division 1.1, 1.2, 1.3, 1.5 or 1.6 individually or in combination are not affected by the presence of Hazard Division 1.4. Use Table Table 6-12 for determining quantity/distance of Hazard Division 1.4 material.

H. Hazard Divisions 1.5 and 1.6

1. This section describes Q-D standards for EIDS (substances) which are hazard classified 1.5, as well as ammunition items loaded with EIDS which are hazard classified 1.6. Refer to Table 6-13.

2. Substances (1.5) and items (1.6) in these divisions are designed to have a very low probability of detonating under normal storage and handling conditions. In order to be so classified, these A&E shall meet stringent tests prescribed in TB 700-2 (reference (e)).

3. Quantity/distance separations for Hazard Division 1.6 ammunition shall be based on the storage location and configuration. This information is detailed in Table 6-14 and footnotes thereto. A maximum of 500,000 NEW shall be permitted at any one location. Any special storage configuration and siting approved for Hazard Division 1.1 ammunition or explosives may be used for storage of like explosive weights of Hazard Division 1.6 ammunition.

4. Blasting agents designated as Hazard Division 1.5 for transportation are considered to be Hazard Division 1.1 for Q-D purposes (storage).

5. When Hazard Division 1.6 is located with Hazard Division 1.1 or 1.5, Hazard Division 1.6 is considered Hazard Division 1.1 for Q-D purposes. When Hazard Division 1.6 is located with Hazard Division 1.2, Hazard Division 1.6 is considered Hazard Division 1.2 for Q-D purposes.

6. When Hazard Division 1.6 is located with Hazard Division 1.3, add the explosives weight of the Hazard Division 1.6 to the weight of Hazard Division 1.3 and consider as Hazard Division 1.3 for Q-D purposes.

I. Airfields

1. These provisions do not apply to explosives items installed on aircraft or contained in survival and rescue kits such as signals, flares, egress systems components, squibs and detonators for jettisoning external stores, engine starter cartridges, fire extinguisher cartridges, destructors in

electronic equipment, explosives components of emergency kits and equipment, and other such items or materials necessary for safe flight operations.

2. These Q-D requirements shall be applied:

a. To any airfield at which A&E are handled or stored.

b. In conjunction with airfield clearance criteria as prescribed by DoD Components and 14 CFR Part 77 (reference (b)). Airfields, heliports, and seadromes not used exclusively by DoD Components, combat aircraft parking areas, ammunition and explosives cargo areas, alert hangars, and shelters shall be located as prescribed in Table 6-15.

c. In separating ammunition and explosives facilities from inhabited buildings, public traffic routes, and other ammunition and explosives facilities, in accordance with Chapters 4 and 6.

3. In applying the requirements prescribed in Table 6-15, distances shall be measured as follows:

a. Loaded aircraft to loaded aircraft. Measure the distance from explosives on one aircraft to explosives on adjacent aircraft.

b. Ammunition and explosives location to taxiways and runways. Measure from the nearest point of the A&E location to the nearest point of the taxiway and to the centerline of the runway.

4. Separation distances between the following areas and from these areas to other targets shall be determined by applying Table 6-16:

a. A&E cargo areas.

b. A&E storage facilities.

c. A&E operating facilities.

5. A&E shall be prohibited under approach/departure zones of fixed and rotary wing aircraft landing facilities. The approach/departure zones for aircraft (surfaces or areas) are described in detail in airfield and airspace criteria directives of the DoD Components. In general, approach/departure zones begin near the end of a runway or landing area and extend outward to a given distance along, and symmetrically on each side of, the extended runway centerline or the aircraft approach axis of a heliport. Such zones flare uniformly from the landing area outward to a prescribed limit.

J. Pier and wharf facilities

1. **Applicability and scope.** This section applies to piers and wharfs and associated facilities at which ammunition and explosives may be handled, or be present in ships' holds or service conveyances. Its provisions do not apply to ammunition or explosives stored in ships' magazines and intended for the service of shipboard armament or aircraft. However, they do apply to loading, off-loading, stowing, and shifting of such ammunition and explosives. Q-D's herein are for Hazard Division 1.1. Effects of an explosion to be expected when these Q-D's are applied are described in Chapter 4. If only ammunition and explosives of other class/division are involved the Q-D's for such hazards shall be applied as appropriate.

2. **Determination of quantity of explosives in a ship**

a. On board ship, the various types of ammunition and explosives are stored relatively close to each other, and a detonation in the HE part of the cargo may receive considerable support from items that are considered normally to be only fragment or fire hazards; therefore, the total quantity of explosives on board a ship shall be determined in accordance with Chapter 4.

b. When ship units are separated by $11W^{1/3}$ distances or greater, Q-D shall be based individually on the quantity of each ship unit. Lesser separation distances require that the explosives in both ship units be totalled for Q-D purposes.

3. **Measurement of separation distance**

a. **Ships at a pier.** Measurement of separation distances between ships shall be from the nearest point of one unit to the nearest point of the other. Movement of cars passing through the clear space is considered as an operations risk. It will generally be impracticable to separate berths at a single pier by enough distance to prevent mass detonation of ships containing complete cargoes of Hazard Division 1.1 ammunition. To the extent operationally feasible, therefore, scheduling shall be such as to reduce the number of such exposures and total time that they are required.

b. **Piers.** The separation distances between piers shall be measured from the nearest point of the ship unit at one pier to the nearest point of the ship unit under consideration at the other pier.

c. **Anchorages.** Measurements from anchorages generally shall be from the boundary of the area designated for the scuttling site or the explosives anchorage. In the case of the explosives anchorage, the separation distance to outside targets shall depend upon whether:

(1) The ship units that are loading or unloading within the explosives anchorage are separated properly, taking into consideration location and the amount of explosives in each ship unit. The ship unit equivalent for an explosives anchorage is a circle, the radius of which is the distance from the mooring buoy or the ship's anchor to the stern of the ship or of the ammunition lighters alongside when riding to the full scope of the chain. To maintain proper separation distance between loading or unloading ship units in the explosives anchorage, the ships shall moor or anchor so that at no time will they have a separation distance less than $11W^{1/3}$ if quantities are not to be totalled.

(2) The ships being loaded or unloaded at one area are separated properly from the loaded ships in another area and whether the loaded ships within the loaded ship area are separated properly from each other. If the latter conditions do not apply, the quantity for entering the table shall be the total quantity rather than the unit quantity.

d. **Dolphins or interrupted quays.** Measurement of separation distance between ships moored to dolphins or interrupted quays shall be from the nearest point of one unit to the nearest point of the other.

e. **Fixed targets.** The measurement of separation distance from moored ships to fixed targets on land shall be from the nearest boundary of the ship or barge unit to the nearest fixed target.

4. **Siting criteria and application of Q-D separation requirements**

a. **Scuttling site**

(1) A properly located scuttling site shall be provided, if practicable, for positioning a ship for its flooding or sinking in the event a vessel catches fire and shall be moved to avert damage to other ships or piers. It shall have sufficient sea room and depth of water to permit the sinking of the largest vessel that may be handled at the installation so that the holds will be flooded completely at low water.

(2) Since an explosion may occur while the vessel is being moved, the location of the scuttling site shall provide the best available protection to other ships, piers, and shore installations.

(3) The location of the scuttling site will depend on the greatest net quantity of mass-detonating explosives that may be in a single ship at any one time. The Q-D tables to be used will depend on the particular types of targets.

b. **Explosives anchorage.** The location of an explosives anchorage shall be separated not only from the main ship channel or from normally traversed routes of ships entering or leaving the harbor by distances given in column 8 of Table 6-1, but also by turning circles and stopping distances of the ships. Assuming that the diameter of the turning circle of a ship is 1,000 yards, an explosives anchorage shall be located so that a ship in the channel with a jammed rudder will clear an anchored explosives-laden ship. From the turning circle standpoint, the separation distance shall be not less than 3,000 feet.

(1) **Separation of ships at explosives anchorages**

(a) When explosives anchorages are used for loading and unloading ships, as well as for fully loaded vessels anchored at their berths, ships that are being loaded or unloaded shall be separated from fully loaded ships.

(b) When the explosives anchorage is used only for loading and unloading ships, to prevent mass detonation, ships in the explosives anchorage shall be separated by at least $11W^{1/3}$ distances. Whenever possible, these distances shall be increased to $18W^{1/3}$ to reduce the loss potential of any incident.

(c) Loaded ships shall be separated one from another by at least $18W^{1/3}$ distances.

(2) **Separation of explosives anchorages from other targets.** Explosives shall be from anchorages separated explosives piers by $40W^{1/3}$ distances except when the anchorage is used only for the loading or unloading of vessels. In such cases, $18W^{1/3}$ may be used.

c. **Separation distances of ship units in tandem at the same pier**

(1) Since the second ship would be in an area of heavy fragment density from the exploding ship, it could be set afire and later caused to mass-detonate. A direct hit by a steel fragment on ammunition alongside the ship or in an open hold could also cause a mass detonation. The separation distances based on blast damage alone accordingly are not enough to take care of such fragment hazards. Berthing of the two ships in tandem will help to decrease the fragment hazard to the explosives cargo of the second ship because of the additional protection afforded by the bow or stern.

(2) When two ships cannot be separated by $11W^{1/3}$ distances and are being loaded through all hatches, the spotting of cars and the loading of hatches in both ships should be planned so as to put the greatest possible distance between open hatches of both ships, and between the trucks and freight cars serving the two ships. When possible, the loading of the ships should be staggered.

d. **Separation of explosives ships from other ships.** Explosives ships being loaded or unloaded shall be separated from nonexplosives-carrying ships and from loaded explosives ships that are not underway by $40W^{1/3}$ distances. Distances given in column 8 of Table 6-1 shall be used for protection of ships that are underway.

e. Occasional watercraft passing through Q-D arcs are not subject to Q-D requirements.

5. **Quantity/distance tables.** Figure 6-2 shall be used in applying Table 6-17 Q-D. Table 6-17 Q-D shall be maintained between explosives pier and wharf facilities and such ES's as administration and industrial areas, terminal boundary, main ship channel, and public traffic routes. As ES, ship or barge units shall be separated from explosives operating and storage facilities (including holding yards) by distances given in column 5 of Table 6-1. As PES, ship or barge units shall be separated from explosives operating facilities by distances given in column 5 of Table 6-1, and from explosives storage facilities by distances given in column 2 of Table 6-17 (barricaded) and distances given in column 3 (unbarricaded) as appropriate.

Table 6-1. Hazard Division 1.1 - Inhabited Building Distance and Public Traffic Route Distances.

Net Explosive Weight		Distance in Feet to Inhabited Building from			Distance in Feet to Public Traffic Route from		
		Standard Earth-covered Magazine		Other PES	Standard Earth-covered Magazine		Other PES
Over	Not over	Front or side	Rear		Front or side	Rear	
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
0	1	35	25	40	21	15	24
1	2	44	32	50	26	19	30
2	5	60	43	69	36	26	40
5	10	75	54	87	45	32	52
10	20	95	68	110	57	41	65
20	30	110	78	125	65	47	75
30	40	120	86	140	72	51	83
40	50	130	92	150	77	55	89
50	100	160	115	190	97	70	115
100	200	205	145	235	125	88	140
200	300	235	165	270	140	100	160
300	400	260	185	295	155	110	175
400	500	280	200	320	165	120	190
500	600	295	210	340	175	125	205
600	700	310	220	355	185	135	215
700	800	325	230	375	195	140	225
800	900	340	240	390	205	145	235
900	1,000	350	250	400	210	150	240
1,000	1,500	400	285	460	240	170	275
1,500	2,000	440	315	505	265	190	305
2,000	3,000	505	360	580	305	215	350
3,000	4,000	555	395	635	335	240	380
4,000	5,000	600	430	685	360	255	410
5,000	6,000	635	455	730	380	275	440
6,000	7,000	670	480	770	400	285	460
7,000	8,000	700	500	800	420	300	480
8,000	9,000	730	520	835	435	310	500
9,000	10,000	755	540	865	450	325	520
10,000	15,000	865	615	990	520	370	595
15,000	20,000	950	680	1,090	570	405	655
20,000	25,000	1,025	730	1,170	615	440	700
25,000	30,000	1,085	775	1,250	650	465	745
30,000	35,000	1,145	820	1,310	685	490	785
35,000	40,000	1,195	855	1,370	720	515	820
40,000	45,000	1,245	890	1,425	745	535	855
45,000	50,000	1,290	920	1,475	775	555	885
50,000	55,000	1,330	950	1,520	800	570	910
55,000	60,000	1,370	980	1,565	820	585	940
60,000	65,000	1,405	1,005	1,610	845	605	965
65,000	70,000	1,440	1,030	1,650	865	620	990
70,000	75,000	1,475	1,055	1,685	885	635	1,010
75,000	80,000	1,510	1,075	1,725	905	645	1,035
80,000	85,000	1,540	1,100	1,760	925	660	1,055
85,000	90,000	1,570	1,120	1,795	940	670	1,075
90,000	95,000	1,595	1,140	1,825	960	685	1,095
95,000	100,000	1,625	1,160	1,855	975	695	1,115
100,000	110,000	1,740	1,290	1,960	1,045	770	1,175
110,000	120,000	1,855	1,415	2,065	1,110	850	1,240
120,000	125,000	1,910	1,480	2,115	1,145	890	1,270
125,000	130,000	1,965	1,545	2,165	1,180	925	1,300
130,000	140,000	2,070	1,675	2,255	1,245	1,005	1,355
140,000	150,000	2,175	1,805	2,350	1,305	1,085	1,410

Table 6-1 (continued). Hazard Division 1.1 - Inhabited Building Distance and Public Traffic Route Distances.

Net Explosive Weight		Distance in Feet to Inhabited Building from			Distance in Feet to Public Traffic Route from		
		Standard Earth-covered Magazine		Other PES	Standard Earth-covered Magazine		Other PES
Over	Not over	Front or side	Rear		Front or side	Rear	
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
150,000	160,000	2,280	1,935	2,435	1,370	1,160	1,460
160,000	170,000	2,385	2,070	2,520	1,430	1,280	1,540
170,000	175,000	2,435	2,135	2,565	1,460	1,280	1,540
175,000	180,000	2,485	2,200	2,605	1,490	1,320	1,565
180,000	190,000	2,585	2,335	2,690	1,550	1,400	1,615
190,000	200,000	2,680	2,470	2,770	1,610	1,480	1,660
200,000	225,000	2,920	2,810	2,965	1,750	1,685	1,780
225,000	250,000	3,150	3,150	3,150	1,890	1,890	1,890
250,000	275,000	3,250	3,250	3,250	1,950	1,950	1,950
275,000	300,000	3,345	3,345	3,345	2,005	2,005	2,005
300,000	325,000	3,440	3,440	3,440	2,065	2,065	2,065
325,000	350,000	3,525	3,525	3,525	2,115	2,115	2,115
350,000	375,000	3,605	3,605	3,605	2,165	2,165	2,165
375,000	400,000	3,685	3,685	3,685	2,210	2,210	2,210
400,000	425,000	3,760	3,760	3,760	2,250	2,250	2,250
425,000	450,000	3,830	3,830	3,830	2,300	2,300	2,300
450,000	475,000	3,900	3,900	3,900	2,340	2,340	2,340
475,000	500,000	3,970	3,970	3,970	2,380	2,380	2,380

Notes:

1. Distances are computed using the following factors:

NEW	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
0 to 100,000	$35W^{1/3}$	$25W^{1/3}$	$40W^{1/3}$	$21W^{1/3}$	$15W^{1/3}$	$24W^{1/3}$
100,000 to 250,000	$.3955W^{.7227}$	$.004125W^{1.0898}$	$2.42W^{.577}$	$.2375W^{.7227}$	$.002475W^{1.0898}$	$1.452W^{.577}$
250,000 to 15,000,000	$50W^{1/3}$	$50W^{1/3}$	$50W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$

2. The policy contained in Subsection B.7, shall be employed for mass-detonating, fragment-producing items.

3. The distance for 0 to 50 pounds may be used only when structures, blast mats, and so forth can completely confine fragments and debris. Lesser distances may be used only if blast, fragments,and debris can be confined completely, as by certain test firing barricades.

4. Applies only to earth-covered magazines with dimensions of 26 feet wide and 60 feet long, or larger.

Table 6-2. Hazard Division 1.1 - Intraline Distances.

Net Expl. Wt. (l b)		Distance in Feet Hazard Factor		Net Expl Wt. (lb)		Distance in Feet Hazard Factor	
		Barri-cade	No Barricade			Barri-cade	No Barricade
Over	Not Over	k = 9	k = 18	Over	Not Over	k = 9	k = 18
Col 1	Col 2	Col 3	Col 4	Col 1	Col 2	Col 3	Col 4
0	50	30	60	65,000	70,000	370	740
50	100	40	80	70,000	75,000	380	760
100	200	50	100	75,000	80,000	390	780
200	300	60	120	80,000	85,000	395	790
300	400	65	130	85,000	90,000	405	810
400	500	70	140	90,000	95,000	410	820
500	600	75	150	95,000	100,000	420	840
600	700	80	160	100,000	125,000	450	900
700	800	85	170	125,000	150,000	480	960
800	900	85	175	150,000	175,000	505	1,010
900	1,000	90	180	175,000	200,000	525	1,055
1,000	1,500	105	210	200,000	225,000	545	1,090
1,500	2,000	115	230	225,000	250,000	565	1,135
2,000	3,000	130	260	250,000	275,000	585	1,170
3,000	4,000	145	290	275,000	300,000	600	1,200
4,000	5,000	155	310	300,000	325,000	620	1,240
5,000	6,000	165	330	325,000	350,000	635	1,270
6,000	7,000	170	340	350,000	375,000	650	1,300
7,000	8,000	180	360	375,000	400,000	665	1,330
8,000	9,000	185	370	400,000	500,000	715	1,430
9,000	10,000	195	390	500,000	600,000	760	1,520
10,000	15,000	225	450	600,000	700,000	800	1,600
15,000	20,000	245	490	700,000	800,000	835	1,670
20,000	25,000	265	530	800,000	900,000	870	1,740
25,000	30,000	280	560	900,000	1,000,000	900	1,800
30,000	35,000	295	590	1,000,000	1,500,000	1,030	2,060
35,000	40,000	310	620	1,500,000	2,000,000	1,135	2,270
40,000	45,000	320	640	2,000,000	2,500,000	1,220	2,440
45,000	50,000	330	660	2,500,000	3,000,000	1,300	2,600
50,000	55,000	340	680	3,000,000	3,500,000	1,365	2,730
55,000	60,000	350	700	3,500,000	4,000,000	1,430	2,860
60,000	65,000	360	720	4,000,000	5,000,000	1,540	3,080

Note: For less than 50 pounds, shorter distances may be used when structures, blast mats, and so forth can completely contain fragments and debris. This distance must be, determined by formula $D = kW^{1/3}$, where k = 9 for barricaded explosives and k = 18 for unbarricaded explosives. When blast, fragments, and debris are confined completely, as by certain test firing barricades, this table is not applicable.

Table 6-3. Hazard Division 1.1 - Intraline Distances from Earth-covered Magazines.

NEW (lbs)	Barricaded			Unbarricaded			NEW (lbs)	Barricaded			Unbarricaded		
	Front	Side	Rear	Front	Side	Rear		Front	Side	Rear	Front	Side	Rear
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
50	35	25	20	60	60	45	40,000	340	240	205	620	545	410
100	45	30	30	80	75	55	45,000	355	250	215	640	570	425
200	60	40	35	100	95	70	50,000	370	260	220	660	590	440
300	65	45	40	120	105	80	55,000	380	265	230	680	610	455
400	75	50	45	130	120	90	60,000	390	275	235	700	625	470
500	80	55	50	140	125	95	65,000	400	280	240	720	645	480
600	85	60	50	150	135	100	70,000	410	290	245	740	660	495
700	90	60	55	160	140	105	75,000	420	295	255	760	675	505
800	90	65	55	170	150	110	80,000	430	300	260	780	690	520
900	95	70	60	175	155	115	85,000	440	310	265	790	705	530
1,000	100	70	60	180	160	120	90,000	450	315	270	810	715	540
1,500	115	80	70	210	185	135	95,000	455	320	275	820	730	545
2,000	125	90	75	230	200	150	100,000	465	325	280	840	745	555
3,000	145	100	85	260	230	175	125,000	500	350	300	900	800	605
4,000	160	110	95	290	255	190	150,000	530	370	320	960	850	650
5,000	170	120	100	310	275	205	175,000	560	390	335	1,010	895	700
6,000	180	125	110	330	290	220	200,000	585	410	350	1,055	935	745
7,000	190	135	115	340	305	230	225,000	610	425	365	1,090	975	795
8,000	200	140	120	260	320	240	250,000	630	440	380	1,135	1,005	840
9,000	210	145	125	370	330	250	275,000	650	455	390	1,170	1,040	890
10,000	215	150	130	390	345	260	300,000	670	470	400	1,200	1,070	935
15,000	245	175	150	450	395	295	325,000	675	520	465	1,240	1,135	1,035
20,000	270	190	165	490	435	325	350,000	680	570	530	1,270	1,200	1,130
25,000	290	205	175	530	470	350	375,000	685	615	600	1,300	1,265	1,230
30,000	310	220	185	560	500	370	400,000	690	665	665	1,330	1,330	1,330
35,000	325	230	195	590	525	390	500,000	715	715	715	1,430	1,430	1,430

Note: Testing has shown some attenuation of the airblast overpressure occurs at the sides and rear of earth-covered magazines relative to the unconfined surface burst configuration. Some slight overpressure increase occurs at the front. To account for this attenuation, the 12 psi (Barricaded) and 3.5 psi (Unbarricaded) Intraline Distances from earth-covered magazines are given according to the factors presented below.

Exposure	NEW Range (lbs)	Vice K9	Vice K18
Front	1 - 300,000	10	18
	300 - 500,000	10 - 9	18
Side	1 - 300,000	7	16
	300 - 400,000	7 - 9	16 - 18
	over 400,000	9	18
Rear	1- 100,000	6	12
	100,000 - 300,000	6	12 - 14
	300,000 - 400,000	6 - 9	14 - 18
	over 400K	9	18

Table 6-4. Hazard Division 1.1 - Intermagazine Hazard Factors and Distances.

Use Part A of this table to find the hazard factor, K, corresponding to the types and aspects of the two magazines. Use the column for this hazard factor in Part B to determine the appropriate distance for the net explosive weight involved. Paragraph D.1.a describes Q-D for various magazine orientations.

Part A - Hazard Factors (K)

Legend: S - side; R - rear; F - front; B - barricaded; U - unbarricaded

	To (ES) ⇩	Standard Earth-covered Magazine[1]				Nonstandard Earth-covered Magazine[2]				Above-ground Magazine (not earth covered)[3]		Modules and/or Cells
From (PES) ⇨		S	R	FU	FB	S	R	FU	FB	U	B	B
Standard Earth-covered Magazine[1]	S	1.25	1.25	2.75	2.75	1.25	1.25	6	6	6	4.5	1.25
	R	1.25	1.25	2	2	1.25	1.25	6	6	6	4.5	1.25
	FU	2.75	2	11	6	2.75	2	11	6	11	6	6
	FB	2.75	2	6	6	2.75	2	6	6	6	6	6
Nonstandard Earth-covered Magazine[2]	S	1.25	1.25	2.75	2.75	1.25	1.25	6	6	6	6	1.25
	R	1.25	1.25	2	2	1.25	1.25	6	6	6	6	1.25
	FU	6	6	11	6	6	6	11	6	11	6	6
	FB	6	6	6	6	6	6	6	6	6	6	6
Above-ground Magazine (not earth covered)[3]	U	4.0	4.0	11	6	4.0	4.0	11	6	11	6	6
	B	4.0	4.0	6	6	4.0	4.0	6	6	6	6	6
Modules and/or Cells	B	1.25	1.25	6	6	1.25	1.25	6	6	6	6	1.1

Notes:

1 Standard earth-covered, arch-type magazines comprise all magazines equal to or stronger than Army igloo magazines; Navy arch-type magazines; and earth-covered, corrugated steel, arth-type magazines. See definition of magazine.

2 Nonstandard earth-covered magazines with earth cover equal to or greater than that required by standard, earth-covered, arch-type magazines.

3 Aboveground magazines are all type above grade (not earth-covered) magazines or storage pads.

Table 6-4 (continued). Hazard Division 1.1 - Intermagazine Hazard Factors and Distances.

Part B

Net Expl. Wt. (lb)		Hazard Factor (k) from Part A									
Over	Not over	1.1	1.25	2	2.75	4	4.5	5	6	8	11
0	100	7	7	9	13	18	21	24	28	36	51
100	200	7	7	12	16	24	26	30	35	48	64
200	300	7	8	13	18	26	30	32	40	52	74
300	400	8	9	15	20	30	33	36	44	60	81
400	500	9	10	16	22	32	36	40	48	64	87
500	600	9	11	17	23	34	38	44	51	68	93
600	700	10	11	18	24	36	40	44	53	72	98
700	800	10	12	19	26	38	42	48	56	76	102
800	900	11	12	19	27	38	43	48	58	76	106
900	1,000	11	13	20	28	40	45	50	60	80	110
1,000	1,500	13	14	23	31	46	52	56	69	92	126
1,500	2,000	14	16	25	34	50	57	64	76	100	139
2,000	3,000	16	18	29	40	58	65	72	86	116	158
3,000	4,000	17	20	32	44	64	72	80	95	128	175
4,000	5,000	19	21	34	47	68	77	84	103	136	188
5,000	6,000	20	23	36	50	72	82	92	109	144	200
6,000	7,000	21	24	38	53	76	86	96	115	152	210
7,000	8,000	22	25	40	55	80	90	100	120	160	220
8,000	9,000	23	26	42	57	84	94	104	125	168	230
9,000	10,000	24	27	43	59	86	97	108	130	172	235
10,000	20,000	30	35	55	75	110	120	140	165	220	300
20,000	30,000	35	40	60	85	120	140	160	185	240	340
30,000	40,000	40	45	70	95	140	150	170	205	280	375
40,000	50,000	40	45	75	100	150	170	180	220	300	405
50,000	60,000	45	50	80	110	160	180	200	235	320	430
60,000	70,000	45	50	80	115	165	185	210	245	320	455
70,000	80,000	45	55	85	120	170	195	220	260	340	475
80,000	90,000	50	55	90	125	180	200	220	270	360	495
90,000	100,000	50	60	95	135	190	210	230	280	380	510
100,000	125,000	55	65	100	140	200	225	250	300	400	550
125,000	150,000	60	65	105	145	210	240	260	320	420	585
150,000	175,000	60	70	110	155	220	250	280	335	440	615
175,000	200,000	65	75	115	160	230	260	290	350	460	645
200,000	225,000	65	75	120	165	240	270	300	365	480	670
225,000	250,000	70	80	125	175	250	285	320	380	500	695

Table 6-4 (continued). Hazard Division 1.1 - Intermagazine Hazard Factors and Distances.

Part B - continued

Net Expl. Wt. (lb)		Hazard Factor (k) from Part A									
Over	Not over	1.1	1.25	2	2.75	4	4.5	5	6	8	11
250,000	300,000	75	85	135	185	270	300	340	400	540	735
300,000	350,000	80	90	140	195	280	320	350	425	560	775
350,000	400,000	80	90	145	205	290	330	370	440	580	810
400,000	450,000	85	95	155	210	310	345	380	460	620	845
450,000	500,000	85	100	160	220	320	360	400	475	640	875
500,000	600,000	95	105	170	230	340	380	420	505	680	930
600,000	700,000	100	110	180	245	360	400	440	535	720	975
700,000	800,000	100	115	185	255	370	420	460	555	740	1,020
800,000	900,000	105	120	195	265	390	435	480	580	780	1,060
900,000	1,000,000	110	125	200	275	400	450	500	600	800	1,100
1,000,000	1,250,000	120	135	215	295	430	485	540	645	860	1,185
1,250,000	1,500,000	125	145	230	315	460	515	570	685	920	1,260
1,500,000	1,750,000	135	150	240	330	480	540	600	725	960	1,325
1,750,000	2,000,000	140	160	250	345	500	570	630	755	1,000	1,385
2,000,000	2,250,000	145	165	260	360	520	590	660	785	1,040	1,440
2,250,000	2,500,000	150	170	270	375	540	610	680	815	1,080	1,495
2,500,000	2,750,000	155	175	280	385	560	630	700	840	1,120	1,540
2,750,000	3,000,000	160	180	290	395	580	650	720	865	1,160	1,585
3,000,000	3,250,000	165	185	295	405	590	670	740	890	1,180	1,630
3,250,000	3,500,000	165	190	305	415	610	680	760	910	1,220	1,670
3,500,000	3,750,000	170	195	310	430	620	700	780	930	1,240	1,710
3,750,000	4,000,000	175	200	315	435	630	715	790	950	1,260	1,745
4,000,000	4,250,000	180	200	325	445	650	730	810	970	1,300	1,780
4,250,000	4,500,000	180	205	330	455	660	740	830	990	1,320	1,815
4,500,000	4,750,000	185	210	335	460	670	760	840	1,010	1,340	1,850
4,750,000	5,000,000	190	215	340	470	680	770	860	1,025	1,360	1,880
5,000,000	5,500,000	195	220	355	485	710	795	880	1,060	1,420	1,940
5,500,000	6,000,000	200	225	365	500	730	820	890	1,090	1,460	2,000
6,000,000	6,500,000	205	235	375	515	750	840	930	1,120	1,500	2,055
6,500,000	7,000,000	210	240	385	525	770	860	960	1,150	1,540	2,105
7,000,000	7,500,000	215	245	390	540	780	880	980	1,175	1,560	2,155
7,500,000	8,000,000	220	250	400	550	800	900	1,000	1,200	1,600	2,200
8,000,000	8,500,000	225	255	410	560	820	920	1,020	1,225	1,640	2,245
8,500,000	9,000,000	230	260	415	570	830	935	1,040	1,250	1,660	2,290
9,000,000	9,500,000	235	265	425	580	850	950	1,060	1,270	1,700	2,330
9,500,000	10,000,000	235	270	430	595	860	970	1,080	1,295	1,720	2,370
10,000,000	11,000,000	245	280	445	610	890	1,000	1,110	1,335	1,780	2,415
11,000,000	12,000,000	250	285	460	630	920	1,030	1,140	1,375	1,840	2,520
12,000,000	13,000,000	260	295	470	645	940	1,060	1,160	1,410	1,880	2,585
13,000,000	14,000,000	265	300	480	665	960	1,085	1,210	1,445	1,920	2,640
14,000,000	15,000,000	270	310	495	680	990	1,110	1,230	1,480	1,980	2,715

Table 6-5. Hazard Division 1.1 - Fragment Hazard (Primary/Secondary).[1]

New Explosive Weight		Distance in Feet to Fragment/Debris Target from				Distance in Feet to Public Traffic Route from			
		Standard/Non-standard Earth-covered Magazine			Other PES	Standard/Non-standard Earth-covered Magazine			Other PES
Over	Not over	Front	Side	Rear		Front	Side	Rear	
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6[4]	Col 7	Col 8	Col 9	Col 10
0	100	500	250	250	670	300	150	150	670[2]
100	200	500	250	250	1,250[3]	300	150	150	1,250[2]
200	500	700	250	250	1,250	420	150	150	1,250
500	30,000	1,250	1,250	1,250	1,250	750	750	750	1,250
30,000	35,000	1,250	1,250	1,250	[6]	750	750	750	[6]
35,000	40,000	1,250	1,250	1,250		750	750	750	
40,000	45,000	1,250	1,250	1,250		750	750	750	
45,000	50,000	1,250	1,250	1,250		750	750	750	
50,000	55,000	[6]	[6]	1,250		[6]	[6]	750	
55,000	60,000			1,250				750	
60,000	65,000			1,250				750	
65,000	70,000			1,250				750	
70,000	75,000			1,250				750	
75,000	80,000			1,250				750	
80,000	85,000			1,250				750	
85,000	90,000			1,250				750	
90,000	100,000			1,250				750	
95,000	100,000			1,250				750	
	100,000			[6]				[6]	

1 Distances in Table 6-1 are authorized for use, if documentation assures that hazardous fragment density is controlled as prescribed in Subparagraph 6.B.6.e or under the conditions of subparagraphs 6.B.6.f through 6.B.6.i.

2 A minimum distance equal to 60 percent of this distance may be used when the conditions of subparagraph 6.B.6.e (2) are met.

3 For NEW not exceeding 11,400 lbs, distances may be reduced to 900 feet, if conditions of subparagraph 6.B.6.f are met.

4 For items that have been adequately evaluated, distances such as those shown in Table 6-6 must be used.

5 Distances for NEW between 30,000 and 250,000 lbs apply only for earth-covered magazines that are at least 26 feet wide and 60 feet long. For smaller earth-covered magazines, containing between 30,000 and 250,000 lbs of NEW, use other PES distances of columns 6 and 10.

6 Blast (overpressure) hazard distances contained in Table 6-1 exceed fragmentation distances at this point and must be used.

Table 6-6. Hazard Division 1.1 - Minimum Fragment Protection Distance for Selected Items.

Nomenclature	Distance Required in Feet			
Col 1	Col 2	Col 3	Col 4	Col 5
	1 Unit	2 Units	5 Units	10 Units[1]
AGM 65/A	400	500	500	500
AIM 7, Mk 38 Warhead	700	700	700	700
AIM 9	400	400	400	400
ASROC	500	[2]500		
Bomb, 750 1b, M117A2	690	820	1020	1470
Bomb, 500 lb, Mk 82	670	860	1080	1240
Chaparral	400	400	400	400
Harpoon	500			
Improved Hawk	900	900	900	900
Nike Hercules	900	1150	1150	1150
Penguin	500	[2]500		
Projectile, 175mm, M437A2	450	580	830	2070
Projectile, 155mm, M107	400	510	720	1490
Projectile, 105mm, Ml[3]	270	350	500	1000
Projectile, 8 in, Mk 25	520	750	960	1240
Projectile, 5 in, Mk 49	280	430	660	1000
Tomahawk	500	[4]600	1250	1250
Torpedoes (Navy) Not Over 1,500 lbs NEW	[5]500	[5]500	[5]500	[5]500

Notes:

1 Ten units or more until the point is reached at which this distance is exceeded by the distance requirements of Table 6-1.

2 This distance applies for a maximum of 3 units.

3 105mm projectiles and 105mm complete rounds not in standard storage and shipping containers are Hazard Division 1.1.

4 This distance applies for a maximum of 4 units. Missiles must be transported and/or handled only two at a time in a nose-to-tail configuration and in their launch capsule and/or shipping container as, well as aligned and/or handled so that each group of two missiles is located outside of the warhead fragment beam spray region of the other two missiles.

5 This distance applies to any torpedoes that are analogous in terms of explosive hazard to those tested; that is, MK 16 war shot.

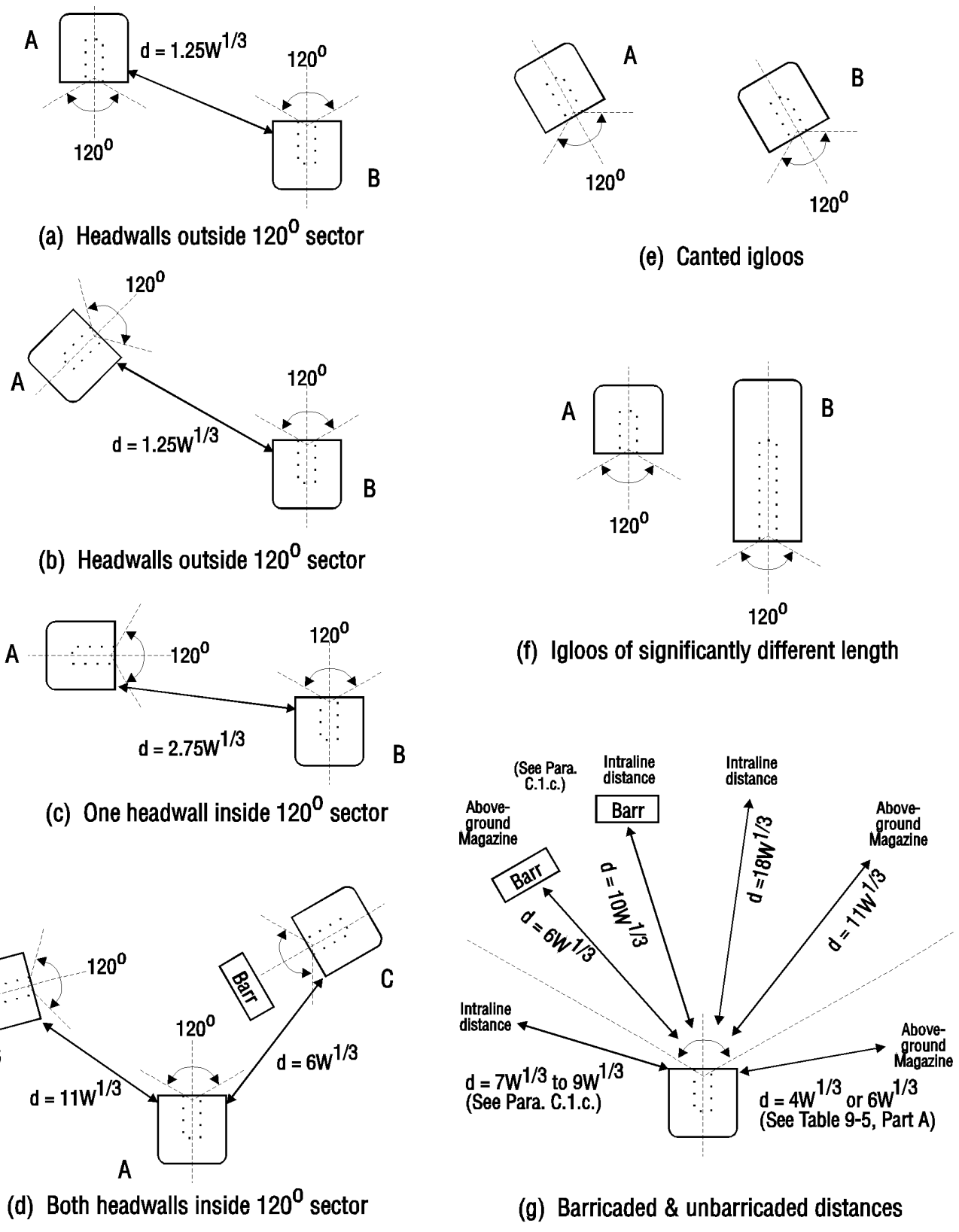

Figure 6-1. Effects of Magazine Orientation on Q-D.

Table 6-7. Category (04), Hazard Division 1.2 - Nonmass-detonating, Fragment-Producing.[1]

Net Explosives Weight	Inhabited Building Distance (ft)	Public Traffic Route Distance (ft)	Intraline Distance (ft)	Magazine Distance (ft)	
				Above-ground	Earth-covered
No limit specifically required for safety reasons	400	240	200	200	(Note 2)

1 Limited quantities of items in this class, for reasons of operational necessity, may be stored in facilities such as hangars, troop buildings, and manufacturing or operating buildings without regard to Q/D. Examples: small destructors, fuzes and firing devices.

2 Earth-covered standard or nonstandard magazines may be used without limit for this category. However, the construction, siting, and orientation requirements of Chapters 4 and 6 for Hazard Division 1.1 must be met.

Note:

List of items (examples only): Small arms ammunition with explosive projectiles; 20mm ammunition with explosive projectiles; fuzed ammunition with non-explosive projectiles when caliber and packing limit the hazard in accordance with this class; WP smoke hand grenades; and nonmass detonating CBUs.

Table 6-8. Category (08), Hazard Division 1.2 - Nonmass-detonating, Fragment-Producing.

Net Explosives Weight	Inhabited Building Distance (ft)	Public Traffic Route Distance (ft)	Intraline Distance (ft)	Magazine Distance (ft)	
				Above-ground	Earth-covered
No limit specifically required for safety reasons	800	480	400 (Note 1)	300	(Note 2)

1 If the HE in (08) 1.2 items at an operating line PES is limited to 5000 lbs, intraline distance may be reduced to 200 ft.

2 Earth-covered standard and nonstandard magazines may be used without limit for this category. However, the construction, siting, and orientation requirements of Chapters 4 and 6 for Hazard Division 1.1 must be met.

Note:

List of items (examples only): Fixed and semifixed ammunition, rockets and rocket components, chemical ammunition containing explosive elements, and nonmass-detonating CBUs.

Table 6-9. Category (12), Hazard Division 1.2 - Nonmass-detonating, Fragment-Producing.[1]

Net Explosives Weight	Inhabited Building Distance (ft)	Public Traffic Route Distance (ft)	Intraline Distance (ft)	Magazine Distance (ft)	
				Above-ground	Earth-covered
500,000	1,200	720	600 (Note 2)	300	(Note 3)

1 Items of this category present a risk of propagation to adjacent aboveground magazines, particularly when packed in combustible containers. Storage in earth-covered magazines is therefore preferred.

2 If the HE in (12) 1.2 items at an operating line PES is limited to 5000 lbs, intraline distance may be reduced to 200 ft.

3 Earth-covered standard and nonstandard magazines may be used without limit for this category. However, the construction, siting, and orientation requirements of Chapters 4 and 6 for Hazard Division 1.1 must be met.

Note:

List of items (examples only): Separate projectiles with explosive "D" filler, except high capacity types, caliber 8-inch or larger; fixed and semifixed ammunition; nonmass-detonating CBUs; rockets,rocket motors and nonmass-detonating rocket heads.

Table 6-10. Category (18), Hazard Division 1.2 - Nonmass-detonating, Fragment-Producing.[1,2]

Net Explosives Weight	Inhabited Building Distance (ft)	Public Traffic Route Distance (ft)	Intraline Distance (ft)	Magazine Distance (ft)	
				Above-ground	Earth-covered
500,000	1,800	1,080	900	300	(Note 2)

1 Items of this category present a risk of propagation to adjacent aboveground magazines, particularly when packed in combustible containers. Storage in earth-covered magazines is therefore preferred.

2 Earth-covered standard and nonstandard magazines may be used without limit for this category. However, the construction, siting, and orientation requirements of Chapters 4 and 6 for Hazard Division 1.1 must be met.

Note:

List of items (examples only): Nonmass-detonating HE-loaded projectiles, fixed and semifixed ammunition, and rockets and rocket heads.

Table 6-11. Hazard Division 1.3 - Mass Fire.

Net Explosives Weight (lbs)	IBD or PTR (ft)	Above-ground IMD OR ILD (ft)	Net Explosives Weight (lbs)	IBD or PTR (ft)	Above-ground IMD OR ILD (ft)	Net Explosives Weight (lbs)	IBD or PTR (ft)	Above-ground IMD OR ILD (ft)
1,000	75	50	92,000	296	196	560,000	627	413
2,000	86	57	94,000	297	197	570,000	632	415
3,000	96	63	96,000	298	198	580,000	636	418
4,000	106	69	98,000	299	199	590,000	641	420
5,000	115	75	100,000	300	200	600,000	645	422
6,000	123	81	110,000	307	205	610,000	649	424
7,000	130	86	120,000	315	210	620,000	654	426
8,000	137	91	130,000	322	215	630,000	658	428
9,000	144	96	140,000	330	220	640,000	662	430
10,000	150	100	150,000	337	225	650,000	667	432
12,000	159	105	160,000	345	230	660,000	671	435
14,000	168	111	170,000	352	235	670,000	675	437
16,000	176	116	180,000	360	240	680,000	679	439
18,000	183	120	190,000	367	245	690,000	684	441
20,000	190	125	200,000	375	250	700,000	688	443
22,000	195	130	210,000	383	255	710,000	692	445
24,000	201	134	220,000	390	260	720,000	696	447
26,000	206	138	230,000	398	265	730,000	700	449
28,000	210	142	240,000	405	270	740,000	704	451
30,000	215	145	250,000	413	275	750,000	708	453
32,000	219	147	260,000	420	280	760,000	712	455
34,000	224	149	270,000	428	285	770,000	716	457
36,000	228	151	280,000	435	290	780,000	720	459
38,000	231	153	290,000	443	295	790,000	724	461
40,000	235	155	300,000	450	300	800,000	728	463
42,000	238	157	310,000	458	305	810,000	732	465
44,000	242	159	320,000	465	310	820,000	735	467
46,000	245	161	330,000	473	315	830,000	739	469
48,000	247	163	340,000	480	320	840,000	743	471
50,000	250	165	350,000	488	325	850,000	747	472
52,000	252	167	360,000	495	330	860,000	750	474
54,000	254	169	370,000	503	335	870,000	754	476
56,000	256	171	380,000	510	340	880,000	758	478
58,000	258	173	390,000	518	345	890,000	761	480
60,000	260	175	400,000	525	350	900,000	765	482
62,000	262	177	410,000	533	355	910,000	769	484
64,000	264	180	420,000	541	361	920,000	772	486
66,000	266	182	430,000	549	366	930,000	776	487
68,000	268	183	440,000	556	371	940,000	779	489
70,000	270	185	450,000	564	376	950,000	783	491
72,000	272	186	460,000	571	381	960,000	786	493
74,000	274	187	470,000	579	386	970,000	790	495
76,000	276	188	480,000	586	391	980,000	793	496
78,000	278	189	490,000	593	395	990,000	797	498
80,000	280	190	500,000	600	400	1,000,000	800	500
82,000	284	191	510,000	605	402			
84,000	287	192	520,000	609	404			
86,000	290	193	530,000	614	407			
88,000	293	194	540,000	618	409			
90,000	295	195	550,000	623	411			

1 For quantities less than 1,000 lbs, the required distances are those specified for 1,000 lbs. The use of lesser distances may be approved when supported by test data and/or analysis.

2 Linear interpolation of NEW quantities between table entries is permitted.

3 For quantities above 1,000,000 lbs, the values given above will be extrapolated by means of cube-root scaling as follows:

4 For inhabited building distance (IBD) and public traffic route (PTR) distance, use $D = 8W^{1/3}$.

5 For aboveground intermagazine distance (IMD) and intraline distance (ILD), use $D = 5W^{1/3}$.

6 List of items (examples only): Military pyrotechnics; solid propellants in bulk, in containers, or in ammunition items; and nontoxic chemical ammunition.

7 Earth-covered buildings may be used to their physical capacity for this division provided they comply with the construction and siting requirements of Subparts D and F, respectively, for Hazard Division 1.1.

8 For reasons of operational necessity, limited quantities of items in this class, such as document destroyers, signaling devices, riot control munitions and the like, may be stored without regard to quantity-distance in accordance with fire protection regulations in facilities such as hangars, arms rooms, and manufacturing or operating buildings.

Table 6-12. Hazard Division 1.4 - Moderate Fire, No Blast[1,2]

Net Explosives Weight	Inhabited Building Distance (ft)	Public Traffic Route Distance (ft)	Intraline Distance (ft)	Magazine Distance (ft)	
				Aboveground	Earth-covered
Larger quantities no limit specifically required for safety reasons	100	100	50 (100 if combustible construction)	50 (100 if combustible construction)	No specified separation requirement

1 With reasonable care in storage, Hazard Division 1.4 items may be stored in any weatherproof warehouse in a warehouse area for general supplies provided such warehouse is separated from all other warehouses by at least the aboveground magazine separation distance specified.

2 Limited quantities of Hazard Division 1.4 items may be stored in facilities such as hangars and manufacturing or operating buildings without regard to Q/D. Examples: small arms ammunition, riot control munitions, and pyrotechnics. Also, small magazines used for similar purposes may be separated by applicable fire protection distances.

Note:

List of items (examples only): Small arms ammunition without explosive projectiles, fuse lighters and squibs, distress signals, 20mm ammunition without explosive projectiles, colored smoke grenades,and explosive valves or switches (see Chapter 3, subsection D.2).

Table 6-13. Hazard Division 1.6N and EIDS Components.

EIDS and EIDS Ammunition	Hazard Classification
EIDS bulk	1.5D
EIDS Loaded projectiles and/or warheads w/o fuzes or with EIDS fuzes[1], [2]	1.6N
EIDS fuzes[1]	1.4D, 1.4S, 1.6N
EIDS loaded projectiles and/or warheads w/1.3 propelling charges and without fuzes or with EIDS fuzes[1, 2]	1.2C, 1.3C, 1.4C
EIDS loaded projectiles and/or warheads with non-EIDS fuzes and without 1.3 propelling charges	1.2D[3, 4], 1.4D[4]
EIDS loaded projectiles and/or warheads with non-EIDS[2,4] fuzes and with 1.3 propelling charges	1.2E[3, 4], 1.4E[4]

1 "EIDS Fuzed" means that the fuze has an EIDS booster with an out-of-line EIDS explosive and two or more independent safety features. The fuze must be certified as invulnerable to accidental detonation of the warhead.

2 Fuzed configuration must be tested for propagation. Fuzed Hazard Division 1.6 ammunition must contain either an EIDS fuze or a non-explosive fuze (fuze contains no explosive); otherwise the ammunition is classified as unit risk Hazard Division 1.2. Minimum fragment distance is based on hazardous fragment areal density requirements, as determined for Hazard Division 1.1 ammunition, applies for unit risk Hazard Division 1.2.

3 Unit risk Hazard Division 1.2 may be justified on a case-by-case basis.

4 Fuze must have two or more independent safety features and independently classified Group D.

Table 6-14. Quantity/Distance Criteria for Hazard Division 1.6 Ammunition.

NEW (lbs)	IBD or PTR (ft)	Aboveground IMD or ILD (ft)	NEW (lbs)	IBD or PTR (ft)	Aboveground IMD or ILD (ft)
100	37	23	75,000	337	211
200	47	29	80,000	345	215
300	54	33	85,000	352	220
400	59	37	90,000	359	224
500	64	40	95,000	365	228
600	67	42	100,000	371	232
700	71	44	110,000	383	240
800	74	46	120,000	395	247
900	77	48	125,000	400	250
1,000	80	50	130,000	405	253
2,000	101	63	140,000	415	260
3,000	115	72	150,000	425	266
4,000	127	79	160,000	434	271
5,000	137	86	170,000	443	277
6,000	145	91	175,000	447	280
7,000	153	96	180,000	452	282
8,000	160	100	190,000	460	287
9,000	166	104	200,000	468	292
10,000	172	108	225,000	487	304
15,000	197	123	250,000	504	315
20,000	217	136	275,000	520	325
25,000	234	146	300,000	536	334
30,000	249	155	325,000	550	344
35,000	262	164	350,000	564	352
40,000	274	171	375,000	577	361
45,000	285	178	400,000	589	368
50,000	295	184	425,000	601	376
55,000	304	190	450,000	613	383
60,000	313	196	475,000	624	390
65,000	322	201	500,000	635	397
70,000	330	206			

1 The same distances are used for aboveground intermagazine distances (IMD) and intraline distances (ILD). Earth-covered magazines, both standard and non-standard, may be used to their physical capacity for this hazard division, provided they comply with the construction and siting requirements of Chapters 4 and 6 for Hazard Division 1.1.

2 For quantities less than 100 lbs, the required distances are those specified for 100 lbs. The use of lesser distances may be approved when supported by test data and/or analysis.

3 Interpolation is permitted. For inhabited building distance (IBD) and public traffic route (PTR) use $D = 8W^{1/3}$. For aboveground IMD and intraline distance (ILD) use $5W^{1/3}$.

4 Unit risk distance applies as a minimum; that is, for IBD or PTR, $D = 40W^{1/3}$ or minimum fragment distance, whichever is greater; and for aboveground IMD or ILD, $D = 18W^{1/3}$, based on a single round of ammunition. Minimum fragment distance is based on hazardous fragment areal density requirements as determined for Hazard Division 1.1 munitions.

5 For Hazard Division 1.6 items packed in non-flammable pallets or packing, stored in earth-covered steel or concrete arch magazines when acceptable to the the cognizant safety office of the PCO on a site-specific basis, the following quantity-distance criteria apply, unless Table 6-14 permits a lesser distance requirement; IBD and PTR -- 100 ft; aboveground IMD and ILD -- 50 ft; earth-covered IMD -- No specified requirement.

Table 6-15. Hazard Division 1.1 - Q/D Requirements for Airfields.[1]

Net Explosives Weight (lb)		Distance (ft)	Net Explosives Weight (lb)		Distance (ft)
Over	Not Over		Over	Not Over	
Col 1	Col 2	Col 3	Col 1	Col 2	Col 3
0	50[2]	110[3]	45,000	50,000	1,105
50	100	140	50,000	55,000	1,140
100	200	175	55,000	60,000	1,175
200	300	200	60,000	65,000	1,205
300	400	220	65,000	70,000	1,235[3]
400	500	240	70,000	75,000	1,265
500	600	255	75,000	80,000	1,295
600	700	265	80,000	85,000	1,320
700	800	280	85,000	90,000	1,345
800	900	290	90,000	95,000	1,370
900	1,000	300	95,000	100,000	1,390
1,000	1,500	345	100,000	125,000	1,500
1,500	2,000	380	125,000	150,000	1,595
2,000	3,000	435	150,000	175,000	1,675
3,000	4,000	480	175,000	200,000	1,755
4,000	5,000	515	200,000	225,000	1,825
5,000	6,000	545	225,000	250,000	1,890
6,000	7,000	575	250,000	275,000	1,950
7,000	8,000	600	275,000	300,000	2,005
8,000	9,000	625	300,000	325,000	2,065
9,000	10,000	645	325,000	350,000	2,115
10,000	15,000	740	350,000	375,000	2,165
15,000	20,000	815	375,000	400,000	2,210
20,000	25,000	875	400,000	425,000	2,250
25,000	30,000	935	425,000	450,000	2,300
30,000	35,000	980	450,000	475,000	2,340
35,000	40,000	1,025	475,000	500,000	2,380
40,000	45,000	1,070			

1 To protect against low-angle, high-speed fragments, barricades should be provided; however, these distances will not be reduced.

2 The distance given for 0 to 50 pounds net explosives weight constitutes the minimum spacing permitted.

3 The minimum distance for Hazard Division 1.1 of 1,250 feet (see Chapter 6, subsection B.6.) does not apply to targets covered by this table.

Table 6-16. Application of Ammunition and Explosives Safety Distances (Airfields, Heliports, and Seadromes).

Table entries refer to the key at the end of the table.

To:	From:				
	Combat Aircraft Parking Area	Ammunition/ Explosives Cargo Area	Ammunition/ Explosives Storage Facility	Ammunition/ Explosives Operating Facility	Ready Ammunition Storage Facility
Combat Aircraft Parking Area	3a	3a	5	5	3a
Ammunition/Explosives Cargo Area	3a	3a	3	3	3a
Ammunition/Explosives Storage Facility	3	3	3	3	3
Ammunition/Explosives Operating Facility	4	4	4	4	4
Ready Ammunition Storage Facility	3	3	3	3	3
Inhabited Building	1	1	1	1	1
Public Traffic Route & Taxiway (joint DoD-Non-DoD use)	2	2	2	2	2
Runway (joint DoD-Non-DoD use)	1	1	1	1	1
Runway/Taxiway (DoD Component use only)	None	None	11	2	None
Aircraft Parking Area	10	10	6	6	10
Aircraft Passenger Loading/Unloading Area	7	7	7	7	7
Recreation Area	8	9	9	9	8

Key to Table 6-16:

1 Use appropriate inhabited building distance.

2 Use appropriate public traffic route distance.

3 Use appropriate intermagazine distance.

3a Use appropriate intermagazine distance. Protects against simultaneous detonation of ammunition on adjacent aircraft, but does not prevent serious damage to aircraft and possible propagation of detonation due to fragments, debris, or fire.

4 Use appropriate intraline distance.

5 Use Table 6-15 distances for mass-detonating items and appropriate public traffic route distances for nonmass-detonating items.

6 Use Table 6-15 distances for DoD Component aircraft parking areas, and appropriate inhabited building distance for non-DoD Component aircraft parking areas.

7 Use appropriate public traffic route distances for locations in the open where passengers enplane and deplane; use appropriate inhabited building distance if a structure is included where passengers assemble, such as a passenger terminal building.

8 No distance required to recreational areas that are used exclusively for alert personnel manning the combat-loaded aircraft. Other recreational areas where people are in the open shall be at appropriate public traffic route distance. When structures, including bleacher stands, are a part of such area, appropriate inhabited building distance shall be used.

9 Recreational areas, where people are in the open, shall be at appropriate public traffic route distance. When structures, including bleacher stands are part of such area, appropriate inhabited building distance shall be used.

10 Within these areas of airfields, heliports, and seadromes exclusively used by DoD Components, the separation of aircraft parking areas from combat aircraft parking areas and their ready ammunition storage facilities and ammunition and explosives cargo areas are considered to be a command function. At joint DoD/non-DoD use airfields, heliports, and seadromes, the combat aircraft parking areas and its ready ammunition storage facilities and ammunition and explosives cargo area shall be separated from non-DoD aircraft as specified in item 6., above.

11 Use $18W^{1/3}$ distances from side or rear of standard earth-cover magazine containing mass-detonating items to taxiway; use appropriate public traffic route distance from side or rear of standard earth-covered magazine containing nonmass-detonating items to taxiway; use appropriate public traffic route distance from front of standard earth-covered magazines, and from any other storage location containing mass-detonating or nonmass-detonating items to runway.

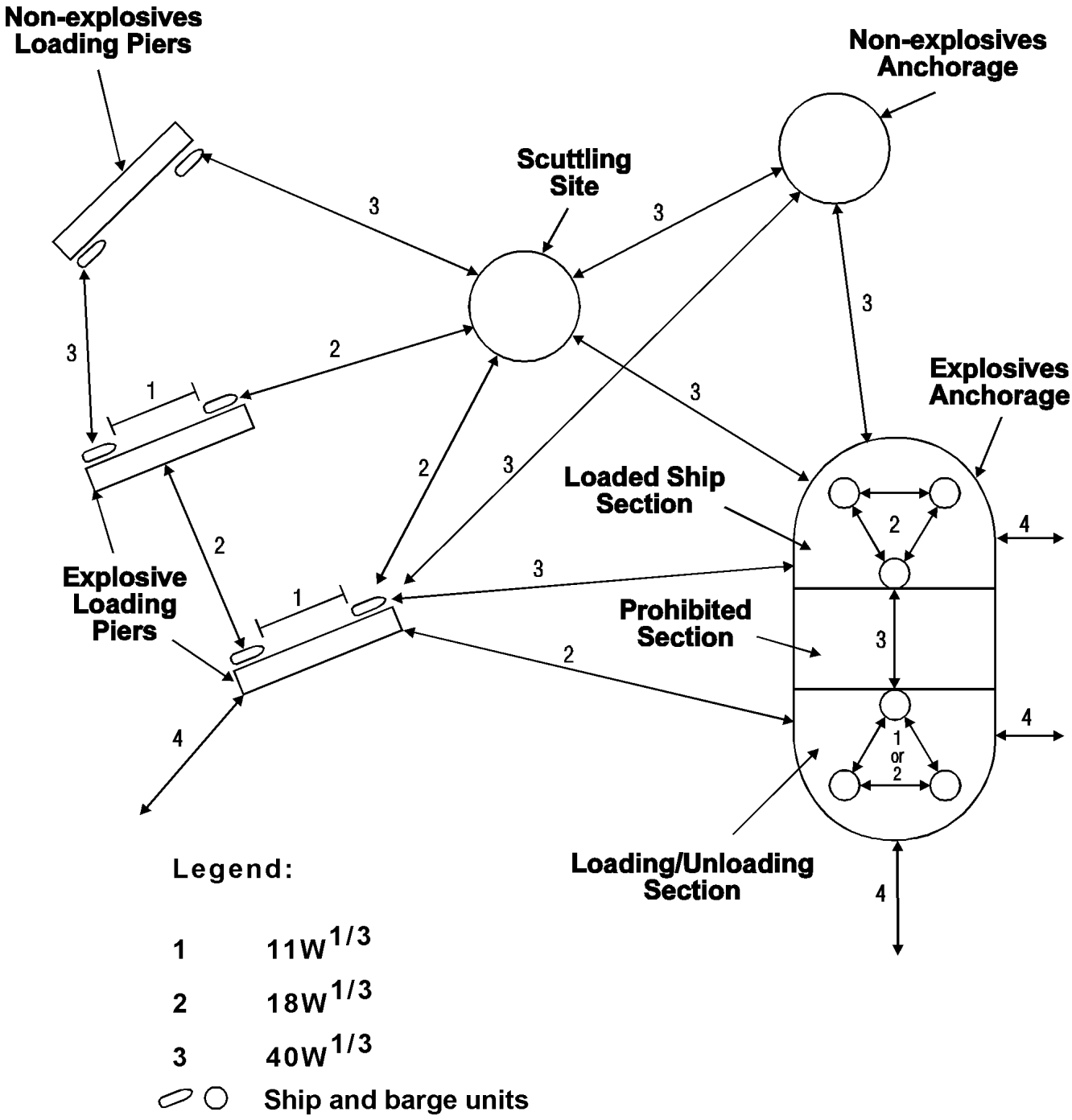

Figure 9-2. Application of Separation Distances for Ship and Barge Units.

Table 6-17. Q/D Separations for Pier and Warf Facilities.

(see Figure 6-2)

Net Explosives Weight (lb)	Distance in feet			
	Hazard Factor (k)			
	6	11	18	40
1,000	60	110	180	400
10,000	130	235	390	860
100,000	280	510	835	1,855
250,000	380	690	1,135	2,520
500,000	475	875	1,430	3,175
600,000	505	930	1,520	3,375
700,000	535	975	1,600	3,550
800,000	555	1,020	1,670	3,715
900,000	580	1,065	1,740	3,860
1,000,000	600	1,100	1,800	4,000
1,250,000	645	1,185	1,940	4,310
1,500,000	690	1,265	2,060	4,580
1,750,000	725	1,325	2,170	4,820
2,000,000	755	1,385	2,270	5,040
2,250,000	785	1,440	2,360	5,240
2,500,000	815	1,495	2,445	5,430
2,750,000	840	1,540	2,520	5,605
3,000,000	865	1,585	2,595	5,770
3,250,000	890	1,630	2,665	5,925
3,500,000	910	1,670	2,735	6,075
3,750,000	930	1,705	2,795	6,215
4,000,000	955	1,750	2,855	6,350
4,250,000	970	1,780	2,915	6,480
4,500,000	990	1,815	2,970	6,605
4,750,000	1,010	1,850	3,025	6,725
5,000,000	1,025	1,880	3,080	6,840
5,500,000	1,060	1,950	3,175	7,060
6,000,000	1,090	2,000	3,270	7,270
6,500,000	1,120	2,055	3,360	7,465
7,000,000	1,145	2,100	3,445	7,650
7,500,000	1,175	2,155	3,525	7,830
8,000,000	1,200	2,200	3,600	8,000
8,500,000	1,225	2,245	3,675	8,165
9,000,000	1,250	2,290	3,745	8,320
9,500,000	1,270	2,330	3,815	8,470
10,000,000	1,290	2,365	3,880	8,620
11,000,000	1,330	2,440	4,005	8,895
12,000,000	1,375	2,520	4,120	9,160
13,000,000	1,410	2,585	4,230	9,405
14,000,000	1,445	2,655	4,340	9,640
15,000,000	1,480	2,715	4,440	9,865

CHAPTER 7

LIQUID PROPELLANT REQUIREMENTS

A. Application

1. These criteria establish Q-D, storage compatibility groupings, and high explosives equivalencies for liquid propellants. They apply to liquid propellant storage facilities (including missiles, rockets, and multi-compartment tanks in which both liquid fuels and liquid oxidizers are stored).

2. If hazard classifications and storage compatibility groups for liquid propellants are not listed in Table 7-1, they may be obtained from the PCO.

B. Determination of propellant quantity

1. For Q-D purposes, the net weight of propellant in a tank, drum, cylinder, or other container shall be used. The quantity of propellant in associated piping (to the point(s) providing means for interrupting the flow in an incident) shall be included in the net weight of propellant in a storage container.

2. When incompatible propellants are not separated by distances prescribed in Table 7-2 or provisions for preventing their mixing are not available, the combined quantity of the two shall be used with appropriate HE equivalency (Table 7-3) to determine the Q-D (Table 7-4).

C. Measurement of separation distances

1. Separation distances shall be measured from the nearest PES (containers, buildings, or positive cutoff point in piping, whichever is controlling).

2. If a building contains a small number of drums or cylinders, or if quantities of propellant in the building are subdivided effectively, distances may be measured from the nearest container or controlling subdivision.

D. Q-D considerations

1. Q-D criteria in this section are based on these premises: construction materials shall be compatible with propellants to which they may be exposed; design shall take into account the properties of the propellant; required fire protection and drainage controls shall be provided; and other special controls (such as nitrogen padding, tank cooling, etc.) shall be provided when required.

2. If group I, II, and III propellants are contaminated, Table 7-2 is not applicable. In such cases, group IV Q-D requirements shall apply except when the PCO specifically approves other criteria.

E. Hazard grouping

Liquid propellants present various types and degrees of hazards. The following propellant groupings are based on these hazards.

1. **Group I.** Considered the least hazardous, these materials have a fire hazard potential and require separation distance as specified in Table 7-2. When group I materials are stored with more hazardous materials under conditions described in Section F, Table 7-3 and Table 7-4, shall determine Q-D requirements.

2. **Group II.** Strong oxidizers, these materials may cause serious fires when they come into contact with material such as organic matter. Table 7-2 specifies quantity limitations and minimum distance requirements. When group II materials are stored with more hazardous materials under conditions described in Section F, Table 7-3 and Table 7-4 shall determine Q-D requirements.

3. **Group III.** Hazardous fragmentation of the container, its protective structure, or other nearby material may be produced by pressure rupture of the storage container or a vapor-phase explosion. Table 7-2 specifies quantity limitations and minimum distance requirements for this group. When group III materials are stored with more hazardous materials, under conditions described in Section F, Table 7-3 and Table 7-4 shall determine Q-D requirements.

4. **Group IV.** These hazards are the same as for mass-detonating explosives (such as air blast overpressure and fragments from the containers and surrounding equipment and material). Table 7-4 shall determine Q-D requirements.

F. Hazards

Propellant groups differ in hazards, as explained above; however, the predominant hazard of the individual propellant varies according to the type of location at which the propellant is stored and the operation(s) in which it is used. These conditions follow, in order of decreasing hazard:

1. **Range launch pads.** Activities at range launch pads include research, development, and testing. The proximity of fuel to oxidizer, the frequency of launchings and the possibility of fall-back (with resultant dynamic mixing on impact) make operations at these facilities very hazardous. Explosives equivalents (Table 7-3) shall be used to determine Q-D (Table 7-4).

2. **Static test stands.** Although these can involve experimental operations, the units remain static and are subject to better control than dynamic ones. Unless run tankages for fuel and oxidizer are mounted one above the other, it is possible to separate the tankages to reduce the hazard. Except as provided in Section G, explosives equivalents (Table 7-3) shall be used to determine Q-D (Table 7-4).

3. **Ready storage.** Ready storage may be located at a minimum of intraline distance from launch and static test stands, based on the propellant requiring the greater distance. Normally, propellant from ready storage is not fed directly into an engine, as is the case with run tankage (see subsection F.7). HE equivalents (Table 7-3) shall be used for propellants in ready storage if the facility design does not guarantee against fuel and oxidizer mixing and against propagation to, or initiation at, the ready storage facility when a mishap occurs at the test stand or launch pad. If

prevention of detonation of ready storage is assured, Q-D's shall be based on the prevailing fire or fragment hazards (Table 7-2).

4. **Cold-flow test operations.** Fire and fragment hazards (Table 7-2) govern if the system is closed (except for approved venting) and completely airtight; if fuel and oxidizer are never employed concurrently, each has an isolated system, and fittings are such that intermixing is impossible; and if the propellants are of required purity. Otherwise, HE equivalents (Table 7-3) shall be used to determine Q-D's (Table 7-4).

5. **Bulk storage.** This is the most remote storage with respect to launch and test operations, because it is never directly connected to any of them. It consists of the area, tanks, and other containers therein, used to hold propellant for supplying ready storage and, indirectly, run tankage where no ready storage is available. Individual bulk storage facilities shall be separated from each other and from unrelated exposures in accordance with Tables 7-2 and 7-4. If positive measures are not taken to prevent mixing of group I, II, and III fuels and oxidizers, TNT equivalents (Table 7-3) shall be used to determine Q-D's (Table 7-4).

6. **Rest storage.** This temporary storage resembles bulk storage. Barges, trailers, tank cars, and portable hold-tanks (used for topping operations) may be used as rest storage facilities. Fire and fragment hazards (Table 7-2) govern. The transporter becomes a part of that storage to which it is connected during propellant transfer.

7. **Run tankage (operating tankage).** Run tankage (operating tankage) consists of the tank and/or other containers and associated piping used to hold the propellants for direct feeding into the engine or device during operations (subsection F.3).

8. **Pipelines.** A distance of 25 feet free of inhabited buildings shall be maintained on either side of the pipelines used for the transfer of group II and III propellants between unloading points and storage areas or between storage areas and points of use.

G. Incompatible storage

Except where effectively subdivided by intervening barriers or other positive means for preventing mixing, separation distance between propellants of different compatibility groups (CGs) shall be the inhabited building distance for the propellant quantity and group that requires the greater distance. Where prevention of mixing is assured, incompatible storage shall be separated from each other by intragroup distance. If different hazard groups are involved, the group requiring the greater distance shall be controlling.

H. Compatible storage

Compatible storage of propellants of different hazard groups shall be separated from other exposures by the greater intragroup storage distance (see Table 7-2).

Table 7-1. Liquid Propellants Hazard and Compatibility Groupings.

Propellant	Hazard Group[1]	Storage Group[2]
Alcohols CH_3OH, C_2H_5OH, $(CH_3)_2CHOH$	I	C
Anhydrous Ammonia NH_3	I	C
Aniline $C_6H_5NH_2$	I	C
Hydrocarbon Fuels JP-4, JP-5, RP-1	I	C
Monopropellant NOS-58-6	I	C
Nitrogen Tetroxide N_2O_4	I	A
Otto Fuel II	I	G
Red Fuming Nitric Acid HNO_3	I	A
Bromine Pentafluoride BrF_5	II	A
Chlorine Trifluoride ClF_3	II	A
Hydrogen Peroxide Greater than 52% H_2O_2	II[3]	A
Liquid Fluorine LF_2	II	A
Liquid Oxygen LO_2	II	A
Perchloryl Fluoride CLO_3 F	II	A
Oxygen Difluoride OF_2	II	A
Ozone Difluoride O_3F_3	II	A
Ethylene Oxide C_2H_4 O	III	D
Hydrazine N_2H_4	III	C
Hydrazine-UDMH Mixtures	III	C
Liquid Hydrogen LH_2	III	C
Mixed Amine Fuels	III	C
Monomethylhydrazine CH_3NHNH_2	III	C
Pentaborane B_5H_9	III	D
Triethyl Boron B $(C_2H_5)_3$	I	D
UDMH (CH_3) NNH_2	III	C
Nitromethane CH_3 NO_2	IV[5]	F[4]
Tetranitromethane $C(NO_2)_4$	IV	F

1 For some of the materials listed, the toxic hazard may be an overriding consideration. Consult applicable regulations and, if necessary, other authorities or publications for determination of toxic siting criteria.

2 All propellants in a compatibility group are considered compatible. Groupings must not be confused with ammunition and explosives compatibility groupings with like letters.

3 Under certain conditions, this propellant can detonate. However, its sensitivity to detonation is not greater than that of a standard energetic double base solid propellant under the same conditions.

4 Nitromethane is chemically compatible with compatibility storage group C liquid propellants, but due to differences in hazards should be stored separately.

5 Technical grade nitromethane in unit quantities of 55 gallons or less in DOT 17E or C drums may be stored as Hazard Group II provided the following apply:

a. Drums are stored only one tier high.

b. Drums are protected from direct rays of sun.

c. Maximum storage life of 2 years, unless storage life tests indicate product continues to meet purchase specification. Such tests are to be repeated at 1 year intervals thereafter.

Table 7-2. Quantity/Distance for Propellants.

Pounds of Propellant		Hazard Group I		Hazard Group II		Hazard Group III		
						IBD, PTR, & Incompatible Group III		Intra-group (ILD) [1] & Group III [11]
Over:	Not over:	IBD, PTR, & Incom-patible Group I [4]	Intra-group (ILD) [1] & Group I [5]	IBD, PTR, & Incom-patible Group II [6]	Intra-group (ILD) [1] & Group II [7]	Unpro-tected [9]	Pro tected [8 10]	
0	[2] 100	30	25	60	30	600	80	30
[2] 100	[2] 200	35	30	75	35	600	100	35
[2] 200	[2] 300	40	35	85	40	600	110	40
[2] 300	[2] 400	45	35	90	45	600	120	45
[2] 400	[2] 500	50	40	100	50	600	130	50
500	600	50	40	100	50	600	135	50
600	700	55	40	105	55	600	140	55
700	800	55	45	110	55	600	145	55
800	900	60	45	115	60	600	150	60
900	1,000	60	45	120	60	600	150	60
1,000	2,000	65	50	130	65	600	175	65
2,000	3,000	70	55	145	70	600	190	70
3,000	4,000	75	55	150	75	600	200	75
4,000	5,000	80	60	160	80	600	210	80
5,000	6,000	80	60	165	80	600	220	80
6,000	7,000	85	65	170	85	600	225	85
7,000	8,000	85	65	175	85	600	230	85
8,000	9,000	90	70	175	90	600	235	90
9,000	10,000	90	70	180	90	600	240	90
10,000	15,000	95	75	195	95	1,200	260	95
15,000	20,000	100	80	205	100	1,200	275	100
20,000	25,000	105	80	215	105	1,200	285	105
25,000	30,000	110	85	220	110	1,200	295	110
30,000	35,000	110	85	225	110	1,200	300	110
35,000	40,000	115	85	230	115	1,200	310	115
40,000	45,000	120	90	235	120	1,200	315	120
45,000	50,000	120	90	240	120	1,200	320	120
50,000	60,000	125	95	250	125	1,200	320	125
60,000	70,000	130	95	255	130	1,200	340	130
70,000	80,000	130	100	260	130	1,200	350	130
80,000	90,000	135	100	265	135	1,200	360	135
90,000	100,000	135	105	270	135	1,200	365	135
100,000	125,000	140	110	285	140	1,800	380	140
125,000	150,000	145	110	295	145	1,800	395	145
150,000	175,000	150	115	305	150	1,800	405	150
175,000	200,000	155	115	310	155	1,800	415	155
200,000	250,000	160	120	320	160	1,800	425	160
250,000	300,000	165	125	330	165	1,800	440	165
300,000	350,000	170	130	340	170	1,800	455	170
350,000	400,000	175	130	350	175	1,800	465	175
400,000	450,000	180	135	355	180	1,800	475	180
450,000	500,000	180	135	360	180	1,800	485	180
500,000	600,000	185	140	375	185	1,800	500	185
600,000	700,000	190	145	385	190	1,800	515	190
700,000	800,000	195	150	395	195	1,800	530	195
800,000	900,000	200	150	405	200	1,800	540	200
900,000	1,000,000	205	155	410	205	1,800	550	205
[3] 1,000,000	2,000,000	235	175	470	235	1,800	630	235
2,000,000	3,000,000	255	190	505	255	1,800	675	255
3,000,000	4,000,000	265	200	535	265	1,800	710	265
4,000,000	5,000,000	275	210	555	275	1,800	740	275
5,000,000	6,000,000	285	215	570	285	1,800	760	285
6,000,000	7,000,000	295	220	585	295	1,800	780	295
7,000,000	8,000,000	300	225	600	300	1,800	800	300
8,000,000	9,000,000	305	230	610	305	1,800	815	305
9,000,000	10,000,000	310	235	620	310	1,800	830	310

1 See Sections G and H.

2 A single standard minimum size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, and so forth, may be handled or stored without regard to distances prescribed.

3 Extrapolations above 1,000,000 lbs extend well outside data included in the Bureau of Mines report from which original Q/D tables were derived; however, they are supported by independent calculations and knowledge of like phenomena.

4 Values are one-half of the Group II inhabited building distance.

5 Values are three-fourths the Group II and Group III intragroup distances.

6 Distances were selected as three-fourths the Group III inhabited building distance and considered reasonable due to the lesser hazard.

7 Distances were derived from the Bureau of Mines, Department of the Interior Report No. 5707, dated 1961, modified and expanded. They average 37.5 percent of the inhabited building distances given in this report.

8 The term "protected" means that protection from fragments is provided by terrain, effective barricades, nets, or other physical means.

9 Distances are necessary to provide reasonable protection from fragments of tanks or equipment that are expected to be thrown in event of a vapor phase explosion.

10 Distances are the recommended inhabited building distances given in the Bureau of Mines, Department of the Interior Report No. 5707, dated 1961, and extrapolation thereof (2 cal/cm^2 on 1 percent water vapor curve).

11 Distances are an average of 37.5 percent of "protected" column.

Table 7-3. Liquid Propellant Explosive Equivalents.

Propellant Combinations	Static Test Stands	Range Launch
LO_2LH_2 or B_5H_9 + an oxidizer	60%	60%
LO_2LH_2 + LO_2/RP-1	Sum of (60% for LO_2LH_2)+ (10% for LOs2sRP-1)	Sum of (60% for LO_2LH_2)+ (20% for LO_2/RP-1)
LO_2RP-1 or LO_2NH_3 or B_5H_9+ a fuel	10%	20% up to 500,000 pounds plus 10% over 500,000 pounds
IRFNA/Aniline (Note 1)	10%	10%
IRFNA/UDMH (Note 1)	10%	10%
IRFNA/UDMH + JP-4 (Note 1)	10%	10%
N_2O_4/UDMH + N_2H_4 (Note 1)	5%	10%
N_2O_4/UDMH + N_2H_4 (Note 1) + solid propellants	5% plus the explosive equivalent of the solid propellants.	10% plus the explosive equivalent of the sold propellant.
Tetranitromethane (alone or in combination)	100%	100%
Nitromethane (alone or in combination)	100%	100%

1 These are hypergolic combinations.

2 The percentage factors given in the table are to be used to determine equivalencies of propellant mixtures at static test stands and range launch pads when such propellants are located aboveground and are unconfined except for their tankage. Other configurations shall be considered on an individual basis to determine equivalencies.

3 The explosives equivalent weight calculated by the use of this table shall be added to any non-nuclear explosive weight aboard before distances can be determined from Tables 7-2 and 7-3.

4 These equivalencies apply also for the following substitutions:

a. Alcohols or other hydrocarbons for RP-1.

b. BrF_5, ClF_3, F_2, H_2, H_2O_2, OF_2, or O_2F_2 for LO_2.

c. MMH for N_2H_4 or UDMH.

d. C_2H_4O for any propellant.

e. NH_3 for any fuel resulting in a hypergolic combination.

5 Use LO_2/RP-1 distance for pentaborane plus a fuel and LO_2/LH_2 distances for pentaborane plus an oxidizer.

6 For quantities of propellant up to but not over the equivalent of 100 pounds of explosives, the distance shall be determined on an individual basis by the PCO. All personnel and facilities, whether involved in the operation or not, shall be protected by operating procedures, equipment design, shielding, barricading, or other suitable means.

7 Distance less than intraline area not specified. Where a number of prepackaged liquid propellant units are stored together, separation distance to other storage facilities shall be determined on an individual basis by the PCO, taking into consideration normal hazard classification procedures.

Table 7-4. Distances for Separation of Propellant Static Testing, Launching, and Storage Sites from Other Facilities.

Maximum weight of explosives or group IV propellant in pounds	Distance in feet from propellant explosive hazard				Maximum weight of explosives or group IV propellant in pounds	Distance in feet from propellant explosive hazard			
	to inhabited buildings	to public traffic routes	Intraline			to inhabited buildings	to public traffic routes	Intraline	
			barricaded	unbarricaded				barricaded	unbarricaded
Col 1	Col 2	Col 3	Col 4	Col 5	Col 1	Col 2	Col 3	Col 4	Col 5
100	190	115	40	80	75,000	1,685	1,010	385	770
200	235	140	50	100	80,000	1,725	1,035	390	780
300	270	160	60	120	85,000	1,760	1,055	395	790
400	295	175	65	130	90,000	1,795	1,075	400	800
500	320	190	70	140	95,000	1,825	1,095	410	820
600	340	205	75	150	100,000	1,855	1,115	415	830
700	355	215	80	160	125,000	2,115	1,270	450	900
800	375	225	85	170	150,000	2,350	1,410	475	950
900	390	235	90	180	175,000	2,565	1,540	500	1,000
1,000	400	240	95	190	200,000	2,770	1,660	525	1,050
1,500	460	275	105	210	225,000	2,965	1,780	550	1,100
2,000	505	305	115	230	250,000	3,150	1,890	575	1,150
3,000	580	350	130	260	275,000	3,250	1,950	585	1,170
4,000	635	380	140	280	300,000	3,345	2,005	600	1,200
5,000	685	410	150	300	325,000	3,440	2,065	620	1,240
6,000	730	440	160	320	350,000	3,525	2,115	635	1,270
7,000	770	460	170	340	375,000	3,605	2,165	650	1,300
8,000	800	480	180	360	400,000	3,685	2,210	665	1,330
9,000	835	500	190	380	500,000	3,970	2,380	715	1,430
10,000	865	520	200	400	600,000	4,215	2,530	780	1,560
15,000	990	595	225	450	700,000	4,440	2,665	825	1,650
20,000	1,090	655	245	490	800,000	4,640	2,785	860	1,720
25,000	1,170	700	265	530	900,000	4,825	2,895	895	1,790
30,000	1,245	745	280	560	1,000,000	5,000	3,000	925	1.850
35,000	1,310	785	295	590	1,500,000	5,725	3,435	1,060	2,120
40,000	1,370	820	310	620	2,000,000	6,300	3,780	1,170	2,340
45,000	1,425	855	320	640	2,500,000	6,785	4,070	1,260	2,520
50,000	1,475	885	330	660	3000,000	7,210	4,325	1,340	2,680
55,000	1,520	910	340	680	3,500,000	7,590	4,555	1,405	2,810
60,000	1,565	940	350	700	4,000,000	7,935	4,760	1,470	2,940
65,000	1,610	965	360	720	5,000,000	8,550	5,130	1,585	3,170
70,000	1,650	990	370	740					

Table 7-5. Factors To Be Used When Converting Gallons of Propellant into Pounds.

Item	Pounds per gallon	At Temperature ^{o}F
Anhydrous ammonia	5.1	68
Aniline	8.5	68
Bromine pentafluoride	20.7	68
Chlorine trifluoride	15.3	68
Ethyl alcohol	6.6	68
Ethylene oxide	7.3	68
Fluorine (liquid)	12.6	-306
Furfuryl alcohol	9.4	68
Hydrocarbon fuel JP-4	6.35	60
Hydrocarbon fuel JP-5	6.84	60
Hydrogen peroxide (90 percent)	11.6	68
Hydrazine	8.4	68
Isopropyl alcohol	6.6	68
Liquid hydrogen	0.59	-423
Liquid oxygen	9.5	-297
Methyl alcohol	6.6	68
Mono methyl hydrazine	7.3	68
Monopropellant NOS-58-6	9.46	68
Nitromethane	9.5	68
Nitrogen tetroxide	12.1	68
Otto fuel	10.5	77
Oxygen difluoride	12.7	-229
Ozone difluoride	14.6	-297
Pentaborane	5.2	68
Perchloryl fluoride	12.0	68
Red fuming nitric acid (IFFNA)	12.5	68
RP-1	6.8	68
Tetranitromethane	13.6	78
Triethyl Boron B	5.8	73
UDMH	6.6	68
UDMH/hydrazine	7.5	68

Note: Conversion of quantities of propellant from gallons to pounds: Pounds of propellant = gallons X density of propellant in pounds per gallon.

CHAPTER 8

MANUFACTURING AND PROCESSING PYROTECHNICS

A. General

The safety precautions for manufacturing and processing pyrotechnics parallel those of many types of explosives and other energetic materials. Pyrotechnics, as a group, display many different characteristics because they are formulated for different purposes. Pyrotechnics can be divided into general categories, such as: initiators (igniters); illuminants; smokes; gas generators; sound generators; heat producers; and timing compositions. Each has its own characteristics and attendant processing requirements. Knowledge of these characteristics is necessary to ensure safety in processing. The range of characteristics associated with pyrotechnics includes easily initiated compositions from those that burn in seconds at temperatures exceeding 2763°C (5000°F) through those that require substantial energy for initiation and have relatively low output temperatures. As examples, the auto-ignition temperature for smoke Compositions is typically about 180°C while for illuminants it is about 500°C; illuminants burn approximately 2.7 times faster than smokes and the heat of reaction is 1.5 times as great; infrared (IR) flare compositions are both hotter and faster-burning than illuminants. Many of the compositions in the ignitor or initiator class are as sensitive to static electricity, friction, or impact as are initiating explosives such as lead azide and lead styphnate. Initiation thresholds to such stimuli as impact, friction, and electrostatic discharge must be known for safety in specific processes. The response of the material in terms of energy release shall be considered in ensuring personnel safety. In addition to the safety precautions generally required for the handling of explosives and other energetic materials, the following paragraphs provide specific guidance pertinent to pyrotechnic operations.

B. Machinery, equipment, and facilities

Except as provided for in this chapter, the design, layout, and operation of facilities and equipment shall follow the mandatory provisions for the processing of explosives and other energetic materials contained elsewhere in this manual. Where guidance is not provided, operations should be governed by the results of hazard analyses performed and documented to address specific operations. Since most pyrotechnic compositions are sensitive to initiation by static electricity, bonding and grounding, along with other means of static elimination and control, have paramount importance.

C. Weighing of raw materials

Separate weight or measurement rooms, cubicles, or areas (dependent upon the quantity and sensitivity of the materials handled) shall be provided -- one for oxidizers and one for combustible materials and metallic powders. It is important that containers, equipment, hand tools, scale pans, etc., used for weighing fuels or oxidizers are not interchanged or shared among incompatible operations, particularly where distance rather than physical barriers separates these areas. Positive measures shall be adopted to ensure the complete separation of such equipment and tools. Personnel weighing or handling exposed oxidizers or fuels shall, at a minimum, wear flame retardant uniforms, cotton undergarments, cotton socks, and conductive shoes.

D. Drying of materials

The minimum temperature necessary to meet processing requirements shall be used to dry components and pyrotechnic materials. Drying rooms or ovens shall meet the requirements of Chapter 13, Section F.

E. Mixing and blending

Mixing and blending of pyrotechnic compositions requires attention because most injury-producing accidents have occurred during the mixing, blending, or subsequent cleanup operations. Because of the variety within and among these compositions, no single type of mixer or blender can be the exclusively approved equipment for pyrotechnic mixing and blending operations.

1. Each mixing device shall be considered separately with respect to the composition to be processed. When a history of safe operation has not been established, the type of mixer or blender and batch size should be evaluated by appropriate hazard analysis or tests. Generally, devices that use a tumbling action shall be preferred to those using rotating blades, to minimize points where frictional heat may develop or where accidentally introduced foreign material can create hot spots through friction or crushing of composition. Mixers and blenders shall be equipped for pressure relief, to preclude a transition from burning to detonation. Personnel exposures during charging and emptying of mixers shall be minimal. When the energetic characteristics and quantities of composition involved so dictate, mixers and blenders shall be charged, operated, and emptied remotely. When hazard analysis or testing has shown this to be safe, mixers or blenders may be charged or emptied manually. Appropriate interlocks, clutch brakes, and similar devices shall be used 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.

2. Mixing and blending operations shall be conducted in buildings or cubicles designed for such purposes. Multiple mixing or blending operations may be conducted in the same building, provided that each blender or mixer is located in a separate room, bay, or cell, and separated from other operations by substantial dividing walls. Two or more mixers or blenders may be located in the same cubicle, provided that the hazards are not increased by such installation. Normally, this would require that the materials in process be of significantly low energy content or slow energy release and the mixers be charged and emptied simultaneously. At least one wall or equivalent panel area in each bay shall be frangible so as to provide pressure relief in the event of an incident. Cell arrangement and pressure relief areas shall be located so that personnel cannot pass in front of these areas while mixers or blenders are operating.

3. Exhaust ventilation equipment shall be installed on mixers or in bays where flammable solvents are used and interlocked with the mixers. The interlock shall be designed to preclude mixer operation without ventilation although operation of the ventilation system without the mixer is permitted. Vapor sensors should be used to give automatic warning of a build-up of flammable vapors to a level approaching that of the lower explosive limit. Such sensors should be interlocked to personnel access control devices. Ventilation system designs shall not permit propagation of an incident in one bay to others served by the same system.

4. The operation of mixers or blenders may be observed by remote means such as closed-circuit television, mirrors, or transparent shields providing operator protection. Direct viewing of blender or mixer operation without intervening barriers is prohibited.

5. Manual mixing blending or scraping of fuels and oxidizers is prohibited.

6. The following are the minimum criteria for rotating blade mixing operations:

a. The mix equipment shall be rigidly fixed and stable during mixing to preclude contact between the bowl and the mix blades.

b. Positive controls are provided to physically block or stop bowl or blender head movement in case of hydraulic or pnuematic malfunction to assure clearance at all times between mix bowl and blades.

c. Mix blades and shaft shall be rigid and structurally strong to ensure minimum flex from weight of the mix and speed of the shaft.

d. Any mixer electrical components shall meet the appropriate National Electric Code (NEC) electrical classification.

e. Mix blade shaft should 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, they shall be periodically tested for contamination and cleaned.

f. A program shall be established whereby mix blade shaft and bearings are monitored and changed before becoming worn and allowing loose play in the blade shaft. Maintain a record of such checks, mixer blade adjustments, and any damage to the mixer blades and bowls.

g. Wet mixing shall not be started until adequate solvent is added to preclude dry mixing.

h. The operating procedures shall contain provisions to verify acceptable blade/bowl clearance, bowl and shaft rigidity, and bearing wear prior to introduction of materials.

i. Electrical service to mixers shall be interlocked with fire protection system controls so that the mixer cannot start when the fire protection system is inoperative.

j. Maintain grounding during charging or discharging of mixes.

k. Maintain torque limits or amperage overload protection.

l. Maintain appropriate solvent traps for vacuum mixing.

F. Pressing, extruding, and pelleting

1. Pressing operations shall be conducted with personnel protected by substantial dividing walls, barricades, or operational shields; or shall take place at intraline distance from the operator and other operations. When it is necessary to repair, adjust, or otherwise clear a jam on a press or extruder, the pyrotechnic material shall be removed from the hopper and the bay or press room before such repairs or adjustments are made. 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 requiring the use of tools be permitted with pyrotechnic material in the bay.

2. The quantity of composition at the pressing location (behind the barricade) shall not exceed that required for the components undergoing the pressing operation. 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.

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. Multiple installations may be permitted within a bay or cubicle, provided that tests or hazard analysis demonstrate that facility and personnel hazards are not increased. Adequate means of pressure relief shall be built into each bay or cubicle.

G. Assembly operations

Individual assembly operations shall be adequately separated from each other, and shall be located in a separate cubicle or building from mixing, blending, and consolidation operations. Pyrotechnic composition shall be kept in closed or covered containers at all times except during processing. Surge, storage, and in-process transit between operations shall also be accomplished with closed containers whenever not absolutely prohibited by the operational configuration. Components in any assembly room, bay, or building, shall be limited to the smallest quantity necessary for safe and efficient operations.

H. Granulation, grinding, and screening

1. Material to be reduced in particle size shall be processed over a mechanical or magnetic separator to remove foreign materials before grinding. Following grinding, the material should be re-screened or passed over a magnetic separator.

2. In the operation of ball mills, hammer mills, granulators, or screeners, the operator shall be protected from the effects of a potential incident by substantial dividing walls or operational shields. Every effort shall be made to fill and discharge grinding, granulating, and screening equipment remotely. Cleaning of such devices shall also afford maximal operator protection.

3. Working surfaces, containers, and hand tools shall be appropriately bonded and grounded.

I. Transportation

Pyrotechnic compositions shall be moved in closed containers only. Individual containers and the transport vehicle (hand cart, hand truck, etc.) should be fabricated of the lightest materials compatible with the composition and having the requisite strength. This shall minimize fragment generation if an incident should occur. Transport vehicles should be equipped with “dead man” brakes. On- and off-loading of transport vehicles should be conducted only in weather-protected areas designated for this purpose. Racks or other support, suited to the size and shape of composition containers, should be provided to prevent them from falling.

J. Rebowling

Rebowling operations transfer materials, typically sensitive and in small quantities, from one container to another. They may be done to recover remains of small quantities of materials, or to subdivide large masses for processing. Operational shields shall be provided to protect operators.

K. Machining of pyrotechnic material

1. Machining of pyrotechnic materials shall be accomplished remotely.

2. General requirements.

a. When required, coolant shall be compatible with the pyrotechnic composition. Positive automatic interlocking devices shall ensure that the machine cannot be started until the coolant is flowing. These controls shall also be capable of stopping the machine should the flow of coolant be interrupted. When it is essential to cut off the coolant to adjust machine tools, it shall be restored, and all automatic controls operating, before machining resumes. If a cutting edge overheats during machining, it is most dangerous when continuous contact with the pyrotechnic material is maintained after the machine has stopped. It is, therefore, essential that coolant continue flowing until the cutter is removed from contact with the pyrotechnic material.

b. Sensors are recommended to detect tooling malfunctions or other potentially hazardous conditions. Machine tool power-consumption monitors,tool force gages, sound or noise detectors, temperature-indicating devices, or IR detectors can be used in this regard.

c. Cutting tools shall be chemically compatible with the pyrotechnic material to be machined, capable of maintaining a sharp cutting edge throughout the machine cycle.

d. Control measures such as guides, bushings, and stops shall limit depth, diameter, and contour of the cut. The lineal and rotational speed of tools for the machining of pyrotechnic material shall be the minimum necessary for safe and efficient operation. Controls should be designed to prevent unintended operator adjustment.

e. Drilling operations shall not impede the flow of chips and coolant in the bore. The drilling of small holes (one-quarter inch or less) and any size of multiple drilling operation shall be performed by remote control, with operator protection, unless documented hazard analysis or tests prove this unnecessary.

f. Contoured cutting tools shall be removed from contact with the pyrotechnic material being machined before personnel are permitted to enter the machining area. Frequently cleaning machine tools during operating hours shall prevent residues from accumulating; a thorough cleaning shall conclude each work shift. Vacuum accumulator systems, immersion in liquid coolant streams, or similar automatic means shall remove the pyrotechnic waste products. Only low pressure (10 pounds per square inch guage (PSIG)) compressed air may be used as a coolant and only when the scattering of pyrotechnic particles is contained by a vacuum collection system. The coolant delivery tube shall have a metallic tip or nozzle grounded to the machine to reduce static charges.

3. Specific guidance for machining.

a. Drilling and facing operations for colored smoke compositions containing organic dyes, potassium chlorates, and sugars should be conducted at not more than 2475 lineal inches per minute, with the feed rate adjusted to enhance the machinability of the composition. For red phosphorous compositions, drilling and facing operations should be conducted at not more than 1100 lineal inches per minute with the feed adjusted to minimize friction and heat buildup. For extruded candles composed of magnesium, tetrafluoroethylene polymers, and fluoroelastomer

binders, drilling and machining operations shall be conducted at not more than 530 lineal inches per minute.

b. Hand trimming and cutting of pyrotechnic candles may be permitted when supported by results of a hazard analysis specific to that composition and candle configuration.

c. Sawing operations require particular care, to prevent work from plunging into the saw blade and to ensure that chips are removed from sawteeth before their next cutting pass. Plunging can occur when thin sections are force-fed into coarse-pitch saw blades. To prevent this, a minimum of two saw teeth shall remain in contact with the work during sawing, or the work feed 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. Additional chip removal equipment such as blade-wiping brushes may be required.

L. Spill control

Spills of pyrotechnic composition and energetic ingredients pose potential hazards. In case of accident, the responsible supervisor should be notified before any action to clean or contain the spill. Standard operating procedures (SOPs) 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 recovery of the spilled material and decontamination of the area shall also be addressed.

M. Collection of pyrotechnic wastes

1. Waste material and scraps shall be removed at regular intervals from all operating areas. All waste material shall be segregated by type and compatibility, and kept separate from common wastes. Containers for these materials shall be distinguished by color and labeled. Filled containers shall be placed at designated collection points.

2. Special care shall preclude the mixing of small quantities of water with powdered or finely granulated metals. Pyrotechnic waste may be maintained dry or submerged in water or oil, whichever is appropriate for disposal. Plastic liners for waste containers facilitate cleaning. Liners should be conductive when contents are subject to initiation by static electrical discharge.

N. Cleaning of pyrotechnic processing equipment

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

2. Solvent solution flushing and cleaning by remote control is required for slurry-type mixing operations. For other applications, the process equipment shall be flushed with a compatible solvent and drained, with the process repeated as often as necessary to remove the pyrotechnic composition. High-pressure water wash may be used when compatible with the pyrotechnic composition. Precautionary measures shall be taken when a solvent represents a fire or toxicological threat. Runoff from cleaning operations shall be controlled to preclude the creation of a secondary hazard from the spread of contamination.

3. When remote cleaning cannot be used, personal protective equipment shall be designed and proven by test to afford operator protection from the maximum quantity of material that could be present, and its use shall be required.

O. Personal protective equipment

1. Personal protective equipment shall not be relied upon as the primary means of operator protection. The primary means should be by reducing the quantities being handled to the minimum necessary or by using operational shields. Supplemental operator protection should be afforded by high-speed deluge systems designed and installed for such purposes. The personal protective apparel prescribed in an SOP shall be based upon the hazards associated with the operation.

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

a. Cotton undergarments and socks.

b. Conductive-soled safety shoes.

c. Flame retardant coveralls.

d. Hair coverings.

3. All employees exposed to hazardous quantities of pyrotechnic compositions shall wear aluminized, thermally protective suit with hood and face plate; aluminized, thermally protective trousers, and aluminized, thermally protective gloves or equivalent. 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. Required levels of protective apparel shall be specified in appropriate SOP steps.

4. When the items described above are required, the design and wearing shall ensure that no areas of the body are exposed. Appropriate seals or joints shall be used to preclude flame intrusion where apparel items overlap or are joined. Particular attention shall be given to possible gaps in coverage provided by the hood in order to prevent flame or hot gas impingement on the face, head, or neck.

P. Additional controls

1. Many materials used to produce pyrotechnics are toxic, represent fire hazards, or both. Operations shall provide protection from these threats. Vapor- and dust-removal and collection systems shall be provided where toxic or flammable dusts or gases are generated. Design and installation of such equipment shall meet safety requirements.

2. Blankets should be provided in easily opened containers within 25 feet of operations where they could be required for wrapping burned employees. Alternate means of achieving the same effect should be provided when blankets are not.

3. When required, conductive shoes shall be checked for conductivity daily before the beginning of work, and retested upon reentry into the building if the employee has walked over

surfaces (grass, mud, oil, paint, etc.) which could render the shoes ineffective. A log of the testing shall be maintained.

Q. Reworking pyrotechnic components

1. All repair, reassembly, or similar operations on loaded pyrotechnic compositions shall take place in a separate bay used only for that purpose.

2. Consolidated or extruded pyrotechnic compositions shall normally be destroyed, not pulverized for reblending. While HC smoke and such compositions are reusable, more sensitive materials, such as IR flare compositions, are not.

R. Fire protection

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

CHAPTER 9

STORAGE OF EXPLOSIVES AND AMMUNITION

A. General

A properly sited segregated and separate storage area is preferred for explosives storage. Earth-covered magazines (igloo or other subsurface) offer the greatest protection to explosives. Such magazines are preferred for the storage of all explosives. Earth-covered magazines provide protection from weather and fire, and relatively constant temperature control.

B. Storage considerations

Factors to consider when designating a structure for explosive storage are:

1. Magazine construction and location.

2. Quantity and characteristics of explosives to be stored.

C. Magazine operational regulations

1. No loose ammunition components, packing materials, conveyors, skids, dunnage, empty boxes, or other such items shall be stored in magazines containing ammunition or explosives.

2. No crew shall work in a spot that requires passing a second crew's work aisle or position to reach an exit in a magazine. The number of crews should not exceed the number of exits. Doors shall remain unlocked and permit rapid egress.

3. Flammable liquids, except when used as the chemical filler of ammunition, or as a prepackaged storable liquid propellant, shall not be stored in magazines containing explosives.

D. Stacking

1. Ammunition and explosives should be stored in original shipping containers or equivalent. Explosives or ammunition in stacks should be grouped and identified according to lots. General rules set forth in subsections D.2 and D.3, below, shall be followed in the absence of applicable storage drawings.

2. Methods used for stacking shall provide for good ventilation to all parts of the stack. Adequate dunnage shall be used for this purpose.

3. Aisles shall be maintained so that units in each stack may be inspected, inventoried, and removed for shipment or surveillance tests. Block storage is permitted, provided adequate ventilation of stacks exists. Unobstructed aisles shall be maintained to permit rapid egress.

4. Only one light box, pallet, or unit should be allowed per lot in storage. Stacked light units should be readily visible and immediately accessible.

E. Loose rounds, damaged containers

Loose rounds of ammunition, or single fiber containers with rounds therein, shall not be stored in magazines containing ammunition items packed in original shipping containers; however, they may be stored in magazines set aside for their exclusive storage. Incomplete boxes of ammunition and explosives may be stored in magazines containing complete boxes packed in original shipping containers. Conspicuously marked to identify contents and quantities, the incomplete boxes shall be placed in designated locations. Explosives and ammunition in damaged containers should not be stored in a magazine with ammunition in serviceable containers. Such containers should be repaired or the contents transferred to new or serviceable containers. Open containers and containers with covers not securely fastened shall not be allowed in magazines. Containers that have been opened shall be properly closed before being restored. Stored containers should be free from loose dust and grit.

F. Repairs to magazines

1. Repairs should not be made to the interiors of magazines containing bulk explosives. Repairs to roofs, ventilators, lightning rods, doors and other parts of, or appendages to, the exteriors of magazines containing bulk explosives shall not normally require removing the explosives. Minor repairs may be made to the interiors of magazines containing finished ammunition or ammunition components.

2. The general safety requirements set forth in this manual, particularly the elimination of fire hazards, shall be followed when magazines are repaired. When necessary, baffles and screens should be used to confine sparks and flames to heating apparatus.

G. Open storage (outdoors)

Open storage of A&E is prohibited.

H. Storage of bulk initiating explosives

Bulk initiating explosives shall not 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. Covers designed and constructed to prevent friction and pinch points should be used. Covers of shipping containers used for long-term storage shall be equipped with a port for observing the level of the liquid contents. The viewing port shall have a transparent plastic cover proven compatible with the initiating explosives being stored. Bulk initiating explosives may, for expediency, be stored in shipping containers without viewing ports, provided they are stored in magazines that will prevent freezing; with containers on end, only one tier high; with passageways for inspection and handling. Bags of initiating explosives in storage containers shall be under distilled water. Alcohol may be added to the distilled water to prevent freezing.

I. Rockets and rocket motors

1. In aboveground magazines, rockets and rocket motor items (in a propulsive state) should be pointed in the direction least exposing personnel and property in case of fire or explosion.

2. Rockets should be stored in dry, cool magazines, out of the direct rays of the sun. Prolonged exposure of rocket ammunition to either high or low temperatures may increase the normal rate of deterioration or render the motors more susceptible to ignition if handled improperly later.

CHAPTER 10

FIRE PROTECTION

A. General

This chapter provides general requirements for personnel developing and implementing fire protection and prevention programs in A&E environments.

B. Fire plan

A written fire plan shall be prepared. Although details may vary, plans for all establishments shall itemize the emergency functions of each department or outside agency, indicating responsible individuals and alternates.

C. Firefighting agreements

Voluntary and mutual agreements with nearby municipalities or industrial centers should include firefighting procedures as established by the plant officials. Plant officials are responsible for informing the assisting firefighters of particular procedures to be followed. Outside firefighters should not assist in fires involving A&E. If the practical need for their doing so can be anticipated, they shall receive advance instruction in A&E firefighting procedures. Outside firefighters shall never attack fires involving Hazard Divisions 1.1 and 1.2.

D. Smoking

Smoking may take place only in safe, specifically designated and posted "smoking locations."

1. Cigarettes, tobacco, and matches shall be discarded in ash receptacles only. They shall not be dropped into trash cans.

2. Electric lighters with automatic pressure cutoffs shall be fixed, ensuring against removal.

3. At least one fire extinguisher shall be provided at smoking locations.

4. Persons wearing clothing contaminated with explosives or other dangerous material should not be permitted in smoking areas.

E. 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.

F. Portable fire extinguishers

Hand extinguishers within buildings can squelch incipient fires before major damage is done. Portable equipment may prove similarly valuable outside aboveground magazines and other buildings with explosives.

G. Hazards in fighting fires involving ammunition and explosives

A fire hazard identification system shall be adopted. This shall assess relative dangers, up to the most hazardous material stored.

1. **Symbol system.** Fire divisions, numbered "1" through "4," correspond to Hazard Divisions 1.1 through 1.4. The lower the number, the greater the hazard. Distinctively shaped placards, instantly recognizable from a distance, signify the different divisions. Each placard, or symbol, shows the fire division number. Black numbers appear on orange backgrounds as used by the North Atlantic Treaty Organization (NATO), United Nations Organization (UNO), International Maritime Organization (IMO), and the U.S. Department of Transportation (DOT). Reflectorized or luminous symbols are preferred.

Fire Division	Hazard Involved	Shape
1	Mass detonation	Octagon
2	Explosion with fragment hazard	Cross
3	Mass fire	Inverted triangle
4	Moderate fire	Diamond

2. **Firefighting procedures**

a. **General**

(1) Fires should be immediately reported and may be fought without specific authorization. However, personnel should evacuate and seek safety if fires involve explosive materials or cannot be controlled by equipment at hand. Training of operational personnel shall cover the characteristics of explosive materials, including their reactions to heat and fire, as well as what to do in case of fire.

(2) Firefighters should be thoroughly informed of the specific reactions of A&E exposed to heat or fire.

(3) Firefighters should be briefed on conditions at the scene before proceeding.

(4) Ammunition containing both explosives and chemicals require special precautionary measures.

b. **Specific**

(1) Personnel shall not attempt to fight fires involving A&E in Hazard Divisions 1.1 and 1.2. Because this material detonates with a fragmentation hazard, personnel shall evacuate immediately, using protective cover and activating deluge systems and fire alarms while escaping. Individuals remain in danger until they reach shelters, although reaching inhabited building distances in the open affords some safety. During exit drills, employees shall be advised of the safest escape routes.

(2) If the fire in a Hazard Division 1.1 or 1.2 building involves nonexplosive material and is small or in a segregated container, an attempt may be made to extinguish the fire. After summoning firefighters, responsible parties should attempt to meet them as they approach to brief

them. When 1.1 or 1.2 materials are directly involved, firefighting forces should maintain inhabited building distance from the fire. The safety of personnel fighting a 1.1 or 1.2 fire depends on the accuracy of the information made available to all firefighting forces. No person shall reenter a burning building containing 1.1 or 1.2 materials.

(3) Personnel in the immediate vicinity of Hazard Division 1.3 explosives should activate deluge systems and alarms. Unless the fire is minor, involves no explosive, and appears controllable, the firefighting organization shall confine its efforts to preventing it from spreading to other buildings. Fire in Hazard Division 1.3 materials creates a wide area of intense radiant heat, dangerous to personnel and equipment. The firefighting organization should exercise extreme caution.

(4) Hazard Division 1.4 A&E present a moderate fire hazard. Fires involving them shall be fought until extinguished.

H. Automatic sprinkler systems

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

I. Clearance under sprinklers

At least 18 inches shall separate sprinkler deflectors from stored materials piled 15 feet high or less; in all other cases, the clearance shall be at least 36 inches. A minimum clearance of 36 inches shall be maintained between sprinklers and extremely hazardous materials, and between sprinklers and baled storage, regardless of height.

J. Deluge systems

1. Deluge systems should supplement sprinklers when the hazards are high, 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. Quick-acting manual controls should serve as backup.

2. To ensure immediate drenching of all parts of the machine, 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.

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 pop immediately. Caps should be attached to outlets to prevent their dropping into equipment during a deluge.

4. Required water flow and pressure should be determined for the hazard.

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

6. The deluge valve should allow for automatic and manual activation. Manual activation devices shall be placed at exits in explosives-operating buildings. They may also be located at the operator stations when hazard analysis determines the risk to personnel acceptable.

7. National Fire Protection Association (NFPA) Standard No. 13, [1] *Installation of Sprinkler Systems* (reference (i)), and No. 15, [2] *Water Spray Fixed Systems* (reference (j)), contain basic installation rules.

K. Hazards in fighting fires involving liquid propellants

For safety's sake, firefighters shall know the burning characteristics and specific hazards of liquid propellants. Burning liquid propellants' fumes are generally toxic, so firefighters should remain on the upwind side. Protective clothing should include an approved, self-contained breathing apparatus.

L. Firebreaks

The primary purpose of vegetation control is to limit the probability of fires causing a hazard to ammunition and explosives areas. Therefore, a firebreak, at least 50 feet wide in all directions, shall be maintained around magazine areas, aboveground magazines and explosives operating buildings/locations. Barricades and other sloping ground, within the firebreak area, should retain enough vegetation to prevent significant erosion. Firebreaks need not be devoid of vegetation but the growth shall be controlled to prevent rapid transmission of fire. Relatively long vegetation of 6 to 8 inches in length, that is green and or sparsely spread, is acceptable but when dry and dense could allow rapid transmission of fire.

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[1] Copies may be obtained from the National Fire Protection Association, Batterymarch Park, Attn: National Fire Codes Subscription - Service Department, Quincy, MA 02269.

[2] See footnote 1.

CHAPTER 11

PROCESS SAFETY MANAGEMENT

A. General.

Chemicals involved in exposives manufacturing require basic guidelines for safe handling. The contractor must be familar with and have policies covering:

1. Material Safety Data Sheets,
2. Respiratory Protection Program,
3. Ventilation to control exposures,
4. Confined Space Entry,
5. Hazard Communication, and
6. Written Safety Directives that control the handling of explosives.

These elements of the safety program shall be administered by qualified personnel. Specific guidance and industry practices can be found in many publications available from publishers and from training seminars readily to the public.

CHAPTER 12

SAFETY REQUIREMENTS FOR EXPLOSIVES FACILITIES

A. General

This chapter contains minimum safety requirements for existing, new, or modified explosives facilities and equipment. For facilities primarily used for general industrial operations, the requirements of this chapter shall apply in areas performing explosives work.

B. Requirements

Special properties of materials and operational hazards may require that national, Federal, and local requirements be exceeded. In such cases, requirements in this chapter shall apply.

C. Requirements for buildings

1. **Building exteriors.** Exterior wall and roof coverings of operating buildings should be noncombustible and, whenever possible, frangible, of "breakaway" construction. The buildings should have no basements and should not exceed one story, except to meet process requirements.

2. **Interior walls, roofs, and ceilings.** Interior wall surfaces and ceilings of operating buildings which might house loose, finely divided explosives materials shall be smooth, free from cracks and crevices, fire resistive and, if painted, be covered with high-gloss paint, to minimize dust accumulation and facilitate cleaning. As further protection against dust, ledges should be avoided; any that exist shall be beveled or kept clean. Wall joints and openings for wiring and plumbing shall be sealed against dust. Roofs and walls should be as light as practicable, constructed and supported to vent an internal explosion with the formation of few large fragments. Firewalls and dividing walls constitute exceptions. When class II hazard locations exist as defined by the *National Electric Code* ® (NEC), National Fire Protection Assocation (NFPA) Standard No. 70 (reference (k)),[1] suspended ceilings and hollow walls are prohibited in explosives facilities. The recommended practice is to install insulation and covering directly on the underside of the roof deck.

3. **Floors and work surfaces.** Floors and work surfaces shall be constructed to facilitate cleaning, with no cracks or crevices in which explosives could lodge. Nonsparking floors and work surfaces are required in all locations where exposed explosives or hazardous concentrations of flammable vapor or gas are present. When necessary, conductive floors (mats or similar static-dissipating floor surfaces), tabletops, and other work surfaces shall be provided. Cove bases at the junctions of walls and floors are preferred. No exposed nails, screws, or bolts in work surfaces shall be permitted.

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1 Copies may be obtained from the National Fire Protection Association, Batterymarch Park, Attn: National Fire Codes Subscription - Service Department, Quincy, MA 02269.

4. **Substantial dividing wall**

a. Substantial dividing walls, constructed in accordance with the requirements of TM 5-1300,[2] *Structures to Resist the Effects of Accidental Explosions* (reference (f)), separate independent concentrations of high explosives so they do not need to be added when determining Q/D requirements.

b. Openings in dividing walls for conveyors, pass-through boxes, or other uses, should be avoided. However, in locations where operationally necessary, the following shall apply:

(1) The opening(s) shall not be larger than the minimum needed for the material's safe passage.

(2) Closures shall have equivalent wall-strength characteristics and fusible links.

5. **Exits and doors.** No explosives hazard shall occupy space between an operator and an exit. Exit doors in buildings containing explosives, except storage magazines, should be casement-type and glazed with non-shatterable plastic material. All interior doors should open in the direction of the flow of material through the building and should open onto unobstructed passageways.

6. **Emergency egress.** When standard exits and fire escapes do not provide for rapid enough egress from work levels above the ground floor, other means of emergency egress (e.g., safety chutes) shall be provided.

7. **Passageways.** Weather-protected passageways between buildings or magazines should be of noncombustible construction and equipped with fire stops to interrupt a fire's progress.

8. **Roads and walkways.** Good all-weather roads should be provided. Only roads serving a single magazine or explosives processing building (including its service facilities) may dead end, and then, only at the magazine or building. The road system should be designed to make it unnecessary to pass through an explosives area to travel from one place to another. Walkways and roads at the entrance to or between adjacent buildings containing explosives should be boardwalks or hard surfaced, preventing employees from tracking stones, grit, and other foreign material into operating buildings.

9. **Windows and skylights.** Non-shatterable glazing is preferred where an explosion accompanied by falling or projected glass could cause injury. When glazing with conventional glass is used, the hazard may be reduced by covering it with properly fixed plastic or wire mesh screening.

10. **Drains and sumps**

a. All drain lines handling explosive wastes shall have sumps or basins of sufficient capacity for the removal of explosives by settling. The drains shall be of adequate capacity; free

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[2] Copies may be obtained from Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

of pockets; and with slopes of at least one-quarter inch per foot to prevent explosives settling-out in the drain line, rather than in the sump or settling basin intended to collect them. Sumps shall be so designed that suspended and settleable solid explosive material cannot be carried beyond the sumps in the wash waters, and so overflow shall not disturb any floating solids. The settling rate of the material and the usual rate of flow shall be taken into account in determining the sump's 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 skimmed off. Bolted sump tanks or other types of construction that permit the explosives to settle in obscure or hidden spaces are prohibited.

b. 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.

c. Drains between the source of explosive and the sump shall be troughs with rounded bottoms and with removable ventilated covers to facilitate inspection for accumulation of explosives. Waste liquids shall not be run into closed drains and sewers. Drains shall be inspected periodically and necessary steps taken to prevent the buildup of explosives deposits in them. Drains and sewers containing explosive waste materials shall not be connected in a manner to empty such wastes into the normal sewage systems carrying inert or sanitary wastes.

11. **Hardware**

a. Hardware in buildings containing exposed explosive materials, explosive dusts, or vapors should be of nonsparking material. Installation of hardware (piping and ducts) should not be affixed to blowout panels or walls.

b. Fasteners such as nuts and bolts which could accidentally drop into explosives or explosive constituents shall be prevented from doing so by being drilled and thonged or otherwise secured.

12. **Ventilation.** Exhaust fans through which combustible dust or flammable vapor pass shall be equipped with nonferrous blades, or the casting shall be lined with nonferrous material. Motors shall be of the proper National Electric Code (NEC) class for the hazard (National Fire Protection Association Standard No. 70 (reference (k)). Exhaust systems shall be cleaned and serviced on a regular schedule. The entire system shall be bonded and grounded.

13. **Steam for processing and heating.** Process steam is that which is in direct contact with explosives, used directly in their manufacture; or that which, in case of equipment failure, would exhaust directly into contact with explosives or explosive fumes. Steam used for heating operating buildings containing explosives should have a maximum pressure of 5 psi (228^{o}F). When necessary, process steam may exceed 5 psi, up to 15 psi. The exterior of steam or hot water pipes in contact with wood, paper, or other combustible materials shall not exceed 160^{o}F. When steam temperature must exceed 228^{o}F in hazardous locations, steam lines shall be covered and painted with an impervious material or otherwise protected against contact with explosives. Requirements for steam pressure exceeding 15 psi shall be evaluated by the contracting officer on a case-by-case basis. When a reducing valve is used, no relief valve shall be bypassed in a manner permitting circumvention of the pressure reduction equipment. The production of superheated

steam caused by the throttling action of reducing valves shall be prevented. Use of a "water leg" or water column to control steam pressure of 5 psi or less is recommended. When close control of steam temperature is necessary, indicating and recording pressure or temperature gauges shall be installed. Such devices should be tested periodically and the test results recorded. When electrical resistance to ground is high, steam lines shall be properly grounded where they enter buildings.

14. **Tunnels.** To prevent possible communication of an explosive, shockwave and blast shall receive special consideration in designing and constructing tunnels between buildings containing explosives.

D. Electrical requirements

The National Electrical Code (NEC), published by the National Fire Protection Association as NFPA 70 (reference (k)), does not address specifically explosives; however, Article 500 of the Code, Hazardous (Classified) Locations, does establish standards for the design and installation of electrical equipment and wiring in atmospheres containing combustible dusts and flammable vapors and gasses that, in general, are comparably hazardous. Exceptions are extraordinarily hazardous explosives, such as nitroglycerin, that require special consideration, including physical isolation from electric motors, devices, lighting fixtures, and the like. National Electrical Code standards and this section are minimum requirements for areas containing explosives.

1. NEC definitions of Class I, Division 1, and Class II, Division 1, hazardous locations are modified as follows for DoD explosives applications.

a. Areas containing explosives dusts or explosives that may through handling produce dust capable of being dispersed in the atmosphere shall be regarded as Class I, Division 1, hazardous locations.

b. Areas in which explosive sublimation or condensation may occur shall be regarded as both Class I, Division 1, and Class II, Division 1, hazardous locations.

2. **Alternate power source.** In special processes and operations requiring a continuous supply of power, provisions shall be made for an alternate source.

3. **Electric power lines.** To prevent broken wires from hitting the building, the distance separating overhead transmission and service lines from magazines and buildings containing explosives shall be greater than that between the poles or towers supporting the lines, unless an effective means is provided to ensure that energized lines on breaking cannot come into contact with the facility or its appurtenances; for example, cable trays and messenger lines. In no case shall overhead transmission lines pass within 50 feet of magazines or other explosives buildings, unless there is a fast acting power shut down system or device that is automatically activated in the event of an incident or other effective means are provided to prevent the energized conductor(s) from coming in contact with buildings containing explosives.

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

b. Public traffic route distance if loss of the line shall not create serious social or economic hardships. (Public traffic route and inhabited building distances shall be based on airblast overpressure only; fragment distances shall not be used.)

c. Electric transmission lines which can be interrupted without loss of power, i.e., power is rerouted through existing lines and/or networks, shall be separated from explosives sites in accordance with subsection D.3, above.

4. **Motors.** Electric motors should not be installed in class I or class II hazardous locations. They should be outside any such room or building. They should be connected to the process building only through mechanical glands or apertures adequately sealed against entrance of hazardous materials into both the location where motors are positioned and the motor enclosure itself.

5. **Motor controls, circuit breakers, and safety switches**

a. Circuit breakers, safety switches, service entrance switches, and speed controllers for hazardous locations should be installed on steel racks:

(1) In separate buildings connected only by electrical conduits between the small building housing the control equipment and the buildings containing the electrical equipment for hazardous locations. Such conduits shall be provided with sealing fittings to prevent communication of flame or arcs from the starters to the hazardous area.

(2) On the outside walls of buildings considered hazardous locations.

b. Limit switches, pressure switches, float switches, and any other control devices which for practical operating reasons cannot be located outdoors shall bear the approval of the Underwriters' Laboratories, Inc., or other nationally recognized testing agencies. Electrical conduit connections to such equipment shall comply with the requirements of the latest edition of the NEC, NFPA Standard No. 70 (reference (k)) for the specific hazard.

c. The primary electric supply to an entire explosives area should be so arranged that it can be cut off by switches located at one or more central points away from the area.

6. **Flashlights and lanterns.** Flashlights and hand lanterns powered by low-voltage dry cell batteries and miners' cap lamps, approved as "Permissible" by the United States Bureau of Mines or, for class I hazardous locations, by Underwriters Laboratories, Inc., or other nationally recognized testing agencies, may be used in both class I and class II hazardous locations.

E. Lightning protection

When lightning protection systems are installed, the installation, inspection, and maintenance shall be in accordance with the National Fire Protection Association, *Lightning Protection Code* (reference (l)), at a minimum. Typically, six month visual tests and 24 month electrical tests of installed systems are acceptable.

F. Static electricity and grounding

1. Detailed discussions of the hazards of static electricity and ways of reducing it are published by the National Fire Protection Association, Underwriters' Laboratories, Inc., the United States Department of Commerce, and the Bureau of Mines, U.S. Department of the Interior. Where static spark discharge may be hazardous, NFPA Standard No. 77, *Static Electricity* (reference (m)), shall apply except as otherwise specified herein.

2. **Grounding of equipment.** Bonding straps shall bridge contact points where oil, paint, or rust could disrupt electrical continuity. Permanent equipment in contact with conductive floors or tabletops is not considered adequately grounded. Static grounds shall not be made to gas, steam, or air lines, dry pipe sprinkler systems, or air terminals of lightning protection systems. They may be made to water pipes, ground cones, buried copper plates, driven ground rods, or to down-conductors of lightning protection systems. All grounds shall be interconnected if a structure is equipped with a lightning protection system. Metallic bonding and grounding cables, straps, or clamps shall be compatible with the explosives being processed.

3. **Belts.** Conductive belting shall be used wherever static is a hazard. Conductive conveyor belts shall have a resistance not to exceed one megohm (one million ohms) as measured between two electrodes placed on the belt and between the conductive conveyor belt and the ground. Static combs shall not be used to drain off static generated from belting or pulleys used in the presence of hazardous concentrations of explosives dust or flammable vapors.

4. **Testing equipment grounds.** Grounding systems shall be tested for electrical resistance and continuity when installation has been completed and, in the case of active equipment, at locally determined intervals. The ground systems of equipment inactive longer than 1 month shall be tested for resistance and continuity before reactivation. All exposed explosive or hazardous materials shall be removed before testing. All test records should be kept. In ground-resistance testing, equipment should be considered as a unit. All conductive parts of equipment shall be grounded so that resistance does not exceed 25 ohms, unless 10 ohms is required for lightning protection. To ensure compliance with ohmic requirements, resistance of the belting is to be excluded in measuring the total resistance to ground for belt-driven machinery. The rate of static generation should be considered before changes in grounding systems are made.

5. **Conductive floors.** Conductive floors and conductive shoes shall be used for grounding personnel at operations with exposed explosives with electrostatic sensitivity of 0.1 joule or less, such as primer, initiator, detonator, igniter, tracer, and incendiary mixtures. Materials sensitive to static sparks, easily ignited or detonated, 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 static electricity discharge. Many flammable liquids and air mixtures tested (ethyl ether, ethyl alcohol, ethyl acetate, acetone, and gasoline) can be ignited by human static discharge. Therefore, areas where personnel might come into contact with the kinds of explosives or mixtures enumerated above shall be equipped with conductive floors, except

when the hazards of dust/air or flammable vapor/air mixtures are eliminated by adequate housekeeping, dust collection, ventilation, or solvent recovery methods.

a. Conductive floors are also required when operations involve the following:

(1) Exposed electro-explosive devices such as squibs, detonators, primers, etc.

(2) Electrically initiated items, such as rockets, with exposed circuitry.

(3) Hazardous materials that could be ignited by human static discharge.

b. When a hazard remains localized, conductive floors and footwear are not required throughout an entire building or room. In such cases, conductive mats or runners may be used. These mats and runners shall meet all the specifications and test requirements that apply to conductive floors.

6. **Conductive floor specifications.** Conductive floors, made of nonsparking materials such as lead, conductive rubber, or conductive flooring compositions, shall meet the following requirements:

a. The flooring and its grounding system shall provide for electrical resistance not to exceed 1 million ohms.

b. The surface of the installed floor shall be free from cracks and reasonably smooth, and the material shall not slough off, wrinkle, or buckle under operating conditions. Conductive tiles are not recommended for areas where explosives dust can cause contamination, because the large number of joints, and the tendency of tiles to loosen, create areas where explosives dust can lodge, not amenable to normal cleanup procedures. Where conductive floors and shoes are required, the resistance of conductive shoes on a person plus the resistance of floor to ground shall not exceed 1 million ohms total. Tabletops used with exposed explosives or dusts should be covered with a properly grounded conductive material meeting the same requirements as those for the flooring. The conductive floors shall be compatible with the particular materials to be processed.

7. Initial tests of conductive floors shall be followed by others at least semiannually. The test results shall be permanently recorded. Testing shall proceed only when the room is free from exposed explosives and flammable gas mixtures.

a. The resistance of the floor shall be more than 5,000 ohms in areas with 110 volts service and 10,000 ohms in areas with 220 volts service, and less than 1 million ohms in all areas as measured between a permanent ground connection and an electrode placed at any point on the floor and also as measured between two electrodes placed 3 feet apart at any points on the floor. Measurements shall be made at five or more locations in each room and at least two of the points shall be heavily trafficked areas. If the resistance during a measurement changes appreciably with time,the value observed after the voltage has been applied for about 5 seconds shall be considered to be the measured value. These resistance values do not apply to metallic floors.

b. The operation and maintenance of test instruments shall be entrusted to competent personnel.

8. **Humidification.** Humidification that 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. It cannot be used with metallic powders, some pyrotechnic mixtures, and other materials susceptible to spontaneous ignition in air with 60 percent relative humidity.

9. **Ionization.** 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, *Static Electricity* (reference (m)).

10. Neither ionization or humidification may be substituted for conductive floors (where required).

CHAPTER 13

SAFETY REQUIREMENTS FOR SPECIFIC EXPLOSIVE MATERIALS AND OPERATIONS

A. General

This chapter provides the minimum safety requirements necessary for the prevention of mishaps involving specific explosives materials and operations that, unless properly controlled, make casualties to personnel, material, equipment, and facilities highly probable. They apply to similar operations and equipment, specifically addressed or not. These requirements, to be used as a basis for developing local program requirements, are in no way comprehensive. The contractor is responsible for analyzing each operation and developing procedures to control or eliminate actual or potential hazards.

B. Properties of explosives

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

1. **Properties of initiating explosives.** Initiating explosives include lead azide, mercury fulminate, lead styphnate, and tetracene. They manifest extreme sensitivity to friction, heat, and impact. When involved in a fire, they can be expected to detonate without burning. In storage, initiating explosives shall be kept wet with water or water/alcohol mixtures. Every effort shall be made to prevent the liquid from freezing; frozen explosives material shall not be handled. Emphasis shall be placed upon cleanliness and general housekeeping since contamination of these explosives with foreign, particularly gritty, material markedly increases their sensitivity. Water used for storage shall be free of bacteria-forming impurities which could react to form gases. Lead azide shall not be allowed contact with 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 lead azide. Likewise, mercury fulminate shall not be allowed contact with aluminum, magnesium, zinc, brass, or bronze.

2. **Properties of boostering explosives.** Explosives used for this purpose include tetryl, RDX, PETN, and RDX with added ingredients. These explosives have sensitivities between initiating explosives and those of explosives used as bursting 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. Local exhaust ventilation, enclosed process systems, automatic handling systems, etc., should be used to minimize dust in the employee's breathing zone.

3. **Properties of bursting explosives.** Bursting explosives include explosive D (ammonium picrate), amatol, picric acid, TNT, tritonal, RDX compositions, HMX compositions, torpex, DBX, and HBX. In general, these materials are less sensitive than initiating or boostering explosives. Alkaline cleaning agents or other alkaline products should not be permitted in buildings where large quantities of these explosives are handled. Amatol forms sensitive

compounds with copper and brass. Where explosive D is processed, lead fusible links and solder-type sprinkler heads should not be used. DBX is an aluminized explosive that is somewhat hygroscopic and reacts with metals in the same manner as amatol. HBX is also an aluminized explosive that outgasses when exposed to water and may create internal pressure when loaded into ammunition. HMX compositions usually result in a very powerful explosive with a high degree of thermal stability. Pentolite tends to separate into its ingredients (PETN and TNT) and should, therefore, be handled as carefully as PETN. Picratol is a mixture of TNT and explosive D; the precautions necessary when handling either shall be observed. Picric acid is highly acidic, corrosive, and toxic; it shall be isolated from lead and lead compounds. Tetrytol is a mixture of tetryl and TNT which is stable in storage but exudes at 149°F. Dry tetrytol slightly corrodes magnesium and aluminum alloys, and wet tetrytol slightly corrodes a copper, brass, aluminum, magnesium, mild steel, and cadmium-plated mild steel. TNT is stable and does not form sensitive compounds with metals. It will, however, form sensitive compounds in the presence of alkalies. It also exhibits well-recognized toxic properties. Torpex is an aluminized explosive used mainly in underwater ordnance. Non-hygroscopic and noncorrosive, it is stable in storage but may outgas (hydrogen) and produce internal pressure when loaded into ammunition. Tritonal is a mixture of TNT and aluminum powder and is more sensitive to impact than TNT. Tritonal shall not be exposed to water. Plastic bonded explosives are conventional high explosives with plastic binders such as polystyrene, viton, estane, etc. Their sensitivity varies with the composition. The series most frequently encountered are identified by prefix PBX or LX and a number.

4. **Properties of other explosives.** Other military explosives frequently encountered include black powder and nitroglycerin. Black powder is a mixture of potassium or sodium nitrate, charcoal, and sulfur, highly sensitive to friction, heat, and impact. It deteriorates rapidly on absorption of moisture but retains its explosive properties indefinitely if kept dry. Nitroglycerin'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.

5. **Research of additional properties.** The foregoing does not comprehensively catalog explosives and properties, but indicates that they can differ significantly. For this reason, it is imperative that contractors investigate pertinent properties before handling these or other explosive materials. Contractors are responsible for understanding all aspects of ammunition and explosives needed to fulfill contractual obligations.

C. Handling low-energy initiators

Typical precautions, such as shielding and safety glasses, shall be supplemented by the following measures, as appropriate, when manufacturing, processing, using, or testing low-energy initiators (initiated by 0.1 joule of energy or less).

1. All metal parts of equipment shall be electrically bonded together and grounded.

2. Personnel shall wear clothing that prevents generation of static electricity. Conductive shoes shall be tested with a resistance meter before an operator enters an area where low-energy initiators are being processed.

3. When low-energy initiators are being handled, personnel shall be directly grounded by wrist straps. The 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.

4. Glass, acrylic, or polycarbonate materials required for transparent shielding shall be periodically coated with an anti-static material to prevent buildup of static electricity.

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

6. Work shall not start in air-conditioned areas until relative humidity and temperature have been checked (see Chapter 12, subsection F.8).

7. No metal surface subjected to rubbing or friction shall be painted. If a lubricant is necessary, it should be of a composition that shall not increase the metal's surface resistance above 25 ohms.

8. Work on or with initiators shall be performed 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.

9. Work shall not be done in the vicinity of actual or potential electromagnetic or electrostatic fields. Sources of static electricity and electromagnetic energy include radio transmission, electrical storms, transformer stations, high voltage transmission lines, improperly grounded electric circuitry, rotating equipment, belts, etc. Adequate lightning protection and grounding and adequate resistances for fixed sources of energy shall be established for locations with low-energy initiator operations. These shall be shielded to afford protection against local mobile radio transmission.

10. Electrical equipment shall be located 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.

11. When not part of an end item or end item subassembly, initiators shall be transported only when packed according to the latest packing specifications for low-energy initiators.

D. Laboratory operations

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

2. Each operation at facilities designed for blast and fragment confinement shall be reviewed to ensure that the explosives limits are within the laboratory or test area capability. Explosives limits and safe separation distances shall be adjusted as the capability to confine fragment and blast decreases.

3. A total-confinement facility shall be inspected after a detonation to ensure structural integrity, possibly reducing the explosives limits to prevent future blasts from exceeding the retention capability.

4. Each proposed program for the laboratory or test facility shall be reviewed to determine all potential hazards. Considerations shall include:

a. Structural limitations of the facility.

b. Remote control viewing and operating equipment, if required.

c. Special safety precautions for personnel elsewhere in the building.

d. Safe separation distances.

e. Required deviations from other sections of this manual.

f. SOPs, which shall, at a minimum, include the following:

(1) Protective clothing.

(2) Warning signals.

(3) Fire and other emergency procedures.

(4) Special testing of equipment needed before operations (such as stray voltage and calibration checks).

(5) Removal of all explosives not needed for the operation.

(6) Arrangements for overnight storage of necessary explosives.

(7) Inspection and cleanup procedures after a test or detonation.

5. Laboratories shall use no more explosives than absolutely required for a given operation. Particularly hazardous laboratory operations involving new or relatively unknown explosives should be done by remote control. Operational shields shall be used in these operations and in new or untested applications of explosives.

6. When laboratories and testing facilities are shielded properly to prevent the release of fragments, the minimum incremental safe separation distances of Tables 13-1 and 13-2 shall apply to operations, facilities, and personnel.

7. If the proposed storage facilities will confine the blast and fragments, or if the incremental safe separation distances are as indicated in subsection D.6, up to 15 pounds of explosives may be stored without consideration of storage compatibility. However, the operation shall be reviewed to determine all potential hazards as outlined in subsection D.4, above.

E. Electrical testing of ammunition and ammunition components

1. **Type of test equipment.** Electrical and electronics test equipment should use the weakest possible power source. Batteries are preferred to 110-volt power sources. No power source should be capable of initiating the explosives item being tested. When exceptions shall be made because more power is needed, steps shall be taken to prevent delivery of power to the explosives item in quantities sufficient to initiate it. Safeguards shall be provided against the possibility of human error.

2. **Layout of test equipment.** Test equipment shall be placed in hazardous atmospheres only when absolutely necessary. Unless the test equipment is, under all circumstances, incapable of initiating the test item, operational shields are required for personnel protection. The most

reliable way of attaining and retaining this initiation incapability is by protecting the test equipment, including leads, from electromagnetic induction and radiation fields and electrostatic energy, and by providing the test equipment with a weak power source.

3. **Use of test equipment.** Test equipment shall be used only as intended by original design. The equipment shall be maintained by qualified personnel, with operator adjustments limited to those required for testing.

F. Heat-conditioning of explosives and ammunition

1. All ovens, conditioning chambers, dry houses and other devices and facilities which are capable, in ordinary service, of heating explosives and ammunition to temperatures in excess of 90 degrees Fahrenheit are heat-conditioning devices. Heat-conditioning devices shall be provided 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, unless otherwise authorized) on the main building steam supply, and a thermostat.

2. Heat-conditioning devices shall be able to discharge overpressure from an internal explosion. Barriers or catching devices shall restrain blowout panels, doors, and other venting apparatus, to prevent excessive displacement during an accidental explosion.

3. Heat-conditioning devices shall be vented to permit any gases produced to escape.

4. Steam should be used to heat conditioning devices; when electric heating elements are unavoidable, they shall be located where there is no possibility of contact with explosives or flammable materials.

5. The blades of a fan in a heat-conditioning device shall be of non-sparking material; its electric motor shall be installed externally. The air shall not recirculate if the heating surfaces exceed 228^{o}F or if the air contains materials that could collect on the heating coils.

6. Electrical equipment and fixtures in or on a heat-conditioning device used for explosives or flammable material shall be approved for use in the hazardous atmosphere in question.

7. The interior of a heat-conditioning device shall be free of crevices, openings, and other protuberances not easily cleaned, where dust or flammable material could lodge.

8. All noncurrent-carrying metal parts of a heat-conditioning device shall be interconnected and electrically grounded.

9. Heat-conditioning devices should be installed in isolated locations, set up to give personnel maximum protection from the effects of an incident. When warranted, operational shields and other personnel protection measures shall be used.

10. Safe separation distances or protective construction shall ensure against an explosives incident in one heat conditioning device from propagating to others. No hazardous materials shall be placed in a room or cubicle containing a heat-conditioning device, unless it can be shown that an accident in the conditioning device would not involve the other materials.

11. Heat-conditioning device operating procedures require:

a. Limiting the explosive materials in the device to the type and quantity authorized for the specific device.

b. Familiarity with the critical parameters of explosives compositions before processing in a heat-conditioning device. The device shall not exceed limits established for the hazardous composition being conditioned.

c. Checking heat-conditioning device temperatures at specified intervals during operation.

d. Cleaning 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.

G. Spray painting

1. Loaded ammunition shall not be electrostatically spray painted.

2. Water wash or dry filter-type spray booths shall be used for loaded ammunition.

3. Controls for ventilating fan motors for spray painting booths shall be interlocked with the controls for the paint sprayer. With this arrangement, failure of the ventilating system will shut off power to the paint sprayer.

4. High-voltage electrically powered paint-spraying equipment shall be installed in accordance with the requirements of National Fire Protection Association, Standard No. 33,[1] *Spray Application Using Flammable and Combustible Materials*, (reference (n)), as applicable.

5. Conventional equipment used for spray painting in standard spray booths shall meet the requirements of NFPA Standard No. 33. The nozzles of all spray guns shall be electrically grounded because of the static electricity generated.

H. Drying freshly painted loaded ammunition

Ovens used in drying loaded ammunition shall comply with the National Fire Protection Association (NFPA). Other requirements include the following:

1. Automatic thermostatic controls shall regulate temperatures once they reach a maximum determined by the ammunition and explosives involved. It is recommended that temperatures not exceed 170^{o}F.

2. Each oven shall be equipped with automatic internal sprinkler systems that conform with NFPA Standard No. 13, *Installation of Sprinkler Systems* (reference (i)). Approved electrical heat-actuated devices, installed as required for NEC-defined class I, division 1, group D, hazardous locations (Refer to NFPA Standard No. 70, *National Electric Code* (reference (k))) may be used for automatic operation of the system.

3. Hot air or other means may supply heat, provided ammunition and explosives are kept from contact with coils, radiators, and heating elements.

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[1] Copies may be obtained from the National Fire Protection Association, Batterymarch Park, Attn: National Fire Codes Subscription - Service Department, Quincy, MA 02269.

4. In case of power failure, the heat supply for any conveyor system shall automatically stop.

5. Electric drying units that are not approved for use in class I hazardous locations should be designed so that solvent vapor concentration in the oven is kept below 25 percent of its lower explosive limit.

I. Rework, disassembly, renovation, and maintenance

1. Rework and disassembly operations shall not be conducted with other inert or explosives operations. When concurrent scheduling cannot be avoided, operations shall be sufficiently distanced from one another to protect adjacent personnel and equipment, and prevent propagation to adjacent explosives. Such separation may be accomplished with Q/D, operational shielding, or the remote control of operations.

2. The operator and all other personnel shall be fully protected during rework and disassembly operations known or expected to use force exceeding assembly specifications.

3. If A&E items have been assembled normally, the same equipment, tools, methods, and applied forces may be used to disassemble them. In such cases, personnel protection required during the assembly operations is also required during the rework or disassembly operations. Care shall be taken, however, to ascertain that the assembly was normal and that the surfaces to be separated are not corroded and not sealed with metallic applicants.

4. When renovation or maintenance not adequately addressed in the contract is required, the contractor shall request specific safety guidance through contract channels.

J. Munitions loading and associated operations

1. **Screening and blending high explosives.** Bulk high explosives intended for processing shall be screened or visually inspected and passed over a magnetic separator to detect extraneous material for removal. Screening equipment shall not subject explosives to pinching, friction, or impact. Explosives screening units without exhaust ventilation shall be thoroughly cleaned as often as necessary and after every shift, to prevent hazardous accumulations of explosives dusts.

2. **Screening and blending initiating explosives.** Suitable operational shields shall be provided for screening and blending operations involving initiating explosives, or operators shall be located at intraline distance from screening and blending facilities.

3. **Explosives melting**

a. Temperatures used for melting explosives and keeping explosives molten should not exceed 228°F. However, steam pressures up to 15 psi (250°F) may be used to melt composition B and similar binary explosives and to maintain a molten state.

b. Melt unit valves and melt mix draw-off or other lines carrying molten explosives shall be constructed and maintained to prevent friction or impact capable of igniting the explosives. Diaphragm-type valves should be disassembled and inspected regularly. Damaged or old diaphragms shall be replaced so no cracks allowing metal-to-metal contact can develop. Draw-off lines should be constructed to prevent exposure of threads, fastening screws, and bolts, both outside and between the flanges. A sealing compound should be used to prevent explosives seepage or vapor condensation on the contacting surfaces of the bolts, flanges, screws, and nuts. Melt mix kettle draw-off pipes should be electrically connected to items being filled during draw-off operations. Items shall be individually grounded unless tests show that grounding through contact surface is adequate.

c. Wet-type collectors effectively remove dust and vapors from exhausted air, and are recommended for melt mix exhausting systems. Water in the wet collector will not be recirculated unless the system removes hazardous suspensions. Water retaining such explosives shall be discharged to a sump designed to keep such explosives wet. The exhaust and collecting equipment shall be regularly inspected and flushed of explosives accumulations. When protective construction prevents propagation of a detonation between melt kettles, a complete dust and vapor collection system shall equip each kettle.

4. **Agitation.** Agitation nitrators, washers, and other machines which, because of the hazard of the process and the possibility of the process material decomposing, are equipped with mechanical agitators, shall have at least two means of agitation, each operating from an independent power source to maintain agitation if one fails.

5. **Machining of explosives**

a. High explosives, cased or uncased, that may be machined without special personnel protection and without coolant, if no metal-to-metal contact is involved, include: Amatol, Octol, TNT, composition B, explosive D, and RDX/TNT compositions containing 60 percent or less RDX.

b. High explosives, cased or uncased, that 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: baratols, pentolite (50-50 and 10-90), tetrytol, and cyclotols (composition B less than 60-40; that is, 70-30).

c. When essential, other high explosives may be machined by remote control, with the operator protected by a suitable operational shield; however, initiating explosives should not be machined if desired shapes or sizes can be obtained by other means, such as forming.

d. When an unprotected operator is involved in drilling, only a single drill, with a diameter greater than 1/4 inch, shall be used.

e. Machining of cased explosives is permitted in an operation requiring removal of metal before or after tool contact with the explosives filler, provided that operators are protected by operational shields and perform it by remote control.

f. Where wet machining is to be performed, automatic interlocking devices shall prevent machining from starting until coolant is flowing. These controls shall also be capable of stopping the machining if the coolant flow is interrupted. When coolant flow must stop for adjustment of machining tools, positive means shall be devised to ensure that flow of coolant is restored and all automatic control devices are operating before machining can resume.

g. The lineal and rotational speeds of tools used for the machining of explosives shall be maintained at the minimum necessary to perform the operation safely and efficiently. These shall not exceed 210 linear feet per minute nor 525 revolutions per minute. The rate of feed should likewise be the lowest consistent with safety and efficiency, based on the explosive materials being machined.

h. Pneumatically or hydraulically driven machine tools are preferred for all machining operations on high explosives. Control mechanisms for hydraulic and pneumatic equipment shall prevent unauthorized personnel from tampering with speeds.

I. In all machining operations on cased or uncased high explosives, procedures during tool adjustments shall prevent contact between moving parts of the machining equipment and metallic parts of the case or holding fixtures.

j. Machining tools shall be compatible with the explosives being processed. Dull or damaged tools shall not be used for machining high explosives.

k. The explosives products resulting from machining operations shall be removed by an exhaust system meeting NEC requirements, or by immersion in a stream of water flowing away from the operation. Refer to NFPA Standard No. 70, *National Electric Code*, (reference (k)).

l. Machining of explosives of questionable quality during an ammunition and explosives demilitarization process shall be accomplished by remote control, with operators protected by operational shields.

6. **Assembly and crimping of complete rounds.** Each assembly and crimping operation shall be separated from other operations by structures or shielding sufficient to contain any fragments produced.

7. **Pressing explosives**

a. Each pelleting operation involving black powder, tetryl, TNT, or other explosives of similar sensitivity; and each operation involving the pressing or reconsolidating of explosives, shall be conducted in a separate room or cubicle having walls of sufficient strength to withstand an explosion of all explosives present.

b. Pressing or reconsolidating explosives in small caliber rounds, tracer bodies, tetryl lead-ins, detonators, and similar items shall be performed on machines having consolidating stations designed to preclude propagation between stations and provide adequate operator protection. Operators shall stay behind tested protective barriers during such operations.

c. Punches and dies shall be in matched sets that have passed inspection. All punches and dies used in explosives pressing operations shall undergo a rigid test, such as a magnaflux or X-ray, before use and regularly thereafter. In a pelleting press, punches and dies shall be replaced with matched sets checked and calibrated by a control laboratory.

8. **Protection of primers.** Equipment, transportation, and operations shall be designed to protect loose primers or primers in components from accidental impact or pressure. When feasible, a protecting cap shall cover the primer.

9. **Explosives washout and flashing facilities.** When washout operations are placed in operating buildings or other locations, they shall be separated from other operations by operational shields or proper distances. Ammunition items subjected to washout operations shall be subsequently inspected to ensure against residual explosives contamination. When contamination is confirmed, decontamination shall precede disposal. Decontamination of ammunition items by flashing (exposure to flame) shall be performed at the explosives destruction (burning) area or in approved incinerators.

10. **Heat sealing equipment.** Electric heat sealing machines should be separated from other operations. Temperature limits for heat sealing equipment shall be established, with a safety factor below the ignition temperature of the explosives, propellants, or pyrotechnics involved.

11. **Rebowling operations.** Rebowling operations involving primary explosives or primer mixes shall be performed by remote control, with the operator protected by an operational shield.

12. **Thread cleaning.**

a. Nonferrous picks shall be used for thread cleaning. Stainless steel brushes may be used to clean threads of explosives-loaded projectiles if a fuze seat liner separates the thread cleaning operation from the explosive charge. Operators do not need operational shields; however, thread cleaning operations should be separated from unrelated operations.

b. Power-actuated thread-chasing tools may be used to clean loaded projectiles when threads are imperfect because of previously applied sealers, provided the operation is 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.

c. Neither correcting cross threads nor thread cutting shall be performed on projectiles containing explosives. Straightening crossed threads is considered thread cutting.

13. **Profile and alignment gaging operations**

a. Operational shields shall enclose each profile and alignment gaging operation, excluding small arms ammunition, to protect adjacent operations. The layout of the equipment and the operational procedures shall be developed to minimize personnel injury and property damage in case of accident.

b. During chamber gaging of high caliber fixed ammunition, the gage should be pointed toward a dividing wall or other barrier and the round inserted and removed by the same operator. In no case shall the round be left in the gage. Rounds of mortar ammunition shall be gaged before attaching propellant increments and, unless prohibited by the design characteristics, before assembly of the ignition system.

Table 13-1. Hazard Division 1.1 - Laboratories Q/D.

Quantity (lbs)		Distance (ft)[1]		
Over	Not over	Inhabited Building Distance	Public Traffic Route	Intraline
0	1	40	25	20
1	2	50	30	25
2	5	70	40	30
5	10	90	55	35
10	20	110	65	45
20	30	125	75	50
30	40	140	85	55
40	50	150	90	60

[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 Chapter 6.

Table 13-2. Hazard Division 1.3 - Laboratories Q/D.

Quantity (lbs)		Distance (ft)		
Over	Not over	Inhabited Building Distance	Public Traffic Route	Intraline
0	5	10	10	10
5	10	15	15	15
10	20	20	20	20
20	30	25	25	25
30	50	30	30	30
50	80	35	35	35
80	100	40	40	40
100	150	45	45	45
150	200	50	50	50

CHAPTER 14

TESTING REQUIREMENTS

A. Program requirements

The contractor is responsible for the safety of testing programs and shall designate an individual to be responsible for each program. Technical information about the ammunition items, explosives, and weapon systems shall be considered so that the required safety measures may be engineered into the test plans.

B. Operating precautions

The following special safety precautions shall be considered during SOP development

1. Protection for percussion elements; i.e., primers, caps, etc., shall be provided in the design of equipment, transportation, and operations to protect them from accidental initiation.

2. Cartridges and projectiles larger than 60 mm, when hand carried, shall be handled one at a time.

3. Fuzed projectiles shall not be handled by the fuzes alone.

4. Powder charges shall be transported in closed containers to prevent accidental ignition.

5. Only trained personnel shall perform operations on explosives-loaded ammunition components.

6. No work, adjustment, or observation should be permitted on a weapon system that is loaded and ready for firing, except to check and adjust azimuth and elevation. In no case shall a lanyard be attached until the piece is ready to be fired. No one shall step over the lanyard once it is attached. On weapons equipped with safety locks, the lock may be released after the lanyard has been attached. In the case of small arms, the bolt shall be kept open at all times except when actually firing.

7. Ammunition and explosives material, except inert components, shall not be delivered to machine shops or other locations not specifically designated for this work or modification without the approval by responsible contractor authority.

8. The premature or improper mixing of fuels and oxidizers, as associated with liquid propellants, shall be avoided. This applies particularly at test stands and test facilities when transferring liquid propellants.

9. Remote control of mechanical devices shall replace manual activation whenever possible.

10. Guns operated by remote control shall be equipped with cease fire devices for halting operations when a hazardous condition occurs. These devices shall be independent of the regular controls so operations can be stopped if the regular controls should fail.

C. Test hazards

1. Inert-loaded or minimum-charged ammunition should be used in lieu of explosives-loaded items when the test objectives are not affected.

2. When temperature-conditioning rooms or boxes are utilized, the following shall apply:

a. Firings from temperature-controlled facilities shall be on an azimuth approved by the contractor's responsible representative. No weapon shall be fired in an enclosed area unless the muzzle is located outside the port opening. Destruction tests, excess pressure tests, and tests of classes of guns known to be unsafe (where the possibility of breech failures exists) shall be conducted with portable shields or equivalents placed on each side of the breech and with a protective plate to the rear of the mount, forming a barrier.

b. All equipment used in the temperature conditioning of explosives shall comply with Q/D requirements, unless in explosives buildings.

c. Heat conditioning equipment shall meet the requirements of Chapter 13, Section F.

3. No firing shall be permitted unless people in the area are under adequate cover.

D. Test clearance

1. Clearance, to be obtained before performing each test, shall be granted only by responsible contractor personnel with jurisdiction in the danger area where the test is to be performed. When required, air space clearances shall be obtained in accordance with local and *Federal Aviation Administration Handbook* (reference (o))[1] requirements.

2. The contractor personnel responsible for the test areas where the weapon system is located shall obtain the necessary coordination and clearance from their counterparts when a test may encroach upon other danger areas.

3. To ensure that danger areas are clear of personnel and ships, vessels, and other craft, clearance for impact and airburst danger areas shall be obtained before firing on or over water.

E. Warning and communication systems

A warning system shall be established for each testing program, comprising some combination of flags, lights, and sound signals. If personnel authorized to enter a test area are not familiar with the system, they shall be escorted by knowledgeable personnel. Test areas should be equipped with adequate communication facilities, such as telephone and radio.

F. Specific items for test

The safety requirements for testing specific items of ammunition vary according to the type of ammunition, design features, explosives characteristics, test facilities, climate and terrain

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1 Copies may be obtained from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

environment, and other related factors. These factors shall be considered and specific test criteria included in the test plan.

1. **Recoilless weapons**

a. All personnel shall be protected against breech blast and malfunction of the round. The danger area in open range firing shall extend to the rear of the weapon: 300 feet for calibers up to and including 75 mm and 450 feet for all others. The danger zone may be reduced only when effective barricades confine the blast effect.

b. The safety switch on a rifle shall not be advanced to the firing position until the breechblock is closed and all preparations for firing are completed.

c. Because the blast from salvo firing can obscure a misfire, ripple firing is preferred. When salvo firing cannot be avoided, a wait of at least 2 minutes shall precede the opening of any breechblock after a one-volley salvo.

d. Unburned propellant from any test firing shall not accumulate in the surrounding area. Safe methods shall be developed for cleanup, decontamination, and disposal.

2. **Pyrotechnics.** Shielded enclosures should be used when testing pyrotechnic items inside a building. Enclosures should be vented to the outside, preferably through the roof, to prevent exposure of personnel to flame, toxic gases, and heat, and to prevent rupture of the enclosures.

3. **Static tests of propellant motors and engines.** Static test stands shall be used for solid propellant motors and liquid propellant engines in any combinations. Fire, blast, and fragments shall be considered in establishing safe distances. Static test stands shall be designed to restrain motors and engines undergoing tests.

G. Malfunctions

For the purposes of this Manual, malfunction applies to the ammunition and the weapon systems or pieces involved.

1. **Cook-off.** Automatic function, or cook-off, of a round left in a hot gun for an extended period is possible in tests involving a high rate of fire, particularly with machine guns and anti-aircraft guns. This possibility largely depends upon the gun's rate of heat dissipation. High air temperature, low wind velocity, low elevation of the gun, and confinement of the gun are also factors. To prevent cook-off, the barrel of the empty gun shall be frequently cooled. If a round is retained or remains in a hot gun with the breech closed, people in the vicinity shall remain under cover until the gun has cooled. If a round jams and the breech fails to close, personnel in the danger zone shall take cover and remain there until the gun has cooled.

a. Adequate cooling periods are:

Type of Cooling	Time (minutes)
Water	5
Air (machine guns)	15
Air (other guns)	30

b. The danger zone for personnel in the vicinity of the gun firing explosive ammunition shall be:

Type of Gun	Radius[1] (feet)
Machine guns	600
Less than or equal to 75 mm	1,200
Over 75 mm through 105 mm	1,800
Over 105 mm	2,400

1 Radii may be halved when ball ammunition or rounds with inert projectiles are used. The use of barricades to confine blast effects may also reduce the danger zone.

c. The danger zone down range shall be maintained as for actual firing until the danger of cook-off has passed.

2. **Premature burst.** If a premature burst occurs, the test shall be suspended or the lateral limits of the danger zone increased in accordance with prescribed safety distances before the test continues. The increased lateral limits shall be maintained until the particular test is completed.

3. **Misfire.** After a misfire, all persons shall stand clear of the breech, in case the round functions and the gun recoils. All electrical connections that could cause firing of the gun shall be disconnected. The appropriate danger zone for the actual firing shall be maintained during the waiting period, until the danger of cook-off has passed. The removed round shall be immediately placed where subsequent detonation could not cause injury or damage. In the case of misfires involving small-caliber rockets and small-arms ammunition, the rounds should be immersed in water (unless the results of prior analyses or investigations preclude such practice). Misfire procedures shall be established to include attempts to refire weapons, waiting periods, cooling, operational precautions, and disposition of ammunition. Once these procedures have been carried out, the firing pin and mechanism shall be checked, and the barrel of the gun examined to ensure that it is clear; then firing may resume. Figures 14-1 through 14-8 provide general guidance on what to do when misfires occur.

4. **Hangfire.** A hangfire is a delayed firing occurring as a short time lag between the striking of the firing pin on the primer and the ignition of the primer, igniter, or propellant. All hangfires shall be immediately reported to responsible personnel. This is particularly important for early detection of trends. In these cases, the firing of a particular lot of ammunition shall be suspended unless responsible authorities advise differently.

H. Ammunition and dud recovery

The following open-air test area recovery requirements shall be followed:

1. **Marking.** When projectiles or bombs with live fuzes, live boosters, or high explosive are fired for impact on, or burst over, a recovery field, observers stationed in a protected place shall record the location of duds and exploded rounds. Before leaving a recovery field or impact area, personnel in charge of cleaning the fields shall mark duds and unexploded rounds with the appropriate color-coded flag or device. Where locations cannot be marked, fields shall be posted with warning signs and entry shall be restricted.

2. **Policing.** Personnel shall be prohibited from touching or in any way disturbing dud ammunition. Unfuzed or inert-fuzed live ammunition or ammunition components that have failed to function during a test shall be recovered only in accordance with the SOP developed by the contractor.

3. **Destruction.** All types of ammunition and explosives shall be disposed of in accordance with this Manual, contract requirements, or instructions provided by the contracting officer.

I. Personnel shelters.

1. **General.** Responsible personnel shall require all within the danger zone to take cover during tests where fragmentation might occur. The person charged with attaching the lanyard shall be the last to leave the gun emplacement, and shall advise the responsible person that all personnel are clear before any firing.

2. **Portable bombproofs for fire observation.** All portable bombproofs used for fire observation shall be on the gun side of the impact point; no closer than 200 yards from the impact point; and in the sectors between compass headings 45 and 80 degrees and between 280 and 315 degrees (compass centered on impact point with 0 and 360 degrees at the firing point). When the impact will result in fragmentation, the bombproof should be located behind the firing line in the sectors between compass headings 100 and 135 degrees and between 225 and 260 degrees (compass centered on firing point with 0 and 360 degrees at the impact point). It should be so oriented with respect to the impact that no wall surface is presented to fragmentation at an angle greater than 60 degrees. This can usually be done by centering one intersection of the walls of a square or U type bombproof, or pointing the apex of a pointed V type, toward the impact point. Under no circumstances shall the orientation expose the rear of the bombproof to gunfire and fragmentation. Observations from bombproofs shall be indirect, using mirrors, periscopes, or other suitable devices. Refer to Figure 14-9.

Type	Location and Use	Wall
Portable reinforced concrete bombproof (open back).[Note]	At firing fronts when alongside or to rear of gun and offset from line of fire for any class of fire.	12 inches
Armored railway mounts.	At firing fronts when alongside or to rear of gun and offset from line of fire for any class of fire.	armorplate
Portable boilerplate barrier.	At firing fronts for inert shrapnel or low explosive up to and including 155 mm and all small-arms ammunition.	3/4-inch steel plate
Portable armor-plate barrier.	At firing fronts when to rear and offset from line of fire for any classes except high explosive or plate firing.	3-inch armorplate
Armorplate sheets.	At firing fronts for grenades, troop signals.	1/2-inch armorplate

Note: This type may be used for fire observation in the field, provided the bombproof is offset from the line depending upon the caliber of guns used, and in accordance with Subsection I.2.

J. Testing of ammunition or devices for small arms

1. Ammunition shall not be placed in any gun until it is in firing position and ready to shoot.

2. Safety devices on gun mounts and ranges shall be kept in operating condition and tested before use. If a malfunction occurs, test operations shall cease and a report made to the responsible supervisors.

3. Every weapon removed from a firing position, storage case, or rack; or picked up by any operator, shall be inspected for the presence of ammunition in the chamber, magazine, or feed mechanism, and for obstruction in the bore.

4. The chamber, magazine, and feed mechanism of all guns should be open during handling and transportation. When practicable, a safety block should be used in the chambers of weapons.

5. Primers of misfired rounds may be hypersensitive; precautions should be taken during their removal from the gun, handling, and disposal.

6. Firing on ballistic ranges, except in function and casualty tests, shall be from fixed rests.

7. When sand butts are used to stop bullets, a reinforced concrete wall should be constructed at sufficient distance behind the retaining wall to permit inspection. This is necessary because bullets tend to tunnel through the sand and penetrate the retaining wall after continued firing. To discover any such penetration, the inner face of the second wall should be inspected frequently. If terrain effectively protects the rear of the range, no concrete wall is necessary.

8. Because bullets tend to ricochet from a sand bank, the roofs of enclosed ranges should be protected, to prevent penetration.

9. When water traps are used to receive a fired bullet, interlocks shall be provided to prevent firing of the test weapon if water pressure failure occurs.

10. Unburnt propellant from any test firing shall not accumulate in the surrounding area. Safe methods shall be developed for cleanup, decontamination and disposal.

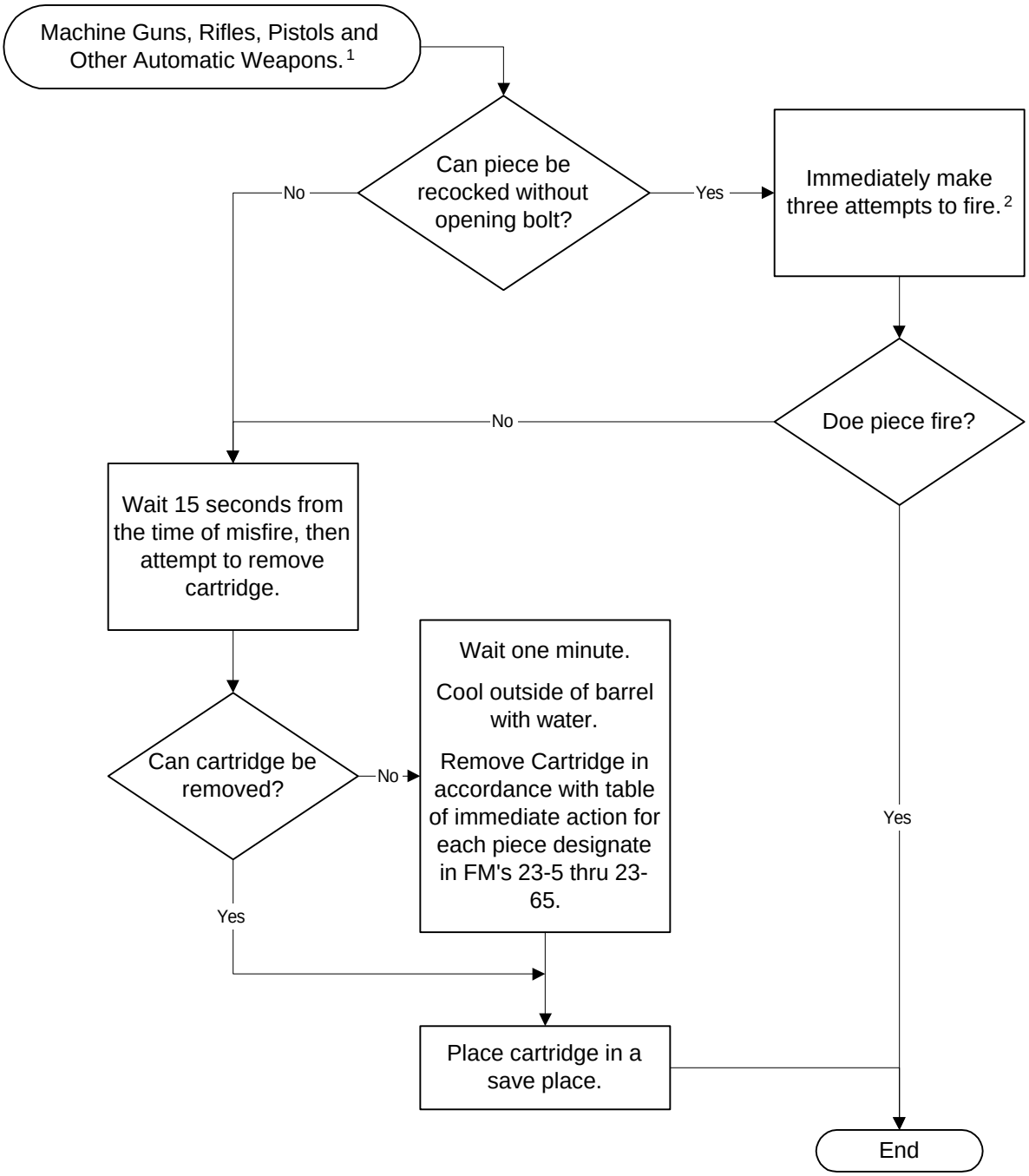
K. Velocity and pressure tests.

Special high pressure tests or tests of unknown pressure ammunition shall be performed only when personnel are protected against injury from gun failures. Operational shields or remote control firing of guns serves this purpose.

L. Primer drop tests.

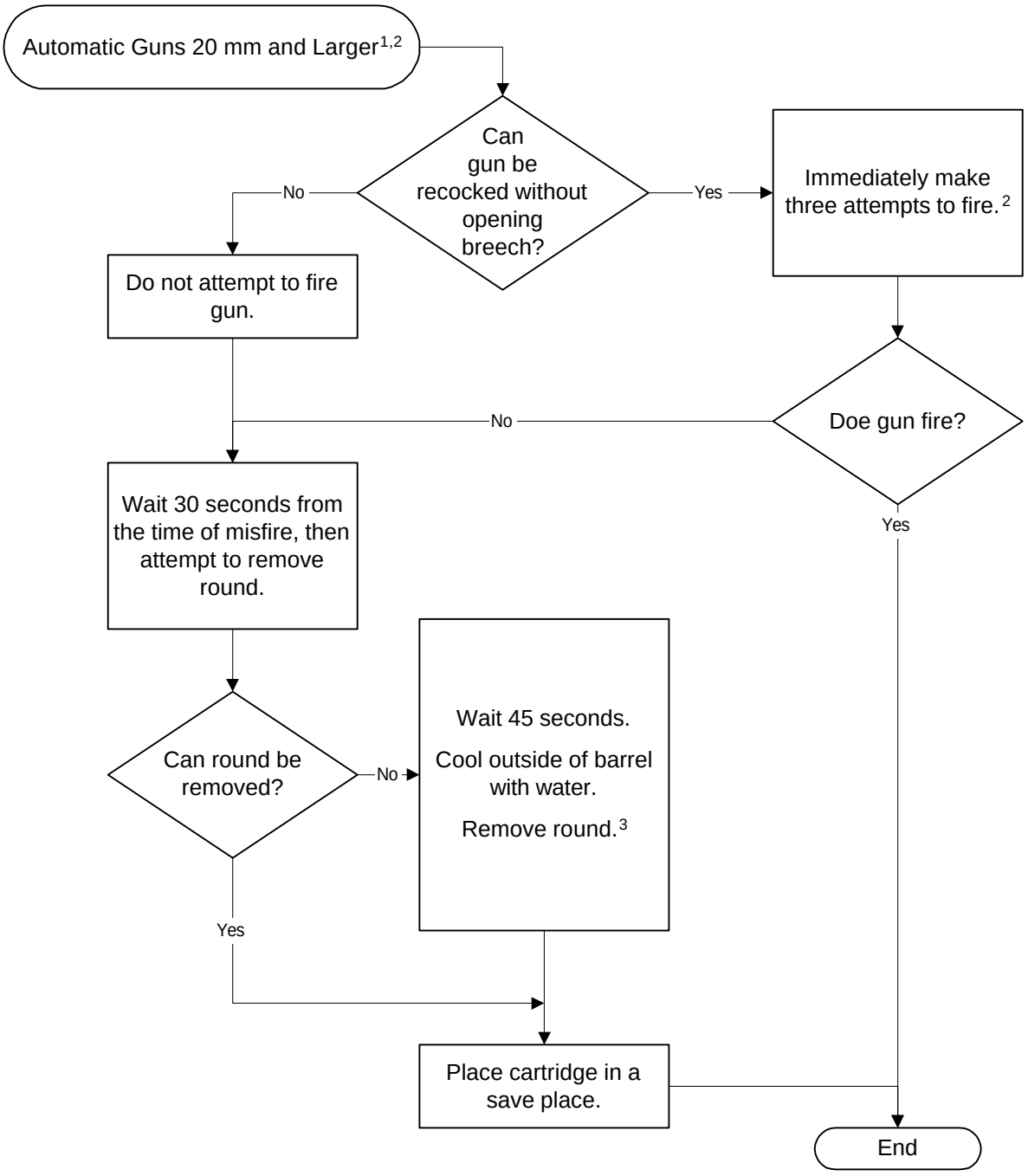
1. Cases containing live primers shall be marked and separated from those containing fired primers.

2. The collecting tube and areas where primer dust could accumulate shall be regularly inspected and cleaned.



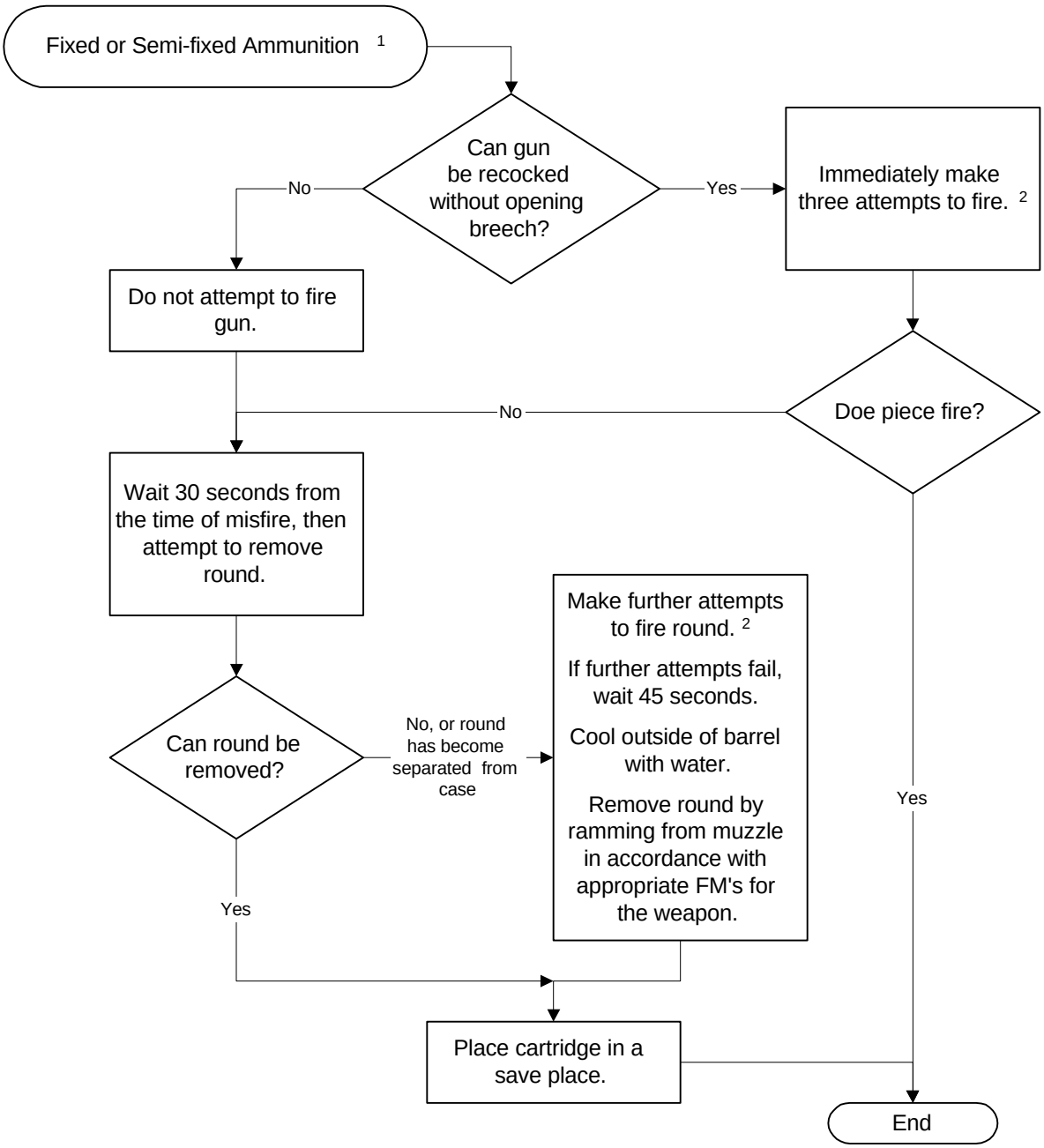
Notes:
1. For misfire of machine gus in which no possibility of automatic cook-off exists.
2. To avoid injury in case of hangfire, make sure that no part of either hand or wrist can be struck by the operating slide should it suddenly move to the rear.

Figure 14-1. Misfire of Machine Guns, Rifles, Pistols, and Other Automatic Weapons.



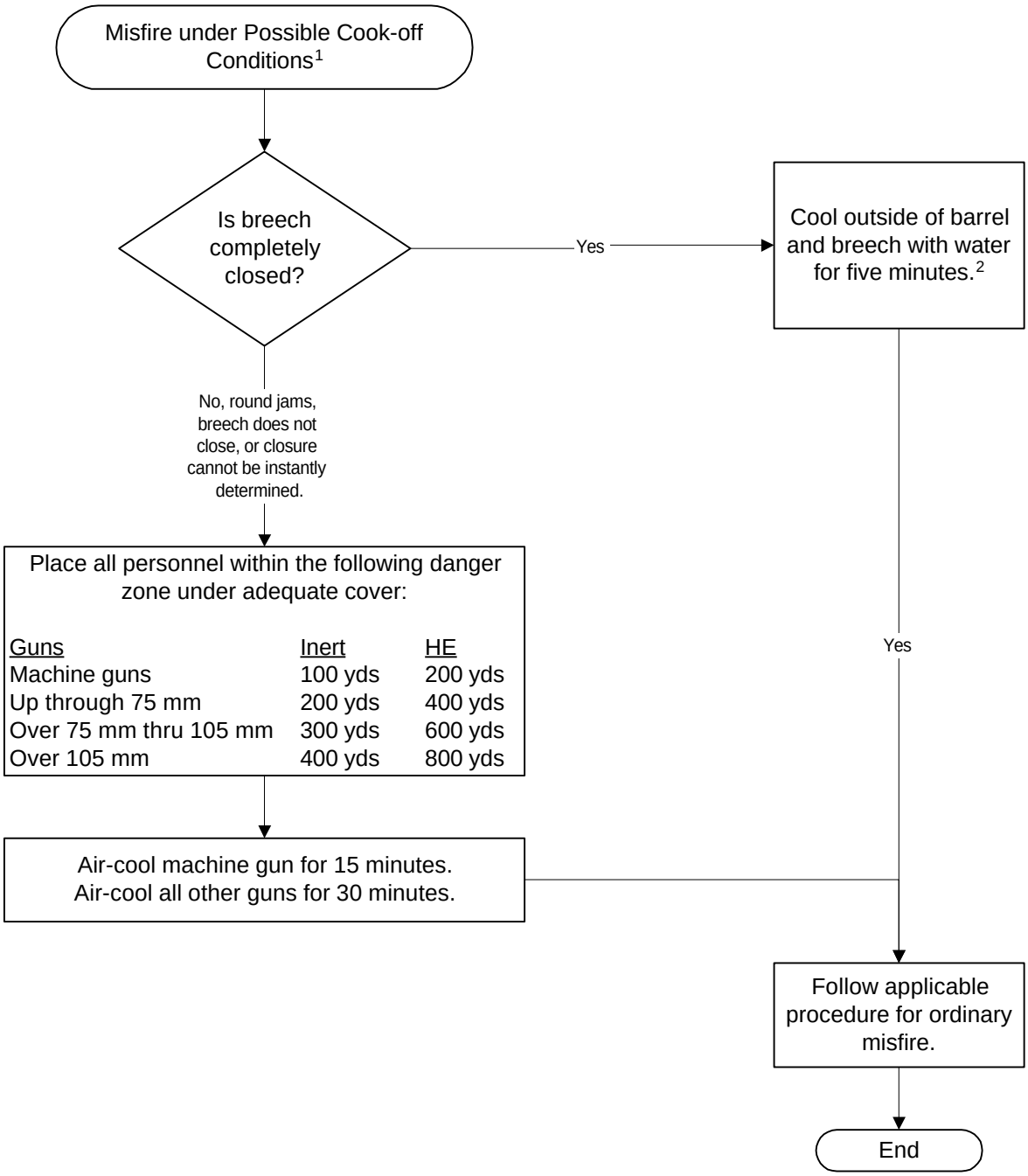
Notes:
1. The safest time to remove a misfired round of fixed ammunition is between 30 and 45 seconds after its occurrence.
2. In which no possibility of automatic function or cook-off exists.
3. If the round separated, follow procedures shown in Figure 14-3.

Figure 14-2. Misfire of Automatic Guns, 20 mm and Larger.



Notes:
1. The safest time to remove a misfired round of fixed ammunition is between 30 and 45 seconds after the misfire.
2. This operation may be tried any number of times after initial cooling of the barrel with water. In all cases, it is better to fire the projectile out than to resort to ramming. Make certain tht all loose powder in the breech is removed before preparing to fire.

Figure 14-3. Misfire of Fixed or Semi-fixed Ammunition.



Notes:
1. For machine guns, aniaircraft guns, or other guns fired at high rates for extended periods.
2. In tests where water cannot be applied, the danger zone as defined in the right column will apply.

Figure 14-4. Misfire under Possible Cook-off Conditions.

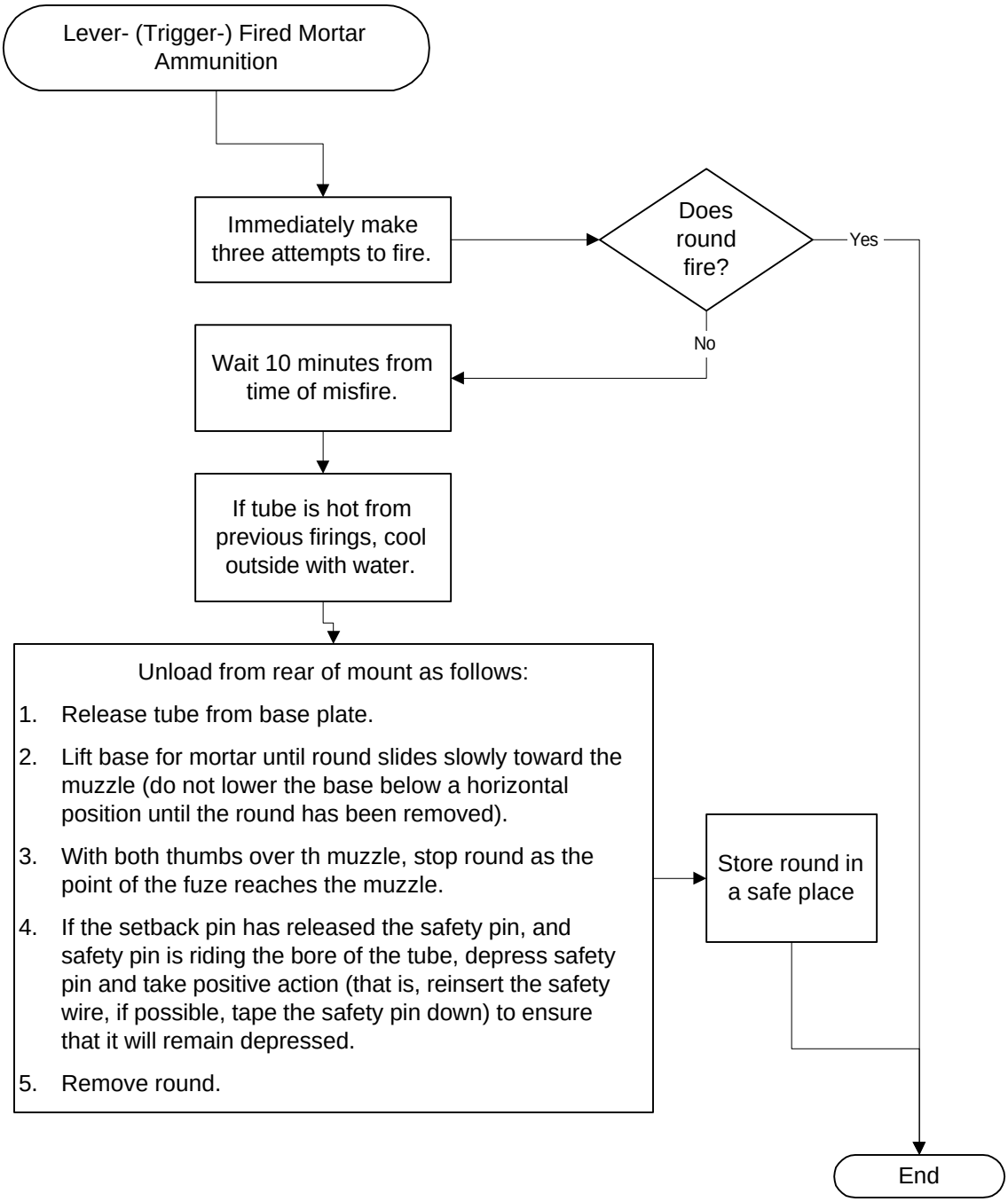


Figure 14-5. Misfire of Lever- (Trigger-) Fired Mortar Ammunition.

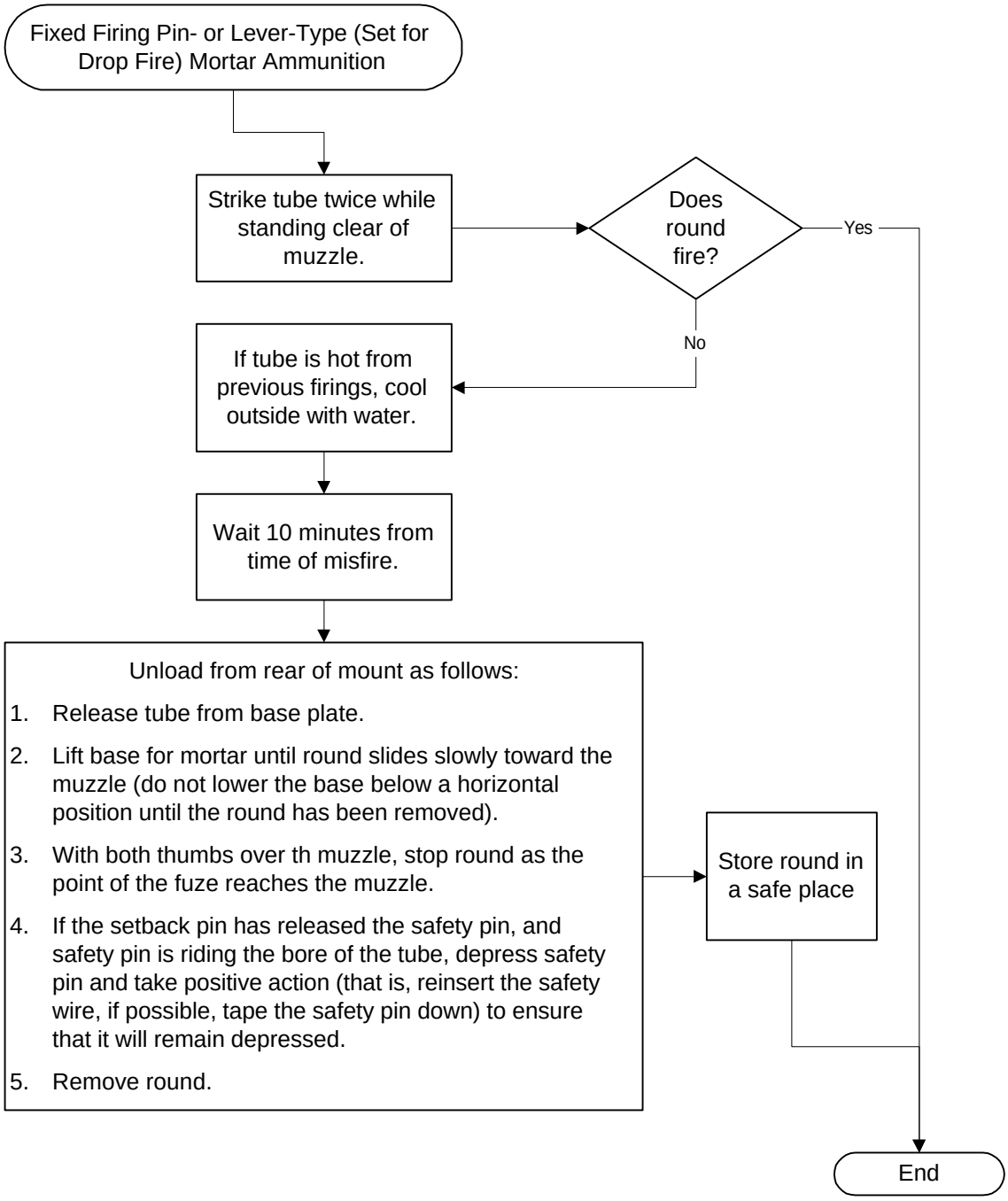
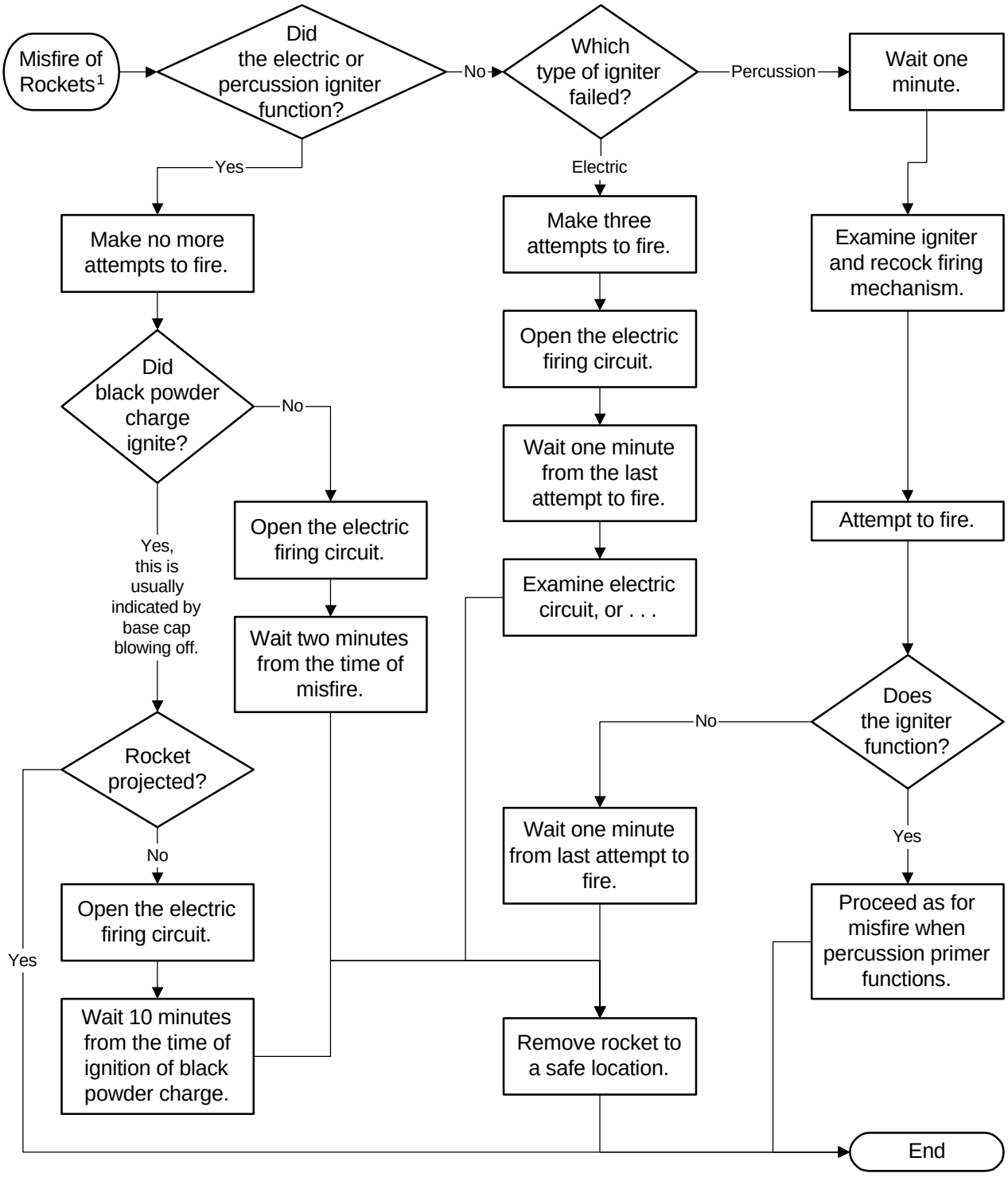


Figure 14-6. Misfire of Fixed Firing Pin- or Lever-Type (Set for Drop Fire) Mortar Ammunition.



Note:

1. For individually fired separate rockets. When firing ripple fire from multiple launchers, all rockets that misfire will be cooled immediately by means of water on the exterior of the launcher or air-cooled for 30 minutes before removal or inspection. In the event there is doubt of igniter functioning after attempting to fire several times using the electric firing circuit, follow the procedure as for misfire when electric or percussion igniter fails.

Figure 14-7. Misfire of Rockets.

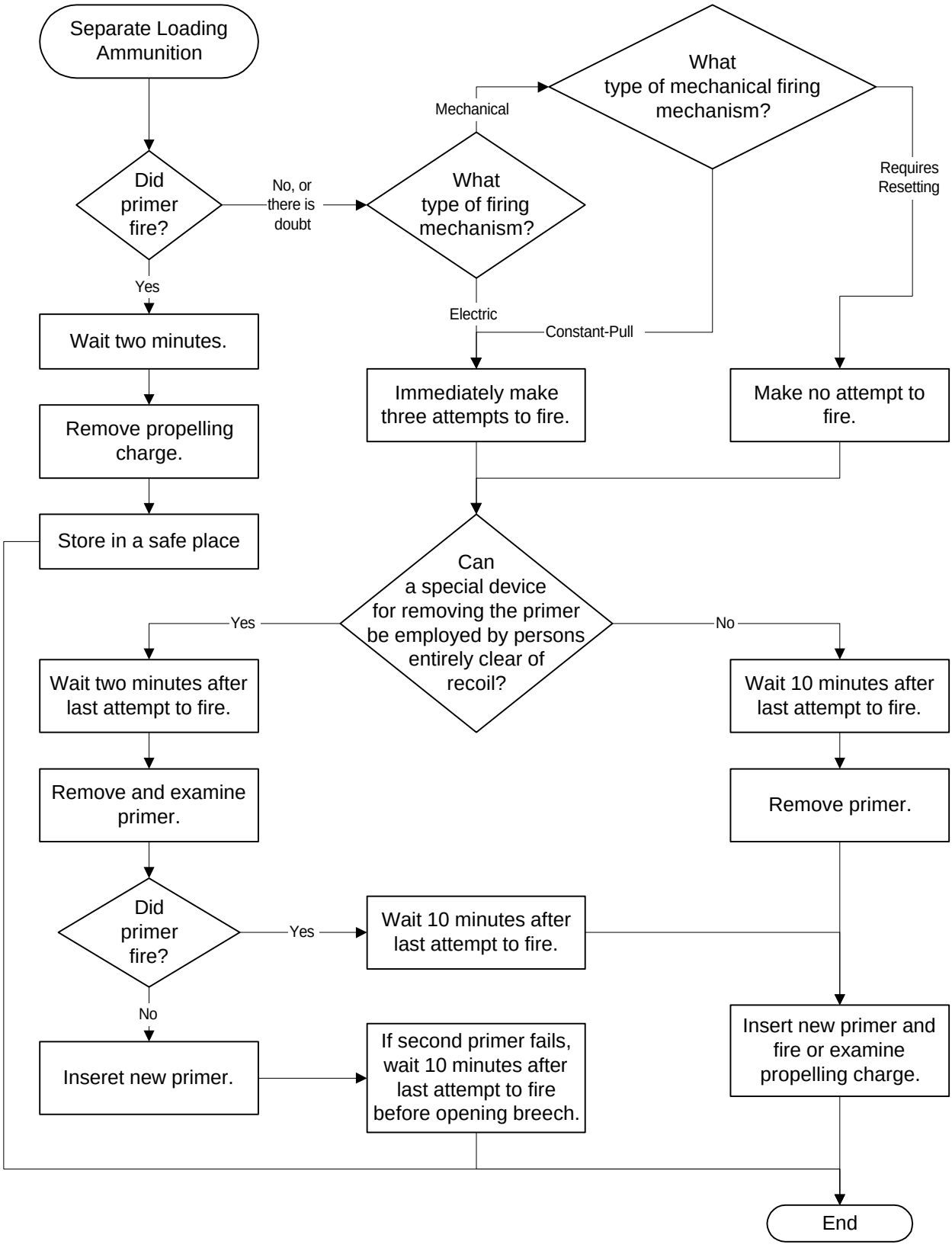
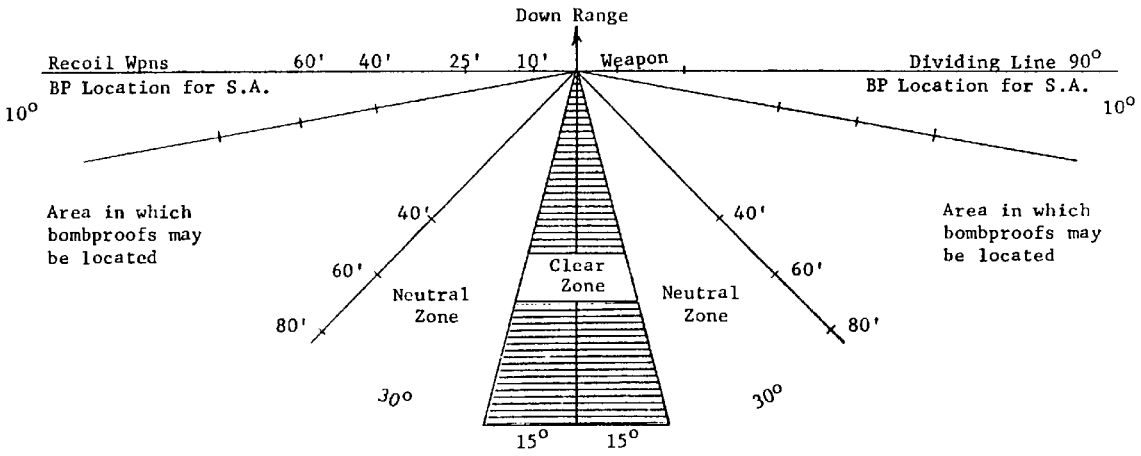


Figure 14-8. Misfire of Separate Loading Ammunition.



Notes:

1. Placement of bombproofs in the neutral zone requires prior approval from the responsible agency.
2. No bombproofs are permitted in the clear zone.
3. The dividing line is the center line of the trunnions.

Figure 14-9. Emplacement of Bombproofs at Firing Points.

CHAPTER 15

COLLECTION AND DESTRUCTION REQUIREMENTS FOR AMMUNITION AND EXPLOSIVES

A. General

This chapter provides safety requirements for the collection and destruction of ammunition and explosives. At this writing, the Environmental Protection Agency is developing regulations that will apply to each contractor and may impose requirements beyond those in this Manual. Explosive safety should not be compromised while meeting environmental considerations.

B. Protection during disposal operations

1. Operational shields and special clothing shall protect personnel in facilities with explosives materials. Fragmentation hazards require, at a minimum, overhead and frontal protection for personnel. Shelters should be located at the inhabited building distance appropriate for the quantity and type of materials being detonated. Personnel shall use such protective measures when destroying explosive materials by detonation and when burning explosive materials that may detonate. Personnel shall not approach the burning site, but shall wait until the fire is out.

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

C. Collection of ammunition and explosives

1. **Water-soluble materials.** Enough water should be used in neutralizing ammonium picrate (explosive D), black powder, and other soluble materials to ensure their complete dissolution. As little material as practicable should be dissolved at one time. Sweeping floors before washing them down reduces the amount of dissolved material in the wash water. When uncertainty exists concerning the purity and composition of wash water, experts shall be consulted.

2. **Solid wastes.** Explosives-contaminated solid waste material shall be collected; placed in closed containers; and swiftly removed to buildings for treatment or holding, or to the burning ground for destruction.

3. **Explosives dusts**

a. High explosives dusts such as TNT, tetryl, explosive D, composition B, and pentolite should be removed by a vacuum system. A “wet collector” that moistens the dust near the point of intake and keeps it wet until the dust is removed for disposal is preferred for all but explosive D, which should be collected in a dry system.

b. More sensitive explosives such as black powder, lead azide, mercury fulminate, tracer, igniter, incendiary compositions, and pyrotechnic materials may be collected 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. Provision should be made for releasing any gases that form. The use of vacuum systems for collecting these more sensitive materials should be confined 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, collection of scrap pyrotechnic, tracer, flare, and similar mixtures in No. 10 mineral motor oil or equivalent is required. Materials collected in the dry state shall be placed in an oil-containing receptacle available at each operation throughout the shift. The oil level should be about 1 inch above the level of any pyrotechnic mixture in the container. Containers of scrap explosive shall be removed from the operating buildings for disposal at least once per shift. Applicably rated class B firefighting equipment shall be available when oil is used.

4. **Design and operation of collection systems**

a. Collection systems and chambers shall be designed 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. Threaded connections are prohibited. The system shall prevent explosives 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. Vacuum application points should be kept to a minimum. Each room requiring vacuum collection should have a separate exhaust line to the primary collection chamber; if this is not possible, no more than two bays shall be serviced by a common header. Wet primary collectors are preferred. The length of vacuum line from points of application of vacuum to the wet collectors should be short. A single secondary collector shall service as few primary collectors as possible. Not more than two dry primary collectors shall be connected to a single secondary collector (wet or dry type). If an operation does not create a dust concentration potentially posing a severe health hazard, manual operation of the suction hose to remove explosives dust is preferred, since permanent attachment to the explosive dust-producing machine increases the likelihood of propagation through the collection system of a detonation at the machine. Manually operated hose connections to explosives dust-producing machines should not interconnect.

b. Two collection chambers shall be serially installed ahead of the pump or exhauster to prevent explosives dust from entering the vacuum producer in a dry vacuum collection system.

c. Slide valves for vacuum collection systems are permitted; however, there shall be no metal-to-metal contact. An aluminum slide operating between two ebonite spacer bars or similar, compatible materials will eliminate unacceptable metal-to-metal contact.

d. Dry-type portable vacuum collectors, limited to five pounds of explosives, shall be located in a separate cubicle having substantial dividing walls, or outside the building; never in a bay or cubicle with explosives. Wet-type portable vacuum collectors may be placed in explosives operating bays or cubicles, provided the quantity of explosives in the collector is limited in accordance with the requirements of paragraphs C.5.a through C.5.c, below. For dry collection of quantities in excess of five pounds or wet collection of quantities in excess of 15 pounds, the provisions of paragraphs C.5.a through C.5.c, below, also apply.

e. The design of wet collectors shall provide for proper immersion of explosives, breaking up air bubbles to release airborne particles; and for removal of moisture from the air

leaving the collector, to prevent moistened particles of explosives from entering the small piping between the collector and the exhauster or pump.

f. At least once every shift, explosives dust shall be removed from the collection chamber to eliminate unnecessary and hazardous concentrations of explosives. The entire system should be cleaned weekly, with parts dismantled as necessary.

g. The entire explosives dust collecting system shall be electrically grounded. The grounding shall be tested on a locally determined schedule.

h. Small vacuum systems positioned close to work stations shall be shielded.

5. **Location of collection chambers**

a. Whenever practicable, dry-type explosives dust collection chambers, except portable units, shall be located in the open, outside operating buildings, or in buildings set aside for the purpose. To protect operating personnel from blast and fragments from the collection chamber, a barricade or operational shield appropriate for the hazardous quantities involved, shall be provided between the operating building and the outside location or separate building housing the collection chamber. At least 3 feet shall separate the collection chamber from the barrier wall.

b. When locating dry-type collection chambers outside the operating building is not feasible, a separate room shall be set aside for this purpose in the building. This room shall neither contain other operations nor be used as a communicating corridor or passageway between other operating locations when explosives are being collected. Walls separating the room from other portions of the operating building shall meet the requirements for operational shields for the quantity of explosives in the collection chamber. If more than one collection chamber is to be located in the room, the room shall be subdivided into cubicles, with only one collection chamber per cubicle.

c. Stationary and portable wet-type collectors may be placed in explosives operating bays or cubicles, provided the quantity of explosives in the collectors does not exceed five pounds. Placed in separate cubicles, quantities may increase to 15 pounds. For wet collectors containing more than 15 pounds, location requirements set forth in paragraphs C.5.a and C.5.b, above, apply.

6. **Explosives/munitions awaiting destruction.** When stored in the open, material awaiting destruction shall be kept inhabited building distance from explosives being destroyed. Provided with adequate frontal and overhead protection, material awaiting destruction may be stored at intraline distance from the explosives being destroyed. All such material shall be protected against accidental ignition or explosion from ambient storage conditions or from fragments, grass fires, burning embers, or blast originating in materials being destroyed.

7. **Containers for waste explosives.** Containers for these explosives shall be the original closed packages or equivalent. Closures shall prevent spillage or leakage of contents when handled or overturned, and shall not pinch or rub explosives during closing and opening. Containers shall be marked clearly to identify contents. No containers constructed from spark-producing or easily ignited material shall be used.

D. Destruction sites

1. **Site criteria**

a. Destruction of ammunition and explosives shall occur as far as possible from magazines, inhabited buildings, public highways, runways, taxiways, and operating buildings. Separation distances shall be at least 1,250 feet or the applicable fragmentation distance unless pits or similar aids limit the range of fragments. Natural barricades should be used between the site and operating buildings or magazines. The possibility that the explosives may detonate when being burned requires use of appropriate protective barriers or separation distances for the safety of personnel and property. Explosives shall not be burned or detonated on concrete, nor in areas having large stones or crevices.

b. In all disposal and destruction activities, the number of A&E units or the explosives quantity that may be destroyed safely at one time shall be predetermined consistent with safe and efficient operations. When tests or other substantiated documentation reveal that fragments and debris are adequately controlled, appropriate inhabited building distances may be used for separation of the destruction site based on the maximum amount of explosives to be destroyed.

c. Firefighting equipment should be available to extinguish grass fires and to wet down the area between burnings and at the close of operations.

d. Ordinary combustible rubbish should not be disposed of near areas where explosives and explosives-contaminated material are destroyed.

2. **Material and equipment usage**

a. Detonation of ammunition or explosives should be initiated by electric blasting caps, using blasting machines or permanently installed electric circuits energized by storage batteries or conventional power lines. When items to be detonated are covered with earth, the initiating explosives should be primed with enough primacord to allow connecting the blasting cap above ground level.

b. Special requirements for using electric blasting caps and electric blasting circuits follow.

(1) The shunt shall not be removed from the lead wires of the blasting cap until the moment of connection to the blasting circuit. If the shunt must be removed to test the blasting cap before priming the charge, short circuit the lead wires again following the test by twisting the bare ends of the wires together. The wires shall remain short circuited in this manner until the moment of connection to the blasting circuit.

(2) When uncoiling the leads of blasting caps, the following shall apply:

(a) No one shall hold the cap at its explosives end.

(b) The explosives end of a hand-held cap should be pointed down, away from the body, to the rear.

(c) The wires shall be held carefully so that there is no tension where they connect to the cap.

(3) The lead wires of electric caps shall be straightened as necessary by hand. These wires shall not be thrown, waved through the air, or uncoiled by snapping as a whip.

(4) Firing wires shall be twisted pairs. The connection between blasting caps and the circuit firing wires shall not be made unless the power ends of the circuit leads (firing wire) are shorted and grounded.

(5) Electric blasting or demolition operations and unshielded electric blasting caps shall be at safe distances from radio frequency energy transmitters.

(6) The blasting circuit shall be tested for extraneous electricity before electric blasting caps are connected to firing wires. To do so, arrange a dummy test circuit similar to the actual blasting circuit except that a radio pilot lamp of known good quality, using no electricity, shall substitute for the blasting cap. If this pilot lamp glows in the dark, indicating possibly dangerous amounts of RF energy, blasting operations shall proceed with non-electric blasting caps and safety fuses. Other instruments, such as the DuPont "Detect-A-Meter" or "Voltohmeter," may be substituted for the radio pilot lamp used in testing.

(7) If the exposure is to radar, television, or other microwave transmitters, the actual blasting circuit, with blasting cap included but without other explosives, shall be used to test for extraneous electricity. Personnel performing such tests shall be protected from the effects of an exploding blasting cap.

(8) Blasting and demolition operations shall be suspended during electrical storms, approaching as well as in progress. At first sign of an electrical storm, cap wires and lead wires shall be short-circuited, and all personnel removed from the demolition area to a safe location.

(9) A galvanometer shall test the firing circuit for electrical continuity before it connects with the blasting machine. Before completing the circuit at the blasting machine or panel and signaling for detonation, the individual assigned to make the connections shall confirm that everyone in the vicinity is in a safe place. 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.

(10) When transported by vehicles with two-way radios, and when in areas presumed to have extraneous electricity, blasting caps shall be in closed metal boxes.

c. When conditions prevent the use of electrical initiators for detonation, safety fuses shall be used. At the beginning of each day's operation and whenever a new coil is used, the safety fuse's burning rate shall be tested. The fuse shall be long enough for personnel to retire to a safe distance. Under no circumstances shall the fuse length be less than that required for a 2-minute burning time. Approved crimpers shall be used to fix fuses to detonators. Only fuses small enough in diameter to enter the blasting cap without forcing shall be used. All personnel except the fuse-actuator shall retire to the personnel shelter or leave the demolition area before ignition.

3. **Servicing of destruction site.**

a. Vehicles transporting explosive material to burning or demolition grounds shall meet the requirements of this Manual. No more than two persons shall ride in the cab. No one shall ride in the truck bed.

b. Vehicles should be unloaded immediately and withdrawn from the burning or demolition area until destruction operations are completed. Containers of explosives shall not be opened before the vehicle has departed.

c. Containers of explosives or ammunition items to be destroyed at the destruction site shall be spotted and opened at least 10 feet from each other and from explosive material set out earlier, to prevent rapid transmission of fire if premature ignition should occur.

d. Empty containers shall be closed and removed to prevent charring or damage during burning of explosives. Delivery vehicles on the return trip shall pick up empty containers.

E. Destruction by burning

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

2. Because of the danger of detonation, ammunition and explosives shall not be burned in containers or in large masses, except as directed by competent contractor authority.

3. Beds for burning explosives shall be no more than 3 inches deep. Wet explosives may require a thick bed of readily combustible material underneath and beyond to ensure that all the explosives shall be consumed upon ignition. An ignition train of combustible material leading to the explosives shall be arranged so that both it and the explosives can be burned in such a fashion to avoid any ignited material from propagating to itself in an uncontrolled manner or from propagating to any other explosive treatment areas. When wind velocity exceeds 15 miles per hour, no disposal by burning shall take place. For direct ignition of a combustible train, 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 shall be used. Tying two or more squibs together may be necessary to ensure ignition of the combustible train. Combustible materials are not needed for burning solid propellants ignited by squibs. The sites of misfires shall be evacuated for at least 30 minutes, after which two qualified persons shall approach the position of the explosives: one shall examine the misfire; the other shall act as backup. Watching the examination from a safe distance, with natural or artificial barriers or other obstructions for protection, the backup shall be prepared to rush to the examiner's aid should an accident occur.

a. If burning is expected to be complete, loose, dry explosives may be burned without being placed on combustible material, leaving the ground uncontaminated. The ground shall be checked for residual unburned explosive for the safety of personnel and operations. Volatile flammable liquids shall not, at any stage, be poured over explosives or the underlying combustible material to accelerate burning.

b. Wet explosives shall always be burned on beds of nonexplosive materials.

c. Explosive powders such as RDX etc., should be burned in desensitized form to promote safe handling and prevent detonation.

d. Pyrotechnic materials in oil containers shall be emptied into shallow metal pans before burning. The open containers may be burned with the explosives.

4. Parallel beds of explosives prepared for burning shall be separated by not less than 150 feet. In subsequent burning operations, care shall be taken to prevent material being ignited from smoldering residue or from heat retained in the ground from previous burning operations. Unless a burned-overplot has been saturated with water, then passed a safety inspection, 24 hours shall elapse before the next burning.

F. Destruction by detonation

1. Detonation of ammunition or explosives being destroyed should occur in a pit not less than 4 feet deep and covered with not less than 2 feet of earth. The components should be placed on their sides or in that position exposing the largest area to the influence of initiating explosives. Demolition blocks shall be placed in intimate contact on top of the item to be detonated, secured by earth packed over them. Under certain circumstances, materials such as bangalore torpedoes and bulk high explosives may be substituted for demolition blocks.

2. Local regulations, atmospheric conditions, earth strata, etc., determine how many projectiles and explosives shall be destroyed at one time, both in pits and open sites. Taking these variables into account, the acceptable quantity shall be based on criteria in Chapter 4. This procedure should be used for destruction of fragmentation grenades, HE projectiles, mines, mortar shells, bombs, photoflash munitions, and HE rocket heads that have been separated from motors. When a demolition area is remote from inhabited buildings, boundaries, work areas, and storage areas, detonation may be accomplished without the aid of a pit, space permitting.

3. After each detonation, the surrounding area shall be searched for unexploded material and items.

4. In cases of misfires, the procedures in Chapter 14, subsection G.3. shall apply.

G. Destruction by neutralization

Certain ammunition and explosives may be disposed of by neutralization. Methods of neutralization include dissolving water-soluble material and chemical decomposition. The contractor, responsible for investigating which of these is most appropriate, shall comply with all applicable local, State, and Federal requirements for disposal and contamination operations.

H. Destruction chambers and incinerators

1. **General.** Small, loaded ammunition components such as primers, fuzes, boosters, detonators, activators, relays, delays, and all types of small-arms ammunition, should be destroyed in destruction chambers and deactivation furnaces. Explosives scrap incinerators should be used for burning tracer and igniter compositions, small quantities of solid propellant, magnesium powder, sump cleanings, absorbent cleaning materials, and similar materials. Destruction chambers and incinerators should be equipped with suitable pollution-control devices, such as

multiple chamber incinerators with thermal incinerator afterburners. The final incineration should take place at 1400°F, minimum.

2. **Operation of incinerators**

a. The feeding conveyor shall not be operated until the incinerator temperature is high enough to ensure complete destruction. Temperature recording devices should be installed.

b. To remove accumulated residue, incinerators shall be shut down and thoroughly cooled. Repairs shall be made only during shutdown. Personnel entering the incinerator to clean it shall be provided with respiratory protection to prevent inhalation of toxic dusts or fumes, such as mercury from tracers and lead from small-arms ammunition.

3. **Operation of destruction chambers and deactivation furnaces**

a. Operation shall be by remote control.

b. Operators shall not approach the unprotected side of the concrete barricade to replenish fuel, adjust the oil flame, or for any other reason, until enough time has elapsed for explosives in the chamber to go off. To keep the feedpipe chute or conveyor obstruction-free, regular inspections shall take place.

c. Components shall be fed into the chamber a few at a time. The exact number permitted at one time for each type of component shall be posted in a place easily seen from the operator's working position.

d. Guards shall be installed on conveyor-feeding mechanisms to facilitate feeding and to prevent items from jamming or falling.

I. Support in disposal of waste

If Government-owned ammunition items or explosives are declared excess or residual and the contract says nothing about disposition, the contractor shall request instructions from the responsible Contract Administration Office. A contractor having trouble safely disposing of residual (scrap) ammunition items or explosives related to contractual operations may request help from the Contract Administration Office.

CHAPTER 16

MANUFACTURING AND PROCESSING PROPELLANTS

A. General

1. These requirements are applicable to propellant manufacturing and augment other requirements contained in this Manual.

2. The safety precautions for fabrication of solid propellants, propellant loaded items, gun ammunition, and rocket motors follow the generally accepted principles used for many types of explosives and energetic materials. Solid propellants can be divided into general categories such as single, double, and triple base, castable composite, and modified double base composite; e.g., castable composite propellant modified with explosive plasticizer such as nitroglycerin.

3. Although processing safety considerations for finished propellant items and loaded rocket motors are similar, each propellant type has its own characteristics for processing of raw materials, intermediate compositions, and final processing. Hazards data testing of intermediate and finished propellant should be accomplished to define the requirements that ensure safety in processing. Initiation thresholds to such stimuli as impact, friction, heat, and electrostatic discharge shall be known for specific processes and handling situations. In evaluating and properly applying the guidelines in this chapter, the response of the materials in terms of energy input sensitivity and magnitude of energy release shall be considered. Safety precautions for ignition system fabrication shall follow the general requirements for manufacturing and processing of pyrotechnics given in Chapter 8. (An exception to this requirement is the processing of a propellant grain igniter which shall be the same as motor propellant until the grain is mated with the initiator assembly.)

4. In addition to generally accepted safety precautions for handling of explosives and other energetic materials, the following paragraphs provide general guidance pertinent to the manufacturing of solid propellants and loaded items and solid propellant rocket motors.

B. In-process hazards

1. During scale up from research and development of new materials to an existing solid propellant manufacturing process, determine the chemical, physical, physiological and explosive hazards of raw materials, intermediate compositions, processing aids, and final solid propellant, both uncured and cured.

2. Testing shall be conducted to determine thermal stability, chemical compatibility of ingredients, exothermic reactions, and sensitivity to ignition or detonation from friction, impact, and electrostatic discharge. Additionally, deflagration-to-detonation and card-gap test data can be valuable. Applicable tests may be selected from TB 700-2, *Explosives Hazard Classification Procedures* (reference (e)).

3. Minimum testing may satisfy the classification requirements for several in-process operations. For example:

a. If reliable data exist that indicate that the propellant mixing operations are H/D 1.1, no testing would be needed to adopt this classification.

b. If testing shows that uncured propellant will detonate, the casting and curing operations shall be considered exposed to H/D 1.1 hazards.

c. If detonation tests show that the cured propellant will detonate, all operations with cured or curing propellant shall be considered as exposed to H/D 1.1 hazards.

4. Safety information for all materials used in the formulation shall be available as required. Personnel shall be trained on the hazards involved in propellant process situations.

C. Quantity-distance (Q-D) requirements

New manufacturing and support facilities for processing of solid propellants and propellant loaded items shall be operated to conform to the latest Q/D requirements for the class/division of the material in the in-process condition.

D. Separation of operations and buildings

1. Propellant and rocket motor manufacturing and processing shall be done in special areas - operating lines - whose boundaries are separated from all other areas outside the line in accordance with appropriate Q/D criteria. Refer to Table 16-1 for remote control and personnel protection requirements for certain propellant processing operations

2. Sequential operations on rocket motors can generally be treated as one process operation in one building.

3. The required separation between buildings (sites, pads, or other such locations), which form a single production or operating line, shall be in accordance with quantity/distance criteria.

4. When the hazard classification of a propellant has not been established, classify the propellant during site and construction planning as the most hazardous class/division that might possibly apply during manufacturing and processing.

5. Safety shelters, lunch rooms, convenience buildings, and private vehicle parking for personnel working in an operating building should be constructed and shall be sited in accordance with applicable Q/D criteria.

E. Equipment and facilities

1. Except as provided for in other applicable documentation, the design, layout, and operation of facilities and equipment for solid propellant operations shall follow the mandatory provisions. Where guidance is not provided, operations should be governed by the results of hazard tests and analyses performed and documented to address specific operations. As some propellants can be sensitive to initiation by static electricity, bonding and grounding of equipment, tooling, and rocket motors along with other means of static elimination and control should be given special consideration. Conductive work surfaces and floors or floor mats shall be provided for assembly of igniters and igniter subassemblies.

2. Nonsparking and nonrusting materials, which are chemically compatible with the propellant material, shall be used for equipment, tooling, and machinery that will come in contact with propellant or propellant ingredients.

3. Certain solid propellant operations involve significant energy input which enhances the possibility of ignition. Examples are rolling mills, machining and drilling operations. In these situations, complete hazard analysis and evaluation shall be conducted prior to starting the operation.

4. Heat-conditioning equipment shall meet the requirements of section.

5. Exposed radiant surfaces in the form of S-shaped smooth pipe or fin-type radiators are considered suitable types of radiators because of the ease with which they can be cleaned. Other types of radiators are acceptable, but are less desirable because of cleaning difficulties.

6. When mechanical ventilating equipment is used in operations involving potential concentrations of solvent vapors, dusts, and nitroester vapors, the electric motor and motor controls shall not be located directly in the potentially contaminated air stream and the system shall be provided with a suitable means of collecting condensate.

7. Air conditioning and cure oven air-circulating equipment of the closed system type shall be designed to prevent contaminated air from contacting the air motor and controls. Recirculated air shall be monitored to ensure concentration of vapors and dusts do not reach flammable (or explosive), or personnel threshold limits. Electric motors and controls shall be dustproof and vaporproof electrical equipment. Air mover blades should be nonmetallic.

8. The equipment shall be rigidly fixed and stable during mixing to preclude contact between fixed and movable parts. Any mix bowl lift-mechanism (elevator) is to be designed so blade-to-blade and blade-to-bowl clearances are assured during the complete operation cycle.

9. Positive controls shall be provided to physically block or stop bowl or mixer head movement in case of drive mechanism malfunction. Assure blade-to-blade and blade-to-bowl clearance is maintained at all times.

10. Mix blades and shaft shall be rigid and structurally strong to ensure minimum flex from viscosity of the mix and speed of the shaft.

11. Electrical components of all mixers shall meet the appropriate electrical classification, be remotely located, or shrouded and purged with inert gas. Purged systems shall be designed to provide automatic warning if gas pressure is lost.

12. Mixer blade shafts shall be equipped with seals or packing glands that prevent migration of liquids or solvent vapors into bearings. Submerged bearings and packing glands should be avoided. However, if used, they shall be periodically tested for contamination and cleaned.

13. A program shall be established to detect significant changes in blade/shaft position relative to mixer head. Clearances between mix blades and mixer bowls shall be checked at regular intervals based on operating time and experience to make sure the clearance is adequate. Maintain a record of such checks, mixer blade adjustments, and any damage to the mixer blades and bowls.

14. Mix bowl, blades, and drive unit are to be electrically bonded and grounded.

15. Inspect blades and other moving parts of new mixers and replacement parts for old mixers. Inspect (magnaflux and/or X-ray) for cracks, crevices, and other flaws.

16. Electric service to propellant mixers shall be interlocked with fire protection system controls so that the mixer cannot start when the fire protection system is inoperative.

17. All process equipment which applies energy to in-process propellant should be checked regularly for wear and misalignment. A record of these checks and maintenance performed should be maintained for the process equipment.

18. Equipment performing sequential operations on propellants, such as extrusion and cutting, shall be controlled to prevent interference.

F. In-process quantities and storage

1. Only the amount of propellant and loaded subassemblies needed to ensure a safe and efficient workflow shall be present in an operating building when operations are being conducted. This does not preclude short-term storage of larger quantities in an operating building when not in use for other operations.

2. Operating buildings of standard construction may be used for storage of completed assemblies with or without installed ignition system. There shall be no other operation in progress and quantity/distance shall be in compliance with requirements.

3. Production igniters may be stored in designated areas within an assembly/disassembly facility.

4. Indoor storage is preferable for all types of explosives and is mandatory for bulk high explosives, solid propellants, and pyrotechnics. Priority of existing indoor storage should be given to items requiring the most protection from the weather (based on the method of packing). Solid propellant and propellant materials shall be protected from overheating by exposure to direct sunlight when in transit or on temporary hold.

5. The propulsive characteristics and the ignition probability of explosive items such as propellant loaded devices, rocket motors, assist take-off units, and missiles shall be taken into consideration during all logistical phases in order to obtain as much safety as possible under the circumstances. Because of the great number of types and sizes of propellant loaded devices and conditions of assembly encountered, it is not feasible to present anything other than general safety guidance in this Manual. Thus, every effort should be made to prevent ignition of any units being manufactured, assembled, disassembled, handled, stored, transported or deployed. Approved flight restraining devices (tie-downs) shall be used to the maximum extent possible. When doubt exists as to whether a given item or configuration (state of assembly) is propulsive or nonpropulsive, the item shall be treated as propulsive until pertinent technical information can be obtained.

G. Ingredients processing

1. Weighing, measuring, and handling raw materials

a. Scales for weighing raw materials shall be electrically grounded, where needed, to properly protect the operation. This grounding is especially important where flammable or combustible materials are involved.

b. Separate weight or measurement rooms, cubicles, or areas (dependent upon the quantity and sensitivity of the materials handled) shall be provided. Oxidizer and metallic powder weighing shall be separated from each other and from other materials by physical barriers rather than distance.

c. It is important that containers, equipment, hand tools, scale pans, etc., used for weighing processes are not mixed with those weighing or measuring oxidizers and fuels, particularly where distance rather than physical barriers separates these areas. Positive measures shall be adopted to ensure the complete separation of such equipment and tools.

d. The designated use of space and equipment shall not be changed without a thorough cleaning and inspection to make sure that all traces of the previous material have been removed if any possibility exists that materials are incompatible.

2. Oxidizer processing

a. Solid propellant oxidizing agents are perchlorates, nitrates, nitroesters, and nitramines used in solid rocket motor propellants.

b. Avoid contaminating an oxidizer agent with any metal or chemical (fuel) which may result in a more sensitive composition.

c. Use closed systems as much as possible for dust, humidity, and tramp material control.

d. Flexible connections (socks) in pipes or duct systems which convey oxidizer materials and dust socks in collectors or hoppers shall be fabricated of fire-retardant materials. These materials shall be chemically compatible with the oxidizers to which they shall be exposed.

e. The pipes and duct systems shall be made electrically continuous. Threaded joints and fittings in contact with oxidizer should be avoided. Quick clamp neuter end pipe joints are preferred.

f. Static electricity control measures shall be used to dissipate static charges to an acceptable level if oxidizer is transported by fluidization.

3. Oxidizer drying

a. The safe temperature for drying each material shall be established and shall not be exceeded at any point in the drying apparatus or drying room.

b. Use thermostatic controls to prevent the maximum safe temperature from being exceeded in the drying process. Redundant controls are required.

c. Electrical heating elements that may contact the oxidizer or oxidizer dust shall not be used.

d. Dust should be held to a minimum in the drying process. A dust collection system shall be used if dusting can create a potential hazard.

e. Care should be exercised to ensure incompatible materials are not being dried simultaneously in the same drying process. An oven, drying room, etc., used for processing flammable or other incompatible materials should not be used for drying oxidizers until it has been cleaned, inspected, and found to be free of any contaminating residual materials.

4. **Screening oxidizers**

a. When screening for process purposes, the screening equipment shall be constructed so oxidizer material is not subjected to pinching, friction, or impact as a result of metal-to-metal contact. Rooms in which screening units are operated shall be kept thoroughly clean to eliminate hazardous accumulations of dust.

b. Oxidizer screens shall be electrically grounded and bonded to the receiving vessel.

5. **Blending oxidizers**

a. If gases are generated during blending of oxidizer, a suitable means of gas pressure relief shall be designed into the blender.

b. The blender shall be electrically bonded throughout.

c. Blending equipment shall be constructed so oxidizer material is not subjected to pinching, friction, or impact between metal-to-metal surfaces.

d. When ammonium perchlorate is blended using powered mechanical equipment, operating personnel shall be protected. Remote control of mechanical blending is mandatory.

e. When powered mechanical methods are used for blending mass-detonating materials (such as RDX or HMX), the operation shall be remotely controlled and personnel protected (See Note 1 to Table 16-1).

6. **Grinding oxidizers**

a. When impact-type mills are used, there shall be sufficient clearance between stationary and moving parts to prevent metal-to-metal contact. Clearances shall be checked as often as needed to ensure they are adequate. Mill bearings should be wind swept (purged) to prevent contamination. Impact-type grinders shall not be used for mass-detonating materials.

b. Oxidizer feed materials shall be passed through a screen mesh with openings no greater than the clearance between hammer and plate. Screen mesh size for ammonium nitrate should be the smallest that allows free flow of the prills. Magnetic separators shall be used if screening is not possible.

c. Use only compatible lubricants in grinding equipment.

d. Heat sensing devices should be installed on the bearing housing of grinding and conditioning equipment.

e. Determine the cleaning cycle and method used for grinding equipment and include in operating procedures.

f. Grinding operations should be provided with wet dust-collection systems, where appropriate.

g. Pneumatic grinding operations shall be thoroughly grounded and bonded to provide for electrostatic charge dissipation.

7. **Preparation of fuel compositions**

a. Sensitivity characteristics of fuel compositions should be determined prior to production mixing operations.

b. Establish compatibility of materials. Develop procedures that preclude the formation of highly sensitive compositions or hazardous conditions during processing, such as, dry AP and powdered metal mixtures.

c. Equipment, piping, and vessels used in fuel preparation should be bonded to form a continuous electrical path with each other and to building ground. When metallic powder and flammable liquids are transferred (poured) from one container to another, the containers should be bonded together prior to transfer.

d. Minimize the formation and accumulation of dust in all preparation operations.

e. Fume hoods, dust socks, closed systems, and dust/fume vacuum exhaust hoses shall be used, as appropriate, to prevent vapors and dust getting into the operating areas.

8. **Transfer operations.**

a. Finely divided powdered ingredients should be transferred by methods that control flow rate and minimize electrostatic charge generation.

b. Flammable solvents should be transferred only after the transfer and receiving vessels have been electrically bonded to eliminate electrostatic potential differences.

H. Mixing

1. Secure hardware and associated equipment to prevent loose items falling into mixers.

2. Liquids and powders to be added to the mix vessels shall first pass through a screen or orifice with an opening(s) less than the smallest clearance in the mixer. Smaller amounts of material may be added directly, provided a positive means exists to ensure the material does not contain any foreign material.

3. Materials which cannot be screened and are opaque or not easily inspected should be examined by other means, such as X-ray.

4. When consistent with the process system and requirements, a cover shall be placed over the mixer bowl after charging or mixing operations are completed. This is to prevent the accidental introduction of foreign objects into the mixer and also to preclude sunlight impinging directly on the materials in the bowl.

5. Use only nonsparking devices to scrape down the sides and blades of mixers by hand. Set up controls to prevent these and other devices from being accidentally introduced into the mixer.

6. Account for all loose tools and equipment before starting or continuing mixing operations.

7. Loose objects such as jewelry, pens and coins shall not be allowed in the mixer operating area where they may accidentally be introduced into mixers. The use of pocketless coveralls is recommended.

8. Direct and unobstructed routes shall be provided for personnel egress from mixer buildings or bays.

9. Personnel shall not attempt to fight propellant fires.

10. Propellant mixers should be equipped, inside and outside of the mixing vessel, with a high-speed deluge system.

I. Casting and curing

1. Local attendance during cast operations is permitted provided a thorough safety review of the operation is conducted.

2. Multiple or production line type casting is permissible provided provision is made to prevent propagation of an incident between individual cast bells or pits.

3. All cast piping and tooling in contact with propellant shall be smooth for ease of cleaning and be free of cracks, pits, crevices, and weld slag. Threaded joints should be avoided as much as possible. Joints requiring disassembly as a process operation or for cleaning should not be threaded type.

4. Cast tooling and mandrel designs shall permit no metal-to-metal friction or impact sites.

5. Valves through which propellant flows shall be designed to prevent propellant from being pinched or compressed between two metal surfaces.

6. Pressurized casting vessels shall be capable of withstanding at least twice the maximum allowable working pressure.

7. Lids shall be secured to pressurized casting vessels in such a manner that they shall withstand the rated pressures of the vessels.

8. Line pressure for pressurizing the casting vessel shall not exceed the working pressure of the vessel. Pressure lines shall have a relief valve downstream of the regulator.

9. Equip each vessel with a blowout disk (burst diaphragm) designed to blow out at less than 120 percent of the vessel's maximum allowable working pressure. The design shall allow for the release of the potential rapid rise of pressure in the vessel should the propellant ignite.

10. Pressure relief shall be provided when propellant is cured or cast under pressure.

11. Pressurization and depressurization for propellant cure shall be done remotely.

12. Casting vessels should be physically or electrically disconnected from lifting devices during cast operations.

J. Extrusion processes

1. Solventless extrusion presses and compression molding equipment should be designed to remove air from the propellant before compaction and extrusion begin. Assure that procedures

provide for checking operation of the vacuum system and for cleaning it of propellant residue and condensed vapors such as those generated from nitroglycerin volatilzation.

2. Ramheads should be checked for alignment with the press bore to preclude metal-to-metal contact. Flashing removal should be included in the process procedures.

3. Interlocks shall be provided to preclude press operation during loading or other attended operations.

K. Propellant loaded items

1. When operations are performed on cured propellant contained in pressure vessels or rocket motor cases and there is a risk of ignition due to energy inputs (such as electrical check of pyrotechnic devices), the unit should be secured in a fixture capable of withstanding the rated thrust of the assembly times a factor of 2.5, minimum.

2. When mechanically applied force is required to "breakaway" the mandrel or other tooling embedded in propellant, it should be applied by remote control. However, see Table 16-1 for exceptions.

3. Moving loaded motors with cores in place is, generally, not recommended. If loaded motors containing cores must be moved, however, the core and motor case shall be supported by or suspended from a common source or in some manner locked or tied together to prevent independent movement of either.

4. Hazard characteristics of individual propellants to be cut, machined, or contoured, shall be evaluated and considered in determining the safest method to use.

5. Propellant machining equipment shall be designed:

a. To prevent contact of cutting tools or blades with motor cases and other metal objects.

b. To minimize generation of heat.

c. To facilitate removal of dust and chips, and to afford personnel protection. The motor or grain should be X-rayed prior to trim if there is a possibility that metal or other foreign objects may be in the propellant.

6. Propellant dust, chips and shavings shall be removed frequently from the work area during machining and contouring.

7. Rocket motors in final assembly process should be positioned to permit ready access to all sides of the motor. Aisles and exit doors shall be kept clear and unobstructed. All exit doors shall have quick-release hardware.

8. The number of items in the final assembly building shall be the minimum consistent with a safe and efficient operation.

9. Grounding of propellant loaded assemblies in storage is optional and shall be reviewed on a case-by-case basis.

10. If the process requires removing an igniter shorting clip, the igniter shall remain shorted until immediately before insertion. Igniter shall remain nonshorted for only the minimum time required for the operation.

11. Means shall be provided for controlled dissipation of static electrical charges during igniter insertion.

12. Operations that involve electrical continuity checking/testing of ignition systems installed in rocket motors shall be conducted according to thoroughly reviewed and approved procedures. These checks shall be conducted by remote control with the motor mounted in a test stand designed to withstand the thrust of the motor times a factor 2.5, minimum.

L. Disassembly.

1. Process equipment and tooling that requires disassembly as a process operation shall be designed as much as possible to avoid metal-to-metal movement and trapping of explosive material.

2. Sanitary, external clamp fittings should be used on pipe assemblies for propellant transfer.

3. Disassembly of equipment and tooling which is nonroutine, such as necessary for equipment repair or for securing the process, should not be started until evaluation of potential hazards from trapped material or process residuals.

Table 16-1. Control and Personnel Protection Requirements for Certain Propellant Processing Operations.

Operation	Remote Controls	Personnel Protected[1]
Blending and screening of ammonium perchlorate	Mandatory	Mandatory
Blending, screening of nitramines and perchlorates other than ammonium	Mandatory[2]	Mandatory[2]
Grinding, and mechanized drying of perchlorates and nitramines	Mandatory	Mandatory
Grinding, blending, screening,and mechanized drying of ammonium nitrates	Advisory	Advisory
Rotating blade propellant mixing	Mandatory	Mandatory[4]
Power-driven cutting, machining, sawing,planing, drilling, or other unconfined operations in which rocket motors or propellant of Hazard Division 1.1 and 1.3 are involved.[2]	Mandatory[3]	Mandatory[3]
Mandrel break away removal from cured propellant	Mandatory[3]	Mandatory[3]
Pressing, extruding, pelletizing or blending	Mandatory	Mandatory
Casting Propellants	Mandatory[3]	Mandatory[3]

1 Operating personnel shall be at K24 or in a control room that will limit overpressure to less than 2.3 psi.
2 Attended screening of wet material may be permitted if shown acceptable by hazard analysis.
3 Attended operation permitted if shown to be acceptable by hazard analysis.
4 When the maximum credible event (MCE) is shown by hazard analysis to be fire hazard only, attended operation is permitted.

CHAPTER 17

HAZARDOUS COMPONENT SAFETY DATA STATEMENTS (HCSDS)

A. General

This chapter describes information contained on hazardous component safety data statements (HCSDS), DD Form 2357.

B. Purpose

HCSDS's are provided on hazardous item contracts as required to alert contractor personnel to the primary hazards involved in the manufacture of ammunition and explosives (A&E), as well as other unique military-related hazardous material. The statements aid in the development of adequate safety programs. The contractor remains responsible for the safety of all employees and other personnel who may be exposed to any of the hazards presented by A&E associated with the contract.

C. Explanation of terms

1. Hazardous item contracts are production or procurement contracts requiring the research, development, manufacture, loading, testing or handling of A&E as well as other unique military-related hazardous material.

2. Unique military-related hazardous materials are chemicals

a. having fire or explosive characteristics, that is, flammables, oxidizers, organic peroxides or posing a serious threat to human health, that is, lethal and incapacitating agents, radioactive materials, corrosives or poisons;

b. that are procured or produced by or for the DoD in accordance with a Government specification that makes the material uniquely different and significantly more dangerous than standard commercial chemicals;

c. that are primarily associated with the loading, assembling and packing of, form a part of, or are incorporated into ammunition and explosives; or

d. that are used by the military in tactical, training demonstration or ceremonial operations to produce visible or audible effects by deflagration or detonation.

3. Standard commercial chemicals, as referred to in this subsection, are those used and shipped commercially which pose a real or potential threat to personnel and property due to their flammable, corrosive or toxic characteristics as defined in accordance with Title 29 Code of Federal Regulations (29 CFR), Part 1910 (reference (p)), 49 CFR Parts 171 through 199 (reference (g)) and Federal Standard No. 313 (reference (q)). The production or procurement of these materials does not constitute a hazardous item contract nor are these hazard characteristics covered with a HCSDS, unless they are intended for initiation, propulsion or detonation as an integral or component part of an A&E or weapon system.

D. Application

The HCSDS's, when applicable, are provided or specified as part of a hazardous item contract and apply to the contractors and subcontractors performing the work or services that involve handling, shipping or storage of A&E. The procurement package or solicitation contains an HCSDS for the procurable A&E item and for every hazardous material, component, and subassembly that forms a part thereof. The contractor is responsible to provide the applicable HCSDS's to subcontractors to whom A&E work will be contracted and provide this information to the administrative contracting officer (ACO). The data presented is a compilation of information that, the developing DoD component believes, best alerts to the hazards associated with contract requirements for handling, shipping and storage of A&E. Use of this data, in conjunction with this manual and other safety provisions of the contract, should assist the contractor and subcontractor in developing and implementing a safety program and operational procedures to assure prevention of A&E mishaps. It should not be assumed that, because of the absence of an HCSDS, a procurable item or a material component or assembly does not possess any unusual hazards.

E. HCSDS data entries

The HCSDS's contain safety data such as sensitivity, hazards, classification and packaging. This is intended to aid the contractor in providing safe environments for the handling, shipping and storage of A&E and establishing methods of protection affording acceptable levels of safety to personnel and property. It is of the utmost importance to understand the significance and limitation of each entry on the HCSDS Form. See Figure 17-1. This is generally stated in the disclaimer at the bottom of each HCSDS. Each entry on the HCSDS form shall be completed as described in subsections E. 1. through E.5, below.

1. **Identification.** This section deals with the proper identification of the items and the applicable and most current HCSDS. In addition, it identified the DoD Federal Acquisition Regulations Supplement (DFARS) that is applicable for the procurable item of A&E or radioactive device for weapon systems.

a. **Line 1 - Date prepared (YY/MM/DD).** Self-explanatory.

b. **Line 2 - Material/Component/Assembly.** This is the title line that contains the nomenclature of the item whose hazards are characterized by the particular HCSDS. It identifies the item with all its parts and ingredients as described in a referenced document, that is, a drawing or specification. It does not refer to a commodity or material of A&E that is in the process of being assembled, loaded, blended, and so forth, but rather as a completed item coming off a manufacturing line.

c. **Line 3 - Number.** Each HCSDS has a distinct number. The developing services are provided with a block of numbers to assign to the HCSDS; for the Army, 0 through 29,999; for the Air Force 30,000 through 39,999; and for the Navy, 40,000 through 59,999.

d. **Line 4 - Revision.** The HCSDSs are dated above the revision block and given a revision letter to identify the latest statements. The date reflects the preparation of the HCSDS. The original submission does not have an entry in the revision line. Subsequent updates are given a progression of alphabetic character starting with capital A.

e. **Line 5 - Applicable DoD FAR Safety Supplement.** The applicable Defense Federal Acquisition Regulation Supplement (DFARS) to the solicitations and resulting contracts are specified, that is DFARS 252.223-7002 (reference (r)) and DFARS 252.223-7006 (reference (s)). The DFARS indicates all the safety standards involved by the clause within the contract are used in conjunction with the HCSDS to develop safe programs and operation.

2. **Sensitivity.** The sensitivity of energetic materials to various stimuli are presented. The results of friction, impact and electrostatic discharge tests are specified along with comparable values of standard military explosives. In addition, the apparatus upon which the results are obtained is indicated. The sensitivity results and values obtained on the same apparatus for the familiar explosives, rank the energetic materials according to their sensitivity to the test stimuli. There are many factors in the performance of the tests, the operator, the apparatus, the evaluation criteria, the sample preparation, environment, and so forth, that affect the test results. The desired objective of presenting the sensitivity results and comparison values obtained on the same apparatus is to show a relative ranking of sensitivity of the test material with standard military explosives to a specific stimuli. The results and the ranking can aid in analyzing the hazards and establishing the measures of protection required to achieve acceptable levels of risk. The tests are not applicable to items of ammunition or to certain materials, for example, grains, pellets, candles, because of size, shape or configuration. A “NA”, indicating not applicable, is recorded if the sensitivity test cannot be run. An “Unknown” is specified if a test is applicable, but has not been conducted and/or the test data is available. In both cases, the sensitivity of the item/material to the stimuli is not ruled out; it has not been determined.

a. **Line 6 - Friction Test.** Friction sensitivity is determined by introducing a sample between two rubbing surfaces. The sensitivity is generally presented as a reaction of the explosive between specified surfaces or the force and speed required to obtain a reaction. In other instances, a standard procedure is used and the results are given as the number of samples activated in a specified number of trials.

b. **Line 7 - Impact Test.** The impact sensitivity is determined by subjecting a sample to the action of a falling weight. Apparatus generally differ in drop weights, confinement, and anvil surfaces. The tests are conducted by varying the drop height and determining minimum height required for activation of the sample in a specific number of trials, or maintaining a specified drop height and determining the number of samples activated in a specific number of trials. The results are generally given as the minimum height of the drop weight or the energy required for actuation or the number of reactions obtained in a specific number of trials.

c. **Line 8 - Electrostatic Discharge Test.** The sensitivity to initiation by electrostatic discharge is a measure of the maximum spark energy in joules for zero probability of initiation. It is determined by discharging a charged condenser through a needle point electrode through a sample and observing the reaction.

3. **Hazards.** The major hazards associated with the item are identified in this section. Adjective ratings are indicated for the fire, explosion and toxicity hazards. This section also includes safety information associated with these hazards. In addition, the hazard class is designated for an unpacked item. The identification of the inherent hazards and the severity that can be expected if an item is exposed to a hostile environment, provide planning guidance for safe procedures and necessary protection.

a. **Line 9 - Fire.** An adjective rating is specified to indicate the hazard category for fire. The adjective is based on the case of ignition, the difficulty of extinguishing the fire and the rapidity of propagation of the flame front. The following subparagraphs summarize the meanings of the adjective ratings.

(1) **Severe.** Very flammable and easily ignited. Extremely difficult to extinguish, instantaneous propagation of flame from ignition source. Examples are flammable gases, highly volatile flammable liquids, ethyl ether.

(2) **High.** Ignitable under normal temperature conditions or rapid burning rate due to own oxygen supply or spontaneously ignites. Requires immediate deluge to extinguish or prevent propagation of flame. Examples are propellants, photoflash powders, white phosphorous, acetone, and gasoline.

(3) **Moderate.** Requires heating before ignition can be obtained. Burning rate or propagation of flame is observable and controllable with standard fire fighting procedures. Examples are combustible liquids, solid fuels, kerosene.

(4) **Low.** Difficult to ignite. Requires high temperatures and long exposure. May not sustain burning without continued heating. Material that readily reacts to produce highly flammable mixtures. Slow propagation of flame. Small flame-producing items. Examples are oxidizers, squibs, rubber, sulfur and linseed oil.

(5) **None**. Nonflammable. Difficult to react to form flammable mixtures.

b. **Line 10 - Auto Ignition Temp.** Auto ignition temperature (AIT) is the lowest temperature at which material begins to self-heat at a high enough rate to result in ignition or cause self-sustained combustion. AIT values vary substantially with apparatus, test techniques and sample preparation, and should be considered approximations, not fundamental. However, they can help to define limits for exposure of the item to

(1) Excessive temperatures in storage and transit;

(2) Excessive temperatures in unpacked, in-process operations; and

(3) Contact with hot surfaces such as gun tubes.

c. **Line 11 - Flash Point.** The lowest temperature is specified at which a material will give off vapors sufficient to form a flammable mixture with air that will flash across the surface when an ignition source is applied. The flash point values represent closed cup tests except where the open cup flash point is designated by “OC” following the figure.

d. **Line 12 - Decomposition Products.** The hazardous products expected from a thermal or explosive decomposition of the item or material are specified. In addition, the type of threat it poses to personnel or property is indicated; that is, flammable gas, toxic fumes, and so forth. There may be additional hazardous decomposition products, or products specified may be altered by the environment, or other materials may be involved in the event. The information provided under this heading is not intended to be all inclusive, but to assist in identifying the hazards known to be produced and present a real threat.

e. **Line 13 - Flammable and/or Explosive Limits.** This is the minimum and maximum concentration of gases or vapors in air which bracket the flammable range in which propagation of

a flame will occur. These boundary line mixtures of vapor or gas with air, which, if ignited will just propagate flame, are known as the lower and upper flammable or explosive limits and are expressed in terms of percentage by volume of vapor or gas in the air. Increasing pressures or temperatures increase the range. Values are presented for ambient environmental conditions unless otherwise noted.

f. **Line 14 - Explosion.** The explosion hazard is categorized by an adjective rating, The basis for the rating is the susceptibility to detonation and the severity that can be expected from the occurrence. The adjective ratings for explosion are as follows:

(1) **Severe.** Capable in themselves of detonation or deflagration in mass. Very sensitive to heat, shock and electrostatic discharge and require precautionary measures to avoid accidental exposure to these stimuli during normal handling operations. Examples are primary explosives and primer mixtures.

(2) **High.** Capable in themselves of detonation or deflagration. Relatively insensitive to heat, shock or electrostatic discharge. Generally require strong initiating source or heating under confinement to detonate in mass. Explosion presents extreme hazard from blast and/or fragments. Examples are secondary explosives, bombs, mines and grenades.

(3) **Moderate.** Not capable in themselves of detonation. Can readily react to form explosive mixtures. Explosion can occur from rapid deflagration of mists or dusts. Examples are powerful oxidizing material, magnesium powder, flammable gasses, highly volatile liquids.

(4) **Low.** Not capable of detonation or deflagration. Becomes unstable at elevated pressures and temperatures. Package, amount or form prevent or contains release of any substantial amount of energy. Can react to form hazardous mixtures. Examples are oxidizers, most metallic powders, combustible materials, explosive bellows and piston actuators.

(5) **None.** Not capable of detonation, deflagration or reaction to form explosive mixes. Stable even at elevated temperatures.

g. **Line 15 - Explosive Temperature.** The value presented is the minimum temperature necessary to produce an explosion, ignition or decomposition of an energetic material when exposed for a 5-second duration. The reaction is noted next to the temperature. The explosion temperature is obtained by immersing a small sample in a hot bath or dropping it onto a hot bar. The values provide reference temperatures that can be used in developing methods to prevent exposures that could result in accidental initiations.

h. **Line 16 - Dusts.** The minimum concentration of a cloud or layer of inflammable dust that will sustain the propagation of flame (lower limit of explosibility) is expressed in terms of the ounces of material per cubic foot of air. This characteristic can provide an awareness of a need for procedures and protection against dust fires and explosions in the handling of inflammable materials.

i. **Line 17 - Health Hazard Information.** The toxic hazard of a material is recorded as an adjective rating to express the toxicity under normal conditions of handling and exposure, including mode of entry, as follows:

(1) **Severe.** Can cause death or irreversible injury with very short exposure, even if given prompt medical attention. Requires special protective clothing and special handling to protect against hazard.

(2) **High.** Can cause death or serious injury with exposure of relatively long periods of time or intake of small amounts. Requires protective clothing and procedures to avoid contact. Prompt medical attention is required. Medical surveillance may be a requirement.

(3) **Moderate.** Can cause injury, incapacitation or possible death with sustained exposure or intake of substantial amounts. Concentrations and durations of exposure have to be controlled. Protective clothing and procedures are recommended, but may not be required. Prompt removal or neutralization of contacted area may be required to prevent injury.

(4) **Low.** Can cause only minor injury, irritation or discomfort. Removal from exposure generally alleviates condition. Cleanliness, ventilation and protective clothing may be employed to limit or avoid exposure.

(5) **None.** Presents no health hazard under ordinary conditions.

j. **Line 18 - Unpacked Hazard Class.** The unpacked hazard division on the HCSDS defines the expected effect of an accidental initiation of the unpacked item of A&E. HCSDS does not deal with manufacturing processes or operations. Until the item, as specified on the title line of an HCSDS, has all its parts loaded and assembled, as defined by the referenced drawing or specification, it is not covered by an HCSDS. When covered by an HCSDS, the data presented is to provide an awareness of the inherent dangers and order the severity that can be expected when an item is exposed to a hostile environment. The unpacked hazard division provides assistance to responsible personnel to develop safe procedures and proper measures of protection for handling the unpacked items of A&E. The unpacked hazard division is to be identified in accordance with Chapter 6, sections B through H. The unpacked hazard group for liquid propellants is to be identified in accordance with Chapter 7, section E.

k. **Line 19 - Special Requirements.** The special requirements section contains any information which further identifies the item and the hazards that are not adequately presented in the other areas of the HCSDS. This section includes such information as follows:

(1) Reference to documents that control and specify the item; for example, drawings and specifications not already specified in the title of the HCSDS.

(2) Schematic and list of parts contained in the specified item with HCSDS and drawing and specification numbers.

(3) Any special precautions peculiar to the specified item not appearing anywhere else in the technical data package (TDP) or production/ procurement package or in the applicable safety manual.

(4) Any additional data or information necessary to alert or clarify a specific hazard.

(5) Any synonyms that can be used to describe the specified item; for example, chemical name or formula or commercial brand name.

(6) Approved packaging drawing numbers. If there are no approved packaging drawings, this fact is indicated; and where the packaging is covered, is so stated; that is, the

specification or provisional packaging number. If packaging is not officially covered, the applicable sections of 49 CFR (reference (g)) for packaging, marking and labeling are specified.

(7) Identifying numbers that are related to the item, such as the United Nations (UN) Number, National Stock Number (NSN), Department of Defense Identification Code (DODIC), experimental (EX-) number, and CA- number.

(8) Status of hazard classifications for shipping and storage as to whether they are interim or final.

4. **Shipping/Storage Classification of Item when Packed in Accordance with Approved Packing Drawings.** The hazardous characteristics of items of A&E are determined and those posing the same threat to health, safety and property are assigned to specified categories for proper transportation and storage. The hazard classification which specifies these categories for the shipping and storage are provided in this section. The DoD hazard divisions and compatibility groups (CGs) are assigned in accordance with Chapter 6, Sections B through H and Chapter 5, section B respectively. Any discrepancies in classifications with other documentation in the contract should be resolved through the procuring contracting officer (PCO) with the developing agency.

5. The Department of Transportation (DoT) hazard classification and container markings are listed in accordance with 49 CFR, Parts 100 through 199 (reference (g)). The DoT classifications are applicable when specified and provided as part of a DoD contract. Otherwise, DoT classifications are provided as guidance and are not to be misconstrued as authorization to ship. Proper approval must be obtained from DoD or DoT in accordance with (reference (g)) prior to offering an item of A&E into commercial transportation.

a. **Line 20 - DoD Hazard Class/Div.** A DoD Hazard Division for the storage of A&E, as described in Chapter 6, sections B through H.

b. **Line 21 - DoD Compatibility Group.** An appropriate CG for storage is designated as one of the 13 categories, A through H, J, L, N and S. These are described in Chapter 5, Section B.

c. **Line 22 - DoT Hazard Class.** The designations of the hazard class corresponding to the hazards of an item are specified. Reference (g) defines an explosive as any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, that is, with substantially instantaneous release of gas and heat, unless such a compound, mixture or devise is otherwise specifically classified in Parts 170 through 199 of reference (g). Classes are defined as follows:

(1) **Class 1.1 Explosive.** Explosives that have a mass explosive hazard. See section 173.50 (b)(1) of reference (g).

(2) **Class 1.2 Explosive.** Explosives that have a projection hazard but not a mass explosion hazard. See section 173.50 (b)(2) of reference (g).

(3) **Class 1.3 Explosive.** Explosives that have a fire hazard. See section 173.50 (b)(3) of reference (g).

(4) **Class 1.4 Explosive.** Explosive devices that present a minor explosive hazard. See section 173.50 (b)(4) of reference (g).

(5) **Class 1.5 Explosive.** Very insensitive explosives. See section 173.50 (b)(5) of reference (g).

(6) **Class 1.6 Explosive.** Extremely insensitive articles which do not have a mass explosive hazard. See section 173.50 (b)(6) of reference (g).

d. **Line 23 - DoT Container Marking.** The container marking to be applied to the outside shipping container is specified in reference (g).

e. **Line 24 - Prepared By.** The name, signature and organization of the person or persons preparing the documents are listed.

f. **Line 25 - Concurred in By.** The name, signature and organization of the person or persons concurring in the presentation of the data on the HCSDS are listed.

g. **Line 26 - Safety Office.** The name, signature and organization of the person or his/her delegated representative that approves that HCSDS is listed. The HCSDS is generally prepared and approved by the developing agency.

HAZARDOUS COMPONENT SAFETY DATA STATEMENT (HCSDS)	1. DATE PREPARED (YYMMDD)	REPORT CONTROL SYMBOL MIL (AR) 1687
2. MATERIAL/COMPONENT/ASSEMBLY	3. NUMBER	4. REVISION

5. APPLICABLE FEDERAL ACQUISITION REGULATION (FAR) SAFETY CLAUSE

PART I - SENSITIVITY (Apparatus and Comparison Values)

6. FRICTION TEST	7. IMPACT TEST	8. ELECTROSTATIC DISCHARGE TEST

PART II - HAZARDS

9. FIRE	10. AUTO IGNITION TEMP	11. FLASH POINT	12. DECOMPOSITION PRODUCTS	
13. FLAMMABLE AND/OR EXPLOSIVE LIMITS		14. EXPLOSION	15. EXPLOSIVE TEMP (5 Sec.)	16. DUSTS
a. LOWER PERCENT	b. UPPER PERCENT			
17. HEALTH HAZARD INFORMATION (Toxicity)			18. UNPACKED (In-Process) HAZARD CLASS (Specify Quantities Involved)	

19. SPECIAL REQUIREMENTS (If additional space is needed, use plain bond paper)

PART III - SHIPPING/STORAGE CLASSIFICATION OF ITEM WHEN PACKED IN ACCORDANCE WITH APPROVED PACKING DRAWINGS

20. DOD HAZARD CLASS/DIV	21. DOD STORAGE COMPATIBILITY GROUP	22. DOT HAZARD CLASSIFICATION	23. DOT CONTAINER MARKING

24. PREPARED BY (Initiator)		
a. TYPED OR PRINTED NAME	b. SIGNATURE	c. ORGANIZATION
25. CONCURRED IN BY		
a. TYPED OR PRINTED NAME	b. SIGNATURE	c. ORGANIZATION
26. SAFETY CHIEF OR AUTHORIZED REPRESENTATIVE		
a. TYPED OR PRINTED NAME	b. SIGNATURE	c. ORGANIZATION

The information relating to safety (herein referred to as "safety data") contained in this document is limited to those instances when the document is provided as a part of a procurement/production package which involves the development, testing, storage, manufacture, modification, renovation, demilitarization, packaging, transportation, handling, disposal, inspection, repair or any other use of the item, (material/component/assembly) which is specified in the contract. The safety data contained herein are examples which shall be used by the contractor to alert contractor personnel as well as other personnel of hazards associated with the procurement/production of the item. No representation is made that compliance with the information provided will prevent any accident to persons or property or that additional warnings may not be appropriate. Neither the foregoing nor any act or failure to act by the Government in regard to alerting personnel to the hazards of the item shall affect or relieve the contractor of responsibility for the safety of contractor personnel or property and for the safety of the general public in connection with the performance of the contract, or impose or add to any liability of the Government for such safety.

DD FORM 2357, APR 85

Figure 17-1. Hazardous Component Safety Data Statement (HCSDS), DD Form 2357.

APPENDIX A

BIBLIOGRAPHY

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