Department of Defense

# MANUAL

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USD(AT&L)

SUBJECT: DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements

References: See Enclosure 1

## V1.1. PURPOSE

V1.1.1. Manual. This Manual is composed of several volumes, each containing its own purpose, and administratively reissues DoD 6055.09-STD (Reference (a)). The purpose of the overall Manual, in accordance with the authority in DoD Directives 5134.01 and 6055.9E (References (b) and (c)), is to establish explosives safety standards (hereafter referred to as "standards") for the Department of Defense.

V1.1.1.1. These standards are designed to manage risks associated with DoD-titled ammunition and explosives (AE) by providing protection criteria to minimize serious injury, loss of life, and damage to property.

V1.1.1.2. Due to the size and complexity of this Manual, alternate paragraph numbering has been approved for use throughout. The initial numeric set (V#) refers to the volume number within the Manual; the second set (E#) refers to the enclosure number; and subsequent numbers refer to the section, paragraph, and subparagraph numbers. If there is no E#, the reference is to a section above the signature of the volume.

V1.1.2. Volume. This Volume provides general explosives safety information and requirements.

## V1.2. APPLICABILITY. This Volume:

V1.2.1. Applies to:

V1.2.1.1. OSD, the Military Departments, the Office of the Chairman of the Joint Chiefs of Staff and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the

Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the Department of Defense (hereafter referred to collectively as the "DoD Components").

V1.2.1.2. DoD-titled AE wherever it is located.

V1.2.1.3. DoD personnel and property when potentially endangered by known host-nation or off-installation AE hazards.

V1.2.1.4. DoD facilities siting and construction, except as indicated in paragraph V1.2.2.

V1.2.1.5. The evaluation of non-DoD explosives siting submissions on DoD installations (see section V4.E5.21.).

V1.2.2. Provided the documentation requirements of paragraph V1.E2.3.5. are met, does not apply to:

V1.2.2.1. Existing facilities, or those approved for construction under then-current editions of these standards. This exception applies for the balance of the useful lives of such facilities provided:

V1.2.2.1.1. The facility continues to be used for its intended purpose.

V1.2.2.1.2. The explosives safety hazards are not increased.

V1.2.2.1.3. Redesign or modification is not practicable.

V1.2.2.1.4. The quantity of AE cannot be reduced for reasons of operational necessity.

V1.2.2.2. Those planned facilities that do not meet these standards, but have been certified by the Heads of the DoD Components (see section V1.E3.4.) as essential for operational or other compelling reasons.

V1.2.2.3. Other situations that, upon analysis by the Heads of the DoD Components and the Department of Defense Explosives Safety Board (DDESB), are determined to provide the required degree of safety through use of protective construction or other specialized safety features.

## V1.3. DEFINITIONS

V1.3.1. Abbreviations and Acronyms. See Glossary.

V1.3.2. Terms. See Volume 8 of this Manual.

V1.4. POLICY. As established in Reference (c) and consistent with peacetime, contingency, or wartime operational requirements and corresponding DoD military munitions requirements from the broadest and most fundamental explosives safety management perspective, it is DoD policy to:

V1.4.1. Provide the maximum possible protection to people and property from the potential damaging effects of DoD military munitions (explosive and chemical). Applying the standards herein provides only the minimum protection criteria for personnel and property, and greater protection should always be provided when practicable.

V1.4.2. Minimize exposures consistent with safe and efficient operations (i.e., expose the minimum number of people for the minimum time to the minimum amount of explosives or chemical agents (CAs)).

V1.5. RESPONSIBILITIES. See Enclosure 2.

V1.6. PROCEDURES. See Enclosures 3 through 11. Criteria provided in this Manual are given in English units (e.g., foot or feet (ft), pounds (lbs), pounds per square inch (psi)), with metric equivalents shown in brackets (e.g., meters (m), kilograms (kg), kilopascals (kPa)).

V1.7. RELEASABILITY. UNLIMITED. This Volume is approved for public release and is available on the Internet from the DoD Issuances Website at http://www.dtic.mil/whs/directives.

V1.8. EFFECTIVE DATE. This Volume is effective upon its publication to the DoD Issuances Website.

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2. Responsibilities
3. Deviations
4. Accident Notification and Reporting Requirements
5. Required Explosives Safety Submissions
6. Hazard Classification, Storage and Compatibility Principles, and Mixing Rules
7. QD, Determining NEWQD, and QD Principles, Measurements, and Calculations
8. Reaction Effects
9. Personnel Protection
10. Hazard Identification for Firefighting and Emergency Planning
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Glossary

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ENCLOSURE 1

REFERENCES

(a) DoD 6055.09-STD, "DoD Ammunition and Explosives Safety Standards," February 29, 2008 (hereby cancelled)
(b) DoD Directive 5134.01, Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)),"  December 9, 2005
(c) DoD Directive 6055.9E, "Explosives Safety Management and the DoD Explosives Safety Board," August 19, 2005
(d) DoD 8910.1-M, "Department of Defense Procedures for Management of Information Requirements," June 30, 1998
(e) DoD Instruction 6055.07, "Accident Investigation, Reporting, and Record Keeping," October 3, 2000
(f) DoD 5400.11-R, "Department of Defense Privacy Program," May 14, 2007
(g) Unified Facilities Criteria UFC 3-340-02, "Structures to Resist the Effects of Accidental Explosions," December 5, 2008[1]
(h) Army Technical Bulletin 700-2, Naval Sea Systems Command Instruction 8020.8B, Technical Order 11A-1-47, Defense Logistics Agency Regulation 8220.1, "Department of Defense Ammunition and Explosives Hazard Classification Procedures," January 5, 1998
(i) Parts 171-177 of title 49, Code of Federal Regulations
(j) ST/SG/AC.10/1/Revision 16, "Recommendations on the Transport of Dangerous Goods, Model Regulations, Volumes I and II," Sixteenth Revised Edition, 2008[2]
(k) Department of Defense Explosives Safety Board, Technical Paper 17, "DDESB Blast Effects Computer Version 6 User's Manual and Documentation," March 10, 2005[3]
(l) Military Standard MIL-STD-398, "Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance," November 5, 1976[4]
(m) Military Standard MIL-STD-1474D, "Noise Limits," February 12, 1997[5]
(n) Federal Standard 595C, "Colors Used in Government Procurement," December 15, 1989[6]
(o) Sections 11001-11022 of title 42, United States Code

[1] Available at http://www.wbdg.org/ccb/DOD/UFC/ufc_3_340_02.pdf.
[2] Available at http://www.unece.org/trans/danger/publi/unrec/mr_pubdet.html.
[3] Available from DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227; http://www.ddesb.pentagon.mil/techpapers.html.
[4] Available at http://www.everyspec.com/MIL-STD/MIL-STD+%280300+-+0499%29/MIL-STD-398_3925/.
[5] Available from Defense Automated Printing, 700 Robbins Avenue, Philadelphia, PA 19111; Phone: 215-697-2179; http://www.acq.osd.mil/atptf/policy/documents/MILSTD1474D.pdf.
[6] Available at https://assist.daps.dla.mil.

# ENCLOSURE 2

# RESPONSIBILITIES

V1.E2.1. UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY, AND LOGISTICS (USD(AT&L)). The USD(AT&L) shall provide overall policy guidance for the DoD Explosives Safety Management Program.

V1.E2.2. CHAIRMAN, DDESB. The Chairman, DDESB, shall report to the Deputy Under Secretary of Defense for Installations and Environment (DUSD(I&E)) and, on behalf of the USD(AT&L) and the DUSD(I&E), shall collaborate with the Military Service-appointed voting DDESB members to maintain explosives safety standards.

V1.E2.3. HEADS OF THE DoD COMPONENTS. The Heads of the DoD Components shall:

V1.E2.3.1. Implement these DoD explosives safety standards.

V1.E2.3.2. Comply with applicable Federal and State laws and regulations. Where this Volume conflicts with such laws and regulations, ensure the safety of DoD personnel and the public while complying and notify the Chairman, DDESB, through the Component's board member, of the conflict. These standards are not intended to be so rigid as to prevent the DoD Components from accomplishing their assigned missions.

V1.E2.3.3. Issue DoD Component guidance that implements these standards and provides DoD Component unique requirements.

V1.E2.3.4. Send a copy of any implementing and supplementary guidance to these standards to the Chairman, DDESB.

V1.E2.3.5. Document the exceptions described in paragraph V1.2.2. in permanent records. These records must include:

V1.E2.3.5.1. The effective date the applicable DoD explosives safety standards were first published.

V1.E2.3.5.2. The date the deviant facility was either approved, from an explosives safety viewpoint, for use or was first used in a manner deviating from the standard.

# ENCLOSURE 3

# DEVIATIONS

V1.E3.1. GENERAL. When strategic or compelling operational requirements necessitate deviation from these standards, the DoD Components shall:

V1.E3.1.1. Acknowledge and accept the added risk to personnel or property.

V1.E3.1.2. Document both the risk and methods used to reduce it to an acceptable level in relation to the operational requirements. A quantitative risk assessment (QRA) (see V6.E5. of this Manual) may be used.

V1.E3.2. WAIVERS. A waiver is a written authority that permits temporary deviation from these standards for strategic or compelling operational requirements. Generally, it is granted for a period not to exceed 5 years pending termination of the waiver or correction of the waived conditions. Exceptional situations may require a waiver to be reissued to allow either completion of the operation requiring the waiver or time for completion of the corrective action. In such cases, the next higher approval authority shall reissue the waiver; the exception is when the Head of the DoD Component or the responsible Combatant Commander has issued the waiver. Waivers shall be reviewed for applicability and currency at intervals not to exceed 2 years. Waivers may be granted by the official with both:

V1.E3.2.1. The assigned responsibilities consistent with the level of risk.

V1.E3.2.2. The authority to control the resources required to accomplish the corrective action.

V1.E3.3. EXEMPTIONS. An exemption is a written authority that permits long-term noncompliance with these standards for strategic or compelling operational requirements. Exemptions shall be reviewed for applicability and currency at intervals not to exceed 5 years. Exemptions may be granted by law, Congressional action, and the official assigned responsibilities consistent with the level of risk.

V1.E3.4. SECRETARIAL EXEMPTIONS OR CERTIFICATIONS. A Secretarial Exemption or Certification is a written authority granted by a Secretary of a Military Department to deviate from the requirements of these standards to allow the construction of new potential explosion sites (PESs) or exposed sites (ESs). To validate the strategic or compelling operational requirements and ensure the identification of risks and exposures, these exemptions or certifications shall be reviewed at intervals not to exceed 5 years.

V1.E3.5. REPORT CONTROL SYMBOL (RCS) DD-AT&L(AR)1643. See DoD 8910.1-M (Reference (d)). When the DDESB requests information on exemptions and waivers, the DoD Components shall provide the following, as applicable:

V1.E3.5.1. Identification number (DoD Component-derived).

V1.E3.5.2. Classification (waiver or exemption), approval authority's title, and date of approval, expiration, or cancellation, as applicable.

V1.E3.5.3. Location.

V1.E3.5.4. Condition waived or exempted.

V1.E3.5.5. Net explosive weight (NEW) or net explosive weight for quantity-distance (NEWQD) by hazard division (HD) at a PES.

V1.E3.5.6. Distance from the PES to any ES and a brief description of the ES to include: type, estimated value of any property involved, and location of the property (e.g., on or off installation).

V1.E3.5.7. Estimated number of DoD and non-DoD personnel located at the ES.

V1.E3.5.8. Calculated hazard distances (see the definition of "public access exclusion distance" in Volume 8 of this Manual), as applicable.

V1.E3.5.9. Planned corrective action, to include the expected completion date.

V1.E3.5.9.1. Estimated cost to correct.

V1.E3.5.9.2. Military construction project number, if assigned.

# ENCLOSURE 4

# ACCIDENT NOTIFICATION AND REPORTING REQUIREMENTS

## V1.E4.1. SCOPE

V1.E4.1.1. Enclosure 5 to DoD Instruction 6055.07 (Reference (e)) identifies the accidents that shall be reported to the DDESB. Accident notifications and reports shall be prepared in accordance with (IAW) implementing regulations to Reference (e). This reporting requirement has been assigned RCS DD-AT&L(AR)1020 IAW Reference (d).

V1.E4.1.2. This enclosure sets forth the minimum data that shall be included in accident notifications and reports submitted to the DDESB. Submit any missing data in subsequent reports.

V1.E4.1.3. Accidents reported to the DDESB need not be reported separately to the Assistant Deputy Under Secretary of Defense for Environment, Safety, and Occupational Health under the special reporting requirements of Enclosure 3 to Reference (e).

V1.E4.1.4. Regardless of format, accident notifications and reports that are prepared in compliance with DoD Component criteria may be used to satisfy these requirements when they contain similar data.

V1.E4.1.5. All accident notifications, reports, and data submitted pursuant to this enclosure shall be reviewed by the cognizant claims officer prior to submittal to ensure the notification or report does not contain unsupported admissions or speculation that could cause harm to the Government.

V1.E4.1.6. These notice and reporting requirements are in addition to, and not in place of, those required by applicable Federal, State, interstate, and local laws and regulations.

V1.E4.1.7. All information accumulated pursuant to this enclosure will be collected, maintained, and utilized in compliance with DoD 5400.11-R (Reference (f)).

## V1.E4.2. SECURITY CLASSIFICATION

V1.E4.2. SECURITY CLASSIFICATION. Accident notifications and reports should be unclassified when possible to ease dissemination of safety information to the DoD Components, industry, and friendly governments.

## V1.E4.3. ACCIDENT NOTIFICATION REQUIREMENTS

V1.E4.3. ACCIDENT NOTIFICATION REQUIREMENTS. The DoD Components shall provide the following data as soon as practical:

V1.E4.3.1. Name and location of the reporting activity.

V1.E4.3.2. Location of accident (activity, city, installation, building number or designation, road names, or similar information).

V1.E4.3.3. Item nomenclature or description (e.g., mark, model, Federal supply class, national identification number, DoD identification code, Navy ammunition logistic code, or ammonium nitrate/fuel oil).

V1.E4.3.4. Quantity involved (number of items and NEWQD).

V1.E4.3.5. Day, date, and local time of initial significant event and when discovered.

V1.E4.3.6. Narrative of the event (include type of operation involved).

V1.E4.3.7. Number of fatalities (military, DoD civilian, or other civilian).

V1.E4.3.8. Number of persons injured (military, DoD civilian, or other civilian).

V1.E4.3.9. Description of material damage (Government or nongovernment).

V1.E4.3.10. Immediate action taken or planned (corrective, investigative, or explosive ordnance disposal assistance).

V1.E4.3.11. Details of any CA hazard or contamination, if applicable.

V1.E4.3.12. Description of news media attention.

V1.E4.4. ACCIDENT REPORTS. In addition to the accident notification data, when accident investigations are concluded, the following accident reporting data, as applicable, shall be provided to the DDESB. CA accidents shall also require the inclusion of the data specified in section V1.E4.5.

V1.E4.4.1. Event Circumstances. Type of operation or transportation mode engaged in at time of the accident. Include reference to applicable standard operating procedure (SOP) or regulatory document.

V1.E4.4.1.1. Description of accident.

V1.E4.4.1.2. Quantity, type, lot number, configuration, and packaging of AE or CAs involved in the accident.

V1.E4.4.1.3. Type of reaction or reactions.

V1.E4.4.1.3.1. Single reaction, such as detonation, deflagration, fire, release, or activation.

V1.E4.4.1.3.2. Multiple reaction, such as detonation and fire.

V1.E4.4.1.3.3. Communication of reactions, such as fire-caused fire, fire-caused detonation, and detonation-caused detonation, and the time between events.

V1.E4.4.1.4. Possible or suspected causes.

V1.E4.4.2. Event Effects. A copy of aerial and ground photographs taken of the accident site shall be submitted to the DDESB as soon as possible after the occurrence. When applicable, include photographs (color, whenever possible), maps, charts, and overlays, showing or listing the following data:

V1.E4.4.2.1. Number of persons killed or injured (military, DoD civilian, or other civilian). Indicate cause of fatalities and injuries, and location of affected persons with respect to the accident origin.

V1.E4.4.2.2. Property damage at the accident origin (Government or nongovernment).

V1.E4.4.2.3. Area containing property with complete destruction.

V1.E4.4.2.4. Area containing property damage beyond economical repair.

V1.E4.4.2.5. Area containing repairable property damage.

V1.E4.4.2.6. Radii of glass breakage. When possible, include type and dimensions of glass broken at farthest point.

V1.E4.4.2.7. Locations and dimensions of craters.

V1.E4.4.2.8. When direct propagation has occurred, identify distances from the accident origin and whether propagation resulted from blast, fragments, or firebrands.

V1.E4.4.2.9. Approximate number, size, and location of hazardous fragments and debris.

V1.E4.4.2.10. Effect on production, operation, mission, or other activity.

V1.E4.4.3. Factors Contributing to or Limiting Event Effects. When applicable, describe the influence of the following factors on the accident:

V1.E4.4.3.1. Environmental and meteorological conditions (e.g., lightning, cloud cover, wind direction and velocity, temperature, relative humidity, electromagnetic radiation, and electrostatic buildup or discharge).

V1.E4.4.3.2. Topography (e.g., hills, forests, and lakes).

V1.E4.4.3.3. Structural features at the accident origin (e.g., exterior and interior walls and bulkheads, roofs and overheads, doors and hatches, cells or magazines, earth cover, and barricades).

V1.E4.4.3.4. Safety features, other than structural, at the accident origin (e.g., remote controls, sprinkler or deluge systems, detectors, alarms, blast traps, and suppressive shielding).

V1.E4.4.4. Structures. When applicable, provide position, orientation, and type of construction of all structures, damaged or not, located within the maximum radius of damage or the applicable quantity-distance (QD), whichever is greater.

V1.E4.4.5. Vessels, Vehicles, and Mobile Equipment. When applicable, provide their location within the maximum radius of damage, or the applicable QD requirement, whichever is greater.

V1.E4.4.6. Personnel. When applicable, provide their location within the maximum radius of damage, or the applicable QD requirements, whichever is greater.

V1.E4.4.7. AE and CAs. When applicable, provide the location, type, configuration, and amounts of AE and CAs in adjacent locations, and describe the protection provided by structures at adjacent locations. This information is required out to the maximum radius of damage to any AE or CAs, or the applicable intermagazine distance (IMD) or intraline distance (ILD) requirements, whichever is greater.

V1.E4.4.8. Prevention of Future Accidents. Provide to the DDESB any supporting analyses, conclusions as to the cause(s) of the accident, and recommendations to prevent future accidents of a similar nature.

V1.E4.5. CA ACCIDENTS. In addition to the data required by section V1.E4.4. for AE accidents, each CA accident report shall contain the following information:

V1.E4.5.1. Personnel

V1.E4.5.1.1. CA safety training received.

V1.E4.5.1.2. The availability, type, and use of protective equipment.

V1.E4.5.1.3. A description of the emergency measures taken or performed at the scene of the accident.

V1.E4.5.1.4. A summary of applicable medical data.

V1.E4.5.1.5. A diagram showing locations where injuries occurred and indicating the distance and direction from the agent source.

V1.E4.5.2. Accident Area. In addition to the environmental and meteorological data required at the accident site by subparagraph V1.E4.4.3.1., provide the following:

V1.E4.5.2.1. Facility filter types and the facility ventilation and air turnover rates.

V1.E4.5.2.2. Rate and manner of agent release and any other data used to determine the downwind hazard.

V1.E4.5.2.3. Status and disposition of any CAs remaining at the accident site.

V1.E4.5.2.4. Details of any remaining CA hazard and contamination, if applicable.

# ENCLOSURE 5

# REQUIRED EXPLOSIVES SAFETY SUBMISSIONS

## V1.E5.1. SITE AND GENERAL CONSTRUCTION PLANS REVIEW

V1.E5.1.1. Submission of Plans. The following site and general construction plans shall be submitted to the DDESB for review and approval:

V1.E5.1.1.1. New construction of:

V1.E5.1.1.1.1. AE facilities. See Volume 8 for the definition of "AE facility."

V1.E5.1.1.1.2. Non-AE related facilities within QD arcs.

V1.E5.1.1.2. Facility modifications, change of mission, or change of operations that increase explosive hazards (e.g., personnel exposures, NEW, change in HD, nature of operation).

V1.E5.1.1.3. Change of use of non-AE related facilities that require application of more stringent explosives safety criteria (e.g., an airfield restricted to DoD use only, changed to joint DoD and non-DoD use).

V1.E5.1.2. Vulnerable Facility Construction. Although site plans for construction of vulnerable facilities (e.g., schools, high-rise buildings, restaurants) located on a DoD installation that are outside but near QD arcs are not required, it is recommended that they be submitted to the DDESB for review and comment.

V1.E5.1.3. Site Plan Submission Requirements

V1.E5.1.3.1. Preliminary. When required by the DoD Component, preliminary site plan submissions shall include, at a minimum, the information specified in subparagraphs V1.E5.1.3.3.1. to V1.E5.1.3.3.6. and V1.E5.1.3.3.12. If sufficient detail is available, the preliminary and final site plan submissions can be combined into a final site plan submission.

V1.E5.1.3.2. Final. A final site plan submission shall include the information in subparagraphs V1.E5.1.3.3.1. to V1.E5.1.3.3.12.

V1.E5.1.3.3. Site Plan Contents. A site plan should consist of:

V1.E5.1.3.3.1. The DoD Component's approval, in the transmittal document, of the proposal, along with any changes, modifications, or specific precautionary measures considered necessary.

V1.E5.1.3.3.2. Drawings at a scale of 1 inch equals not more than 400 ft or metric equivalent. Smaller scale drawings may periodically be necessary to properly reflect certain

distance and structure relationships within the area surrounding a given project. When standard drawings exist for a building or group of buildings that the DDESB has reviewed and declared acceptable (the definitive drawing), the drawing does not need to be resubmitted. In such cases, the site plan must note the definitive drawings for each building or structure to be constructed.

V1.E5.1.3.3.3. The distances between the facility to be constructed or modified and all ESs within QD arcs impacted by the project, to include on- and off-installation power transmission and utility lines, the installation's boundary, public railways, and public highways.

V1.E5.1.3.3.4. A description of use and occupancy of each ES within inhabited building distance (IBD), or the risk-based evaluation distance for risk-based site plans, of the facility to be constructed or modified.

V1.E5.1.3.3.5. The NEW for each AE HD that will be stored or handled in the facility to be constructed or modified or that will impact the project.

V1.E5.1.3.3.6. Anticipated personnel limits for the new or modified facility, to include a breakdown by room or bay, when appropriate.

V1.E5.1.3.3.7. Approved drawings or, when approved drawings are not used, general construction details to include materials used, 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, hazardous waste disposal systems, lightning protection systems, static grounding systems, process equipment, and auxiliary support structures.

V1.E5.1.3.3.8. A summary of the design procedures for any engineering protections that are to be used that the DDESB has not already approved. The summary shall include a statement of the design objectives in terms of protection categories to be obtained (see Unified Facilities Criteria 3-340-02 (Reference (g))), the explosives quantities involved, the design loads applied, any material properties and structural behavior assumptions made, references, and the sources of methods used. Only engineers who are experienced in the field of structural dynamics and who use design procedures accepted by professionals in that field may design explosion resistant facilities.

V1.E5.1.3.3.9. Information on the type and arrangement of explosives operations or chemical-processing equipment.

V1.E5.1.3.3.10. A topography map with contours (when terrain features are considered to provide natural barricading) or topography that otherwise influences the facility's layout, as in some chemical operations.

V1.E5.1.3.3.11. When CAs are involved, information on:

V1.E5.1.3.3.11.1. Personnel protective clothing and equipment to be used.

V1.E5.1.3.3.11.2. Treatment of all effluent and waste materials and streams.

V1.E5.1.3.3.11.3. The adequacy of medical support.

V1.E5.1.3.3.11.4. The average wind speed and direction.

V1.E5.1.3.3.11.5. Other support facilities pertinent to chemical safety.

V1.E5.1.3.3.11.6. The warning and detection systems to be used.

V1.E5.1.3.3.11.7. Any hazard analysis performed.

V1.E5.1.3.3.12. An indication of any deviations from pertinent safety standards that local conditions cause.

V1.E5.1.3.4. Records

V1.E5.1.3.4.1. The installation that submits the site plan shall maintain a copy of:

V1.E5.1.3.4.1.1. The complete site plan and the final safety submission.

V1.E5.1.3.4.1.2. The DDESB approval.

V1.E5.1.3.4.2. Installations shall develop and maintain current (with the latest site plan approval) installation maps, and drawings that show QD arcs or risk-based evaluation distances, as applicable.

V1.E5.1.3.4.3. Installations shall ensure that site plans are reconciled with the installation's master planning documents.

V1.E5.2. SITE PLANS NOT REQUIRED. Site plans are not required to be submitted to the DDESB for the following specific situations (the DoD Components shall specify siting and documentation requirements for these situations):

V1.E5.2.1. Storage and associated handling of HD 1.4S (see paragraph V3.E3.4.3.).

V1.E5.2.2. Interchange yards limited to those operations described in section V4.E5.5.

V1.E5.2.3. Inspection stations where only the operations described in section V4.E5.9. are performed.

V1.E5.2.4. Parking of aircraft loaded with specific munitions (see paragraph V4.E3.5.2.) while in designated aircraft parking areas that meet airfield criteria, and associated handling of these munitions, provided the quantity of munitions involved in the operation is limited to a single aircraft load.

V1.E5.2.5. The handling of HD 1.3 and HD 1.4 material (≤ 300 lbs NEW) [≤ 136.1 kg] necessary for ships' security and safety at sea (see subparagraph V4.E4.1.2.2.).

V1.E5.2.6. Storage of, and operations involving, limited quantities of HD 1.2.2, HD 1.3, or HD 1.4 for reasons of operational necessity, as permitted by paragraph V3.E3.2.11., footnote a of Table V3.E3.T~~13~~*14*., and footnote g of V3.E3.T~~14~~*15*.

V1.E5.2.7. Certain contingency and combat training operations as described in section V6.E3.3.

V1.E5.2.8. Inert storage accessed by personnel related to the explosives mission.

V1.E5.2.9. Locations used for a demilitarization processing operation of expended .50-caliber and smaller cartridge casings that meet paragraphs V4.E5.18.1. and V4.E5.18.2. and are located outside of IBD from all PESs.

V1.E5.2.10. Site and general construction plans or amendments to existing plans need not be submitted to the DDESB for facility modifications, mission changes, changes in operations, NEW increases, or HD additions that do not:

V1.E5.2.10.1. Increase explosives safety or CA risks.

V1.E5.2.10.2. Identify requirements for additional or increased explosives or CA hazard controls.

V1.E5.2.10.3. Increase any QD arcs.

V1.E5.2.11. Roll-on/roll-off meeting the requirements of section V4.E5.11.

# ENCLOSURE 6

# HAZARD CLASSIFICATION, STORAGE AND COMPATIBILITY PRINCIPLES, AND MIXING RULES

V1.E6.1. HAZARD CLASSIFICATION. To ease identification of hazard characteristics for storage and transportation, the Department of Defense shall use:

V1.E6.1.1. DoD AE hazard classification procedures as a basis for assigning hazard classifications to all AE for both storage and transportation applications. (See Army Technical Bulletin 700-2/Naval Sea Systems Command Instruction 8020.8B/Technical Order 11A-1-47/Defense Logistics Agency Regulation 8220.1 (Reference (h)).)

V1.E6.1.2. The applicable Department of Transportation hazardous materials regulations per parts 171 to 177 of title 49, Code of Federal Regulations (Reference (i)).

V1.E6.1.3. The United Nations' international system of classification developed for the transport of dangerous goods. (See ST/SG/AC.10/1/Revision 16 (Reference (j).)

## V1.E6.2. DoD HAZARD CLASSIFICATION SYSTEM

V1.E6.2.1. Hazard Classes and Divisions. The DoD hazard classification system consists of nine hazard classes plus a non-regulated category that applies when explosives and hazardous materials are present in an item, but not to the degree that criteria for assignment to one of the nine classes are met. AE is assigned to the class that represents an item's predominant hazard characteristic. Class 1 applies to AE where the explosive hazard predominates. The six Class 1 divisions and three division 1.2 subdivisions (subdivisions are only applicable for storage applications), which are outlined in subparagraphs V1.E6.2.1.1. through V1.E6.2.1.6., are used to indicate the character and predominance of explosive hazards. In addition to the classes, divisions, subdivisions, and the non-regulated category, 13 compatibility groups (CGs) are used for segregating AE on the basis of similarity of function, features, and accident effects potential. Furthermore, a parenthetical number is also 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 is placed to the left of the hazard classification designators 1.1 through 1.3 (e.g., (18)1.1, (08)1.2.3, or (02)1.3). To simply express an item's hazard classification, this Manual uses the term "HD" to avoid repeatedly using the more cumbersome terminology "Subdivision X of Division Y of Class Z." The six Class 1 divisions and three hazard subdivisions are:

V1.E6.2.1.1. Mass explosion (HD 1.1).

V1.E6.2.1.2. Non-mass explosion, fragment producing (HD 1.2). (See section V3.E3.2.)

V1.E6.2.1.2.1. HD 1.2.1. Those items with a NEWQD > 1.60 lbs [0.73 kg] or that exhibit fragmentation characteristics similar to or greater than (higher density, longer distance) M1 105-millimeter (mm) projectiles regardless of NEWQD.

V1.E6.2.1.2.2. HD 1.2.2. Those items with an NEWQD ≤ 1.60 lbs [0.73 kg] or that at most exhibit fragmentation characteristics similar to high-explosive 40-mm ammunition regardless of NEWQD.

V1.E6.2.1.2.3. HD 1.2.3. AE that exhibits no reaction more severe than burning in the liquid fuel or external fire, bullet impact, and slow heating tests. Additionally, in the sympathetic reaction tests, all acceptors in packages surrounding the donor package exhibit at most an explosion reaction.

V1.E6.2.1.3. Mass fire, minor blast or fragment (HD 1.3).

V1.E6.2.1.4. Moderate fire, no significant blast or fragment (HD 1.4).

V1.E6.2.1.5. Explosive substance, very insensitive (with mass explosion hazard) (HD 1.5).

V1.E6.2.1.6. AE that exhibits no reaction more severe than burning in the liquid fuel or external fire, bullet impact, and slow heating tests. Additionally, in the sympathetic reaction tests, all acceptors exhibit at most an explosion reaction (HD 1.6).

V1.E6.2.2. Storage and Transportation CGs. The 13 CGs assigned to AE based on similarity of function, features, and accident effects potential are:

V1.E6.2.2.1. Group A. Initiating (primary) explosives. Bulk initiating explosives that have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples include bulk lead azide, lead styphnate, mercury fulminate, tetracene, dry cyclotrimethylenetrinitramine (also known as cyclonite, hexogen, or royal demolition explosive (RDX)), and dry pentaerythritol tetranitrate (PETN).

V1.E6.2.2.2. Group B. Detonators and similar initiating devices not containing two or more effective protective features. Items containing initiating (primary) explosives that are designed to initiate or continue the functioning of an explosive train. Examples include detonators, blasting caps, small arms primers, and fuzes.

V1.E6.2.2.3. Group C. Bulk propellants, propelling charges, and devices containing propellant with, or without, its own means of ignition. Examples include bulk single-, double-, or triple-base and composite propellants, rocket motors (solid propellant), and propelled AE with inert projectiles.

V1.E6.2.2.4. Group D. Bulk black powder, bulk high explosives (HE) (secondary explosives), and AE without a propelling charge, but containing HE (secondary explosives) without its own means of initiation (i.e., no initiating device is present or the device has two or

more effective protective features). Examples include bulk trinitrotoluene (also known as TNT), Composition B, and black powder; bulk wet RDX or PETN; and bombs, projectiles, cluster bomb units, depth charges, and torpedo warheads.

V1.E6.2.2.5. Group E. AE containing HE (secondary explosives) without its own means of initiation and either containing, or with, a solid propelling charge. Examples include artillery AE, rockets, and guided missiles.

V1.E6.2.2.6. Group F. AE containing HE (secondary explosives) with its own means of initiation, i.e., the initiating device present has less than two effective protective features, and with or without a solid propelling charge. Examples include grenades, sounding devices, and similar items having explosive trains with less than two effective protective features.

V1.E6.2.2.7. Group G. Illuminating, incendiary, and smoke- (including hexachlorethane (HC)) or tear-producing AE, excluding those that are water-activated or that contain white phosphorus (WP) or a flammable liquid or gel. Examples include flares, signals, and pyrotechnic substances.

V1.E6.2.2.8. Group H. AE containing WP. AE in this group contains fillers that are spontaneously flammable when exposed to the atmosphere. Examples include WP and plasticized white phosphorus (PWP).

V1.E6.2.2.9. Group J. AE containing flammable liquids or gels other than those that are spontaneously flammable when exposed to water or the atmosphere. Examples include liquid- or gel-filled incendiary AE, fuel-air explosive devices, and flammable liquid-fueled missiles and torpedoes.

V1.E6.2.2.10. Group K. AE containing toxic CAs. AE in this group contain chemicals specifically designed for incapacitating effects more severe than lachrymation (tear-producing). Examples include artillery or mortar AE (fuzed or unfuzed), grenades, rockets and bombs filled with a lethal or incapacitating CA. (See footnote d, Table V1.E6.T1.)

V1.E6.2.2.11. Group L. AE not included in other CGs, having characteristics that present a special risk that does not permit storage with other types of AE, or other kinds of explosives, or dissimilar AE of this group. Examples include water-activated devices, pyrophorics and phosphides and devices containing these substances, prepackaged hypergolic liquid-fueled rocket engines, triethyl aluminum (TEA), thickened TEA (TPA), and damaged or suspect AE of any group. Different types of AE in CG L presenting similar hazards may be stored together.

V1.E6.2.2.12. Group N. AE containing only extremely insensitive detonating substances (EIDS). An example is HD 1.6 AE.

V1.E6.2.2.13. Group S. AE that presents no significant hazard, packaged or designed so that any hazardous effects from accidental functioning are limited to the extent that they do not

significantly hinder firefighting. Examples include explosive switches or valves and small arms ammunition.

V1.E6.2.3. Sensitivity Groups (SGs). For the purpose of storage within a high performance magazine (HPM) (see paragraph V1.E6.3.7.) or where ARMCO, Inc. or equivalent earth-filled steel bin revetments (see paragraph V2.E5.4.5.) or substantial dividing walls are utilized to reduce maximum credible event (MCE), each HD 1.1 and HD 1.2 AE item is designated, based on its physical attributes, into one of five SGs. Directed energy weapons are further identified by assigning the suffix "D" following the SG designation (e.g., SG 2D). The SG assigned to an HD 1.1 and HD 1.2 AE item is found in the Joint Hazard Classification System (JHCS).

V1.E6.2.3.1. The five SGs in relative order from least sensitive to most sensitive, are:

V1.E6.2.3.1.1. SG 2: Non-robust military munitions (see Volume 8).

V1.E6.2.3.1.2. SG 1: Robust military munitions (see Volume 8).

V1.E6.2.3.1.3. SG 3: Fragmenting military munitions (see Volume 8).

V1.E6.2.3.1.4. SG 4: Cluster bombs/dispenser unit military munitions (see Volume 8).

V1.E6.2.3.1.5. SG 5: Sympathetic detonation sensitive military munitions (see the definition of "sensitivity group" in Volume 8).

V1.E6.2.3.2. Item-specific testing or analyses can be used to change an item's SG.

## V1.E6.3. STORAGE AND COMPATIBILITY PRINCIPLES

V1.E6.3.1. Separate storage of AE by HD and type provides the highest degree of safety. Because such storage is generally not feasible, mixed storage—subject to compliance with these standards—is normally implemented when such storage facilitates safe operation and promotes overall storage efficiency.

V1.E6.3.2. The CG assigned to AE indicates what it can be stored with, without significantly increasing either an accident's probability or, for a given quantity, the magnitude of an accident's effects. Only compatible AE will be stored together.

V1.E6.3.3. AE may not be stored with dissimilar substances or articles (e.g., flammable or combustible materials, acids, or corrosives) that may present additional hazards to the AE unless they have been assessed to be compatible. Nonregulated AE and AE assigned to Classes 2 through 9 may have a CG assigned. When so assigned, the AE may be stored in an explosives magazine IAW the CG. The explosive weight of nonregulated AE and AE assigned to Classes 2 through 9 is not considered for QD purposes.

V1.E6.3.4. The DoD hazard classification system classifies articles that contain riot control substances, without explosives components, and bulk toxic CAs as HD 6.1.

V1.E6.3.5. AE in damaged packaging, in a suspect condition, or with characteristics that increase risk in storage, are not compatible with other AE and will be stored separately (in CG L).

V1.E6.3.6. If different types of CG N munitions are mixed together and have not been tested to ensure non-propagation, the mixed munition types are individually considered to be HD 1.2.1 D or HD 1.2.2 D based on their NEWQD or overriding fragmentation characteristics.

V1.E6.3.7. Because of its construction (see section V2.E5.7.), each HPM storage cell is treated as a separate magazine for the purposes of meeting compatibility and mixing requirements. Within an HPM cell, all current compatibility and mixing regulations apply. The maximum allowable NEWQD is 30,000 lbs [13,608 kg] in an HPM cell and 60,000 lbs [27,215 kg] in the loading dock with the following restraints:

V1.E6.3.7.1. When SG 1, 2, or 3 AE is present in an HPM cell, the allowable NEWQD in all cells (adjacent, across, and diagonal) and in the loading dock remains the maximum.

V1.E6.3.7.2. When SG 4 AE is present in an HPM cell, the allowable NEWQD in each adjacent cell and in the cell directly across from it is reduced to 15,000 lbs [6,804 kg]. The allowable NEWQD in diagonal cells and in the loading dock remains the maximum.

V1.E6.3.7.3. When SG 5 AE is present in an HPM, the NEWQD of all cells and the loading dock must be summed for QD purposes.

V1.E6.3.7.4. When directed energy weapons are present in an HPM, they must be oriented in such a manner that if initiation were to occur, the consequences would be directed away from any other cell. Otherwise, the NEWQD of all cells and the loading dock must be summed for QD purposes.

V1.E6.3.7.5. When HDs and SGs are mixed within an HPM cell, the most sensitive SG associated with the AE in that cell controls the allowable NEWQD in each adjacent cell. For example, when HD 1.3, HD 1.4, and HD 1.6 items are stored with HD 1.1 or HD 1.2 items, the most sensitive SG of the HD 1.1 and HD 1.2 items controls the storage requirements.

V1.E6.4. MIXED CG STORAGE. AE of different CGs may only be mixed in storage as indicated in Table V1.E6.T1. The exceptions are when V6.E3. is being applied, and at specific continental United States locations that a DoD Component designates to store AE packaged and configured for rapid response (e.g., rapid deployment force) for which the DDESB has approved the site plan. Such designated locations are authorized to mix CGs, without complying with the compatibility and mixing requirements, as operationally required to achieve the optimum load needed by the intended receiving troops. The MCE allowable at any of these storage sites shall be limited to 8,818 lbs NEWQD [4,000 kg net explosive quantity (NEQ)]. When computing QD

requirements for such sites, Volumes 3, 4, and 5 apply. However, the following AE will be excluded for NEWQD determination at such storage sites:

V1.E6.4.1. Propelling charges in HD 1.2 fixed, semi-fixed, mortar, and rocket AE.

V1.E6.4.2. The NEWQD of HD 1.3 items, except at sites that contain only HD 1.3 items. At such sites, HD 1.3 QD applies. (In the application of this paragraph to separate loading AE, the explosive weight of propelling charges is generally excluded when matched pairs of projectiles and propelling charges are at the site. However, if the quantity of propelling charges at the site exceeds the maximum usable for the quantity of projectiles at the site, the explosive weights of all propelling charges and projectiles at the site must be summed for NEWQD determination.)

Table V1.E6.T1. Storage Compatibility Mixing Chart[a, b, c, d, e, f, g, h, i, j]

| CGs | A | B | C | D | E | F | G | H | J | K | L | N | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | X | Z | | | | | | | | | | | |
| B | Z | X | Z | Z | Z | Z | Z | | | | | X | X |
| C | | Z | X | X | X | Z | Z | | | | | X | X |
| D | | Z | X | X | X | Z | Z | | | | | X | X |
| E | | Z | X | X | X | Z | Z | | | | | X | X |
| F | | Z | Z | Z | Z | X | Z | | | | | Z | X |
| G | | Z | Z | Z | Z | Z | X | | | | | Z | X |
| H | | | | | | | | X | | | | | X |
| J | | | | | | | | | X | | | | X |
| K | | | | | | | | | | Z | | | |
| L | | | | | | | | | | | | | |
| N | | X | X | X | X | Z | Z | | | | | X | X |
| S | | X | X | X | X | X | X | X | X | | | X | X |

| | |
|---|---|
| a | An "X" at an intersection indicates that the groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per footnote b. |
| b | A "Z" at an intersection indicates that, when warranted by operational considerations or magazine non-availability and when safety is not sacrificed, mixed storage of limited quantities of some items from different groups may be approved by the DoD Components. Such approval documentation must be kept on site. Component approval of mixed storage in compliance with Z intersections does not require a waiver or exemption. Mixed storage of items within groups where no X or Z exists at that pair's intersection beyond the prohibitions and limitations of footnote g, however, requires an approved waiver or exemption. Examples of acceptable storage combinations are:<br>1. HD 1.1A initiating explosives with HD 1.1B fuzes not containing two or more effective protective features.<br>2. HD 1.3C bulk propellants or bagged propelling charges with HD 1.3G pyrotechnic substances. |
| c | Equal numbers of separately packaged components of hazard-classified complete rounds of any single type of AE may be stored together. When so stored, compatibility is that of the complete round. |
| d | CG K requires not only separate storage from other groups, but also may require separate storage within the group. The controlling DoD Component will determine which items under CG K may be stored together and those that must be stored separately. Such documentation must be kept on site. |
| e | AE classed outside Class 1 may be assigned the same CG as Class 1 AE containing similar hazard features, but where the explosive hazard predominates. Non-Class 1 AE and Class 1 AE assigned the same CG may be stored together. |
| f | The DoD Components may authorize AE-designated "Practice" or "Training" by nomenclature, regardless of the CG assigned, to be stored with the tactical AE it simulates. Such documentation must be kept on site. |
| g | The DoD Components may authorize the mixing of CGs, except items in CG A, K, and L, in limited quantities generally of 1,000 lbs [454 kg] total NEWQD or less. Such documentation must be kept on site. |
| h | For purposes of mixing, all AE must be packaged in its standard storage and shipping container. AE containers will not be opened for issuing items from storage locations. Outer containers may be opened in storage locations for inventorying and for magazines storing only HD 1.4 items, unpacking, inspecting, and repackaging the HD 1.4 ammunition. |
| i | When using the Z mixing authorized by footnote b for articles of either CG B or CG F, each will be segregated in storage from articles of other CGs by means that prevent propagation of CG B or CG F articles to articles of other CGs. |
| j | If dissimilar HD 1.6N AE are mixed together and have not been tested to ensure non-propagation, the mixed AE are individually considered to be HD 1.2.1D or HD 1.2.2D based on their NEWQD or overriding fragmentation characteristics for purposes of transportation and storage. When mixing CG N AE with CG B through CG G or with CG S, see subparagraphs V1.E7.2.3.1.1., V1.E7.2.3.4., V1.E7.2.3.10., and V1.E7.2.3.11. to determine the HD for the mixture. |

# ENCLOSURE 7

## QD, DETERMINING NEWQD, AND QD PRINCIPLES, MEASUREMENTS, AND CALCULATIONS

V1.E7.1. GENERAL. The damage or injury potential of explosions is normally determined by the separation distance between a PES and an ES; the ability of the PES to suppress blast overpressure and primary and secondary fragments; and the ability of the ES to resist explosion effects.

V1.E7.1.1. This Manual:

V1.E7.1.1.1. Defines permissible exposures for both accidental and intentional detonations.

V1.E7.1.1.2. Sets minimum standards for separation distances between PESs and ESs by taking into account anticipated explosion effects, suppression, and resistance.

V1.E7.1.1.3. Establishes explosives safety siting criteria (QD relationships) for PESs and ESs based on blast, fragment, firebrand, thermal, and ground shock effects. QD is determined by the effect requiring the greatest distance.

V1.E7.1.2. If QD requirements of this Manual cannot be met, risk-based siting may be used IAW conditions and criteria in V6.E5.

### V1.E7.2. DETERMINING THE QUANTITY OF EXPLOSIVES

V1.E7.2.1. General. The NEWQD in an AE facility is calculated as shown in paragraphs V1.E7.2.2. and V1.E7.2.3. If DDESB-approved buffer configurations are provided, the NEWQD is the explosives weight of the largest stack plus the explosives weight of the buffer material, excluding the NEW of HD 1.4. Where the DDESB has approved an HE equivalence for a propellant or pyrotechnic, then this HE equivalence may be used in determining NEWQD. The JHCS provides explosives weights for all DoD hazard classified AE.

V1.E7.2.2. Determining the NEWQD for a Single HD

V1.E7.2.2.1. Mass-explosion (HD 1.1). The NEWQD is the total high explosive weight (HEW) and the total net propellant weight (NPW). For HD 1.1, NEWQD equals the NEW.

V1.E7.2.2.2. Non-mass Explosion, Fragment Producing (HD 1.2)

V1.E7.2.2.2.1. HD 1.2.1. The NEWQD is the HEW plus the NPW in all HD 1.2.1 items. In certain situations, the MCE, as outlined in paragraph V3.E3.2.6., shall be used as the basis for determining applicable QD.

V1.E7.2.2.2.2. HD 1.2.2. The NEWQD is the HEW plus the NPW in all HD 1.2.2 items.

V1.E7.2.2.2.3. HD 1.2.3. The NEWQD is the HEW plus the NPW in all HD 1.2.3 items. This material is treated as HD 1.3; however, a minimum IBD shall apply, as outlined in paragraph V3.E3.2.13.

V1.E7.2.2.3. Mass Fire, Minor Blast, or Fragment (HD 1.3). The NEWQD is the HEW plus the NPW plus the total weight of pyrotechnics in all HD 1.3 items.

V1.E7.2.2.4. Moderate Fire, No Blast, or Fragment (HD 1.4). The NEWQD is the HEW plus the NPW plus the total weight of pyrotechnics in all HD 1.4 items.

V1.E7.2.2.5. Explosive Substance, Very Insensitive (with Mass Explosion Hazard) (HD 1.5). The NEWQD is the HEW plus the NPW in all HD 1.5 items. For HD 1.5, NEWQD equals the NEW.

V1.E7.2.2.6. Explosive Article, Extremely Insensitive (HD 1.6). The NEWQD is the total weight of EIDSs in all HD 1.6 items. However, the weight of EIDSs in a single HD 1.6 item shall also be considered, as specified in Table V3.E3.T15., for determining QD.

V1.E7.2.2.7. Exclusions. Munitions' fillers that do not contribute to explosive effects (e.g., colored and HC smoke, dyes, irritants, WP, PWP, and TPA) are excluded when determining NEWQD.

V1.E7.2.3. Determining the NEWQD for Mixed HDs

V1.E7.2.3.1. General

V1.E7.2.3.1.1. The presence of HD 1.4 does not affect the NEWQD of mixed HDs. However, for QD determinations, HD 1.4 criteria shall be considered.

V1.E7.2.3.1.2. When HD 1.1 is mixed with any other HD, treat the mixture as HD 1.1 except as noted in subparagraph V1.E7.2.3.2.

V1.E7.2.3.1.3. HD 1.5 is always treated as HD 1.1.

V1.E7.2.3.1.4. When dissimilar HD 1.6 are mixed and have not been tested to ensure non-propagation, the mixed HD 1.6 AE shall be individually considered to be HD 1.2.1 or HD 1.2.2, based on their individual NEWQD or overriding fragmentation characteristics.

V1.E7.2.3.2. HD 1.1 with HD 1.2 (HD 1.2.1, HD 1.2.2, and HD 1.2.3). Use whichever of the following generates the largest QD:

V1.E7.2.3.2.1. Sum the NEWQD for HD 1.1 and NEWQD for HD 1.2 and treat the mixture as HD 1.1.

V1.E7.2.3.2.2. The NEWQD of the mixture is the NEWQD of the HD 1.2 subdivision requiring the largest QD.

V1.E7.2.3.3. HD 1.1 with HD 1.3. Sum the NEWQD for HD 1.1 and the NEWQD for HD 1.3 and treat the mixture as HD 1.1.

V1.E7.2.3.4. HD 1.1 with HD 1.6. Sum the NEWQD for HD 1.1 and the NEWQD for HD 1.6 and treat the mixture as HD 1.1.

V1.E7.2.3.5. HD 1.2.1 with HD 1.2.2. The NEWQD for the mixture is the NEWQD of the subdivision requiring the largest QD.

V1.E7.2.3.6. HD 1.2.1 with HD 1.2.3. The NEWQD for the mixture is the NEWQD of the subdivision requiring the largest QD.

V1.E7.2.3.7. HD 1.2.2 with HD 1.2.3. The NEWQD for the mixture is the NEWQD of the subdivision requiring the largest QD.

V1.E7.2.3.8. HD 1.2.1 with HD 1.2.2 with HD 1.2.3. The NEWQD for the mixture is the NEWQD of the subdivision requiring the largest QD.

V1.E7.2.3.9. HD 1.2 (HD 1.2.1, HD 1.2.2, and HD 1.2.3) with HD 1.3. The NEWQD for the mixture is the NEWQD of the HD requiring the largest QD.

V1.E7.2.3.10. HD 1.2 (HD 1.2.1, HD 1.2.2, and HD 1.2.3) with HD 1.6. Treat the HD 1.6 as HD 1.2.3 and determine NEWQD IAW subparagraphs V1.E7.2.3.6. through V1.E7.2.3.8., as applicable.

V1.E7.2.3.11. HD 1.3 with HD 1.6. Sum the NEWQD for the HD 1.6 and the NEWQD for the HD 1.3 and treat the mixture as HD 1.3.

## V1.E7.3. QD PRINCIPLES

V1.E7.3.1. The bases for determining required separation distances (i.e., QD) are:

V1.E7.3.1.1. The HD types and NEWQD of AE present in an AE facility.

V1.E7.3.1.2. The NEWQD of the HD requiring the greatest separation establishes the QD for the facility when it is used for multiple operations.

V1.E7.3.1.3. The NEWQD for the HPM is based on its MCE (i.e., the sum of the contents of an individual open cell and the loading dock, rather than the aggregate NEWQD for the entire magazine). The MCE for the HPM shall not exceed 60,000 lbs [27,215 kg].

V1.E7.3.2. The bases for subdividing a quantity of AE into smaller units for the purpose of QD reduction are:

V1.E7.3.2.1. Separation by Time. When two or more stacks of equal NEWQD detonate within short time intervals, the blast waves will coalesce. A short time interval is defined as a time in milliseconds (ms) that is less than $4.0W^{1/3}$ [$5.21Q^{1/3}$] of any one stack in lbs [kg] for lateral (side-to-side) target positions and less than $5.6W^{1/3}$ [$7.29Q^{1/3}$] of any one stack in lbs [kg] for axial target positions. (In the preceding formulas, the unit for the constant is $ms/lbs^{1/3}$ [$ms/kg^{1/3}$].) The combined shock wave, after coalescence, will be that of a single detonation of a charge equal to the summation of the several stacks. When coalescence does not occur, the MCE for the stacks is equal to the NEWQD for one stack.

V1.E7.3.2.2. Separation by Barriers. Barriers designed per the principles of Reference (g) shall ensure no propagation between AE stacks. When barriers are constructed per this guidance or when supported by test data, the MCE is equal to the NEWQD of the AE stack with the largest QD requirement. Otherwise, QD computations must be based upon the summation of NEWQD for all of the AE stacks. Barrier design shall include adequate standoff distances and take into account acceptor AE sensitivity.

V1.E7.3.3. The QD criteria for a PES-ES pair, when both contain AE, are determined by considering each location, in turn, as a PES and an ES. The quantity of AE to be permitted in each PES shall be the amount permitted by the distance specified in the appropriate QD tables. The separation distance required for the pair is the greater of the two separation distances. An exception is permitted for service magazines supporting an AE operation.

V1.E7.3.4. Flight ranges for units (e.g., rockets, missile motors, and cartridge or propellant actuated devices) in a propulsive state shall be disregarded because it is impractical to specify QD separations that allow for their designed flight range.

## V1.E7.4. QD MEASUREMENTS

V1.E7.4.1. Separation distances are measured along straight lines. For large intervening topographical features such as hills, measure over or around the feature, whichever is shorter. For golf courses, measure to the nearest edge of the tee or green or to the centerline of fairways.

V1.E7.4.2. Measurements of distance for determining the maximum allowable quantity of AE shall be made to the nearest part of an ES from:

V1.E7.4.2.1. The nearest wall of the PES.

V1.E7.4.2.2. The exterior of the nearest intervening wall to the controlling AE stack, when the PES is subdivided.

V1.E7.4.3. When an AE conveyance (e.g., railroad car or motor vehicle) containing AE is not separated from a PES in such a manner as to prevent mass detonation, then the conveyance and PES shall be considered as a unit and their NEWQD shall be summed. The separation distance shall be measured from the nearest outside wall of the PES or conveyance, as appropriate, to an ES. If the AE are separated so that mass detonation will not occur, the separation distance shall be measured from the nearest controlling PES or conveyance to an ES.

## V1.E7.5. QD CALCULATIONS

V1.E7.5.1. QD K-factors. Throughout this Manual, NEW is used to calculate QD by means of a formula of the type $D\ (ft) = K \bullet W^{1/3}$, where "D" is the distance in feet, "K" is a factor (also called K-factor) that is dependent upon the risk assumed or permitted, and "W" is the NEW in pounds. When metric units are used, the symbol "Q" denotes NEQ in kilograms. In the formula $D\ (m) = K_m \bullet Q^{1/3}$, the distance "D" is expressed in meters. Thus, the units of the K-factor are $ft/lb^{1/3}$ ("K" in the English system) and $m/kg^{1/3}$ ("$K_m$" in the metric system). The value of "K" in English units is approximately 2.52 times "$K_m$." For example, if $D\ (m) = 6 \bullet Q^{1/3}$, then $D\ (ft) = 15.12 \bullet W^{1/3}$. Distance requirements determined by the formula with English units are sometimes expressed by the value of "K," using the terminology K9, K11, K18, to mean K = 9, K = 11, and K = 18.

V1.E7.5.2. Rounding. When performing QD calculations using formulas, resulting answers with a decimal value of 0.5 or more may be rounded up to the nearest whole number, and resulting answers with a decimal value of less than 0.5 may be rounded down to the nearest whole number. See Figure V1.E7.F1. for examples.

Figure V1.E7.F1. Examples for Rounding of QD Calculations

If calculating the required distance:

$D = K(NEWQD)^{1/3} = 40(1{,}500\ lbs)^{1/3} = 457.89\ ft = 458\ ft$

$D = K(NEWQD)^{1/3} = 18(200\ lbs)^{1/3} = 105.26\ ft = 105\ ft$

If calculating the allowable NEWQD:

$NEWQD = (D/K)^3 = (1{,}150\ ft/40)^3 = 23{,}763.67\ lbs = 23{,}764\ lbs$

$NEWQD = (D/K)^3 = (700\ ft/18)^3 = 58{,}813.44\ lbs = 58{,}813\ lbs$

# ENCLOSURE 8

# REACTION EFFECTS

V1.E8.1. INTRODUCTION. This enclosure describes the expected effects of AE reactions.

V1.E8.2. HD 1.1 EFFECTS

V1.E8.2.1. Blast

V1.E8.2.1.1. Blast Wave Phenomena. In an incident involving HD 1.1 or HD 1.1 with any other HD (an HD 1.1 event), the violent release of energy creates a sudden and intense pressure disturbance termed the "blast wave." The blast wave is characterized by an almost instantaneous rise from ambient pressure to a peak incident pressure. This pressure increase, or "shock front," travels radially outward from the detonation point, with a diminishing velocity that is always in excess of the speed of sound in that medium. Gas molecules making up the front move at lower velocities. This velocity, which is called the "particle velocity," is associated with the "dynamic pressure," or the pressure formed by the winds produced by the shock front.

V1.E8.2.1.1.1. As the shock front expands into increasingly larger volumes of the medium, the incident pressure decreases and, generally, the duration of the pressure-pulse increases.

V1.E8.2.1.1.2. If the shock wave impinges a rigid surface (e.g., a building) at an angle to the direction of the wave's propagation, a reflected pressure is instantly developed on the surface and this pressure rises to a value that exceeds the incident pressure. This reflected pressure is a function of the incident wave's pressure and the angle formed between the rigid surface and the plane of the shock front.

V1.E8.2.1.2. Partially Confined Explosions. When an explosion occurs within a structure, the peak pressure associated with the initial shock front will be both high and amplified by reflections within the structure. In addition, the accumulation of gases from the explosion will exert additional pressure and increase the load duration within the structure. This effect may damage or destroy the structure unless the structure is designed to either withstand or vent the gas and shock pressures. Structures that have one or more strengthened walls may be vented for relief of excessive gas by either using frangible construction for the remaining walls or roof or through the use of openings. This type of construction will allow the gas from an internal explosion to spill out of the structure. Once released from confinement, these pressures, referred to as "exterior" or "leakage" pressures, expand radially and may affect external structures or personnel.

V1.E8.2.1.3. Expected Blast Pressures at QD. Table V1.E8.T~~1~~2. presents the incident pressures that would be expected at various K-factors from HD 1.1 events.

Table V1.E8.T~~1~~2. Expected Peak Incident Pressures from HD 1.1 Events

| Location | K-Factor ($ft/lb^{1/3}$)<br>*$K_m$-Factor $[m/kg^{1/3}]$* | Incident Pressure (psi)<br>*Incident Pressure [kPa]* |
|---|---|---|
| Barricaded Aboveground IMD | 6<br>*2.38* | 27<br>*186.2* |
| Barricaded ILD | 9<br>*3.57* | 12<br>*82.7* |
| Unbarricaded Aboveground IMD | 11<br>*4.36* | 8<br>*55.2* |
| Unbarricaded ILD | 18<br>*7.14* | 3.5<br>*24.1* |
| Public Traffic Route Distance (PTRD) | | |
| W < 100,000 lbs | 24 | 2.3 |
| *Q < 45,400 kg* | *9.52* | *15.9* |
| W > 250,000 lbs | 30 | 1.7 |
| *Q > 113,400 kg* | *11.9* | *11.7* |
| IBD | | |
| W < 100,000 lbs | 40 | 1.2 |
| *Q < 45,400 kg* | *15.87* | *8.3* |
| W > 250,000 lbs | 50 | 0.9 |
| *Q > 113,400 kg* | *19.84* | *6.2* |

V1.E8.2.1.4. General Blast Effects on Structures

V1.E8.2.1.4.1. Conventional Structures. Conventional structures are generally designed to withstand roof-snow loads of 0-50 pounds per square foot ($lbs/ft^2$) [0-2.4 kPa] or wind loads up to 90 miles per hour (mph) [145 kilometers per hour (kph)] or both. At 90 mph [145 kph], the wind load equates to 0.14 psi [1.0 kPa]. Given the pressures shown in Table V1.E8.T~~1~~2. for the selected K-factors, it is evident that, even at IBD, conventional structures may not provide complete protection from the blast. Generally, the weakest portions of any conventional structure are the windows. Table V1.E8.T~~2~~3. provides the probability of breaking typical windows at various K-factors and associated incident pressures from HD 1.1 events.

Table V1.E8.T~~2~~3. Probability of Window Breakage from Incident Pressure

| K-Factor ($ft/lb^{1/3}$) | Incident Pressure (psi) | Probability of Breakage (%) for Windows Facing PES | | |
|---|---|---|---|---|
| *$K_m$-Factor $[m/kg^{1/3}]$* | *Incident Pressure [kPa]* | Window 1[a] | Window 2[b] | Window 3[c] |
| 40 | 1.2 | 85 | 100 | 100 |
| *15.87* | *8.3* | | | |
| 50 | 0.9 | 60 | 100 | 100 |
| *19.84* | *6.2* | | | |
| 60 | 0.7 | 41 | 100 | 100 |
| *23.80* | *4.8* | | | |
| 70 | 0.6 | 26 | 100 | 100 |
| *27.77* | *4.1* | | | |
| 80 | 0.5 | 16 | 94 | 100 |
| *31.74* | *3.4* | | | |
| 90 | 0.4 | 10 | 76 | 100 |
| *35.70* | *2.8* | | | |
| 100 | 0.3 | 6 | 55 | 100 |
| *39.67* | *2.1* | | | |
| 150 | 0.2 | 1 | 8 | 49 |
| *59.51* | *1.4* | | | |
| 328 | 0.0655 | 0 | 0.1 | 0.8 |
| *130.12* | *0.45* | | | |

| | |
|---|---|
| a | 12 inches x 24 inches x 0.088 inches float annealed (area = 2 $ft^2$) |
| | *30.5 centimeters (cm) x 61 cm x 0.223 cm float annealed (area = 0.186 square meters ( $m^2$))* |
| b | 24 inches x 24 inches x 0.088 inches float annealed (area = 4 $ft^2$) |
| | *61 cm x 61 cm x 0.223 cm float annealed (area = 0.372 $m^2$)* |
| c | 42 inches x 36 inches x 0.12 inches float annealed (area = 10.5 $ft^2$) |
| | *106.7 cm x 91.4 cm x 0.305 cm float annealed (area = 0.975 $m^2$)* |

V1.E8.2.1.4.2. Aboveground Structures. These are generally considered conventional structures and provide little protection from blast or fragmentation. (See paragraph V1.E8.2.5.)

V1.E8.2.1.4.3. Earth-covered Magazines (ECMs). High reflected pressure and impulse produced by an explosion at an adjacent ECM can damage doors and headwalls and propel debris into an ECM so that explosion is communicated by impact of such debris upon the contents. When separated from each other by the minimum distances required by Table V3.E3.T6., ECMs (see section V2.E5.5.) provide virtually complete protection of AE against the propagation effects of an explosion. However, AE in adjacent ECMs may be damaged and structural damage ranging from cracks in concrete, to damage to ventilators and doors, to complete structural failure, may occur. When ECMs containing HD 1.1 AE are sited so that any one is in the forward sector of another, the two must be separated by distances greater than the

minimum permitted for side-to-side orientations. 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.

V1.E8.2.1.4.4. Underground Storage Facilities. Underground facilities sited per V5.E5. provide a high degree of protection against propagation of an explosion between chambers, and between underground and aboveground structures. An HD 1.1 explosion in an underground storage facility causes very high pressures of prolonged duration. Blast waves and the accompanying gas flows will travel throughout the underground facility at high velocity.

V1.E8.2.1.4.5. Barricaded Open-storage Modules. Barricaded open-storage modules (see section V2.E5.6.) provide a high degree of protection against propagation of explosion. However, if flammable materials are present in nearby cells, subsequent propagation of explosion by fire is possible. When an explosion occurs, AE in adjacent modules separated by K1.1 [$K_m$ 0.44] will be thrown tens of meters, covered with earth, and unavailable for use until extensive uncovering operations, and possibly maintenance, are completed. Items at K2.52 [$K_m$ 1.0] separation distance from a donor explosion are expected to be readily accessible.

V1.E8.2.1.4.6. HPMs. When separated from other AE storage magazines by the minimum distances required by Table V3.E3.T6., the HPM provides virtually complete protection of AE against the propagation effects of an explosion. The HPM's 2-story transfer and storage areas are enclosed by a pre-engineered metal building, which may be severely damaged as a result of an explosion at a nearby PES. The amount of damage to be expected at various pressure levels is described in paragraph V1.E8.2.5. Access to the AE in an HPM may require extensive cleanup and the use of a mobile crane unless special design considerations are incorporated into the metal building design. The HPM contains multiple storage cells, which are designed to limit the MCE, as discussed in subparagraph V1.E7.3.1.3. In the event of an internal explosion involving the MCE, the pre-engineered metal building can be expected to be completely destroyed, and AE not involved in the explosion can be expected to be significantly damaged and no longer usable.

V1.E8.2.1.5. General Blast Effects on Personnel. Tables V1.E8.T~~3~~*4*. through V1.E8.T~~5~~*6*. describe the expected effects of blast on personnel.

V1.E8.2.1.6. Computation of Blast Effects. Many of the blast effects described in this section were computed with the DDESB Blast Effects Computer (DDESB Technical Paper 17 (Reference (k))), which can be used to estimate similar effects associated with various NEWs, facilities, and distances.

Table V1.E8.T~~34~~. General Blast Effects on Personnel – Eardrum Rupture

| ~~Effect~~ | ~~Incident Pressure (psi)~~<br>~~*Incident Pressure [kPa]*~~ | ~~K-Factor ($ft/lb^{1/3}$)~~<br>~~*$K_m$-Factor [$m/kg^{1/3}$]*~~ | ~~Probability (%)~~ |
|---|---|---|---|
| ~~Eardrum Rupture~~ | ~~3.0~~ | ~~20.0~~ | ~~1~~ |
| | ~~*20.7*~~ | ~~*7.87*~~ | |
| | ~~3.6~~ | ~~17.9~~ | ~~2~~ |
| | ~~*24.5*~~ | ~~*7.08*~~ | |
| | ~~4.9~~ | ~~14.6~~ | ~~5~~ |
| | ~~*33.8*~~ | ~~*5.78*~~ | |
| | ~~6.6~~ | ~~12.2~~ | ~~10~~ |
| | ~~*45.7*~~ | ~~*4.84*~~ | |
| | ~~9.0~~ | ~~10.3~~ | ~~20~~ |
| | ~~*62.1*~~ | ~~*4.10*~~ | |
| | ~~15.0~~ | ~~8.0~~ | ~~50~~ |
| | ~~*103.6*~~ | ~~*3.16*~~ | |
| | ~~74.4~~ | ~~3.9~~ | ~~99~~ |
| | ~~*513.0*~~ | ~~*1.55*~~ | |

| *Effect* | *Incident Pressure* (psi)<br>*[kPa]* | *K-Factor* ($ft/lb^{1/3}$)<br>*[$m/kg^{1/3}$]* | *Probability*<br>*Minor*[a]<br>*(%)* | *Moderate*[b]<br>*(%)* | *Major*[c]<br>*(%)* |
|---|---|---|---|---|---|
| *Eardrum Rupture* | 3.0<br>*20.7* | 20.0<br>*7.87* | *3.2* | *0.2* | *0* |
| | 3.6<br>*24.5* | 17.9<br>*7.08* | *7.3* | *0.7* | *0* |
| | 4.9<br>*33.8* | 14.6<br>*5.78* | *21.0* | *3.9* | *0* |
| | 6.6<br>*45.7* | 12.2<br>*4.84* | *41.3* | *12.8* | *0.2* |
| | 9.0<br>*62.1* | 10.3<br>*4.10* | *63.7* | *29.8* | *1.5* |
| | 15.0<br>*103.6* | 8.0<br>*3.16* | *88.8* | *65.0* | *15.1* |
| | 74.4<br>*513.0* | 3.9<br>*1.55* | *100* | *99.8* | *97.8* |

| | |
|---|---|
| *a* | *Minor rupture includes minor slits, and linear disruption of the drum fibers producing a meshlike effect.* |
| *b* | *Moderate rupture consists of large tears, or multiple small holes or tears.* |
| *c* | *Major rupture is total disruption of the drum with large flaps of drum.* |

Table V1.E8.T45. General Blast Effects on Personnel – Lung Damage

| ~~Effect~~ | ~~Incident Pressure (psi)~~<br>~~*Incident Pressure [kPa]*~~ | ~~Pulse Duration (ms)~~ |
|---|---|---|
| ~~Lung Damage~~ | ~~174~~<br>~~*1200*~~ | ~~0.5~~ |
| | ~~94~~<br>~~*648*~~ | ~~1~~ |
| | ~~31~~<br>~~*214*~~ | ~~5~~ |
| | ~~22~~<br>~~*152*~~ | ~~10~~ |
| | ~~15~~<br>~~*103.4*~~ | ~~50~~ |
| | ~~15~~<br>~~*103.4*~~ | ~~100~~ |

| *Effect* | *Incident Pressure* (psi)<br>*[kPa]* | *Pulse Duration (ms)* |
|---|---|---|
| *Threshold Lung Damage (standing person)* | 191.0<br>*1,316.9* | *0.2* |
| | 87.6<br>*604.0* | *0.5* |
| | 50.0<br>*344.8* | *1* |
| | 32.5<br>*224.1* | *2* |
| | 19.3<br>*133.1* | *5* |
| | 14.4<br>*99.3* | *10* |
| | 12.1<br>*83.4* | *20* |
| | 10.9<br>*75.2* | *50* |
| | 10.5<br>*72.4* | *100* |

Table V1.E8.T~~5~~6. General Blast Effects on Personnel – Lethality Due to Lung Rupture

| ~~Effect[a]~~ | ~~Weight (lbs)~~ / ~~*Weight [kg]*~~ | ~~Range (ft)~~ / ~~*Range [m]*~~ | ~~K-Factor (ft/lb$^{1/3}$)~~ / ~~*$K_m$-Factor [m/kg$^{1/3}$]*~~ | ~~Incident Pressure (psi)~~ / ~~*Incident Pressure [kPa]*~~ | ~~Pulse Duration (ms)~~ | ~~Positive Impulse (psi-ms)~~ / ~~*Positive Impulse [kPa-s]*~~ |
|---|---|---|---|---|---|---|
| ~~Lethality due to Lung Rupture~~ | ~~8,000~~ / ~~*3,628.7*~~ | ~~35.8~~ / ~~*10.92*~~ | ~~1.79~~ / ~~*0.71*~~ | ~~386.9~~ / ~~*2,667.8*~~ | ~~8.8~~ | ~~412.5~~ / ~~*2,844.5*~~ |
| | ~~27,000~~ / ~~*12,247*~~ | ~~99.8~~ / ~~*30.42*~~ | ~~3.33~~ / ~~*1.32*~~ | ~~107.1~~ / ~~*738.3*~~ | ~~51.1~~ | ~~665.6~~ / ~~*4,589.2*~~ |
| | ~~125,000~~ / ~~*56,699*~~ | ~~189.8~~ / ~~*57.85*~~ | ~~3.80~~ / ~~*1.51*~~ | ~~79.3~~ / ~~*546.6*~~ | ~~82.6~~ | ~~985.3~~ / ~~*6,793.8*~~ |

~~a~~ ~~Lethality due to lung rupture is caused by a combination of pressure and impulse. This combination will vary with the charge weight. In this example, the probability of lethality is assumed to be 99.9 percent.~~

| *Effect[a]* | *Probability* | *Weight* | *Range* | *K-Factor* | *Incident Pressure* | *Pulse Duration* | *Positive Impulse* |
|---|---|---|---|---|---|---|---|
| | *%* | (lbs) / *[kg]* | (ft) / *[m]* | (ft/lb$^{1/3}$) / *[m/kg$^{1/3}$]* | (psi) / *[kPa]* | *(ms)* | (psi-ms) / *[Pa-s]* |
| *Lethality Due to Lung Rupture* | *1* | 8,000 / *3,628.7* | 95.0 / *29.0* | 4.75 / *1.88* | 47.2 / *325.4* | *31.3* | 317.5 / *2,189.1* |
| | | 27,000 / *12,247.0* | 155.0 / *47.2* | 5.19 / *2.06* | 38.5 / *265.4* | *47.4* | 437.9 / *3,019.2* |
| | | 125,000 / *56,699.0* | 277.6 / *84.6* | 5.55 / *2.20* | 33.0 / *227.5* | *80.9* | 685.2 / *4,724.2* |
| | *50* | 8,000 / *3,628.7* | 76.1 / *23.2* | 3.80 / *1.51* | 79.0 / *544.7* | *33.0* | 393.5 / *2,713.1* |
| | | 27,000 / *12,247.0* | 128.4 / *39.1* | 4.28 / *1.70* | 60.1 / *414.4* | *47.8* | 526.7 / *3,631.5* |
| | | 125,000 / *56,699.0* | 234.1 / *71.4* | 4.68 / *1.86* | 48.8 / *336.5* | *78.4* | 805.1 / *5,551.0* |
| | *99* | 8,000 / *3,628.7* | 57.7 / *17.6* | 2.89 / *1.15* | 146.8 / *1,012.1* | *32.6* | 493.4 / *3,401.8* |
| | | 27,000 / *12,247.0* | 103.8 / *31.6* | 3.46 / *1.37* | 97.9 / *675.0* | *50.8* | 643.2 / *4,434.7* |
| | | 125,000 / *56,699.0* | 195.8 / *59.7* | 3.92 / *1.56* | 73.8 / *508.8* | *81.8* | 956.5 / *6,594.8* |

*a* *Lethality due to lung rupture is caused by a combination of pressure and impulse. This combination will vary with the charge weight.*

V1.E8.2.2. Fragments. An important consideration in the analysis of the hazards associated with an explosion is the effect of any fragments produced. Although most common in HD 1.1 or HD 1.2 events, fragmentation may occur in any incident involving AE. Depending on their origin, fragments are referred to as "primary" or "secondary" fragments.

V1.E8.2.2.1. Primary fragments result from the shattering of a container (e.g., shell casings, kettles, hoppers, and other containers used in the manufacture of explosives; rocket engine housings) in direct contact with the explosive. These fragments usually are small, initially travel at thousands of feet per second, and may be lethal at long distances from an explosion.

V1.E8.2.2.2. Secondary fragments are debris from structures and other items in close proximity to the explosion. These fragments, which are somewhat larger in size than primary fragments and initially travel at hundreds of feet per second, do not normally travel as far as primary fragments.

V1.E8.2.2.3. The earth cover of an underground facility may rupture and create a significant debris hazard.

V1.E8.2.2.4. A hazardous fragment is one having an impact energy of 58 ft-lbs [79 joules] or greater.

V1.E8.2.2.5. The hazardous fragment distance is the distance at which the areal density of hazardous fragments or debris becomes one per 600 $ft^2$ [55.7 $m^2$].

V1.E8.2.3. Thermal Hazards

V1.E8.2.3.1. General. Thermal hazards from an HD 1.1 event are generally of less concern than blast and fragment hazards.

V1.E8.2.3.2. Personnel. It normally takes longer to incur injury from thermal effects than from either blast or fragmentation effects because both blast and fragmentation occur almost instantaneously. The time available to react to a thermal event increases survivability.

V1.E8.2.3.3. Structures, Material, and AE. The primary thermal effect on structures, material, and AE is their partial or total destruction by fire. The primary concern with a fire involving AE is that it may transition to a more severe reaction, such as a detonation.

V1.E8.2.4. Ground Shock and Cratering

V1.E8.2.4.1. General

V1.E8.2.4.1.1. In an airburst, there may be a downward propagation of ground shock and cratering may be reduced or eliminated.

V1.E8.2.4.1.2. In a surface burst, ground shock is generated and cratering can be significant.

V1.E8.2.4.1.3. A buried or partially buried detonation produces the strongest ground shock; however, if the explosion is deep enough, no crater will be formed.

V1.E8.2.4.2. Underground Facilities. AE protection can be achieved by proper chamber spacing. An HD 1.1 explosion will produce ground shocks that may rupture the earth cover and eject debris. (See V5.E5.)

V1.E8.2.5. Expected Consequences

V1.E8.2.5.1. Barricaded Aboveground Magazine (AGM) Distance - $6W^{1/3}$ ft [$2.38Q^{1/3}$ m] - 27 psi [186.1 kPa]

V1.E8.2.5.1.1. Effects at This Distance

V1.E8.2.5.1.1.1. Unstrengthened buildings will be destroyed.

V1.E8.2.5.1.1.2. Personnel will be killed by blast, being struck by debris, or impact against hard surfaces.

V1.E8.2.5.1.1.3. Transport vehicles will be overturned and crushed by the blast.

V1.E8.2.5.1.1.4. Explosives-loaded vessels will be damaged severely, with propagation of explosion likely.

V1.E8.2.5.1.1.5. Aircraft will be destroyed by blast, thermal, and debris effects.

V1.E8.2.5.1.2. Control. Barricades are effective in preventing immediate propagation of explosion by high-velocity, low-angle fragments. However, they provide only limited protection against any delayed propagation of explosives caused by a fire resulting from high-angle firebrands.

V1.E8.2.5.2. Barricaded ILD - $9W^{1/3}$ ft [$3.57Q^{1/3}$ m] - 12 psi [82.7 kPa]

V1.E8.2.5.2.1. Effects at This Distance

V1.E8.2.5.2.1.1. Unstrengthened buildings will suffer severe structural damage approaching total destruction.

V1.E8.2.5.2.1.2. Personnel will be subject to severe injuries or death from direct blast, building collapse, or translation.

V1.E8.2.5.2.1.3. Aircraft will be damaged beyond economical repair both by blast and fragments. If the aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires.

V1.E8.2.5.2.1.4. Transport vehicles will be damaged heavily, probably to the extent of total loss.

V1.E8.2.5.2.1.5. Improperly designed barricades or structures may increase the hazard from flying debris, or may collapse in such a manner as to increase the risk to personnel and equipment.

V1.E8.2.5.2.2. Control. Barricading is required. Direct propagation of explosion between two explosive locations is unlikely when barricades are placed between them to intercept high-velocity, low-angle fragments. Exposed structures containing high-value, mission-critical equipment or personnel may require hardening.

V1.E8.2.5.3. Unbarricaded AGM Distance - $11W^{1/3}$ ft [$4.36Q^{1/3}$ m] - 8 psi [55.3 kPa]

V1.E8.2.5.3.1. Effects at This Distance

V1.E8.2.5.3.1.1. Unstrengthened buildings will suffer damage approaching total destruction.

V1.E8.2.5.3.1.2. Personnel are likely to be injured seriously due to blast, fragments, debris, and translation.

V1.E8.2.5.3.1.3. There is a 15-percent risk of eardrum rupture.

V1.E8.2.5.3.1.4. Explosives-loaded vessels are likely to be damaged extensively and delayed propagation of explosion may occur.

V1.E8.2.5.3.1.5. Aircraft will be damaged heavily by blast and fragments; destruction by resulting fire is likely.

V1.E8.2.5.3.1.6. Transport vehicles will sustain severe body damage, minor engine damage, and total glass breakage.

V1.E8.2.5.3.2. Control. Barricading will significantly reduce the risk of propagation of explosion and injury of personnel by high-velocity, low-angle fragments.

V1.E8.2.5.4. Unbarricaded ILD - $18W^{1/3}$ ft [$7.14Q^{1/3}$ m] - 3.5 psi [24 kPa]

V1.E8.2.5.4.1. Effects at This Distance

V1.E8.2.5.4.1.1. Direct propagation of explosion is not expected.

V1.E8.2.5.4.1.2. Delayed propagation of an explosion may occur at the ES, as either a direct result of a fire or as a result of equipment failure.

V1.E8.2.5.4.1.3. Damage to unstrengthened buildings may approximate 50 percent or more of the total replacement cost.

V1.E8.2.5.4.1.4. There is a 2-percent chance of eardrum damage to personnel.

V1.E8.2.5.4.1.5. Personnel may suffer serious injuries from fragments, debris, firebrands, or other objects.

V1.E8.2.5.4.1.6. Fragments could damage the decks and superstructure of cargo ships and overpressure could buckle their doors and bulkheads on weather decks.

V1.E8.2.5.4.1.7. Aircraft can be expected to suffer considerable structural damage from blast. Fragments and debris are likely to cause severe damage to aircraft at distances calculated from the formula $18W^{1/3}$ [$7.2Q^{1/3}$] when small quantities of explosives are involved.

V1.E8.2.5.4.1.8. Transport vehicles will incur extensive, but not severe, body and glass damage consisting mainly of dishing of body panels and cracks in shatter-resistant window glass.

V1.E8.2.5.4.2. Control. Suitably designed suppressive construction at the PES or protective construction at the ES may be practical for some situations. Such construction is encouraged when there is insufficient distance to provide the required protection.

V1.E8.2.5.5. PTRD (under 100,000 lbs of HE) - $24W^{1/3}$ ft [$9.52Q^{1/3}$ m] - 2.3 psi [15.8 kPa]

V1.E8.2.5.5.1. Effects at This Distance

V1.E8.2.5.5.1.1. Unstrengthened buildings can be expected to sustain damage approximately 20 percent of the replacement cost.

V1.E8.2.5.5.1.2. Occupants of exposed structures may suffer temporary hearing loss or injury from blast effects, building debris, and displacement.

V1.E8.2.5.5.1.3. Although personnel in the open are not expected to be killed or seriously injured by blast effects, fragments and debris may cause some injuries. The extent of these injuries depends largely upon the PES structure and the amount and fragmentation characteristics of the AE involved.

V1.E8.2.5.5.1.4. Vehicles on the road should suffer little damage, unless they are hit by a fragment or the blast causes a momentary loss of control.

V1.E8.2.5.5.1.5. Aircraft may suffer some damage to the fuselage from blast and possible fragment penetration, but should be operational with minor repair.

V1.E8.2.5.5.1.6. Cargo-type ships should suffer minor damage to deck structure and exposed electronics from blast and possible fragment penetration, but such damage should be readily repairable.

V1.E8.2.5.5.2. Control. Barricading can reduce the risk of injury or damage due to fragments for limited quantities of AE at a PES. When practical, suitably designed suppressive construction at the PES or protective construction at the ES may also provide some protection.

V1.E8.2.5.6. PTRD (over 250,000 lbs HE) - $30W^{1/3}$ ft [$11.9Q^{1/3}$ m] - 1.7 psi [11.7 kPa]

V1.E8.2.5.6.1. Effects at This Distance

V1.E8.2.5.6.1.1. Unstrengthened buildings can be expected to sustain damage that may approximate 10 percent of their replacement cost.

V1.E8.2.5.6.1.2. Occupants of exposed, unstrengthened structures may be injured by secondary blast effects, such as falling building debris.

V1.E8.2.5.6.1.3. Pilots of aircraft that are landing or taking off may lose control and crash.

V1.E8.2.5.6.1.4. Parked military and commercial aircraft will likely sustain minor damage due to blast, but should remain airworthy.

V1.E8.2.5.6.1.5. Although personnel in the open are not expected to be killed or seriously injured by blast effects, fragments and debris may cause some injuries. The extent of these injuries will largely depend upon the PES structure, the NEW, and the fragmentation characteristics of the AE involved.

V1.E8.2.5.6.2. Control. Barricading or the application of minimum fragmentation distance requirements may reduce the risk of injury or damage due to fragments for limited quantities of AE at a PES.

V1.E8.2.5.7. IBD - $40W^{1/3}$ ft to $50W^{1/3}$ ft [$15.87Q^{1/3}$ m to $19.8Q^{1/3}$ m] - 1.2 psi to 0.90 psi [8.3 kPa to 6.2 kPa]

V1.E8.2.5.7.1. Effects at This Distance

V1.E8.2.5.7.1.1. Unstrengthened buildings can be expected to sustain damage that approximates five percent of their replacement cost.

V1.E8.2.5.7.1.2. Personnel in buildings are provided a high degree of protection from death or serious injury; however, glass breakage and building debris may still cause some injuries.

V1.E8.2.5.7.1.3. Personnel in the open are not expected to be injured seriously by blast effects. Fragments and debris may cause some injuries. The extent of injuries will depend upon the PES structure and the NEW and fragmentation characteristics of the AE involved.

V1.E8.2.5.7.2. Control. Elimination of glass surfaces is the best control. If determined to be necessary, reducing the use of glass or the size of any glass surfaces and the use of blast-resistant glass will provide some relief. For new construction, building design characteristics**,** to include consideration of how any required glass surfaces are oriented and use of blast-resistant glass, can reduce glass breakage and structural damage.

## V1.E8.3. HD 1.2 EFFECTS

### V1.E8.3.1. Blast

V1.E8.3.1.1. HD 1.2, when not stored with HD 1.1 or HD 1.5, is not expected to mass detonate. In an incident involving HD 1.2, when stored by itself or with HD 1.3, HD 1.4, or HD 1.6 (an HD 1.2 event), AE can be expected to both explode sporadically and burn. Fire will propagate through the mass of the AE over time. Some AE may neither explode nor burn. Blast effects from the incident are limited to the immediate vicinity and are not considered to be a significant hazard.

V1.E8.3.1.2. An HD 1.2 event may occur over a prolonged period of time. Generally, the first reactions are relatively nonviolent and, typically, begin a few minutes after flames engulf the AE. Later reactions tend to be more violent. Reactions can continue for some time (hours), even after a fire is effectively out. Generally, smaller AE tends to react earlier in an incident than larger AE.

V1.E8.3.1.3. The results of an accidental explosion in an underground facility will depend on the type and quantity of munitions, the type of explosion produced, and the layout of the facility. Hazards created outside the underground facility will likely not be as severe as those produced by HD 1.1 or HD 1.3 material.

### V1.E8.3.2. Fragments

V1.E8.3.2.1. The primary hazard from an HD 1.2 event is fragmentation. Fragmentation may include primary fragments from AE casings or secondary fragments from containers and structures. At longer ranges, primary fragments are the major contributors to fragment hazards.

V1.E8.3.2.2. During an HD 1.2 event, fragmentation may extensively damage exposed facilities. However, less fragmentation damage can be expected from a given quantity of HD 1.2 than would be expected from the corresponding quantity of HD 1.1 because not all the HD 1.2 will react.

### V1.E8.3.3. Thermal Hazards

V1.E8.3.3.1. An incident involving a quantity of HD 1.2 poses considerably less thermal risk to personnel than an incident involving corresponding quantities of either HD 1.1 or HD 1.3 because an HD 1.2 event's progressive nature allows personnel to immediately evacuate the area.

V1.E8.3.3.2. A HD 1.2 event's progressive nature provides an opportunity for a fire suppression system, if installed, to put out a fire in its early stages.

V1.E8.3.4. Ejected Items. In HD 1.2 events, a reaction may eject (lob) unreacted-AE or AE components from the event site. These ejected items may subsequently react.

V1.E8.3.5. Propelled Items. In HD 1.2 events, some AE or AE components may become propulsive and travel well beyond IBD.

V1.E8.3.6. Firebrands. In an incident involving only HD 1.2 or HD 1.2 with HD 1.4, firebrands are considered to be a hazard only in the immediate vicinity of the incident site.

V1.E8.3.7. Expected Consequences

V1.E8.3.7.1. The expected consequences for HD 1.2 AE are similar to those for HD 1.1. The effects of HD 1.2 AE are NEW dependent.

V1.E8.3.7.2. The principal hazard to personnel in the open, to aircraft, and to occupied vehicles is fragments.

V1.E8.3.7.3. Airblast, fragment, and thermal hazards to buildings and parked aircraft or vehicles cannot be predicted reliably because the effects will depend on the MCE.

V1.E8.4. HD 1.3 EFECTS

V1.E8.4.1. Gas Pressures. In an incident involving only HD 1.3 or HD 1.3 with HD 1.4 (an HD 1.3 event):

V1.E8.4.1.1. Where sufficient venting is provided, gas pressures generated by the event are not a significant concern. Examples of sites with sufficient venting include open storage and structures where internal pressures do not exceed 1-2 psi [6.9-13.8 kPa] (non-confinement structure).

V1.E8.4.1.2. Where venting is insufficient, internal gas pressures may be substantial. In such situations, these pressures may blow out vent panels or frangible walls and, in some instances, cause partial or complete structural failure.

V1.E8.4.1.3. Where there is minimal venting and structural containment (extreme confinement), a detonation of the HD 1.3 may occur with effects similar to those of an HD 1.1 explosion. For example, HD 1.3 AE is considered HD 1.1 (mass explosion) for QD purposes when stored in underground chambers.

V1.E8.4.2. Fragments. In an HD 1.3 event, fragments are considerably less hazardous than those produced by HD 1.1 and HD 1.2 events. Internal gas pressures may produce fragments from the bursting of containers or the rupture of containment facilities. In general, such fragments will be large and of low velocity. (For exceptions, see subparagraph V1.E8.4.1.3.)

V1.E8.4.3. Thermal Hazards. In an HD 1.3 event, heat flux presents the greatest hazard to personnel and assets. Energetic materials in HD 1.3 articles include both fuel components and oxidizers. Burning these materials emits fuel-rich flammable gases, fine particles, or both. This unburned material may ignite when it comes in contact with air and cause a large fireball. This fireball will expand radially from the ignition site and could wrap around obstacles, even those designed to provide line-of-sight protection from HD 1.1 events. Shields and walls can be designed to provide protection from thermal effects. (See Enclosure 9 of this Volume.)

V1.E8.4.3.1. The nominal spherical fireball that would be expected from the rapid burning of HD 1.3 can be calculated by $D_{FIRE} = 10 \times W_{EFF}^{1/3}$ where "$D_{FIRE}$" is the diameter of the fireball (ft) and "$W_{EFF}$" is the quantity of HD 1.3 involved (lbs), multiplied by a 20-percent safety factor (e.g., "W" of 100 lbs = "$W_{EFF}$" of 120 lbs) [$D_{FIRE}$ (m) = 3.97 x $W_{EFF}$ (kg) $^{1/3}$].

V1.E8.4.3.2. In addition to the fireball itself, the thermal flux from the fireball can ignite fires out to IMD.

V1.E8.4.4. Propelled Items. In an HD 1.3 event, some AE or AE components may become propulsive and travel well beyond IBD.

V1.E8.4.5. Firebrands. In an HD 1.3 event, a severe fire-spread hazard may result from firebrands projected from the incident site. Firebrands can be expected to be thrown more than 50 ft [15.2 m] from an HD 1.3 event. Firebrands can ignite fires well beyond the distance to which a fireball poses a threat.

V1.E8.4.6. Expected Consequences

V1.E8.4.6.1. Exposed personnel may receive severe burns from fireballs or flash burning in an HD 1.3 event. The hazard distance is dependent on the quantity and burning rate of the HD 1.3 involved.

V1.E8.4.6.2. Buildings, vehicles, and aircraft may be ignited by radiant heat, sparks, or firebrands or may be damaged by heat (searing, buckling, etc.).

V1.E8.4.6.3. Personnel in nearby buildings, vehicles, or aircraft may be injured unless evacuated before heat conditions reach hazardous levels.

V1.E8.5. HD 1.4 EFFECTS

V1.E8.5.1. Blast. There is no blast associated with an incident involving only HD 1.4 (an HD 1.4 event).

V1.E8.5.2. Fragmentation. An HD 1.4 event will not produce fragments of appreciable energy (i.e., greater than 14.8 ft-lbs [20 joules]). Fragments from HD 1.4S have energies less than or equal to 5.9 ft-lbs [8 joules].

V1.E8.5.3. Thermal Hazard. AE given this designation are considered to provide only a moderate fire hazard. A fireball or jet of flame may extend 3 ft [1 m] beyond the location of the HD 1.4 event. A burning time of less than 330 seconds (5.5 minutes) for 220 lbs [100 kg] of the HD 1.4 AE is expected.

V1.E8.5.4. Firebrands. No fiery projections are expected beyond 50 ft [15.2 m].

V1.E8.5.5. CG S Items. HD 1.4 AE assigned a CG S designation (see subparagraph V1.E6.2.2.13.) is the most benign of all AE. In an HD 1.4 event that only involves CG S, the expected blast, thermal, and projection effects will not significantly hinder firefighting or other emergency responses.

V1.E8.5.6. Expected Consequences. There may be minor consequences (projection, fire, smoke, heat, or loud noise) beyond the AE itself.

V1.E8.6. HD 1.5 EFFECTS. HD 1.5 effects are similar to those produced by HD 1.1, without the fragmentation effects.

V1.E8.7. HD 1.6 EFFECTS. HD 1.6 effects are similar to those produced by HD 1.3.

# ENCLOSURE 9

# PERSONNEL PROTECTION

V1.E9.1. SCOPE AND APPLICATION. This enclosure establishes blast, fragment, and thermal hazards protection principles. It applies to all operations and facilities within an explosives safety QD arc in which personnel are exposed to AE hazards. Reference (g) contains design procedures to achieve personnel protection, protect facilities and equipment, and prevent propagation of explosions.

V1.E9.2. RISK ASSESSMENT. The responsible DoD Component shall perform a risk assessment on new or modified operations and facilities involving AE. Based upon such an assessment, engineering design criteria for facilities and operations shall be developed for use in the selection of equipment, shielding, engineering controls, and protective clothing for personnel.

V1.E9.2.1. The risk assessment shall include:

V1.E9.2.1.1. Initiation sensitivity.

V1.E9.2.1.2. Quantity of materials.

V1.E9.2.1.3. Heat output.

V1.E9.2.1.4. Rate of burn.

V1.E9.2.1.5. Potential ignition and initiation sources.

V1.E9.2.1.6. Protection capabilities of shields, various types of clothing, and fire protection systems.

V1.E9.2.1.7. Personnel exposure.

V1.E9.2.2. New or modified facilities located within the IBD arc of any PES, and that include glass panels and contain personnel, shall have a glass breakage personnel hazards risk assessment conducted.

V1.E9.3. PERMISSIBLE EXPOSURES

V1.E9.3.1. Accidental Ignition or Initiation of Explosives

V1.E9.3.1.1. When a risk assessment indicates that there is an unacceptable risk from an accidental explosion or a flash fire, personnel shall be provided protection from blast, fragments, and thermal effects, to include respiratory and circulatory hazards.

V1.E9.3.1.2. When required, personnel protection must limit incident blast overpressure to 2.3 psi [15.9 kPa], fragments to energies of less than 58 ft-lbs [79 joules], and thermal fluxes to ~~0.3 calories per square centimeter ($cm^2$) per second [12.56 kilowatts (kW) per $m^2$]~~ *prevent the onset of second-degree burns (heat fluxes and exposure times experienced by personnel should be less than that given by the equation $t=200q^{-1.46}$ where "t" is the time in seconds that a person is exposed and "q" is the received heat flux in kilowatts (kW) per $m^2$).*

V1.E9.3.1.3. K24 [$K_m$9.52] distance provides the required level of protection for blast and thermal effects only.

V1.E9.3.1.4. Shields that comply with Military Standard MIL-STD-398 (Reference (l)) provide acceptable protection for blast, thermal, and fragment effects.

V1.E9.3.2. Intentional Ignition or Initiation of AE. At operations (e.g., function, proof, lot acceptance testing) where intentional ignition or initiation of AE are conducted and where shielding is required, as determined on a case-by-case basis by the DoD Component concerned, personnel protection shall:

V1.E9.3.2.1. Meet the requirements of subparagraph V1.E9.3.1.2.

V1.E9.3.2.2. Limit overpressure levels in personnel-occupied areas to satisfy Military Standard MIL-STD-1474D (Reference (m)).

V1.E9.3.2.3. Contain or defeat all fragments.

V1.E9.3.2.4. Limit thermal flux ~~to $0.62t^{-0.7423}$ calories/$cm^2$/second where "t" is the time in seconds that a person is exposed to the radiant heat~~ *and exposure time to prevent the onset of second-degree burns (heat fluxes and exposure times experienced by personnel should be less than that given by the equation $t=200q^{-1.46}$ where "t" is the time in seconds that a person is exposed and "q" is the received heat flux in kW/$m^2$).* Shields that comply with Reference (l) provide acceptable protection.

V1.E9.4. PROTECTIVE MEASURES. Personnel protection may be achieved by:

V1.E9.4.1. Eliminating or establishing positive control of ignition and initiation stimuli.

V1.E9.4.2. Using sufficient distance or barricades to protect from blast or fragments.

V1.E9.4.3. Using fire detection and extinguishing systems (e.g., infrared actuated deluge system) in those areas where exposed, thermally energetic materials that have a high probability of ignition and a large thermal output are handled. Such systems shall maximize the speed of detection, have adequate capacity to extinguish potential flash fires in their incipient state, and maximize the speed of the application of the extinguishing agent.

V1.E9.4.4. Using thermal shielding between the thermal source and personnel in AE operational areas, where it is essential for personnel to be present and the risk assessment indicates that an in-process thermal hazard exists. Any shielding used shall comply with Reference (l). When shielding is either not possible or inadequate, to include a failure to protect exposed personnel's respiratory and circulatory systems, augmentation with improved facility engineering design and personnel protective clothing and equipment may be necessary.

V1.E9.4.5. Using thermal protective clothing that is capable of limiting bodily injury to ~~first degree burns (0.3 calories/cm$^2$/second [12.56 kW/m$^2$])~~ *prevent second-degree burns (heat fluxes and exposure times experienced by personnel should be less than that given by the equation $t=200q^{-1.46}$ where "t" is the time in seconds that a person is exposed and "q" is the received heat flux in kW/m$^2$)* with personnel taking turning-evasive action, when the maximum quantity of combustible material used in the operation is ignited.

V1.E9.4.6. Using protective clothing capable of providing respiratory protection from the inhalation of hot vapors or any toxicological effects, when the risk assessment indicates adverse effects would be encountered from the inhalation of combustion products.

V1.E9.4.7. Minimizing the number and size of glass panels in an ES and, if possible, orienting the ES to minimize blast loads on glass panels, when a risk assessment (see section V1.E9.2.) indicates that a glass hazard is present.

V1.E9.4.7.1. When use of window panels is determined to be necessary and a risk assessment determines that there will be an associated glass hazard, blast-resistant windows of sufficient strength, as determined by an engineering analysis, shall be used for:

V1.E9.4.7.1.1. Existing ESs, upon major modification or modified operations.

V1.E9.4.7.1.2. New construction; however, the use of glass panels in new construction should be avoided.

V1.E9.4.7.2. The framing and sash of such panels shall be of sufficient strength to retain the panel in the structure for the expected blast loads from an explosion at any PES.

V1.E9.5. QRA. A QRA tool for risk management of explosives storage and operating scenarios, and the associated exposures (related or unrelated personnel and facilities) to those scenarios, can provide for a comparison of risks prior to acceptance of risks associated with the selected scenarios. (See V6.E5. for additional information on QRA.)

# ENCLOSURE 10

# HAZARD IDENTIFICATION FOR FIREFIGHTING AND EMERGENCY PLANNING

## V1.E10.1. SCOPE AND APPLICATION

V1.E10.1.1. This enclosure establishes standard firefighting hazard identification measures to ensure a minimum practicable risk in fighting fires involving AE. These identification measures are based on the classification of AE fires into four fire divisions according to their predominant hazard. Guidelines are provided to DoD Components for the development of emergency plans, which include safety, security, and environmental protection. These plans shall be coordinated with local authorities.

V1.E10.1.2. The following are outside the scope of this enclosure and are the responsibility of the DoD Component:

V1.E10.1.2.1. Firefighting procedures.

V1.E10.1.2.2. Training of firefighting personnel.

V1.E10.1.2.3. Use and maintenance of firefighting equipment and vehicles.

V1.E10.1.2.4. Provision of water supply and alarm systems.

V1.E10.1.2.5. First-aid measures.

V1.E10.1.2.6. Other measures required in firefighting.

V1.E10.1.3. AE hazard symbols and supplemental symbols including CA symbols (see section V1.E10.4.) are for firefighting situations.

## V1.E10.2. FIRE DIVISIONS

V1.E10.2. FIRE DIVISIONS. There are four fire divisions. Fire division 1 indicates the greatest hazard. The hazard decreases with ascending fire division numbers from 1 to 4 and is related to the HD as shown in Table V1.E10.T~~1~~7.

Table V1.E10.T~~1~~7. Fire Divisions

| Fire Division | Predominant Hazard | HD |
|---|---|---|
| 1 | Mass explosion | 1.1 and 1.5 |
| 2 | Non-mass explosion, fragment producing | 1.2 and 1.6 |
| 3 | Mass fire, minor blast or fragment | 1.3 |
| 4 | Moderate fire, no blast or fragment | 1.4 |

V1.E10.3. FIRE DIVISION SYMBOLS

V1.E10.3.1. The four fire divisions are represented by four distinctive symbols so that firefighting personnel can recognize the hazards. A fire division number is shown on each symbol. For the purpose of identifying these symbols from long range, the symbols differ in shape as shown in Table V1.E10.T~~2~~*8*.

Table V1.E10.T~~2~~*8*. Fire Division Symbols

| Shape | Fire Division Symbol |
|---|---|
| Octagon | 1 |
| Cross | 2 |
| Inverted Triangle | 3 |
| Diamond | 4 |

V1.E10.3.2. The shape and dimensions of the symbols are shown in Figure V1.E10.F~~1~~*2*. This shape and color scheme is consistent with United Nations, North Atlantic Treaty Organization, and International Maritime Organization requirements. For application on doors or lockers inside buildings, half-sized symbols may be used.

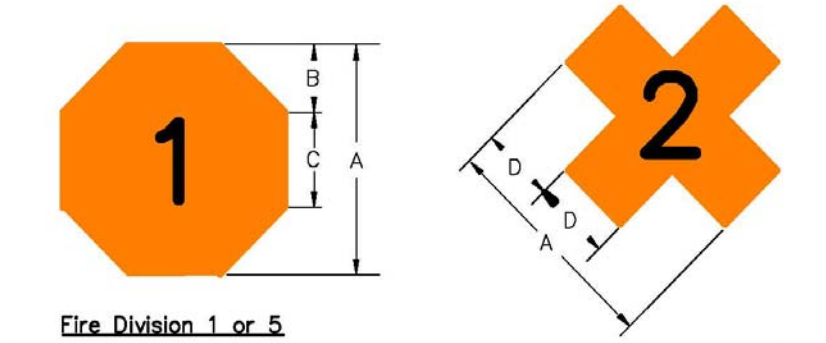
V1.E10.3.3. At the discretion of the DoD Components, circumstances (e.g., security) may make it undesirable to post fire symbols at an AE storage site.

V1.E10.4. CA AND CHEMICAL MUNITION HAZARD SYMBOLS

V1.E10.4.1. The storage of CAs and chemical munitions requires the use of chemical hazard symbols. These symbols (see Figures V1.E10.F~~2~~*3*. and V1.E10.F~~3~~*4*.) shall be used in conjunction with fire symbols, where appropriate. Some of the common CAs used in AE, the CG of that AE, and the chemical hazard symbols required in storage are specified in Table V1.E10.T~~3~~*9*.

V1.E10.4.2. The following sections describe these symbols, the hazards indicated by the symbols, and the recommended protective clothing and equipment to be used for fighting fires involving these CAs and chemical munitions. The DoD Components shall determine protective clothing requirements for other than firefighting situations.

Figure V1.E10.F~~1~~2. Fire Division Symbols



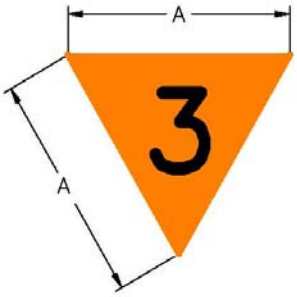

Fire Division 1 or 5

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




Fire Division 2 or 6

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




Fire Division 3

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

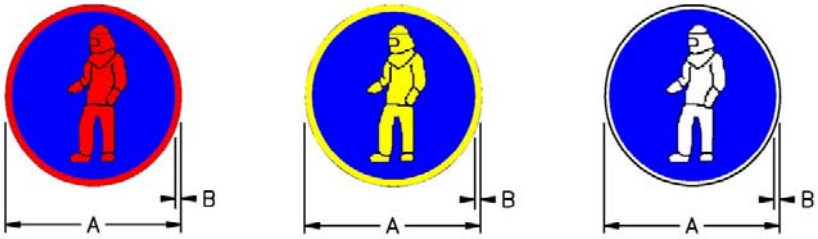

Fire Division 4

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

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

Colors (per Federal Standard 595C (Reference (n)) or
General Services Administration (GSA) Catalog)
Background: Orange #12246
Letters: Black #17038

Figure V1.E10.F~~2~~3. Chemical Hazard Symbols

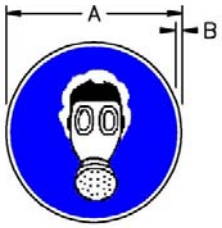



Symbol 1. Wear full protective clothing.
Background is blue, and figure and rim are as follows:

Red for Set 1 Protective Clothing:
24-inch: NSN 7690-01-081-9586
12-inch: NSN 7690-01-081-9585

Yellow for Set 2 Protective Clothing:
24-inch: NSN 7690-01-081-9587
12-inch: NSN 7690-01-082-0291

White for Set 3 Protective Clothing:
24-inch: NSN 7690-01-083-6272
12-inch: NSN 7690-01-081-9588



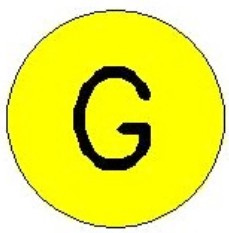

Symbol 2. Wear breathing apparatus.
Background is blue.
Figure and rim are white.
24-inch: NSN 7690-01-081-9589
12-inch: NSN 7690-01-082-6710


Symbol 3. Apply no water.
Background is white.
Circle and Diagonal are red.
Figures are in black.
24-inch: NSN 7690-01-082-2254
12-inch: NSN 7690-01-082-0292

| Dimensions | Large Symbol | | Small Symbol | |
|---|---|---|---|---|
| | inches | metric (mm) | inches | metric (mm) |
| A | 24 | 610 | 12 | 305 |
| B | .5 | 13 | .25 | 6 |
| C | 2 | 51 | 1 | 25 |

Colors (per Reference (n) or GSA Catalog)
Red #11105
Blue #15102
Yellow #13538
White #17875
Black #17038

Figure V1.E10.F~~3~~4. Supplemental Chemical Hazard Symbols

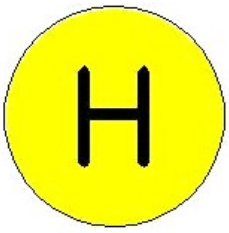



G–Type Nerve Agents

24–inch: NSN 7690–01–082–5418
12–inch: NSN 7690–01–081–7481

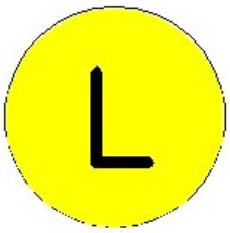

VX Nerve Agents

24–inch: NSN 7690–01–081–7483
12–inch: NSN 7690–01–081–7482




H–Type Mustard Agents

24–inch: NSN 7690–01–082–6713
12–inch: NSN 7690–01–083–1663




Lewisite

24–inch: NSN 7690–01–082–6715
12–inch: NSN 7690–01–082–6714

Colors (per Reference (n) or GSA Catalog)
Background: Yellow #13538
Letters: Black #17038, as follows:

12 inches [305 mm] high and 2 inches [51 mm] thick on a 24-inch [610-mm] diameter circle
6 inches [152 mm] high and 1 inch [25 mm] thick on a 12-inch [305-mm] diameter circle

Table V1.E10.T~~3~~9. CG and Chemical Hazard Symbols Required for Storage of Chemical Ammunition and Substances

| CAs and Munitions | CG[a] | Full Protective Clothing | | | Breathing Apparatus | Apply No Water |
|---|---|---|---|---|---|---|
| | | Set 1 | Set 2 | Set 3 | | |
| Toxic Agents[b] | K | X | | | | |
| Tear Gas, O-Chlorobenzol | G | | X | | | |
| Smoke, Titanium Tetrachloride | G | | X | | | |
| Smoke, Sulphur trioxide-chlorosulphonic acid solution | G | | X | | | |
| Smoke, Aluminum-zinc oxide-hexachloroethane | G | | | | X | X |
| WP | H | | | X | | |
| PWP | H | | | X | | |
| Thermite or Thermate | G | | | | X | X |
| Pyrotechnic Material (common name for a magnesium incendiary mixture with an agent symbol of "PT") | G | | | | X | X |
| Calcium Phosphide | L | | | | X | X |
| Signaling Smokes | G | | | | X | |
| Isobutyl methacrylate with oil | J | | | | X | |
| Napalm | J | | | X | | X |
| TEA | L | | | X | | X |

| | |
|---|---|
| a | See Enclosure 6 of this Volume for information pertaining to CGs. |
| b | Toxic agents without explosives components that normally would be assigned to HD 6.1 may be stored as CG K. |

V1.E10.4.2.1. Set 1 of chemical hazard symbol 1 requires full protective clothing (see Figure V1.E10.F~~2~~3. and Table V1.E10.T~~3~~9.) and indicates the presence of highly toxic CAs that may cause death or serious damage to body functions. The following full protective clothing shall be used:

V1.E10.4.2.1.1. Service-certified protective gas mask.

V1.E10.4.2.1.2. Impermeable suit.

V1.E10.4.2.1.3. Impermeable hood.

V1.E10.4.2.1.4. Impermeable boots.

V1.E10.4.2.1.5. Impermeable undergarments.

V1.E10.4.2.1.6. Impermeable coveralls.

V1.E10.4.2.1.7. Impermeable protective footwear.

V1.E10.4.2.1.8. Impermeable gloves.

V1.E10.4.2.2. Set 2 of chemical hazard symbol 1 requires full protective clothing (see Figure V1.E10.F~~2~~*3*. and Table V1.E10.T~~3~~*9*.) and indicates the presence of harassing agents (riot control agents and smokes). Firefighting personnel equipped with normal heat-resistant clothing (e.g., bunker suit) and gas mask or SCBA do not require the set 2 protective clothing. For all others, the following protective clothing shall be used:

V1.E10.4.2.2.1. Service-certified protective gas masks or self-contained breathing apparatus (SCBA).

V1.E10.4.2.2.2. Permeable coveralls.

V1.E10.4.2.2.3. Protective gloves.

V1.E10.4.2.3. Set 3 of chemical hazard symbol 1 requires full protective clothing (see Figure V1.E10.F~~2~~*3*. and Table V1.E10.T~~3~~*9*.) and indicates the presence of WP or other spontaneously combustible material. Firefighting personnel equipped with normal heat-resistant clothing (e.g., bunker suit) and gas mask or SCBA do not require the set 3 protective clothing. For all others, the following protective clothing shall be used:

V1.E10.4.2.3.1. Service-certified protective gas masks or SCBA.

V1.E10.4.2.3.2. Flame-resistant coveralls.

V1.E10.4.2.3.3. Flame-resistant gloves.

V1.E10.4.2.4. Chemical hazard symbol 2 requires the wearing of a breathing apparatus (see Figure V1.E10.F~~2~~*3*. and V1.E10.T~~3~~*9*.) and indicates the presence of incendiary or readily flammable CAs that present an intense radiant heat hazard. Protective masks shall be used to prevent inhalation of smoke from burning incendiary mixtures.

V1.E10.4.2.5. Chemical hazard symbol 3 warns against applying water (see Figure V1.E10.F~~2~~*3*. and V1.E10.T~~3~~*9*.) and indicates a dangerous reaction will occur if water is used in an attempt to extinguish fire.

## V1.E10.5. FIREFIGHTING MEASURES

### V1.E10.5.1. General

V1.E10.5.1.1. Firefighters should have a thorough knowledge of the hazards associated with AE fires and expected AE reactions. The DoD Component shall brief the firefighting forces and other essential personnel before approaching the scene of the fire. They shall be informed of the known hazards and conditions existing at the fire scene prior to proceeding to the fire location.

V1.E10.5.1.2. Fires involving AE will be fought according to the HD, fire division, the progression of the fire, and the procedures specified by the DoD Component. Special firefighting instructions addressing AE hazards will be developed according to the needs of the DoD Component.

V1.E10.5.1.3. All fires in the vicinity of AE shall be immediately reported and:

V1.E10.5.1.3.1. Shall be fought if not involving AE.

V1.E10.5.1.3.2. Shall not be fought if the fire involves AE, or is supplying heat to the AE, or is so large that it cannot be extinguished with the equipment at hand. Personnel shall be evacuated per paragraph V1.E10.5.2.

V1.E10.5.2. Emergency Withdrawal Distances. Commanders are responsible for developing evacuation plans that include the applicable withdrawal distances as part of the installation's emergency planning. (See section V1.E10.6.)

V1.E10.5.2.1. Nonessential Personnel. These emergency withdrawal distances are intended for application in emergency situations only and are not used for facility siting.

V1.E10.5.2.1.1. The initial withdrawal distance for nonessential personnel shall be at least IBD for the PES involved. If the fire involves AE, AE involvement is imminent, or the fire is or may become uncontrollable, then use the emergency withdrawal distances listed in Table V1.E10.T4*10*. The emergency withdrawal distances depend on fire involvement and on whether or not the HD, fire division, and quantity of explosives are known. If fire is not affecting AE or involvement is not imminent, then emergency authorities shall determine the withdrawal distance based on the situation at hand.

V1.E10.5.2.1.2. Structures or protected locations offering equivalent protection for the distances in Table V1.E10.T4*10*. may be used in lieu of relocating personnel from the structure or location to the specified emergency withdrawal distance.

V1.E10.5.2.2. Essential Personnel. Emergency authorities on site shall determine the withdrawal distance for essential personnel at accidents. Emergency authorities shall determine the essential personnel.

V1.E10.5.3. Firefighting Involving CAs. AE containing both explosives and CAs (see Table V1.E10.T~~3~~*9*.) requires special attention and precautions in firefighting. Fires involving such AE

shall be fought IAW their fire division characteristics. Responding personnel must consider the additional hazards and precautions discussed in V6.E4. for the CAs involved.

Table V1.E10.T*410*. Emergency Withdrawal Distances for Nonessential Personnel[a]

| HD | Unknown Quantity (ft) *[m]* | Known Quantity (ft) *[m]* |
|---|---|---|
| Unknown, located in facility, truck, or tractor trailer | 4,000 *[1,219]* | 4,000 *[1,219]* |
| Unknown, located in railcar | 5,000 *[1,524]* | 5,000 *[1,524]* |
| 1.1[b] and 1.5 | Same as unknown facility, truck, trailer, or railcar as appropriate | For Transportation:<br>NEWQD ≤ 500 lbs: D = 2,500 ft<br>*NEWQD ≤ 226.8 kg: D = 762 m*<br>NEWQD > 500 lbs:<br>D = 5,000 ft for railcars<br>D = 4,000 ft for other modes<br>*NEWQD > 226.8 kg:*<br>*D = 1,524 m for railcars*<br>*D =1,219 m for other modes*<br>For bombs and projectiles with caliber 5 inch [127 mm] or greater:<br>D = 4,000 ft<br>*D = 1,219 m* |
| | | For Facilities:<br>NEWQD ≤ 15,000 lbs: D = 2,500 ft<br>*NEWQD ≤ 6,804 kg: D = 762 m*<br>15,000 lbs < NEWQD ≤ 55,285 lbs:<br>D = 4,000 ft<br>*6,804 kg < NEWQD ≤ 25,077 kg:*<br>*D = 1,219 m*<br>NEWQD > 55,285 lbs: D = $105W^{1/3}$<br>*NEWQD > 25,077 kg: D = $41.65Q^{1/3}$* |
| 1.2[b] and 1.6 | 2,500 *[762]* | 2,500 *[762]* |
| 1.3 | 600 *[183]* | Twice IBD with a 600 ft [183 m] minimum (V3.E3.T13) |
| 1.4 | 300 *[91.5]* | 300 *[91.5]* |

| | |
|---|---|
| a | Emergency withdrawal distances do not consider the potential flight range of propulsion units. |
| b | For HD 1.1 and HD 1.2 AE, if known, the maximum range that fragments and debris will be thrown (including the interaction effects of stacks of items, but excluding lugs, strongbacks, and/or nose and tail plates) may be used to replace the distances given. |

V1.E10.5.4. Firefighting Involving Underground Storage Facilities. Entry to underground storage facilities following a fire or explosion requires special precautions. Emergency personnel shall monitor for the presence of toxic fumes or oxygen-depleted atmospheres and evaluate structural damage during initial entry following an accident. Commanders shall develop written procedures that define actions to be taken in such emergency situations.

V1.E10.6. EMERGENCY PLANNING. Installations or responsible activities shall develop SOPs or plans designed to provide safety, security, and environmental protection for accidents involving AE. Plans shall be coordinated with the applicable Federal, State, and local emergency response authorities (e.g., law enforcement, fire departments, and hospitals) and any established local emergency planning committees. The SOPs or plans shall include the following:

V1.E10.6.1. Specific sections and guidance that address emergency preparedness, contingency planning, and security. For security, the SOPs or plans shall limit access to accident sites to trained and authorized personnel.

V1.E10.6.2. Procedures that minimize the possibility of an unpermitted or uncontrolled detonation, release, discharge, or migration of AE out of any storage unit when such release, discharge, or migration may endanger human health or the environment.

V1.E10.6.3. Provisions for prompt notification to emergency response and environmental agencies and the potentially affected public for an actual or potential detonation or uncontrolled release, discharge, or migration of AE that may endanger human health or the environment.

V1.E10.6.4. Provisions for complying with sections 11001-11022 of title 42, United States Code (commonly known as the “Emergency Planning Community Right-To-Know Act (EPCRA)”) (Reference (o))), and DoD or DoD Component implementing policies.

# ENCLOSURE 11

## TERMINATION OF USE OF FACILITIES FOR STORING AE

V1.E11.1. Each storage facility no longer used to store AE must undergo a process to ensure that AE and any visible explosives residues are removed within 180 days from the last use of the storage facility. This helps ensure that no threats to human health or the environment remain when the unit is no longer to be used to store AE. This process shall include the following:

V1.E11.1.1. Emptying the storage facility of all AE and related materials.

V1.E11.1.2. Cleaning the storage facility, as required, to remove any visible explosives residue.

V1.E11.1.3. Visually inspecting the storage facility for the presence of remaining ammunition or explosives or visible explosives residue by a knowledgeable individual appointed by the installation or responsible activity commander.

V1.E11.1.4. Removing from the storage facility all fire and chemical hazard symbols and marking the storage facility as empty.

V1.E11.1.5. Securing the storage facility to prevent inadvertent use or access.

V1.E11.1.6. Notifying the applicable emergency response and regulatory authorities of the change in the storage facility's use.

V1.E11.1.7. Recording the date the storage facility was inspected, the name and position of the inspector, and the results in permanent real estate records.

V1.E11.2. Ammunition storage units that have been used to store waste military munitions must also comply with the closure procedures in section V7.E5.6.

# GLOSSARY

## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AE | ammunition and explosives |
| AGM | aboveground magazine |
| CA | chemical agent |
| CG | compatibility group |
| cm | centimeter |
| $cm^2$ | square centimeter |
| DDESB | Department of Defense Explosives Safety Board |
| DUSD(I&E) | Deputy Under Secretary of Defense for Installations and Environment |
| ECM | earth-covered magazine |
| EIDS | extremely insensitive detonating substance |
| ES | exposed site |
| ft | foot or feet |
| $ft^2$ | square foot or square feet |
| GSA | General Services Administration |
| HC | hexachlorethane |
| HD | hazard division |
| HE | high explosive |
| HEW | high explosive weight |
| HPM | high performance magazine |
| IAW | in accordance with |
| IBD | inhabited building distance |
| ILD | intraline distance |
| IMD | intermagazine distance |
| JHCS | Joint Hazard Classification System |
| kg | kilogram |
| kPa | kilopascal |
| kph | kilometers per hour |
| kW | kilowatt |
| lbs | pounds |
| m | meter |

| | |
|---|---|
| $m^2$ | square meter |
| MCE | maximum credible event |
| MIL-STD | Military Standard |
| mm | millimeter |
| mph | miles per hour |
| ms | millisecond |
| NEQ | net explosive quantity |
| NEW | net explosive weight |
| NEWQD | net explosive weight for quantity-distance |
| NPW | net propellant weight |
| PES | potential explosion site |
| PETN | pentaerythritol tetranitrate |
| psi | pounds per square inch |
| PTRD | public traffic route distance |
| PWP | plasticized white phosphorus |
| QD | quantity-distance |
| QRA | quantitative risk assessment |
| RCS | report control symbol |
| RDX | cyclotrimethylenetrinitramine (also known as cyclonite, hexogen, or royal demolition explosive) |
| SCBA | self-contained breathing apparatus |
| SG | sensitivity group |
| SOP | standard operating procedure |
| TEA | triethyl aluminum |
| TPA | thickened triethyl aluminum |
| USD(AT&L) | Under Secretary of Defense for Acquisition, Technology, and Logistics |
| WP | white phosphorus |