Notes:

1. Emergency withdrawal distances do not consider the potential flight range of propulsion units.
2. For HD 1.1 and HD 1.2 AE, if known, the maximum range fragments and debris shall 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.

C8.6.1.3. 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.

C8.6.1.4. Provisions for complying with the "Emergency Planning Community Right-To-Know Act (EPCRA)" (reference (n)), and Department of Defense or DoD Component implementing policies.

C9. CHAPTER 9
QUANTITY-DISTANCE AND SITING

C9.1. GENERAL

The damage or injury potential of explosions is normally determined by the separation distance between PES and ES; the ability of the PES to suppress blast overpressure, primary and secondary fragments; and the ability of the ES to resist explosion effects. This Chapter:

C9.1.1. Defines permissible exposures for both accidental and intentional detonations.

C9.1.2. Sets minimum standards for separation distances between PES and ES by taking into account anticipated explosion effects, suppression, and resistance.

C9.1.3. Establishes explosives safety siting criteria (QD relationships) for PES and ES, based on blast, fragment, firebrand, thermal, and groundshock effects. QD is determined by the effect requiring the greatest distance.

C9.2. DETERMINING THE QUANTITY OF EXPLOSIVES

C9.2.1. General. The NEWQD in an AE facility is calculated as shown below. 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. (NOTE: The JHCS provides explosives weights for all DoD Hazard Classified AE.)

C9.2.1.1. Mass-explosion (HD 1.1). The NEWQD is the total high explosives weight (HEW) and the total net propellant weight (NPW). For HD 1.1, NEWQD equals the NEW.

C9.2.1.2. Non-mass explosion, fragment producing (HD 1.2).

C9.2.1.2.1. 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 subparagraph C9.4.2.5., shall be used as the basis for determining applicable QD.

C9.2.1.2.2. HD 1.2.2. The NEWQD is the HEW plus the NPW in all HD 1.2.2 items.

C9.2.1.2.3. HD 1.2.3 (Unit Risk HD 1.2). 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 subparagraph C9.4.2.12.

C9.2.1.3. 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.

C9.2.1.4. 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.

C9.2.1.5. 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.

C9.2.1.6. Explosive article, extremely insensitive (EI) (HD 1.6). The NEWQD is the total weight of EIDS in all HD 1.6 items. However, the weight of EIDS in a single HD 1.6 item shall also be considered, as specified in Table C9.T15., for determining QD.

C9.2.1.7. 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.

C9.2.2. Determining the NEWQD for Mixed HD.

C9.2.2.1. General.

C9.2.2.1.1. The presence of HD 1.4 does not affect the NEWQD of mixed HD. However, for QD determinations, HD 1.4 criteria shall be considered.

C9.2.2.1.2. When HD 1.1 is mixed with any other HD, treat the mixture as HD 1.1 except as noted in subparagraph C9.2.2.2.

C9.2.2.1.3. HD 1.5 is always treated as HD 1.1.

C9.2.2.1.4. 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 over-riding fragmentation characteristics.

C9.2.2.2. 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:

C9.2.2.2.1. Sum the NEWQD for HD 1.1 and NEWQD for HD 1.2 and treat the mixture as HD 1.1.

C9.2.2.2.2. The NEWQD of the mixture is the NEWQD of the HD 1.2 sub-division requiring the largest QD.

C9.2.2.3. 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.

C9.2.2.4. 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.

C9.2.2.5. HD 1.2.1 with HD 1.2.2. The NEWQD for the mixture is the NEWQD of the sub-division requiring the largest QD.

C9.2.2.6. HD 1.2.1 with HD 1.2.3. The NEWQD for the mixture is the NEWQD of the sub-division requiring the largest QD.

C9.2.2.7. HD 1.2.2 with HD 1.2.3. The NEWQD for the mixture is the NEWQD of the sub-division requiring the largest QD.

C9.2.2.8. HD 1.2.1 with HD 1.2.2 with HD 1.2.3. The NEWQD for the mixture is the NEWQD of the sub-division requiring the largest QD.

C9.2.2.9. 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.

C9.2.2.10. 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 in accordance with (IAW) subparagraphs C9.2.2.6. through C9.2.2.8., as applicable.

C9.2.2.11. 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.

C9.3. QD PRINCIPLES

C9.3.1. General.

C9.3.1.1. The bases for determining required separation distances (QD) are:

C9.3.1.1.1 The HD types and NEWQD of AE present in an AE facility.

C9.3.1.1.2. The NEWQD of the HD requiring the greatest separation establishes the QD for the facility when it is used for multiple operations.

C9.3.1.1.3. 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). (NOTE: The MCE for the HPM shall not exceed 60,000 lbs [27,215 kg].)

C9.3.1.2. The bases for subdividing a quantity of AE into smaller units for the purpose of QD reduction are provided below.

C9.3.1.2.1. 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 that is less than $4.0W^{1/3}$ [$1.59Q^{1/3}$] of any one stack in lbs [kg] for lateral (side-to-side) target positions and less than $5.6W^{1/3}$ [$2.22Q^{1/3}$] of any one stack in lbs [kg] for axial target positions. 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.

C9.3.1.2.2. Separation by barriers. Barriers designed per the principles of reference (j) 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. (NOTE: Barrier design shall include adequate standoff distances and take into account acceptor AE sensitivity).

C9.3.1.3. 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 (see below).

C9.3.1.4. Flight ranges for units (e.g., rockets, missile motors, and cartridge or propellant actuated devices (CAD/PAD)) in a propulsive state shall be disregarded because it is impractical to specify QD separations that allow for their designed flight range.

C9.3.1.5. Separation distances are measured along straight lines. For large intervening topographical features such as hills, measure over or around the feature, whichever is the shorter. For golf courses, measure to the nearest edge of the tee or green or to the centerline of fairways.

C9.3.1.6. Measurements of distance for determining the maximum allowable quantity of AE shall be made to the nearest part of an ES from:

C9.3.1.6.1. The nearest wall of the PES.

C9.3.1.6.2. The exterior of the nearest intervening wall to the controlling AE stack, when the PES is subdivided.

C9.3.1.7. 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.

C9.4. QD CRITERIA FOR ACCIDENTAL DETONATIONS

C9.4.1. HD 1.1.

C9.4.1.1. Permissible Exposures To Airblast Overpressure.

C9.4.1.1.1. 12 psi [82.7 kPa] at $9W^{1/3}$ [$3.57Q^{1/3}$]. (Barricading is required.)

C9.4.1.1.1.1. Buildings that house:

C9.4.1.1.1.1.1. Successive steps of a single production, renovation, or maintenance operation.

C9.4.1.1.1.1.2. A security alert force.

C9.4.1.1.1.1.3. A tactical missile site, where greater distances from the PES cannot be provided for technical or tactical reasons.

C9.4.1.1.1.1.4. Breakrooms and change houses that are both part of an operating line and used exclusively by personnel operating the line. An exception is when the breakroom is integral to the PES and used only by personnel from that PES. For this situation, no QD applies.

C9.4.1.1.1.1.5 Dunnage preparation or similar non-AE operations, if used only by personnel employed at the PES.

C9.4.1.1.1.1.6. Temporary holding areas for AE conveyances servicing production or maintenance facilities.

C9.4.1.1.1.1.7. AE related operations in magazine areas, when performing minor maintenance, preservation, packaging, or surveillance inspection.

C9.4.1.1.1.1.8. Barricaded service magazines that are part of an operating line. Separation distances shall be based on the NEWQD and the HD of the AE in the magazine and not that in other parts of the operating line.

C9.4.1.1.1.2. Exceptions:

C9.4.1.1.1.2.1. Unmanned auxiliary utility facilities (e.g., transformer stations, water treatment and pollution abatement facilities) that serve, but are not an integral function in the PES, and that would not create an immediate secondary hazard, if lost. Such unmanned facilities need not be barricaded. See subparagraph C9.8.1.2. for situations where

auxiliary facilities serving only one PES or AE operation are permitted to be separated from the facility or operation they support based on fire separation distance only.

C9.4.1.1.1.2.2. Unmanned auxiliary power generation or conversion facilities that exclusively supply power to an AE storage area or security fence lighting may be located at fire protection distance (50 ft [15.2 m] for non-combustible structures, 100 ft [30.5 m] for combustible structures) from AE facilities.

C9.4.1.1.2. 3.5 psi [24 kPa] at $18W^{1/3}$ [$7.14Q^{1/3}$]

C9.4.1.1.2.1. Facilities that house:

C9.4.1.1.2.1.1. Labor-intensive AE operations (e.g., surveillance, maintenance, inspection) closely related to the PES.

C9.4.1.1.2.1.2. Buildings, excluding magazine-area loading docks, for comfort, safety, or convenience (e.g., lunchrooms, motor pools, area offices, auxiliary fire stations, transportation dispatch points, and shipping and receiving buildings) that are used exclusively in support of the PES.

C9.4.1.1.2.1.3. Parallel operating lines, whether or not barricaded, provided the AE involved in each operating line present similar hazards. (NOTE: The criticality or survivability of one or more of the operating lines may require that each line be given IBD-level protection.)

C9.4.1.1.2.1.4. Operational support buildings (e.g., day rooms, operation offices, and similar functions) that only personnel from the activity operating the PES use or attend.

C9.4.1.1.2.1.5. Training functions (e.g., classroom and field training of personnel who may be required to engage in AE work) that only personnel from the activity operating the PES use or attend. (NOTE: Maneuver areas, proving ground tracks, and similar facilities for armored vehicles also may be exposed to 3.5 psi [24 kPa] because the vehicles provide adequate protection to the operators from fragments and debris.)

C9.4.1.1.2.1.6. Maintenance of military vehicles or equipment that are located outside the U.S., when the PES is a basic load or a ready storage area. In such cases:

C9.4.1.1.2.1.6.1. The NEWQD at each PES is limited to 8,818 lbs [4,000 kg] or less.

C9.4.1.1.2.1.6.2. The maintenance work must be performed exclusively for the unit for which the basic load of AE is stored.

C9.4.1.1.2.1.7. Auxiliary power and utilities functions including auxiliary power plants; compressor stations; electric power transformers; tool and consumable supplies storage and issue; and handling equipment service, battery charging, and minor repair.

C9.4.1.1.2.1.7.1. When such facilities serve an entire naval station or base complex, or when loss of the facility shall cause an immediate loss of vital function, the minimum exposure level shall be IBD ($40\text{-}50W^{1/3}$ [$15.87\text{-}19.84Q^{1/3}$]).

C9.4.1.1.2.1.7.2. Naval station "cold-iron" ship support facilities (e.g., supply and mechanical support) are excluded from QD criteria when they are not continuously

manned; when they are serving only the waterfront area; and when the PES is a ship or AE handling location on the waterfront.

C9.4.1.1.2.1.8. Minimum distance between separate groups of AE-loaded, combat-configured aircraft or between aircraft and a pre-load or "quick-turn" site that serves to arm an aircraft. The use of intervening barricades is required to eliminate propagation by primary fragment impact; thereby eliminating the need to total NEWQD. (NOTE: Loading AE aboard aircraft can be accomplished with each group of aircraft without additional protection.)

C9.4.1.1.2.1.9. Unbarricaded service magazine separation distances shall be based on the NEWQD and the HD of the AE in the magazine and not that in other parts of the operating line.

C9.4.1.1.2.1.10. Container stuffing and unstuffing operations that provide routine support to a PES. This applies only to main support functions that are set aside for support of ship-loading, depot, or manufacturing operations. When in connection with ship-loading and unloading and the ES is an AE ship, the quantity at the container site governs. (NOTE: Container stuffing and unstuffing in a magazine area are permitted at IMD IAW Table C9.T6.) Criteria applicable to the loading and unloading of a conveyance at a magazine are addressed in subparagraph C9.8.20.

C9.4.1.1.2.1.11. Combat Aircraft Support Facilities.

C9.4.1.1.2.1.11.1. Between AE-loaded combat aircraft and those non-AE facilities that directly support the servicing and launching of a unit's armed aircraft. Such facilities include operating facilities that handle AE on the flightline, prepare and service armed aircraft, and those that house personnel who fly combat aircraft.

C9.4.1.1.2.1.11.2. Direct flightline combat aircraft associated facilities, which may contain field offices, breakrooms, unit training rooms, and equipment and supply rooms, as well as petroleum, oils, lubricants (POL) hydrant facilities and civil engineer fire protection stations. (NOTE: Morale, welfare, and recreation (MWR) facilities; base civil engineering headquarters; industrial facilities, including central base supply are required to be at IBD.)

C9.4.1.1.2.1.12. Parking lots for privately owned automobiles belonging to personnel employed at or stationed at multiple PES. When a parking lot supports a single PES, it may be separated at less than ILD only from its associated facility. A minimum distance of 100 ft [30.5 m] is required to the associated facility to protect it from vehicle fires. Access for emergency vehicles must be provided.

C9.4.1.1.2.2. Exposures indicated in this section that are provided blast suppression and structure hardening so that comparable protection levels for personnel and equipment as provided by $18W^{1/3}$ [$7.14Q^{1/3}$] may be sited at $9W^{1/3}$ [$3.57Q^{1/3}$].

C9.4.1.1.3. 2.3 psi [15.8 kPa] at $24W^{1/3}$ [$9.52Q^{1/3}$]. Personnel exposed to remotely controlled operations.

C9.4.1.1.4. 2.3-1.7 psi [15.8-11.7 kPa] at 24-$30W^{1/3}$ [9.52-$11.9Q^{1/3}$]

C9.4.1.1.4.1. PTRD with medium and low traffic densities as described in subparagraph C9.4.1.2.1.1.5.

C9.4.1.1.4.2. On-base roads. The DoD Components may provide protection less than 60 percent of IBD to installation-related personnel transiting QD arcs, when the risks are evaluated, are documented, and are IAW DoD Component-established procedures. (NOTE: Effective October 1, 2000, all new construction of AE storage and operating facilities, and any change in operations within existing facilities that increases the explosive safety risk should provide both the general public and installation-related personnel who are not involved in munitions-related operations protection that provides a minimum of 60 percent of IBD.) When a DoD Component determines exposures at less than 60 percent of IBD to be necessary, the DoD Component should consider use of methods to inform transients of potential risks (e.g., written acknowledgement of the risk by vendors or others with a recurring need to transit the ESQD area, warning signs, flashing lights, physical barriers, etc.). The DoD Component's decision to provide transients' protection at less than 60 percent of IBD shall be:

C9.4.1.1.4.2.1. Supported by a qualitative risk assessment considering factors such as:

C9.4.1.1.4.2.1.1. Operational necessity.

C9.4.1.1.4.2.1.2. The operation being performed (e.g., static storage, maintenance, and production).

C9.4.1.1.4.2.1.3. Operational activity cycles.

C9.4.1.1.4.2.1.4. Alternate routes.

C9.4.1.1.4.2.1.5. Traffic density.

C9.4.1.1.4.2.1.6. Accident records.

C9.4.1.1.4.2.1.7. Time interval of exposure.

C9.4.1.1.4.2.1.8. Type and quantity of AE in proximity to the area transited.

C9.4.1.1.4.2.1.9. The closest distance from the area transited to the PES.

C9.4.1.1.4.2.1.10. The need for installation-related personnel to transit the ESQD arc.

C9.4.1.1.4.2.2. Reviewed as changes occur to either operations, which would increase the explosive safety risk, or the number of exposed, and upon change of the approving authority.

C9.4.1.1.4.3. Open-air recreation facilities (e.g., ball diamonds, golf courses and volleyball courts), which do not contain structures, used for MWR and community relations' purposes at military installations and activities. As an exception, neither blast nor fragment criteria apply, when such facilities are located near AE support operations and used by off-duty military or on-duty military or DoD civilians or contractors (e.g., munitions workers, security guards, firefighters) who directly support these AE operations. However, when possible, such facilities should fully comply with this Standard.

C9.4.1.1.4.4. Training areas (e.g., observation points, classrooms or other instruction areas for ranges and similar fixed facilities designed for occasional use coincident with the use of the range). As an exception, to allow for realism in training, this separation does

not apply to AE needed for any particular exercise or on-the-job training. However, this separation or equivalent protection is required from permanent PES and AE supply points.

C9.4.1.1.4.5. Open-air aircraft passenger loading and unloading areas.

C9.4.1.1.4.6. Parking lots for administrative areas. (NOTE: Minimum fragment distances apply, see subparagraph C9.4.1.2.)

C9.4.1.1.4.7. Inert storage located in the open (no structures involved) when not directly related to the explosives mission and when accessed by personnel not directly related to the explosives mission. (See subparagraph C9.4.1.1.6.9 if located within a structure.)

C9.4.1.1.5. 1.7 psi [11.7 kPa] at $30W^{1/3}$ [$11.9Q^{1/3}$]. Combat aircraft parking areas exposed to AE storage and operating facilities.

C9.4.1.1.6. 1.2 - 0.90 psi [8.3 - 6.2 kPa] at 40 - $50W^{1/3}$ [15.87 - $19.84Q^{1/3}$]

C9.4.1.1.6.1. Inhabited buildings, administrative and housing areas.

C9.4.1.1.6.2. An installation boundary, unless the area outside the boundary naturally prohibits access, is government land that is not open to the public, or access is restricted and controlled by other means. When IBD QD arcs penetrate an installation's boundary, the Service shall both certify IBD protection need not be applied to the encumbered area and establish procedures to monitor the area for any change in status.

C9.4.1.1.6.3. Recreation facilities (e.g., ball diamonds, golf courses and volleyball courts) that contain structures.

C9.4.1.1.6.4. Flight-line passenger service functions (e.g., terminal buildings).

C9.4.1.1.6.5. Main powerhouses that provide vital utilities to a major portion of an installation.

C9.4.1.1.6.6. Shops that by reason of their vital strategic nature, or high intrinsic value of their contents, should not be placed at risk.

C9.4.1.1.6.7. Functions that, if momentarily put out of action, would cause an immediate secondary hazard by reason of their failure to function.

C9.4.1.1.6.8. PTRD with high traffic density as described in subparagraph C9.4.1.2.1.1.5.

C9.4.1.1.6.9. Inert storage located in a structure when not directly related to the explosives mission and when accessed by personnel not directly related to the explosives mission. (See subparagraph C9.4.1.1.4.7. if no structure is involved.)

C9.4.1.2. Minimum Fragment Distances.

C9.4.1.2.1. The minimum distance for protection from hazardous fragments shall be based on primary and secondary fragments from the PES and the population or traffic density of the ES. It is defined as the distance at which the density of hazardous fragments becomes 1 per 600 ft^2 [55.7 m^2]. (NOTE: This distance is not the maximum fragment range.) DDESB approved analyses and/or approved tests may be used to determine minimum distances for both primary and secondary fragments. DDESB TP 13 (Reference (o)) is an example of a method to determine minimal distances for building debris, while DDESB TP 16 (Reference (p)) provides

similar information to determine minimal distances for primary fragments. In the absence of appropriate analyses or tests, default hazardous debris distances defined below apply:

C9.4.1.2.1.1. For populous locations provided IBD protection, the minimum distance shall be the hazardous fragment distance (HFD). If this distance is not known, the following shall apply:

C9.4.1.2.1.1.1. For all types of Hazard Division 1.1 in quantities $\leq$ 450 lbs NEWQD [204 kg], the hazardous fragment distance (HFD) shall be determined as follows (NOTE: PTRD is 60 percent of the specified HFD):

C9.4.1.2.1.1.1.1. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, use "Earth-Covered Magazine" distances shown in Table C9.T1., as discussed in subparagraph C9.4.1.3. ILD shall be IAW subparagraph C9.4.1.4.1.

C9.4.1.2.1.1.1.2. For Hazard Division 1.1 in an Undefined ECM, where the loading density = NEWQD (lbs)/internal volume (ft^3) [EQN C9.4-1] is $\leq$ 0.028 lbs/ft^3 [d = NEWQD/internal volume (m^3) [EQN C9.4-2] $\leq$ 0.449 kg/m^3] use "Earth-Covered Magazine" distances shown in Table C9.T1., as discussed in subparagraph C9.4.1.3. ILD shall be IAW subparagraph C9.4.1.4.1.

C9.4.1.2.1.1.1.3. For Hazard Division 1.1 in an Undefined ECM where the loading density is > 0.028 lbs/ft^3 [> 0.449 kg/m^3], use "Earth-Covered Magazine - side and rear" distances of Table C9.T1. and for front exposure, apply the greater of "Earth-Covered Magazine - front" IBD distance of Table C9.T1. or the HFD from the "STRUCTURE" column of Table C9.T2., for the NEW in the ECM. ILD shall be IAW subparagraph C9.4.1.4.1.

C9.4.1.2.1.1.1.4. Where ECM, regardless of structural designation, have been designed, analyzed, or tested to have a reduced IBD and have been approved by the DDESB, use the approved IBD. ILD shall be IAW subparagraph C9.4.1.4.1.

C9.4.1.2.1.1.1.5. For Hazard Division 1.1 in a structure (excluding ECM) capable of stopping primary fragments, but which can contribute to the debris hazard, use hazardous debris and PTRD distances found in Table C9.T10. ILD shall be IAW subparagraph C9.4.1.4. Structures that are capable of stopping primary fragments include all heavy wall (H) and heavy wall/roof (H/R) aboveground structure/site (AGS), as defined in the legend for Table C9.T8. Doors and other openings through which primary fragments could exit must be capable of stopping primary fragments from exiting the facility or shall be barricaded IAW section C5.3. to trap primary fragments that could exit the facility.

C9.4.1.2.1.1.1.6. For Hazard Division 1.1 in the open or in a structure incapable of stopping primary fragments, use HFD listed in the "OPEN" column of Table C9.T2. ILD shall be IAW subparagraph C9.4.1.4. Structures (other than ECM) that are capable of stopping primary fragments include all H and H/R AGS, as defined in the legend for Table C9.T8. All other structures (other than ECM) are considered incapable of stopping primary fragments.

C9.4.1.2.1.1.1.7. Selected items have been evaluated for minimum HFD with results shown in Table C9.T3. Other items, through testing, have been hazard classified with a specific HFD presented in the format HD (xx)1.1. The HFD for these items is specified in hundreds of feet (in parenthesis), and they may not be listed in Table C9.T3. The distances for these two categories of select items apply only to items in the open. When in facilities,

secondary debris as well as primary fragments must be considered. If in a facility that can contain primary fragments, apply criteria of subparagraphs C9.4.1.2.1.1.1.1. through C9.4.1.2.1.1.1.5. above. If in a facility that cannot stop primary fragments, use the greater distance from Table C9.T3. (for the item being considered) or the HFD associated with the (xx)(1.1) item or from Table C9.T2. for determining the applicable HFD. ILD shall be IAW subparagraph C9.4.1.4.

C9.4.1.2.1.1.1.8. For bare explosives in the open, distance is computed by the formula $d=40W^{1/3}$ [$15.87Q^{1/3}$]. **[EQN C9.4-3] [EQN C9.4-4]**

C9.4.1.2.1.1.2. For Hazard Division 1.1 NEWQDs in the range 451 to 30,000 lbs [205 to 13,608 Kg], HFD shall be determined according to the below criteria. PTRD is 60 percent of the specified HFD, and ILD shall be IAW subparagraph C9.4.1.4.

C9.4.1.2.1.1.2.1. The minimum HFD shall be 1250 ft [381 m], as shown in Table C9.T1. Lesser distances are permitted if supported by a structural analysis. Facilities sited at 1,235 ft [376 m] or 1,245 ft [380 m] per past standards shall be considered to be in compliance with the 1,250 ft [381 m] minimum requirement.

C9.4.1.2.1.1.2.2. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, use "Earth-Covered Magazine" distances shown in Table C9.T1., as discussed in subparagraph C9.4.1.3.

C9.4.1.2.1.1.2.3. For Hazard Division 1.1 in an Undefined ECM, where the loading density is ≤ 0.028 lbs/ft^3 [≤ 0.449 kg/m^3], use "Earth-Covered Magazine" distances shown in Table C9.T1., as discussed in subparagraph C9.4.1.3.

C9.4.1.2.1.1.2.4. For Hazard Division 1.1 in an Undefined ECM with minimum internal dimensions of 26 ft [7.92 m] wide and 60 ft [18.29 m] long, use "Earth-Covered Magazine - side and rear" distances of Table C9.T1. and "Other PES" distance of Table C9.T1. for the front exposure.

C9.4.1.2.1.1.2.5. For Hazard Division 1.1 in an Undefined ECM where the loading density is > 0.028 lbs/ft^3 [> 0.449 kg/m^3] and internal dimensions are less than 26 ft [7.92 m] wide and 60 ft [18.29 m] long, use "Other PES" distances of Table C9.T1. for front, side, and rear exposures.

C9.4.1.2.1.1.2.6. Selected items have been evaluated for minimum HFD with results shown in Table C9.T3. Other items, through testing, have been hazard classified with a specific HFD presented in the format HD (xx)1.1. The HFD for these items is specified in hundreds of feet (in parenthesis), and they may not be listed in Table C9.T3. The distances for these two categories of select items apply only to items in the open. When these items are placed in a facility, apply the criteria of subparagraphs C9.4.1.2.1.1.2.1. through C9.4.1.2.1.1.2.5. above, as appropriate.

C9.4.1.2.1.1.2.7. For bare explosives in the open, distance is computed by the formula $d=40W^{1/3}$ [$15.87Q^{1/3}$]. **[EQN C9.4-3] [EQN C9.4-4]**

C9.4.1.2.1.1.3. For Hazard Division 1.1 NEWQDs > 30,000 lbs [13,608 kg] HFD will be in accordance with Table C9.T1. Lesser distances are permitted if supported by a structural analysis. PTRD is 60 percent of HFD and intraline criteria will be in accordance with subparagraph C9.4.1.4. The following apply to use of the reduced "Earth-Covered Magazine"

distances shown in Table C9.T1, for the NEW range between 30,000 lbs [13,608 kg] and 250,000 lbs [113,398 kg]:

TABLE C9.T1. HD 1.1 IBD and PTRD

NEWQD	IBD From:				PTRD From:			
	ECM			Other	ECM			Other
	Front[1,2]	Side[1]	Rear[3]	PES[4]	Front[5,6]	Side[5]	Rear[5]	PES[5]
(lbs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
[kg]	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*
1	500	250	250	NOTE 4	300	150	150	NOTE 5
0.45	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
1.5	500	250	250		300	150	150	
0.68	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
2	500	250	250		300	150	150	
0.91	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
3	500	250	250		300	150	150	
1.4	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
5	500	250	250		300	150	150	
2.3	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
7	500	250	250		300	150	150	
3.2	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
10	500	250	250		300	150	150	
4.5	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
15	500	250	250		300	150	150	
6.8	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
20	500	250	250		300	150	150	
9.1	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
30	500	250	250		300	150	150	
13.6	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
50	500	250	250		300	150	150	
22.7	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
70	500	250	250		300	150	150	
31.8	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
100	500	250	250		300	150	150	
45.4	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
150	500	250	250		300	150	150	
68.0	*152.4*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
200	700	250	250		420	150	150	
90.7	*213.6*	*76.2*	*76.2*		*91.4*	*45.7*	*45.7*	
300	700	250	250		420	150	150	
136.1	*213.6*	*76.2*	*76.2*		*128.0*	*45.7*	*45.7*	
450	700	250	250		420	150	150	
204.1	*213.6*	*76.2*	*76.2*	▼	*128.0*	*45.7*	*45.7*	▼
500	1,250	1,250	1,250	1,250	750	750	750	750
226.8	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
700	1,250	1,250	1,250	1,250	750	750	750	750
317.5	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
1,000	1,250	1,250	1,250	1,250	750	750	750	750
453.6	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*

TABLE C9.T1. HD 1.1 IBD and PTRD (continued)

NEWQD	IBD From:				PTRD From:			
	ECM			Other	ECM			Other
	Front[1,2]	Side[1]	Rear[3]	PES[4]	Front[5,6]	Side[5]	Rear[5]	PES[5]
(lbs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
[kg]	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*
1,500	1,250	1,250	1,250	1,250	750	750	750	750
680.4	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
2,000	1,250	1,250	1,250	1,250	750	750	750	750
907.2	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
3,000	1,250	1,250	1,250	1,250	750	750	750	750
1,360.8	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
5,000	1,250	1,250	1,250	1,250	750	750	750	750
2,268.0	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
7,000	1,250	1,250	1,250	1,250	750	750	750	750
3,175.1	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
10,000	1,250	1,250	1,250	1,250	750	750	750	750
4,535.9	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
15,000	1,250	1,250	1,250	1,250	750	750	750	750
6,803.9	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
20,000	1,250	1,250	1,250	1,250	750	750	750	750
9,071.8	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
30,000	1,250	1,250	1,250	1,250	750	750	750	750
13,607.7	*381.0*	*381.0*	*381.0*	*381.0*	*228.6*	*228.6*	*228.6*	*228.6*
45,000	1,250	1,250	1,250	1,423	750	750	750	854
20,411.6	*381.0*	*381.0*	*381.0*	*433.7*	*228.6*	*228.6*	*228.6*	*260.3*
50,000	1,289	1,289	1,250	1,474	774	774	750	884
22,679.5	*392.9*	*392.9*	*381.0*	*448.9*	*235.7*	*235.7*	*228.6*	*269.4*
70,000	1,442	1,442	1,250	1,649	865	865	750	989
31,751.3	*439.5*	*439.5*	*381.0*	*502.2*	*263.7*	*263.7*	*228.6*	*301.3*
100,000	1,625	1,625	1,250	1,857	975	975	750	1,114
45,359.0	*495.0*	*495.0*	*381.0*	*565.6*	*297.0*	*297.0*	*228.6*	*339.4*
150,000	2,177	2,177	1,804	2,346	1,306	1,306	1,083	1,408
68,038.5	*663.5*	*663.5*	*550.0*	*715.2*	*398.1*	*398.1*	*330.0*	*429.1*
200,000	2,680	2,680	2,469	2,770	1,608	1,608	1,481	1,662
90,718.0	*816.8*	*816.8*	*752.5*	*844.4*	*490.1*	*490.1*	*451.5*	*506.6*
250,000	3,149	3,149	3,149	3,151	1,889	1,889	1,889	1,891
113,397.5	*959.8*	*959.8*	*959.8*	*960.4*	*575.9*	*575.9*	*575.9*	*576.2*
300,000	3,347	3,347	3,347	3,347	2,008	2,008	2,008	2,008
136,077.0	*1,020.5*	*1,020.5*	*1,020.5*	*1,020.5*	*612.3*	*612.3*	*612.3*	*612.3*
500,000	3,969	3,969	3,969	3,969	2,381	2,381	2,381	2,381
226,795.0	*1,209.9*	*1,209.9*	*1,209.9*	*1,209.9*	*725.9*	*725.9*	*725.9*	*725.9*

Notes for C9.T1 (see subparagraph C9.4.1.2.1.1):

1. For NEWQD < 45,000 lbs [20,412 kg], the distance is controlled by fragments. When fragments are absent or if the HFD (1/600 ft^2 [1/55.7 m^2]) is less than the blast hazard range, then the following blast criteria may be used.

(NEWQD in lbs, d in ft)

NEWQD $\leq$ 45,000 lbs: $d = 35NEWQD^{1/3}$ **[EQN C9.T1-1]**

45,000 lbs < NEWQD $\leq$ 100,000 lbs: $d = 35NEWQD^{1/3}$ **[EQN C9.T1-2]**

100,000 lbs < NEWQD $\leq$ 250,000 lbs: $d = 0.3955NEWQD^{0.7227}$ **[EQN C9.T1-3]**

250,000 lbs < NEWQD:	$d = 50NEWQD^{1/3}$	**[EQN C9.T1-4]**
(NEWQD in kg, d in m)		
NEWQD ≤ 20,412 kg:	$d = 13.88NEWQD^{1/3}$	**[EQN C9.T1-5]**
20,412 kg < NEWQD ≤ 45,359 kg:	$d = 13.88NEWQD^{1/3}$	**[EQN C9.T1-6]**
45,359 kg < NEWQD ≤ 113,398 kg:	$d = 0.2134NEWQD^{0.7227}$	**[EQN C9.T1-7]**
113,398 kg < NEWQD:	$d = 19.84NEWQD^{1/3}$	**[EQN C9.T1-8]**
(d in ft, NEWQD in lbs)		
d ≤ 1,245 ft:	$NEWQD = d^3/42{,}875$	**[EQN C9.T1-9]**
1,245 ft < d ≤ 1,625 ft:	$NEWQD = d^3/42{,}875$	**[EQN C9.T1-10]**
1,625 ft < d ≤ 3,150 ft:	$NEWQD = 3.60935d^{1.3837}$	**[EQN C9.T1-11]**
3,150 ft < d:	$NEWQD = d^3/125{,}000$	**[EQN C9.T1-12]**
(d in m, NEWQD in kg)		
d ≤ 379.3 m:	$NEWQD = d^3/2{,}674.04$	**[EQN C9.T1-13]**
379.3 m < d ≤ 495.0 :	$NEWQD = d^3/2{,}674.04$	**[EQN C9.T1-14]**
495.0 m < d ≤ 960.3 m:	$NEWQD = 8.4761d^{1.3837}$	**[EQN C9.T1-15]**
960.3 m < d:	$NEWQD = d^3/7{,}809.53$	**[EQN C9.T1-16]**

2. IBD for Frontal exposures applies to all directions from HPM. The MCE in the HPM is used as the NEWQD. The limit on the design MCE in an HPM is 60,000 lbs [27,215 kg].

3. For NEWQD < 100,000 lbs [45,359 kg], the distance is controlled by fragments and debris. When fragments and debris are absent or the range to a hazardous debris density of 1/600 ft^2 [1/55.7 m^2] is less than the blast hazard range, then the blast criteria may be used.

(NEWQD in lbs, d in ft)		
NEWQD ≤ 100,000 lbs:	$d = 25NEWQD^{1/3}$	**[EQN C9.T1-17]**
100,000 lbs < NEWQD ≤ 250,000 lbs:	$d = 0.004125NEWQD^{1.0898}$	**[EQN C9.T1-18]**
250,000 lbs < NEWQD:	$d = 50NEWQD^{1/3}$	**[EQN C9.T1-19]**
(NEWQD in kg, d in m)		
NEWQD ≤ 45,359 kg:	$d = 9.92NEWQD^{1/3}$	**[EQN C9.T1-20]**
45,359 kg < NEWQD ≤ 113,398 kg:	$d = 0.002976NEWQD^{1.0898}$	**[EQN C9.T1-21]**
113,398 kg < NEWQD:	$d = 19.84*NEWQD^{1/3}$	**[EQN C9.T1-22]**
(d in ft, NEWQD in lbs)		
d ≤ 1,160 ft:	$NEWQD = d^3/15{,}625$	**[EQN C9.T1-23]**
1,160 ft < d ≤ 3,150 ft:	$NEWQD = 154.2006d^{0.91760}$	**[EQN C9.T1-24]**
3,150 ft < d:	$NEWQD = d^3/125{,}000$	**[EQN C9.T1-25]**
(d in m, NEWQD in kg)		
d ≤ 353.8 m:	$NEWQD = d^3/976.19$	**[EQN C9.T1-26]**
353.8 m < d ≤ 960.3 m:	$NEWQD = 208.0623d^{0.91760}$	**[EQN C9.T1-27]**
960.3 m < d:	$NEWQD = d^3/7{,}809.53$	**[EQN C9.T1-28]**

4. For NEWQD < 30,000 lbs [< 13,608 kg], the distance is controlled by fragments and debris. Lesser distances may be permitted for certain situations (see subparagraph C9.4.1.2.1.1).

(NEWQD in lbs, d in ft)		
30,000 lbs < NEWQD ≤ 100,000 lbs:	$d = 40NEWQD^{1/3}$	**[EQN C9.T1-29]**
100,000 lbs < NEWQD ≤ 250,000 lbs:	$d = 2.42NEWQD^{0.577}$	**[EQN C9.T1-30]**
250,000 lbs < NEWQD:	$d = 50NEWQD^{1/3}$	**[EQN C9.T1-31]**
(NEWQD in kg, d in m)		
13,608 kg < NEWQD ≤ 45,359 kg:	$d = 15.87NEWQD^{1/3}$	**[EQN C9.T1-32]**
45,359 kg < NEWQD ≤ 113,398 kg:	$d = 1.1640NEWQD^{0.577}$	**[EQN C9.T1-33]**
113,398 kg < NEWQD:	$d = 19.84NEWQD^{1/3}$	**[EQN C9.T1-34]**
(d in ft, NEWQD in lbs)		
1,243 ft < d ≤ 1,857 ft:	$NEWQD = d^3/64{,}000$	**[EQN C9.T1-35]**
1,857 ft < d ≤ 3,150 ft:	$NEWQD = 0.2162d^{1.7331}$	**[EQN C9.T1-36]**
3,150 ft < d:	$NEWQD = d^3/125{,}000$	**[EQN C9.T1-37]**
(d in m, NEWQD in kg)		
378.6 m < d ≤ 565.6 m:	$NEWQD = d^3/3{,}989.42$	**[EQN C9.T1-38]**
565.6 m < d ≤ 960.3 m:	$NEWQD = 0.7686d^{1.7331}$	**[EQN C9.T1-39]**
960.3 m < d:	$NEWQD = d^3/7{,}809.53$	**[EQN C9.T1-40]**

5. Computed as 60 percent of applicable IBD.

6. PTRD applies to all directions from HPM. The MCE in the HPM is used as the NEWQD.

TABLE C9.T2. HD 1.1 HFD

NEWQD (lbs) *[kg]*	OPEN (ft) *[m]*	STRUCTURE (ft) *[m]*
≤ 0.5	236	200
≤ 0.23	*71.9*	*61.0*
0.7	263	200
0.3	*80.2*	*61.0*
1	291	200
0.45	*88.8*	*61.0*
2	346	200
0.91	*105.5*	*61.0*
3	378	200
1.4	*115.3*	*61.0*
5	419	200
2.3	*127.7*	*61.0*
7	445	200
3.2	*135.6*	*61.0*
10	474	200
4.5	*144.4*	*61.0*
15	506	200
6.8	*154.2*	*61.0*
20	529	200
9.1	*161.1*	*61.0*
30	561	200
13.6	*170.9*	*61.0*
31	*563.0*	200
14.1	*171.7*	*61.0*
50	601	388
22.7	*183.2*	*118.2*
70	628	519
31.8	*191.3*	*158.1*
100	658	658
45.4	*200.4*	*200.4*
150	815	815
68.0	*248.5*	*248.5*
200	927	927
90.7	*282.6*	*282.6*
300	1085	1085
136.1	*330.6*	*330.6*
450	1243	1243
204.1	*378.7*	*378.7*
> 450	1250	1250
>204.1	*381.0*	*381.0*

Notes for Table C9.T2 (See subparagraph C9.4.1.2.1.1):

(1) OPEN

NEWQD < 100 lbs: HFD = 291.3 + [79.2 x ln(NEWQD)]; **[EQN C9.T2-1]**

NEWQD ≥ 100 lbs: HFD = -1133.9 + [389 x ln(NEWQD)]; **[EQN C9.T2-2]**

NEWQD in lbs, HFD in ft, with a minimum distance of 236 ft; ln is natural logarithm.

NEWQD < 45.4 kg: HFD = 107.87 + [24.14 x ln(NEWQD)]; **[EQN C9.T2-3]**

NEWQD ≥ 45.4 kg: HFD = -251.87 + [118.56 x ln(NEWQD)]; **[EQN C9.T2-4]**

NEWQD in kg, HFD in m, with a minimum distance of 71.9 m; ln is natural logarithm.

(2) OPEN

HFD < 658 ft; NEWQD = exp [(HFD/79.2) - 3.678]; **[EQN C9.T2-5]**

658 ft ≤ HFD < 1250 ft; NEWQD = exp [(HFD/389) + 2.914]; **[EQN C9.T2-6]**

NEWQD in lbs, HFD in ft; exp [x] is e^x.

HFD < 200.5 m; NEWQD = exp [(HFD/24.14) – 4.4685]; **[EQN C9.T2-7]**

200.5 m ≤ HFD < 381 m; NEWQD = exp [(HFD/118.56) + 2.1244]; **[EQN C9.T2-8]**

NEWQD in kg, HFD in m; exp [x] is e^x.

(3) STRUCTURES

NEWQD ≤ 31 lbs HFD = 200 feet

31 lbs < NEWQD ≤ 450 lbs HFD = -1133.9 + [389 x ln(NEWQD)]; **[EQN C9.T2-9]**

NEWQD in lbs, HFD in ft; ln is natural logarithm.

NEWQD ≤ 14.1 kg HFD = 61.0 m

14.1 kg <NEWQD≤ 204.1 kg HFD = -251.87 + [118.56 x ln(NEWQD)]; **[EQN C9.T2-10]**

NEWQD in kg, HFD in m; ln is natural logarithm.

(4) STRUCTURES

HFD ≤ 200 feet NEWQD ≤ 31 lbs

200 ft < HFD ≤ 1250 ft NEWQD = exp[(HFD/389) + 2.914] **[EQN C9.T2-11]**

NEWQD in lbs, HFD in ft, exp [x] is e^x

HFD ≤ 61.0 m NEWQD ≤ 14.1 kg

61.0 m < HFD ≤ 381.0 m NEWQD = exp[(HFD/118.56) + 2.2144] **[EQN C9.T2-12]**

NEWQD in kg, HFD in m, exp [x] is e^x

(5) Use of equations given in Notes (1) through (4), to determine other HFD-NEWQD combinations, is allowed.

(6) PTRD is 60 percent of HFD.

TABLE C9.T3. HFD FOR OPEN STACKS OF SELECTED HD 1.1 AE

Nomenclature[a]	Number of Units									
	1	2	3	4	5	6	7	8	9	10
Sparrow, AIM-7[b]	280	565	770	955	1120	1245				
	85.3	*172.2*	*234.7*	*291.1*	*341.4*	*379.5*				
Sidewinder, AIM-9	400	400	400	400	400	400	400	400	400	400[1]
	121.9	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*[1]
Chaparral, MIM-72H	400	400	400	400	400	400	400	400	400	400[1]
	121.9	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*	*121.9*[1]
Maverick, AGM 65 A/B/D	400	500	500							
	121.9	*121.9*	*152.4*							
Maverick, AGM 65 E/F/G	670	900[2]	1200[2]							
	204.2	*274.3*[2]	*365.8*[2]							
ASROC	500	500	500							
	152.4	*152.4*	*152.4*							
CBU-87*	800	800	910	945	965	982	1000	1020	1035	1055[3]
	243.8	*243.8*	*277.4*	*288.0*	*291.4*	*299.3*	*304.8*	*310.9*	*315.5*	*321.6*[3]
Improved Hawk	900	900	900	900	900	900	900	900	900	900[1]
	274.3	*274.3*	*274.3*	*274.3*	*274.3*	*274.3*	*274.3*	*274.3*	*274.3*	*274.3*[1]
Penguin*	500	500	500							
	152.4	*152.4*	*152.4*							
Projectile, 105 mm[c]	340	355	525	660	725	775	810	845	870	890[3]
	103.6	*108.2*	*160.0*	*201.2*	*221.0*	*236.2*	*246.9*	*257.6*	*265.2*	*271.3*[3]
Projectile, 155 mm	415	590	770	955	1035	1095	1145	1195	1235	
	126.5	*179.8*	*234.7*	*291.1*	*315.5*	*333.8*	*349.0*	*364.2*	*376.4*	
Projectile, 5"/54	300	375	475	570	680	790	860	925	1005	1085
	91.4	*114.3*	*144.8*	*173.7*	*207.3*	*240.8*	*262.1*	*281.9*	*306.3*	*330.7*
Harpoon*	500	600[4]	600[4]	600[4]						
	152.4	*182.9*[4]	*182.9*[4]	*182.9*[4]						
Tomahawk*	500	600[4]	600[4]	600[4]						
	152.4	*182.9*[4]	*182.9*[4]	*182.9*[4]						
Bomb, 500-pound, MK 82	670									
	204.2									
Bomb, 1000-pound, MK 83	815									
	248.4									
Bomb, 2000-pound, MK 84	925									
	281.9									
Bomb, BLU-109	880									
	268.2									
Bomb, 750-pound, M117	690									
	210.3									
Torpedo, MK 46	500	500	500	500	500	500	500	500		
	152.4	*152.4*	*152.4*	*152.4*	*152.4*	*152.4*	*152.4*	*152.4*		
Torpedo, MK 48[d]	630	775	875	925						
	192.0	*236.2*	*266.7*	*281.9*						
Torpedo, MK 48 with shield[d,e]	500	500	550	600	635	670	700	725	755	780[3]
	152.4	*152.4*	*167.6*	*182.9*	*193.5*	*204.2*	*213.4*	*221.0*	*230.1*	*237.7*[3]

Notes for Table C9.T3:

1. Ten units or more until the point is reached at which this distance is exceeded by the distance requirements of Table C9.T1.
2. Use the distance shown only where there are less than 25 unrelated people exposed in any arc encompassing 45 degrees from 900 ft [274 m] to 1250 ft [381 m] from the PES.
3. More than 10 units may be involved before 1250 ft [381 m] is exceeded. For distances involving more than 10 units consult the applicable Service guidance.
4. When handling more than one missile, the missiles must be transported or handled in a nose-to-tail configuration and in their launch capsule or shipping container; furthermore, they must be aligned and/or handled so that each group of two missiles is located outside of the warhead fragment beam spray region of the other two missiles.

General Comments:

(a) Items identified by an asterisk "*" include fragments from shipping or storage container(s). However, all of the HFD in this table may be applied to both packaged and unpackaged configurations.

(b) Those items with WAU-17 warhead.

(c) 105-mm projectiles and 105-mm complete rounds not in standard storage or shipping containers are HD 1.1.

(d) All MODS (includes ADCAP).

(e) Sandbag shield is required only during handling of torpedoes from motor vehicles. Sandbag shield requirement is equivalent to a minimum thickness of 2-feet [0.61 m] of sand between the motor vehicle cab and the torpedoe(s). The sandbags must shield all parts of the motor vehicle cab from the torpedo warhead. The barricade is not required during handling from boats, torpedo transporters, forklifts, or portable cranes.

C9.4.1.2.1.1.3.1. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, where internal dimensions are a minimum of 26 ft [7.92 m] wide and 60 ft [18.29 m] long, use "Earth-Covered Magazine" distances shown in Table C9.T1.

C9.4.1.2.1.1.3.2. For Hazard Division 1.1 in a 7-Bar or a 3-Bar ECM, where internal dimensions are less than 26 ft [7.92 m] wide and 60 ft [18.29 m] long, use "Other PES" distances of Table C9.T1. for front, side, and rear exposures.

C9.4.1.2.1.1.3.3. For Hazard Division 1.1 in an Undefined ECM, where internal dimensions are a minimum of 26 ft [7.92 m] wide and 60 ft [18.29 m] long, use "Earth-Covered Magazine - side and rear" distances of C9.T1. and "Other PES" distance of Table C9.T1. for the front exposure.

C9.4.1.2.1.1.3.4. For Hazard Division 1.1 in an Undefined ECM, where internal dimensions are less than 26 ft [7.92 m] wide and 60 ft [18.29 m] long, use "Other PES" distances of Table C9.T1. for front, side, and rear exposures.

C9.4.1.2.1.1.4. For sparsely populated locations (i.e., no more than 25 persons located in any sector bounded by the sides of a 45 degree angle, with the vertex at the PES, and the 900 ft [274 m] and 1,250 ft [381 m] arcs from the PES), the minimum 1,250 ft [381 m] fragment distance may be reduced to 900 ft [274 m] if the NEWQD of the PES does not exceed 11,400 lbs [5,171 kg].

C9.4.1.2.1.1.5. For PTR, the minimum fragment distance for HD 1.1 AE shall be based on the traffic density considered at three levels: high, medium, and low traffic density. The traffic density shall be averaged over a normal (non-holiday) week in terms of number of passengers during a 24-hour period. Minimum fragment distance reductions based on sparse population considerations addressed above, do not apply to public traffic routes. (NOTE: In applying criteria other than the default values given below (which are based on car (and rail) speed of 50 mph (80 kph), and a ship speed of 10 mph (16 kph)), considerations such as the following shall be taken into account to establish exposure levels: speed of vehicles, number of passengers per vehicle, protection afforded by the vehicle, variation in daily traffic levels in relation to AE activities, and seasonal traffic trends. The default value of two passengers per car may be used to estimate traffic density.)

C9.4.1.2.1.1.5.1. High Traffic Density. If routes have 10,000 or more car or rail passengers per day, or 2,000 or more ship passengers per day, then IBD criteria apply.

C9.4.1.2.1.1.5.2. Medium Traffic Density. If routes have between 400 and 10,000 car or rail passengers per day, or between 80 and 2,000 ship passengers per day, then 60 percent of the specified minimum fragment distance for IBD applies. As a minimum, these criteria apply to any recreational activity that is extensive and occurs on a regular basis.

C9.4.1.2.1.1.5.3. Low Traffic Density. If routes have fewer than 400 car or rail passengers per day, or fewer than 80 ship passengers per day, then no minimum fragment distance is required. Minimum distance shall be based on blast criteria ($24W^{1/3}/30W^{1/3}$ $[9.52Q^{1/3}/11.9Q^{1/3}]$).

C9.4.1.2.1.1.5.4. For other exposures that are permitted at PTRD, fragment distance minima for HD 1.1 AE shall be at least 60 percent of the specified minimum fragment distance for IBD.

C9.4.1.2.1.2. Minimum fragment distances apply to:

C9.4.1.2.1.2.1. An installation's boundary unless the area outside the boundary naturally prohibits access or is government land that is not open to the public. When a QD arc extends beyond an installation's boundary, and the above exclusion applies, the DoD Component shall certify IBD protection need not be applied to the encumbered area and shall establish procedures to monitor the area for any change in status.

C9.4.1.2.1.2.2. Administration and housing areas.

C9.4.1.2.1.2.3. Recreation facilities (e.g., ball diamonds, golf courses and volleyball courts). (NOTE: See subparagraph C9.4.1.2.1.3.1. for situations where minimum fragment distances do not apply to recreational facilities.)

C9.4.1.2.1.2.4. Flight-line passenger service functions (e.g., terminal buildings).

C9.4.1.2.1.2.5. Main powerhouses that provide vital utilities to a major portion of an installation.

C9.4.1.2.1.2.6. Inert storage and shops that by reason of their vital strategic nature, or high intrinsic value of their contents, should not be placed at risk.

C9.4.1.2.1.2.7. Functions that, if momentarily put out of action, would cause an immediate secondary hazard by reason of their failure to function.

C9.4.1.2.1.2.8. Private vehicles parked in administrative areas.

C9.4.1.2.1.3. Examples when minimum fragment and firebrand distances need not apply are:

C9.4.1.2.1.3.1. Recreation or training facilities when such facilities are located near AE support operations and are used by off-duty military or on-duty military or DoD civilians or contractors (e.g., munitions workers, security guards, firefighters) who directly support these AE operations.

C9.4.1.2.1.3.2. Related and support DoD-controlled functions for which IMD and ILD would normally apply.

C9.4.1.2.1.3.3. Maintenance, supply, training facilities, and operations offices for logistical or operational support of combat aircraft, battalion-size or smaller delivery or AE supply units, separate air defense firing batteries, or a single pier or wharf for which the AE in a PES is intended.

C9.4.1.2.1.3.4. Between a PES and inert storage, whether in a facility or in the open.

C9.4.1.2.1.3.5. Between facilities in an operating line; between operating lines; and between operating lines and storage locations.

C9.4.1.3. IBD and PTRD. Subparagraph C9.4.1.2.1.1. specifies required separation distances to inhabited buildings and public traffic routes for ECM and other types of PESs containing HD 1.1. Permissible exposures at these distances are listed in subparagraphs C9.4.1.1.4. through C9.4.1.1.6.

C9.4.1.3.1. ECM. Specified separations from ECM consider reductions in blast overpressure attributable to the earth cover of ECM, when the earth cover has a minimum thickness of 2 ft [0.61 m]. See subparagraph C9.4.1.2.1.1. for application of "Earth-Covered Magazine" distances of Table C9.T1. to 7-Bar, 3-Bar, and Undefined ECM. The definitions for "front", "side", and "rear" for ECM are illustrated in Figure C9.F1. and are described below:

C9.4.1.3.1.1. The forward sector, or "front," for ECM is that area 60 degrees either side of the ECM's centerline (120 degrees combined angle), with the vertex of the angle placed so that the sides of the angle pass through the intersection of the headwall and sidewalls

C9.4.1.3.1.2. The rear sector, or "rear", of an ECM is that area 45 degrees either side of the magazine centerline (90 degrees combined angle) with the vertex of the angle placed so that the sides of the angle pass through the intersection of the rear and side walls

C9.4.1.3.1.3. All other orientations are considered "side" sectors.

C9.4.1.3.2. HPM. Testing has shown that the design of the earth-bermed HPM attenuates pressures relative to an unconfined surface burst similar to that indicated above for an ECM. The following pertain to siting of an HPM:

C9.4.1.3.2.1. An HPM has a "front" sector and a "side" sector. The definition of "front" for ECM (see subparagraph C9.4.1.3.1.1. above) applies to an HPM. All other

orientations are considered "side" sectors. Figure C9.F8. illustrated the sectors associated with an HPM. (NOTE: An HPM has no "rear" sector.)

C9.4.1.3.2.2. The values shown in Table C9.T4. for front exposure from an ECM also apply to the front of an HPM.

C9.4.1.3.2.3. The values shown in Table C9.T4. for side exposure from an ECM apply to the remainder (all but the front) of an HPM.

C9.4.1.4. ILD. Separation distances required between AE and non-AE buildings and sites within an AE operating line are listed for various quantities of HD 1.1 AE in Table C9.T5. Permissible exposures at ILD are listed in subparagraphs C9.4.1.1.1. (barricaded ILD) and C9.4.1.1.2. (unbarricaded ILD). In order to apply barricaded ILD, barricades must comply with paragraph C5.3.2. (NOTE: The separation distance between an operating building and its service magazine shall be based on the NEWQD and the HD of the AE in the magazine and not that in other parts of the operating line).

C9.4.1.4.1. ILD from ECM. Testing has shown that some attenuation of airblast overpressure relative to an unconfined surface burst occurs out the sides and rear of an ECM and a slight increase occurs out the front of an ECM. The equivalent $9W^{1/3}$ [$3.57Q^{1/3}$] (12 psi [82.7 kPa] (barricaded)) and $18W^{1/3}$ [$7.14\ Q^{1/3}$] (3.5 psi [24 kPa] (unbarricaded)) ILD from an ECM, when accounting for this attenuation, are given in Table C9.T4. (NOTE: Airblast forms the bases for the equations given in the Notes for this table.)

C9.4.1.4.2. Barricaded ILD from an ECM. Subparagraph C9.4.1.5.4. provides criteria for the application of barricaded ILD from an ECM.

C9.4.1.4.3. ILD from HPM. The values shown in Table C9.T4. for front exposure from an ECM also apply to front exposures from an HPM. The values shown in Table C9.T4. for side exposure from an ECM apply to all other orientations of an HPM. (NOTE: The side of an HPM is considered barricaded, provided the earth barricading complies with the design drawing.)

C9.4.1.5. IMD. Magazines for HD 1.1 shall be separated one from another per Tables C9.T6., C9.T7A., and C9.T7B. (NOTE: Table C9.T6. provides orientation relationships for ECM and Tables C9.T7A. and C9.T7B. provide the actual separation distances.)

C9.4.1.5.1. For examples of siting rules for various magazine orientations see Figures C9.F1. through C9.F8.

C9.4.1.5.2. Barricaded IMD from ECM. Paragraph C9.4.1.5.4. provides criteria for the application of barricaded IMD from ECM.

C9.4.1.5.3. Other factors limiting ECM storage include:

C9.4.1.5.3.1. Quantities above 500,000 lbs [226,795 kg] NEWQD in one ECM are not authorized, except for energetic liquids.

C9.4.1.5.3.2. The 7-foot separation distance given in Table C9.T7A. for 100 lbs [45.4 kg] NEWQD constitutes the minimum side-to-side magazine separation distance.

C9.4.1.5.4. Application of Barricaded ILD and Barricaded IMD from an ECM. Figure C9.F7. illustrates the IMD relationships that can exist between an ECM and AGM and the ILD relationships that can exist between an ECM and facilities permitted to be at ILD or

barricaded ILD from an ECM, when each contain HD 1.1 AE. Permissible exposures at ILD are listed in subparagraphs C9.4.1.1.1. (barricaded ILD) and C9.4.1.1.2. (unbarricaded ILD). Siting criteria for AGM are provided in Table C9.T6. The following criteria shall apply to the use of barricaded IMD for AGM and for use of barricaded ILD:

C9.4.1.5.4.1. Front Sector of an ECM. Use of barricaded ILD or barricaded IMD, as applicable, between an ECM and a facility located within the ECM's front sector requires that a properly constructed, intervening barricade be located between the ES and the PES. This barricade must meet the construction and location criteria of section C5.3. If it does not meet these criteria, then unbarricaded IMD or unbarricaded ILD, as applicable, shall be used for siting purposes.

C9.4.1.5.4.2. Side and Rear Sectors of an ECM. If an ECM's earth cover meets all construction criteria of section C5.3., it will qualify as a barricade, and use of barricaded ILD or barricaded IMD, as applicable, from the sides or rear of the ECM is permissible. Failure of the ECM's earth cover to meet these criteria shall require use of unbarricaded IMD or unbarricaded ILD, as applicable, for siting purposes.

C9.4.1.5.5. Application of Barricaded ILD and Barricaded IMD from an HPM. Permissible exposures at ILD are listed in subparagraphs C9.4.1.1.1. (barricaded ILD) and C9.4.1.1.2. (unbarricaded ILD). Siting criteria for HPM containing HD 1.1 are provided in Table C9.T6. The following applies to an HPM:

C9.4.1.5.5.1. Front Sector of an HPM. Use of barricaded ILD or barricaded IMD, as applicable, between an HPM and a facility located within the HPM's front sector requires that a properly constructed, intervening barricade be located between the ES and the PES. This barricade must meet the construction and location criteria of section C5.3. If it does not meet these criteria, then unbarricaded IMD or ILD, as applicable, shall be used for siting purposes.

C9.4.1.5.5.2. Side Sector of an HPM. If the earth berm surrounding an HPM meets all construction criteria shown on the DDESB-approved construction drawing, it will qualify as a barricade and use of barricaded ILD or barricaded IMD, as applicable, from the HPM's sides is permissible. Failure to meet these criteria shall require use of unbarricaded IMD or unbarricaded ILD, as applicable, for siting purposes.

C9.4.1.5.6. These IMD standards apply only to storage of HD 1.1 AE. Existing ECM, regardless of orientation, that meet the construction and barricading requirements of chapter 5 and are sited one from another for a minimum of 100 lbs [45.4 kg] NEWQD of HD 1.1 may be used to their physical storage capacity for HD 1.2, HD 1.3, and HD 1.4 AE; provided distances to other exposures comply with applicable QD requirements.

TABLE C9.T4. HD 1.1 ILD FROM ECM

NEWQD	Barricaded			Unbarricaded		
	Front[1]	Side[2]	Rear[3]	Front[4]	Side[5]	Rear[6]
(lbs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
[kg]	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*
50	37	26	22	66	59	44
22.7	*11.2*	*7.9*	*6.7*	*20.2*	*18.0*	*13.5*
70	41	29	25	74	66	49
31.8	*12.6*	*8.8*	*7.5*	*22.6*	*20.1*	*15.1*
100	46	32	28	84	74	56
45.4	*14.2*	*9.9*	*8.5*	*25.5*	*22.6*	*17.0*
150	53	37	32	96	85	64
68.0	*16.2*	*11.3*	*9.7*	*29.1*	*25.9*	*19.4*
200	58	41	35	105	94	70
90.7	*17.8*	*12.5*	*10.7*	*32.1*	*28.5*	*21.4*
300	67	47	40	120	107	80
136.1	*20.4*	*14.3*	*12.2*	*36.7*	*32.7*	*24.5*
500	79	56	48	143	127	95
226.8	*24.2*	*17.0*	*14.5*	*43.5*	*38.7*	*29.0*
700	89	62	53	160	142	107
317.5	*27.1*	*19.0*	*16.2*	*48.7*	*43.3*	*32.5*
1,000	100	70	60	180	160	120
453.6	*30.5*	*21.4*	*18.3*	*54.9*	*48.8*	*36.6*
1,500	114	80	69	206	183	137
680.4	*34.9*	*24.5*	*20.9*	*62.8*	*55.9*	*41.9*
2,000	126	88	76	227	202	151
907.2	*38.4*	*26.9*	*23.0*	*69.1*	*61.5*	*46.1*
3,000	144	101	87	260	231	173
1,360.8	*44.0*	*30.8*	*26.4*	*79.1*	*70.4*	*52.7*
5,000	171	120	103	308	274	205
2,268.0	*52.2*	*36.5*	*31.3*	*93.8*	*83.4*	*62.5*
7,000	191	134	115	344	306	230
3,175.1	*58.4*	*40.9*	*35.0*	*104.9*	*93.3*	*70.0*
10,000	215	151	129	388	345	259
4,535.9	*65.7*	*46.0*	*39.4*	*118.2*	*105.1*	*78.8*
15,000	247	173	148	444	395	296
6,803.9	*75.2*	*52.7*	*45.1*	*135.3*	*120.3*	*90.2*
20,000	271	190	163	489	434	326
9,071.8	*82.8*	*58.0*	*49.6*	*148.9*	*132.4*	*99.3*
30,000	311	218	186	559	497	373
13,607.7	*94.8*	*66.4*	*56.8*	*170.5*	*151.6*	*113.6*
50,000	368	258	221	663	589	442
22,679.5	*112.4*	*78.7*	*67.4*	*202.1*	*179.7*	*134.7*

TABLE C9.T4. HD 1.1 ILD FROM ECM (continued)

NEWQD	Barricaded			Unbarricaded		
	Front[1]	Side[2]	Rear[3]	Front[4]	Side[5]	Rear[6]
(lbs)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
[kg]	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*	*[m]*
70,000	412	288	247	742	659	495
31,751.3	*125.7*	*88.0*	*75.4*	*226.1*	*201.1*	*150.7*
100,000	464	325	278	835	743	557
45,359.0	*141.6*	*99.1*	*84.9*	*254.6*	*226.5*	*169.8*
150,000	531	372	319	956	850	653
68,038.5	*162.1*	*113.5*	*97.2*	*291.5*	*259.2*	*199.1*
200,000	585	409	351	1,053	936	746
90,718.0	*178.4*	*124.9*	*106.9*	*320.8*	*285.3*	*227.4*
300,000	669	469	402	1,205	1,071	937
136,077.0	*204.2*	*143.0*	*122.4*	*367.2*	*326.6*	*285.7*
500,000	715	714	714	1,429	1,429	1,429
226,795.0	*218.0*	*217.7*	*217.7*	*435.4*	*435.4*	*435.4*

NOTES for Table C9.T4:

1. (NEWQD in lbs, d in ft)

NEWQD $\leq$ 300,000 lbs	$d = 10*NEWQD^{1/3}$	**[EQN C9.T4-1]**
300,000 lbs < NEWQD $\leq$ 500,000 lbs	$d = (13.659 - 1.6479 \times 10^{-5}*NEWQD + 1.4358 \times 10^{-11}* NEWQD^2)*$ $NEWQD^{1/3}$	**[EQN C9.T4-2]**
d $\leq$ 669 ft	$NEWQD = d^3/1000$	**[EQN C9.T4-3]**
669 ft < d $\leq$ 715 ft	$NEWQD = 1.50138 \times 10^8 - 6.73914 \times 10^5 *d + 1002.9*d^2 - 0.4938*d^3$	**[EQN C9.T4-4]**

(NEWQD in kg, d in m)

NEWQD $\leq$ 136,077 kg	$d = 3.97*NEWQD^{1/3}$	**[EQN C9.T4-5]**
136,077 kg < NEWQD $\leq$ 226,795 kg	$d = (5.419 - 1.4410 \times 10^{-5}*NEWQD + 2.7684 \times 10^{-11}* NEWQD^2)*NEWQD^{1/3}$	**[EQN C9.T4-6]**
d $\leq$ 204.2 m	$NEWQD = d^3/62.429$	**[EQN C9.T4-7]**
204.2 < d $\leq$ 218.0 m	$NEWQD = 6.80924 \times 10^7 - 1.002764 \times 10^6*d + 4895.93*d^2 - 7.90884*d^3$	**[EQN C9.T4-8]**

2. (NEWQD in lbs, d in ft)

NEWQD $\leq$ 300,000 lbs	$d = 7*NEWQD^{1/3}$	**[EQN C9.T4-9]**
300,000 lbs < NEWQD $\leq$ 400,000 lbs	$d = (1.0848 + 1.986 \times 10^{-5}*NEWQD)*NEWQD^{1/3}$	**[EQN C9.T4-10]**
NEWQD > 400,000 lbs	$d = 9*NEWQD^{1/3}$	**[EQN C9.T4-11]**
d $\leq$ 469 ft	$NEWQD = d^3/343$	**[EQN C9.T4-12]**
469 ft < d $\leq$ 663 ft	$NEWQD = 57{,}424 + 515.89*d$	**[EQN C9.T4-13]**
d > 663 ft	$NEWQD = d^3/729$	**[EQN C9.T4-14]**

	(NEWQD in kg, d in m)		
	NEWQD ≤ 136,077 kg	$d = 2.78*NEWQD^{1/3}$	**[EQN C9.T4-15]**
	136,077 kg < NEWQD ≤ 181,434 kg	$d = (0.4303 + 1.7369 \times 10^{-5}*NEWQD)*NEWQD^{1/3}$	**[EQN C9.T4-16]**
	NEWQD > 181,436 kg	$d = 3.57*NEWQD^{1/3}$	**[EQN C9.T4-17]**
	d ≤ 143.7 m	$NEWQD = d^3/21.413$	**[EQN C9.T4-18]**
	143.7 m < d ≤ 202.8 m	$NEWQD = 26,048 + 767.73*d$	**[EQN C9.T4-19]**
	d > 202.8 m	$NEWQD = d^3/45.511$	**[EQN C9.T4-20]**
3.	(NEWQD in lbs, d in ft)		
	NEWQD ≤ 300,000 lbs	$d = 6*NEWQD^{1/3}$	**[EQN C9.T4-21]**
	300,000 lbs < NEWQD ≤ 400,000 lbs	$d = (-3.059 + 3.0228 \times 10^{-5}*NEWQD)*NEWQD^{1/3}$	**[EQN C9.T4-22]**
	NEWQD > 400,000 lbs	$d = 9*NEWQD^{1/3}$	**[EQN C9.T4-23]**
	d ≤ 402 ft	$NEWQD = d^3/216$	**[EQN C9.T4-24]**
	402 ft < d ≤ 665 ft	$NEWQD = 148,160 + 379.7*d$	**[EQN C9.T4-25]**
	d > 665 ft	$NEWQD = d^3/729$	**[EQN C9.T4-26]**
	(NEWQD in kg, d in m)		
	NEWQD ≤ 136,077 kg	$d = 2.38*NEWQD^{1/3}$	**[EQN C9.T4-27]**
	136,077 kg < NEWQD ≤ 181,436 kg	$d = (-1.2135 + 2.6437 \times 10^{-5}*NEWQD)*NEWQD^{1/3}$	**[EQN C9.T4-28]**
	NEWQD > 181,436 kg	$d = 3.57*NEWQD^{1/3}$	**[EQN C9.T4-29]**
	d ≤ 122.6 m	$NEWQD = d^3/13.485$	**[EQN C9.T4-30]**
	122.6 m < d ≤ 202.8 m	$NEWQD = 67,206 + 565.05*d$	**[EQN C9.T4-31]**
	d > 202.8 m	$NEWQD = d^3/45.511$	**[EQN C9.T4-32]**
4.	(NEWQD in lbs, d in ft)		
	NEWQD ≤ 500,000 lbs	$d = 18*NEWQD^{1/3}$	**[EQN C9.T4-33]**
	d ≤ 1429 ft	$NEWQD = d^3/5,832$	**[EQN C9.T4-34]**
	(NEWQD in kg, d in m)		
	NEWQD ≤ 226,795 kg	$d = 7.14*NEWQD^{1/3}$	**[EQN C9.T4-35]**
	d > 435.4 m	$NEWQD = d^3/364.086$	**[EQN C9.T4-36]**
5.	(NEWQD in lbs, d in ft)		
	NEWQD ≤ 300,000 lbs	$d = 16*NEWQD^{1/3}$	**[EQN C9.T4-37]**
	300,000 lbs < NEWQD ≤ 400,000 lbs	$d = (9.9683 + 2.0135 \times 10^{-5}*NEWQD)*NEWQD^{1/3}$	**[EQN C9.T4-38]**
	NEWQD > 400,000 lbs	$d = 18*NEWQD^{1/3}$	**[EQN C9.T4-39]**
	d ≤ 1071 ft	$NEWQD = d^3/4,096$	**[EQN C9.T4-40]**
	1071 ft < d ≤ 1328 ft	$NEWQD = -118,180 + 390.35*d$	**[EQN C9.T4-41]**
	d > 1328 ft	$NEWQD = d^3/5,832$	**[EQN C9.T4-42]**

(NEWQD in kg, d in m)

NEWQD $\leq$ 136,077 kg	$d = 6.35*NEWQD^{1/3}$	**[EQN C9.T4-43]**
136,077 kg < NEWQD $\leq$ 181,436 kg	$d = (3.9544 + 1.76097 \times 10^{-5}*NEWQD)*NEWQD^{1/3}$	**[EQN C9.T4-44]**
NEWQD > 181,436 kg	$d = 7.14*NEWQD^{1/3}$	**[EQN C9.T4-45]**
d $\leq$ 326.6 m	$NEWQD = d^3/255.709$	**[EQN C9.T4-46]**
122.6 m < d $\leq$ 202.8 m	$NEWQD = -53{,}605 + 580.89*d$	**[EQN C9.T4-47]**
d > 404.7 m	$NEWQD = d^3/364.086$	**[EQN C9.T4-48]**

6. (NEWQD in lbs, d in ft)

NEWQD $\leq$ 100,000 lbs	$d = 12*NEWQD^{1/3}$	**[EQN C9.T4-49]**
100,000 lbs < NEWQD $\leq$ 300,000 lbs	$d = (11.521 + 1.9918 \times 10^{-6}*NEWQD + 2.0947 \times 10^{-11}* NEWQD^2)* NEWQD^{1/3}$	**[EQN C9.T4-50]**
300,000 lbs < NEWQD $\leq$ 400,000 lbs	$d = (1.9389+ 4.0227 \times 10^{-5}*NEWQD)* NEWQD^{1/3}$	**[EQN C9.T4-51]**
NEWQD > 400,000 lbs	$d = 18*NEWQD^{1/3}$	**[EQN C9.T4-52]**
d $\leq$ 557 ft	$NEWQD = d^3/1{,}728$	**[EQN C9.T4-53]**
557 ft < d $\leq$ 938 ft	$NEWQD = -193{,}080+526.83*d$	**[EQN C9.T4-54]**
938 ft < d $\leq$ 1328 ft	$NEWQD = 60{,}778 + 255.83*d$	**[EQN C9.T4-55]**
d > 1328 ft	$NEWQD = d^3/5{,}832$	**[EQN C9.T4-56]**

(NEWQD in kg, d in m)

NEWQD $\leq$ 45,359 kg lbs	$d = 4.76*NEWQD^{1/3}$	**[EQN C9.T4-57]**
45,359 kg < NEWQD $\leq$ 136,077 kg	$d = (4.5704 + 1.7420 \times 10^{-6}*NEWQD + 4.0389 \times 10^{-11}* NEWQD^2)* NEWQD^{1/3}$	**[EQN C9.T4-58]**
136,077 kg < NEWQD $\leq$ 181,436 kg	$d = (0.7692+ 3.5182 \times 10^{-5}*NEWQD)* NEWQD^{1/3}$	**[EQN C9.T4-59]**
NEWQD 181,436 kg	$d = 7.14*NEWQD^{1/3}$	**[EQN C9.T4-60]**
d $\leq$ 169.8 m	$NEWQD = d^3/107.877$	**[EQN C9.T4-61]**
169.8 m < d $\leq$ 285.7 m	$NEWQD = -87{,}578 + 784.00*d$	**[EQN C9.T4-62]**
285.7 m < d $\leq$ 404.7 m	$NEWQD = 27{,}568 + 380.7*d$	**[EQN C9.T4-63]**
d > 404.7 m	$NEWQD = d^3/364.086$	**[EQN C9.T4-64]**

TABLE C9.T5. HD 1.1 ILD

NEWQD (lbs) *[kg]*	BARRICADED DISTANCE[1] (ft) *[m]*	UNBARRICADED DISTANCE[2] (ft) *[m]*
50[3]	33	66
22.7[3]	*10.1*	*20.2*
70	37	74
31.8	*11.3*	*22.6*
100	42	84
45.4	*12.7*	*25.5*
150	48	96
68.0	*14.6*	*29.1*
200	53	105
90.7	*16.0*	*32.1*
300	60	120
136.1	*18.4*	*36.7*
500	71	143
226.8	*21.8*	*43.5*
700	80	160
317.5	*24.4*	*48.7*
1,000	90	180
453.6	*27.4*	*54.9*
1,500	103	206
680.4	*31.4*	*62.8*
2,000	113	227
907.2	*34.6*	*69.1*
3,000	130	260
1,360.8	*39.6*	*79.1*
5,000	154	308
2,268.0	*46.9*	*93.8*
7,000	172	344
3,175.1	*52.5*	*104.9*
10,000	194	388
4,535.9	*59.1*	*118.2*
15,000	222	444
6,803.9	*67.6*	*135.3*
20,000	244	489
9,071.8	*74.5*	*148.9*
30,000	280	559
13,607.7	*85.2*	*170.5*

TABLE C9.T5. HD 1.1 ILD (continued)

NEWQD (lbs) *[kg]*	BARRICADED DISTANCE[1] (ft) *[m]*	UNBARRICADED DISTANCE[2] (ft) *[m]*
50,000	332	663
22,679.5	*101.1*	*202.1*
70,000	371	742
31,751.3	*113.0*	*226.1*
100,000	418	835
45,359.0	*127.3*	*254.6*
150,000	478	956
68,038.5	*145.7*	*291.5*
200,000	526	1,053
90,718.0	*160.4*	*320.8*
300,000	602	1,205
136,077.0	*183.6*	*367.2*
500,000[4]	714	1,429
226,795.0[4]	*217.7*	*435.4*
700,000	799	1,598
317,513.0	*243.6*	*487.1*
1,000,000	900	1,800
453,590.0	*274.3*	*548.6*
1,500,000	1,030	2,060
680,385.0	*314.0*	*628.0*
2,000,000	1,134	2,268
907,180.0	*345.6*	*691.2*
3,000,000	1,298	2,596
1,360,770.0	*395.6*	*791.2*
5,000,000	1,539	3,078
2,267,950.0	*469.0*	*938.1*

NOTES for Table C9.T5:

1. (d in ft, NEWQD in lbs)

$$d = 9*NEWQD^{1/3} \quad \textbf{[EQN C9.T5-1]}$$

(d in m, NEWQD in kg)

$$d = 3.57*NEWQD^{1/3} \quad \textbf{[EQN C9.T5-2]}$$

(NEWQD in lbs, d in ft)

$$NEWQD = d^3/729 \quad \textbf{[EQN C9.T5-3]}$$

(NEWQD in kg, d in m)

$$NEWQD = d^3/45.511 \quad \textbf{[EQN C9.T5-4]}$$

2. (d in ft, NEWQD in lbs)

$$d = 18*NEWQD^{1/3} \quad \textbf{[EQN C9.T5-5]}$$

(d in m, NEWQD in kg)

$$d = 7.14*NEWQD^{1/3} \quad \textbf{[EQN C9.T5-6]}$$

(NEWQD in lbs, d in ft)

$$NEWQD = d^3/5{,}832 \quad \textbf{[EQN C9.T5-7]}$$

(NEWQD in kg, d in m)

$$NEWQD = d^3/364.086 \quad \textbf{[EQN C9.T5-8]}$$

3. For less than 50 lbs [22.7 kg], less distance may be used when structures, blast mats, and the like can completely contain fragments and debris. This table is not applicable when blast, fragments, and debris are completely confined, as in certain test firing barricades.

4. Quantities above 500,000 lbs [226,795 kg] NEWQD are authorized only for HD 1.1 energetic liquids.

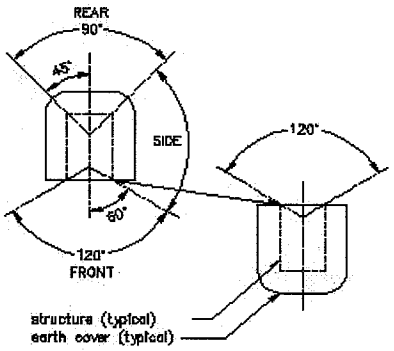


FIGURE C9.F1. ECM Orientation Effects on IMD: Side-to-Side Orientation (see subparagraph C9.4.1.5)

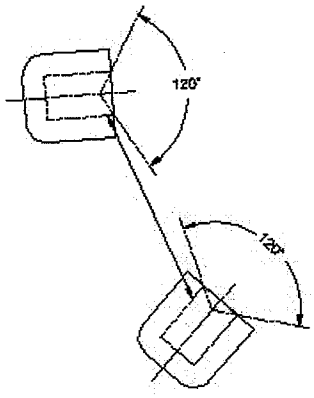
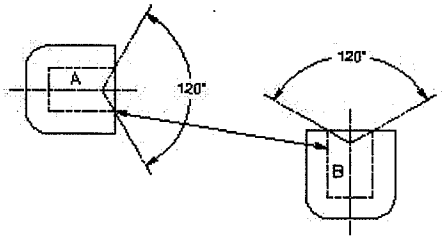


FIGURE C9.F2. ECM Orientation Effects on IMD: Side-to-Side Orientation (see subparagraph C9.4.1.5)



NOTES:

Site A as a Side-to-Front (unbarricaded) ES
Site B as a Front (unbarricaded)-to-Side ES

FIGURE C9.F3. ECM Orientation Effects on IMD (see subparagraph C9.4.1.5)

TABLE C9.T6. HD 1.1 IMD Hazard Factors

To EXPOSED SITE (ES)		From POTENTIAL EXPLOSION SITE (PES)									
		ECM[1]				AGM[2]		Modules and/or Cells		HPM[3,9]	
		S	R	FB	FU	B	U	B	U	S	F[4]
ECM (7-Bar)	S	1.25 *0.50*	1.25 *0.50*	2.75 *1.09*	2.75 *1.09*	4.5 *1.79*	4.5 *1.79*	4.5 *1.79*	4.5 *1.79*	1.25 *0.50*	2.75 *1.09*
	R	1.25 *0.50*	1.25 *0.50*	2 *0.79*	2 *0.79*	4.5 *1.79*	4.5 *1.79*	4.5 *1.79*	4.5 *1.79*	1.25 *0.50*	2 *0.79*
	FU	2.75 *1.09*	2 *0.79*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	2.75 *1.09*	6 *2.38*
	FB[5]	2.75 *1.09*	2 *0.79*	4.5 *1.79*	6 *2.38*	4.5 *1.79*	6 *2.38*	4.5 *2.38*	6 *2.38*	2.75 *1.09*	6 *2.38*
ECM (3-Bar)	S	1.25 *0.50*	1.25 *0.50*	2.75 *1.09*	2.75 *1.09*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	1.25 *0.50*	2.75 *1.09*
	R	1.25 *0.50*	1.25 *0.50*	2 *0.79*	2 *0.79*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	1.25 *0.50*	2 *0.79*
	FU	4.5 *1.79*	4.5 *1.79*	6 *3.57*	9 *3.57*	6 *2.38*	9 *3.57*	6 *2.38*	9 *3.57*	4.5 *1.79*	9 *3.57*
	FB[5]	4.5 *1.79*	4.5 *1.79*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	4.5 *1.79*	6 *2.38*
ECM (Undefined)	S	1.25[6] *0.50*[6] 2[7] *0.79*[7]	1.25[6] *0.50*[6] 2[7] *0.79*[7]	4.5[6] *1.79*[6] 6[7] *2.38*[7]	4.5[6] *1.79*[6] 6[7] *2.38*[7]	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	1.25 *0.50*	4.5 *1.79*
	R	1.25 *0.50*	1.25 *0.50*	2 *0.79*	2 *0.79*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	1.25 *0.50*	2 *0.79*
	FU	6 *2.38*	6 *2.38*	6 *2.38*	11 *4.36*	6 *2.38*	11 *4.36*	6 *2.38*	11 *2.38*	6 *2.38*	11 *4.36*
	FB[5]	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*
AGM	U	6 *2.38*	6 *2.38*	6 *2.38*	11 *4.36*	6 *2.38*	11 *4.36*	6 *2.38*	11 *2.38*	6 *2.38*	11 *4.36*
	B	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*
Modules and/or Cells	U	6 *2.38*	6 *2.38*	6 *2.38*	11 *4.36*	6 *2.38*	11 *4.36*	1.1[8] *0.44*[8]	11 *4.36*	6 *2.38*	11
	B	1.25 *0.50*	1.25 *0.50*	6 *2.38*	6 *2.38*	6 *2.38*	6 *2.38*	1.1[8] *0.44*[8]	1.1[8] *0.44*[8]	1.25 *0.50*	6 *2.38*
HPM	S,F[9]	1.25 *0.50*	1.25 *0.50*	2.75 *1.09*	2.75 *1.09*	4.5 *1.79*	4.5 *1.79*	4.5 *1.79*	4.5 *1.79*	1.25 *0.50*	2.75 *1.09*

LEGEND for Table C9.T6:

S—Side; **R**—Rear; **F**—Front: **B**—Barricaded; **U**—Unbarricaded; **FU**—Front Unbarricaded; **FB**—Front Barricaded.

ECM—earth-covered magazine (7-bar, 3-bar, or undefined, which refers to the structural strength of the headwall and door(s)).

AGM—aboveground magazine

HPM—high performance magazine

NOTES for Table C9.T6:

1. Descriptions of ECM are in paragraph C5.2.1.

2. AGM are all types of above grade (non earth-covered) magazines or storage pads.
3. A description of an HPM can be found at paragraph C5.2.4. Additional information is provided in subparagraph C9.4.1.3. The MCE in an HPM is limited to a maximum of 60,000 lbs [27,216 kg].
4. The unbarricaded front (entrance to Loading Area) is a factor when the HPM is the PES because the MCE includes AE in the loading area. The hazard factors have been determined accordingly.
5. Those barricades serve to mitigate both fragments and overpressure hazards. See section C5.3. for their requirements.
6. Use this K-factor for NEWQD in PES up to 250,000 lbs [113,398 kg].
7. Use this K-factor for NEWQD in PES greater than 250,000 lbs [113,398 kg].
8. Modules and/or Cells are defined in paragraph C5.2.2.
9. The storage areas in the HPM are barricaded on all sides and protected by a reinforced concrete cover. All directions are, therefore, considered to be Side (S) orientations when it is the ES. For siting purposes, an HPM has no "Rear" (R) sector. See Figure C9.F8. for an illustration of the front and side sectors of an HPM.

TABLE C9.T7A. QD For HD 1.1 AE For K = 1.1, 1.25, 2, 2.75, 4.5, and 5

NEWQD	Hazard Factor, K					
	1.1	1.25	2	2.75	4.5	5
	0.44	*0.50*	*0.79*	*1.09*	*1.79*	*1.98*
(lbs)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)
[kg]	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*
100	7.0	7.0	9.3	13	21	23
45.4	*2.1*	*2.1*	*2.8*	*3.9*	*6.4*	*7.1*
150	7.0	7.0	11	15	24	27
68.0	*2.1*	*2.1*	*3.2*	*4.4*	*7.3*	*8.1*
200	7.0	7.3	12	16	26	29
90.7	*2.1*	*2.2*	*3.5*	*4.9*	*8.0*	*8.9*
300	7.4	8.4	13	18	30	33
136.1	*2.3*	*2.6*	*4.1*	*5.6*	*9.2*	*10.2*
500	8.7	9.9	16	22	36	40
226.8	*2.7*	*3.0*	*4.8*	*6.6*	*10.9*	*12.1*
700	9.8	11	18	24	40	44
317.5	*3.0*	*3.4*	*5.4*	*7.4*	*12.2*	*13.5*
1,000	11	13	20	27	45	50
453.6	*3.4*	*3.8*	*6.1*	*8.4*	*13.8*	*15.2*
1,500	13	14	23	31	52	57
680.4	*3.9*	*4.4*	*6.9*	*9.6*	*15.7*	*17.4*
2,000	14	16	25	35	57	63
907.2	*4.3*	*4.8*	*7.6*	*10.6*	*17.3*	*19.2*
3,000	16	18	29	40	65	72
1,360.8	*4.9*	*5.5*	*8.8*	*12.1*	*19.8*	*21.9*

TABLE C9.T7A. QD For HD 1.1 AE For K = 1.1, 1.25, 2, 2.75, 4.5, and 5 (Continued)

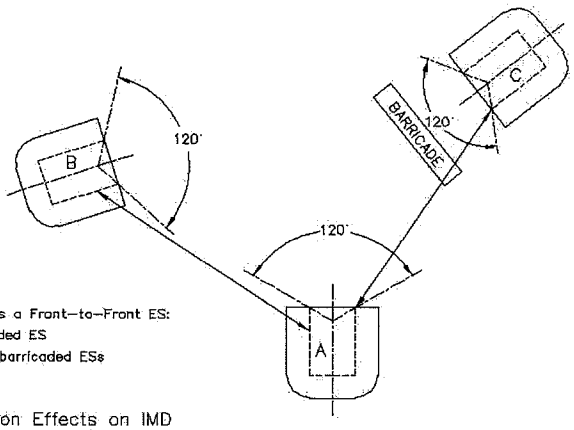
NEWQD	Hazard Factor, K					
	1.1	1.25	2	2.75	4.5	5
	0.44	*0.50*	*0.79*	*1.09*	*1.79*	*1.98*
(lbs)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)
[kg]	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*
5,000	19	21	34	47	77	85
2,268.0	*5.8*	*6.6*	*10.4*	*14.3*	*23.5*	*26.0*
7,000	21	24	38	53	86	96
3,175.1	*6.5*	*7.3*	*11.6*	*16.0*	*26.3*	*29.1*
10,000	24	27	43	59	97	108
4,535.9	*7.3*	*8.3*	*13.1*	*18.0*	*29.6*	*32.8*
15,000	27	31	49	68	111	123
6,803.9	*8.3*	*9.5*	*15.0*	*20.7*	*33.9*	*37.5*
20,000	30	34	54	75	122	136
9,071.8	*9.2*	*10.4*	*16.5*	*22.7*	*37.3*	*41.3*
30,000	34	39	62	85	140	155
13,607.7	*10.5*	*11.9*	*18.9*	*26.0*	*42.7*	*47.3*
50,000	41	46	74	101	166	184
22,679.5	*12.5*	*14.2*	*22.4*	*30.9*	*50.7*	*56.0*
70,000	45	52	82	113	185	206
31,751.3	*13.9*	*15.8*	*25.0*	*34.5*	*56.7*	*62.7*
100,000	51	58	93	128	209	232
45,359.0	*15.7*	*17.8*	*28.2*	*38.9*	*63.8*	*70.6*
150,000	58	66	106	146	239	266
68,038.5	*18.0*	*20.4*	*32.3*	*44.5*	*73.1*	*80.8*
200,000	64	73	117	161	263	292
90,718.0	*19.8*	*22.5*	*35.5*	*49.0*	*80.4*	*89.0*
300,000	74	84	134	184	301	335
136,077.0	*22.6*	*25.7*	*40.6*	*56.1*	*92.1*	*101.8*
500,000	87	99	159	218	357	397
226,795.0	*26.8*	*30.5*	*48.2*	*66.5*	*109.2*	*120.7*
700,000	98	111	178	244	400	444
317,513.0	*30.0*	*34.1*	*53.9*	*74.4*	*122.1*	*135.1*
1,000,000	110	125	200	275	450	500
453,590.0	*33.8*	*38.4*	*60.7*	*83.7*	*137.5*	*152.1*

TABLE C9.T7B. QD for HD 1.1 AE For K = 6, 8, 9, 11, 18, 40

NEWQD	Hazard Factor, K					
	6	8	9	11	18	40
	2.38	*3.17*	*3.57*	*4.36*	*7.14*	*15.87*
(lbs)	(ft/lb$^{1/3}$)	(ft/lb$^{1/3}$)	(ft/lb$^{1/3}$)	(ft/lb$^{1/3}$)	(ft/lb$^{1/3}$)	(ft/lb$^{1/3}$)
[kg]	*[m/kg$^{1/3}$]*	*[m/kg$^{1/3}$]*	*[m/kg$^{1/3}$]*	*[m/kg$^{1/3}$]*	*[m/kg$^{1/3}$]*	*[m/kg$^{1/3}$]*
100	28	37	42	51	84	186
45.4	*8.5*	*11.3*	*12.7*	*15.5*	*25.5*	*56.6*
150	32	43	48	58	96	213
68.0	*9.7*	*12.9*	*14.6*	*17.8*	*29.1*	*64.8*
200	35	47	53	64	105	234
90.7	*10.7*	*14.2*	*16.0*	*19.6*	*32.1*	*71.3*
300	40	54	60	74	120	268
136.1	*12.2*	*16.3*	*18.4*	*22.4*	*36.7*	*81.6*
500	48	63	71	87	143	317
226.8	*14.5*	*19.3*	*21.8*	*26.6*	*43.5*	*96.8*
700	53	71	80	98	160	355
317.5	*16.2*	*21.6*	*24.4*	*29.7*	*48.7*	*108.3*
1,000	60	80	90	110	180	400
453.6	*18.3*	*24.4*	*27.4*	*33.5*	*54.9*	*121.9*
1,500	69	92	103	126	206	458
680.4	*20.9*	*27.9*	*31.4*	*38.3*	*62.8*	*139.6*
2,000	76	101	113	139	227	504
907.2	*23.0*	*30.7*	*34.6*	*42.2*	*69.1*	*153.6*
3,000	87	115	130	159	260	577
1,360.8	*26.4*	*35.1*	*39.6*	*48.3*	*79.1*	*175.9*
5,000	103	137	154	188	308	684
2,268.0	*31.3*	*41.6*	*46.9*	*57.3*	*93.8*	*208.5*
7,000	115	153	172	210	344	765
3,175.1	*35.0*	*46.6*	*52.5*	*64.1*	*104.9*	*233.3*
10,000	129	172	194	237	388	862
4,535.9	*39.4*	*52.5*	*59.1*	*72.2*	*118.2*	*262.7*
15,000	148	197	222	271	444	986
6,803.9	*45.1*	*60.1*	*67.6*	*82.6*	*135.3*	*300.7*
20,000	163	217	244	299	489	1,086
9,071.8	*49.6*	*66.1*	*74.5*	*90.9*	*148.9*	*331.0*

TABLE C9.T7B. QD for HD 1.1 AE For K = 6, 8, 9, 11, 18, 40 (continued)

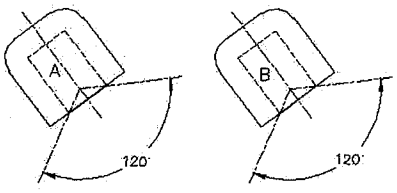
NEWQD	Hazard Factor, K					
	6	8	9	11	18	40
	2.38	*3.17*	*3.57*	*4.36*	*7.14*	*15.87*
(lbs)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)	($ft/lb^{1/3}$)
[kg]	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*	*[$m/kg^{1/3}$]*
30,000	186	249	280	342	559	1,243
13,607.7	*56.8*	*75.7*	*85.2*	*104.1*	*170.5*	*378.9*
50,000	221	295	332	405	663	1,474
22,679.5	*67.4*	*89.7*	*101.1*	*123.4*	*202.1*	*449.2*
70,000	247	330	371	453	742	1,649
31,751.3	*75.4*	*100.4*	*113.0*	*138.1*	*226.1*	*502.5*
100,000	278	371	418	511	835	1,857
45,359.0	*84.9*	*113.1*	*127.3*	*155.5*	*254.6*	*566.0*
150,000	319	425	478	584	956	2,125
68,038.5	*97.2*	*129.4*	*145.7*	*178.0*	*291.5*	*647.9*
200,000	351	468	526	643	1,053	2,339
90,718.0	*106.9*	*142.4*	*160.4*	*195.9*	*320.8*	*713.1*
300,000	402	536	602	736	1,205	2,678
136,077.0	*122.4*	*163.1*	*183.6*	*224.3*	*367.2*	*816.3*
500,000	476	635	714	873	1,429	3,175
226,795.0	*145.1*	*193.3*	*217.7*	*265.9*	*435.4*	*967.8*
700,000	533	710	799	977	1,598	3,552
317,513.0	*162.4*	*216.3*	*243.6*	*297.4*	*487.1*	*1,082.7*
1,000,000	600	800	900	1,100	1,800	4,000
453,590.0	*182.9*	*243.6*	*274.3*	*335.0*	*548.6*	*1,219.4*



NOTE:

1. Site each magazine as a Front-to-Front ES:
   Site C as a Barricaded ES
   Site A and B as unbarricaded ESs

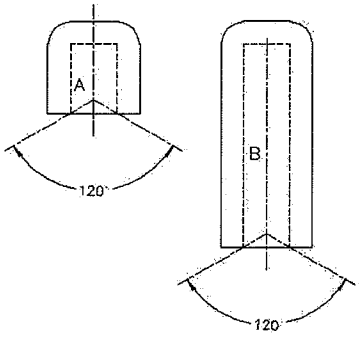
C9.F4. ECM Orientation Effects on IMD (see paraph C9.4.1.5)



NOTES:

1. Site A as a Side-to-Front (unbarricaded) ES.
2. Site B as a Front (unbarricaded)-to-side ES.

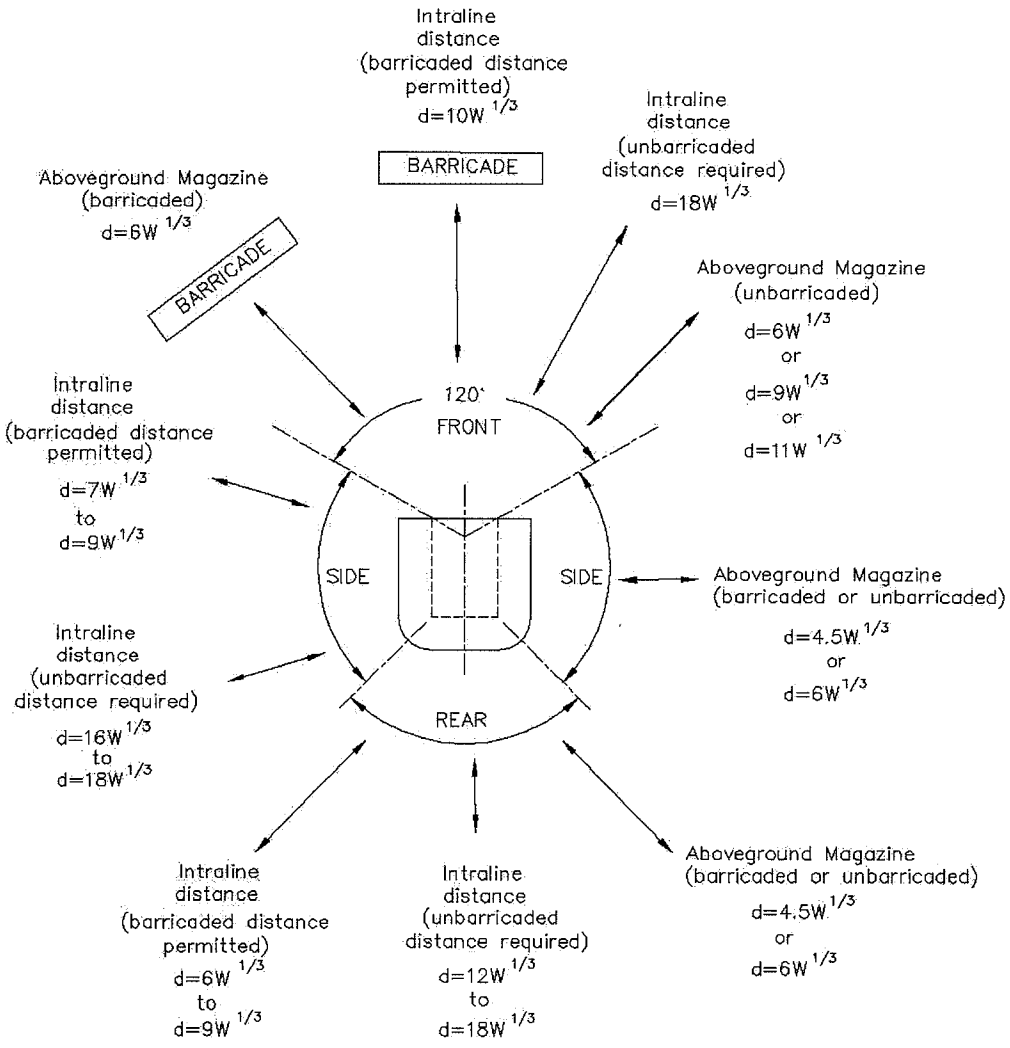
C9.F5. ECM Orientation Effects on IMD: Canted ECM (see paragraph C9.4.1.5)



NOTES:

1. Site A as a Side-to-Front (unbarricaded) ES.
2. Site B as a Front (unbarricaded)-to-side ES.

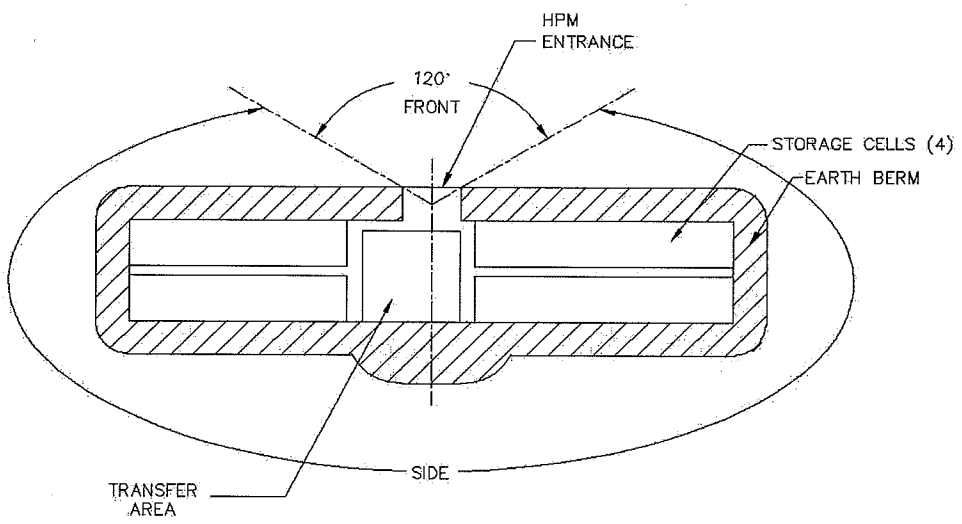
C9.F6. ECM Orientation Effects on IMD: ECM of Significantly Different Lengths (see paraph C9.4.1.5)



NOTES:

1. See C9.4.1.4.1. for application of intraline distances from an ECM.
2. See C9.4.1.5.2. for application of barricaded IMD and ILD from an ECM.
3. See C9.T6. for application of intermagazine distances between ECM and Aboveground Magazines.

C9.F7. ECM Orientation Effects on Barricaded and Unbarricaded IMD and ILD.



NOTES:

1. As an ES: Treat all exposures as sides.
2. As a PES: The HPM has a front, and all other exposures are considered sides.
3. See C9.4.1.3 for IBD/PTR criteria, C9.4.1.4 for ILD criteria, and C9.4.1.5 for IMD criteria associated with an HPM.

C9.F8. High Performance Magazine (HPM) Orientation Effects

C9.4.2. HD 1.2.

C9.4.2.1. General.

C9.4.2.1.1. HD 1.2 are items configured for storage and transportation that do not mass detonate when a single item or package in a stack is initiated. Explosions involving the items result in their burning and exploding progressively with no more than a few at a time reacting. These reactions will project fragments, firebrands, and unexploded items from the explosion site. Blast effects are limited to the immediate vicinity and are not the primary hazard.

C9.4.2.1.2. Small quantities of HD 1.2.1 ($\leq$ 450 pounds NEWQD [204 kg],), in certain packaging configurations, will react in a manner more typical of an HD 1.1 event. When located in structures that stop primary fragments, but which generate a secondary debris hazard (e.g. certain ECM and hardened structures), the structural damage and debris hazards produced from these events are more characteristic of an HD 1.1 explosion, rather than the progressive nature of an HD 1.2.1 event, as described above. When the NEWQD and the MCE of the packaged HD 1.2.1 items fall within the ranges specified in equation {NEWQD $\leq$ MCE $\leq$ 450 lbs [204 kg]}, the HD 1.2.1 shall be treated as HD 1.1 and the criteria of subparagraph C9.4.1.2.1.1.1., as applicable, shall be used. If they fall outside the ranges of the equation, then the criteria of Table C9.T8. shall be applied.

C9.4.2.2. The NEW of an HD 1.2 item (used for transportation) is the sum of the weight of the HD 1.1 and 1.3 material contained within the item. The NEWQD for an item is equal to NEW (NEWQD = NEW) unless testing has been conducted. Based on testing, the NEWQD may include a reduced contribution (less than or equal to 100 percent) from the HD 1.3 material as a result of the HD 1.1 material being functioned. The NEWQD should be determined by the Single Package Test (UN Test 6 (a) or its equivalent), not the Bonfire Test (UN Test 6 (c)). The NEWQD for a specific item may be obtained from the JHCS. The effects produced by the functioning of HD 1.2 items vary with the size and weight of the item. HD 1.2 AE is separated into two sub-divisions in order to account for the differences in magnitude of these effects for purposes of setting QD criteria. The more hazardous items are referred to as HD 1.2.1 items. The less hazardous items are referred to as HD 1.2.2. These two HD 1.2 sub-divisions are shown below with their definitions (NOTE: It is important not to exaggerate the significance of the value of 1.60 lbs [0.73 kg] used above. It is based on a break point in the database supporting the quantity-distance relationships and tables and the NEWQD of the rounds tested. If comprehensive data are available for a particular item, then the item may be placed in that category of HD 1.2 supported by the data and allocated the relevant quantity-distances.):

C9.4.2.2.1. HD 1.2.1: NEWQD > 1.60 lbs [0.73 kg]

C9.4.2.2.2. HD 1.2.2: NEWQD $\leq$ 1.60 lbs [0.73 kg]

C9.4.2.3. The MCE for HD 1.2.1 is the NEWQD of an item times the number of items in three unpalletized, outer shipping packages, unless a different MCE is demonstrated by testing or analogy. The authorized MCE for a specific HD 1.2.1 item is listed in the JHCS.

C9.4.2.4. The QD specified for HD 1.2 AE achieve the desired degree of protection against immediate hazards from an incident. Events involving HD 1.2 items lob large amounts of unexploded rounds, components, and subassemblies, which will remain hazardous after impact. Such items are likely to be more hazardous than in their original state because of possible damage to fuze safety devices or other features by heat and impact. Many types of AE containing sub-munitions, such as cluster bombs, can be expected to be projected out to distances as great as the relevant inhabited building distances. Furthermore, it is impractical to specify quantity distances, which allow for the maximum possible flight ranges of propulsive items.

C9.4.2.5. Table C9.T8. provides a summary matrix of all the appropriate IBD, PTRD, and ILD separations for HD 1.2.1 and HD 1.2.2 AE, for the various combinations of ES and PES. When HD 1.2.1 items are stored in structures that may contribute to the debris hazard, the IBD is determined by using the larger of the following two distances: either that given in Table C9.T9. for the appropriate Explosive Weight (number of items x NEWQD) or that given in Table C9.T10. for the appropriate MCE. (NOTE: Hazardous debris distance (HDD) specified in Table C9.T10. equates to IBD.)

C9.4.2.6. IMD are dependent upon the types of structures acting as both the PES and the ES.

C9.4.2.7. PTRD given in Tables C9.T8. through C9.T11. give consideration to the transient nature of the exposure in the same manner as for HD 1.1. PTRD is computed as 60 percent of the IBD for items in this HD, with minimum distances specified in Table C9.T8.

C9.4.2.8. ILD given in Tables C9.T8. through C9.T11. take into account the progressive nature of explosions involving these items (normally resulting from fire spread), up to the magnitude of the MCE, and the ability to evacuate personnel from endangered areas before the progression involves large numbers of items. Exposed structures may be extensively damaged by projections and delayed propagation of explosions may occur due to the ignition of combustibles by projections. ILD is computed as 36 percent of the IBD for items of this HD, with a minimum distance equal to the IMD given in Table C9.T8. for the applicable PES-ES combination.

C9.4.2.9. When storing mixed sub-divisions of HD 1.2 AE (HD 1.2.1 and HD 1.2.2), the following rule shall apply: Consider each sub-division separately and apply the greater of the two distances. The general mixing rules for HD 1.2 AE are given in Table C9.T12.

C9.4.2.10. For reasons of operational necessity, limited quantities of HD 1.2.2 items may be stored in facilities such as hangars, troop buildings, and manufacturing or operating buildings without regard to quantity distance. Fragmentation shielding shall be provided.

C9.4.2.11. Unit Risk HD 1.2 is a special storage sub-division (HD 1.2.3) for AE (see subparagraph C3.2.1.2.3.).

C9.4.2.12. The IBD for Unit Risk HD 1.2 (HD 1.2.3) is determined using Table C9.T13. (HD 1.3 QD) for the NEWQD of the HD 1.2.3 item multiplied by the number of rounds present, but with a minimum IBD determined as follows:

TABLE C9.T8. SUMMARY OF HD 1.2.1, 1.2.2, AND 1.2.3 QD

To EXPOSED SITE (ES)		From POTENTIAL EXPLOSION SITE (PES)				
		ECM		AGS		
		S or R	F	(H)	(H/R)	(L)
ECM (7 bar/3 bar) (IMD)	S	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	R	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	FU	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	FB	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
ECM (Undefined) (IMD)	S	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	R	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
	FU	0 (note 1)	200/300/100 *61.0/91.4/30.5*	200/300/100 *61.0/91.4/30.5*	200/300/100 *61.0/91.4/30.5*	200/300/100 *61.0/91.4/30.5*
	FB	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
AGS (H/R) (IMD)	U or B	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)	0 (note 1)
AGS (H or L) (IMD)	U or B	0 (note 1)	200/300/100 *61.0/91.4/30.5*	200/300/100 *61.0/91.4/30.5*	200/300/100 *61.0/91.4/30.5*	200/300/100 *61.0/91.4/30.5*
ILD[5]		0 (Note 1)	Note 2	Note 2	Note 2	Note 2
PTRD[5]		200/300/100 *61.0/91.4/30.5*	Note 3	Note 3	Note 3	Note 3
IBD[5]		200/300/100 *61.0/91.4/30.5*	Note 4	Note 4	Note 4	Note 4

LEGEND for Table C9.T8:

AGS (H)—Aboveground structure, Heavy Wall; Buildings with wall thickness ≥ 12 inches (304.8 mm) of reinforced concrete; as an ES, door must be barricaded if it faces a PES.

AGS (H/R)—Aboveground structure, Heavy Wall and Roof; AGS (H) with roof thickness > 5.9 inches (149.9 mm) of reinforced concrete; as an ES, door must be barricaded if it faces a PES; side/rear exposures may or may not be barricaded.

AGS (L)—Aboveground structure, Light; Light structure, open stack, truck, trailer, or railcar (open stacks—see Note 4).

NOTES:

1. Practical considerations such as firefighting and security will dictate specific separation distances as specified by DoD Component.
2. ILD = 36 percent of IBD with a minimum distance equal to the IMD given in this table for the applicable PES-ES combination.
3. PTRD = 60 percent of IBD with a minimum distance equal to the IMD given in this table for light structures, open stacks, trucks, trailers, or rail cars. Such structures are designated as AGS (L).
4. For HD 1.2.1 items in any structure, truck, trailer, or railcar, use the larger of the two applicable values given in Tables C9.T9. and C9.T10.;for HD 1.2.1 items in the open use Table C9.T9.; for HD 1.2.2 items use Tablw C9.T11.
5. See subparagraph C9.4.2.12. for HD 1.2.3.

6. When the NEWQD and the MCE of the packaged HD 1.2.1 items fall within the ranges specified in equation {NEWQD $\leq$ MCE $\leq$ 450 lbs [204 kg]}, the HD 1.2.1 shall be treated as HD 1.1 and the criteria of subparagraph C9.4.1.2.1.1.1., as applicable, shall be used (see subparagraph C9.4.2.1.2.).

GENERAL COMMENTS:

(a): For PES-ES combinations where three distances are given: the first refers to a PES containing HD 1.2.1 AE with an MCE < 100 lbs [45.4 kg]; the second to a PES containing HD 1.2.1 AE with an MCE $\geq$ 100 lbs [45.4 kg]; and the third refers to a PES containing HD 1.2.2 AE. Where three IMD are given, the IMD from a PES containing only HD 1.2.3 AE to an ES containing other than HD 1.2.3 is K11 [4.36] based on the NEWQD of a single round of the largest (greatest NEWQD) HD 1.2.3 AE in the PES.

(b) For an ES containing only HD 1.2.3 items, the IMD from any PES to such an ES is 0 (Note 1).

TABLE C9.T9. HD 1.2.1 QD (IBD, PTR, ILD) FOR AE WITH NEWQD > 1.60 lbs [0.73 kg]

EXPLOSIVE WEIGHT[1] (lbs) *[kg]*	IBD[2,3,4] (ft) *[m]*	PTRD[5] (ft) *[m]*	ILD[6] (ft) *[m]*
2	200	200	200
0.9	*61.0*	*61.0*	*61.0*
3	200	200	200
1.4	*61.0*	*61.0*	*61.0*
4	200	200	200
1.8	*61.0*	*61.0*	*61.0*
5	200	200	200
2.3	*61.0*	*61.0*	*61.0*
7	200	200	200
3.2	*61.0*	*61.0*	*61.0*
10	200	200	200
4.5	*61.0*	*61.0*	*61.0*
15	200	200	200
6.8	*61.0*	*61.0*	*61.0*
20	200	200	200
9.1	*61.0*	*61.0*	*61.0*
30	200	200	200
13.6	*61.0*	*61.0*	*61.0*
50	200	200	200
22.7	*61.0*	*61.0*	*61.0*
70	200	200	200
31.8	*61.0*	*61.0*	*61.0*
100	268	200	200
45.4	*81.7*	*61.0*	*61.0*
150	348	209	200
68.0	*106.0*	*63.6*	*61.0*
200	403	242	200
90.7	*123.0*	*73.8*	*61.0*
300	481	288	200
136.1	*146.5*	*87.9*	*61.0*
500	576	346	207
226.8	*175.5*	*105.3*	*63.2*
700	638	383	230
317.5	*194.3*	*116.6*	*70.0*
1,000	702	421	253
453.6	*213.9*	*128.3*	*77.0*

TABLE C9.T9. HD 1.2.1 Q-D (IBD, PTR, ILD) FOR AE WITH NEWQD > 1.60 lbs [0.73 kg] (continued)

EXPLOSIVE WEIGHT[1] (lbs) *[kg]*	IBD[2,3,4] (ft) *[m]*	PTRD[5] (ft) *[m]*	ILD[6] (ft) *[m]*
1,500	774	464	278
680.4	*235.8*	*141.5*	*84.9*
2,000	824	494	296
907.2	*251.0*	*150.6*	*90.4*
3,000	893	536	321
1,361	*272.1*	*163.3*	*98.0*
5,000	978	587	352
2,268	*298.1*	*178.9*	*107.3*
7,000	1,033	620	372
3,175	*314.8*	*188.9*	*113.3*
10,000	1,090	654	392
4,536	*332.3*	*199.4*	*119.6*
15,000	1,154	692	415
6,804	*351.7*	*211.0*	*126.6*
20,000	1,198	719	431
9,072	*365.2*	*219.1*	*131.5*
30,000	1,260	756	453
13,608	*383.9*	*230.3*	*138.2*
50,000	1,335	801	481
22,680	*406.8*	*244.1*	*146.4*
70,000	1,383	830	498
31,751	*421.5*	*252.9*	*151.7*
100,000	1,433	860	516
45,359	*436.8*	*262.1*	*157.3*
150,000	1,489	893	536
68,039	*453.8*	*272.3*	*163.4*
200,000	1,528	917	550
90,718	*465.6*	*279.3*	*167.6*
300,000	1,581	949	569
136,077	*481.8*	*289.1*	*173.5*
500,000	1,646	988	593
226,795	*501.7*	*301.0*	*180.6*
>500,000	NOTE 4	NOTE 5	NOTE 6
>226,795	*NOTE 4*	*NOTE 5*	*NOTE 6*

NOTES for Table C9.T9:

1. Explosive Weight = Number of Items x NEWQD.
2. IBD in ft, NEWQD in lbs; ln is natural logarithm

   [71 lbs < explosive weight]

   IBD = -735.186 + [237.559 x (ln(Number of items x NEWQD))] - [4.274 x (ln(Number of items x NEWQD))^2], with a minimum of 200 ft **[EQN C9.T9-1]**

   IBD in m, NEWQD in kg; ln is natural logarithm.

   [18.6 kg < explosive weight]

   IBD = -167.648 + [70.345 x (ln(Number of items x NEWQD))] - [1.303 x (ln(Number of items x NEWQD))^2], with a minimum of 61.0 m **[EQN C9.T9-2]**
3. IBD in ft, NEWQD in lbs; exp (x) is e^x

   [200 ft < IBD < 2016 ft]

   Number of items x NEWQD = exp[27.791 - (600.392 - 0.234 x IBD)$^{1/2}$]; **[EQN C9.T9-3]**

   IBD in m, NEWQD in kg; exp (x) is e^x

   [61.0 m < IBD < 614.5 m]

   Number of items x NEWQD = exp[27.000 – (600.287 – 0.768 x IBD)$^{1/2}$]; **[EQN C9.T9-4]**
4. Use of equations given in Notes (2) and (3) to determine other IBD-weight combinations is allowed.
5. PTRD = 60 percent of IBD with a minimum distance equal to the IMD given in Table C9.T8. for AGS (L) in. For other structures as either ES or PES, see Table C9.T8.
6. ILD = 36 percent of IBD with a minimum distance equal to the IMD given in Table C9.T8. for the applicable PES-ES combination. For structures other than AGS (L) as either ES or PES, see Table C9.T8.

GENERAL COMMENTS

(a) The quantity-distance criteria for HD 1.2.1 items are based on the hazards from primary fragments. When stored in structures which may contribute to the debris hazard (secondary fragments), the IBD for HD 1.2.1 items whose MCE is greater than 31 lbs (14.1 kg) is determined by using the larger of the following two distances: those given in this table for the appropriate Explosive Weight or those given in Table C9.T10. for the appropriate MCE. Structures that may contribute to the debris hazard for storage of HD 1.2.1 AE include: (a) all ECM) – Frontal exposure only. Side and rear exposures have fixed minimum distances for IBD; (b) all AGS—Including heavy wall (H), heavy wall/roof (H/R), and light wall (L) as defined in C9.T8., unless data/analyses are provided to show that the structural debris contribution is less. Note that ILD and PTRD are based on 36 percent and 60 percent, respectively, of the applicable IBD as determined in this note with the following minimum distances: ILD minimum distances are given in Table C9.T8. for applicable PES-ES combinations and PTR minimum distances are given in Table C9.T8. for AGS (L).

(b) See Table C9.T8. for a summary of IMD and minimum distances for ILD and PTRD.

TABLE C9.T10. HDD FOR HD 1.2.1 AE STORED IN STRUCTURES THAT CAN CONTRIBUTE TO THE DEBRIS HAZARD

MCE (lbs) [kg]	HAZARDOUS DEBRIS DISTANCE[1,2,3] (ft) [m]	PTRD[4] (ft) [m]	ILD[5] (ft) [m]
≤ 31	200	200	200
≤ 14.1	*61.0*	*61.0*	*61.0*
50	388	233	200
22.7	*118.2*	*70.9*	*61.0*
70	519	311	200
31.8	*158.1*	*94.9*	*61.0*
100	658	395	237
45.4	*200.4*	*120.2*	*72.1*
150	815	489	293
68.0	*248.5*	*149.1*	*89.4*
200	927	556	334
90.7	*282.6*	*169.5*	*101.7*
300	1085	651	391
136.1	*330.6*	*198.4*	*119.0*
400	1197	718	431
181.4	*364.7*	*218.8*	*131.3*
450	1243	746	447
204.1	*378.7*	*227.2*	*136.3*
>450	1250	750	450
>204.1	*381.0*	*228.6*	*137.2*

NOTES for Table C9.T10:

1. MCE in lbs, HDD in ft; ln is natural logarithm;

   [31 lbs < MCE ≤ 450 lbs]

   HDD = -1133.9 + [389 x ln(MCE)] **[EQN C9.T10-1]**

   with a minimum distance of 200 feet.

   MCE in kg, HDD in m; ln is natural logarithm

   [14.1 kg < MCE ≤ 204 kg]

   HDD = -251.87 + [118.56 x ln(MCE)] **[EQN C9.T10-2]**

   with a minimum distance of 61 m.

2. MCE in lbs, HDD in ft; exp [x] is e^x

   [200 ft < HDD ≤ 1250 ft]

   MCE = exp [(HDD/389) + 2.914] **[EQN C9.T10-3]**

MCE in kg, HDD in m; exp [x] is e^x.

[61.0 m < HDD ≤ 381 m]

$$MCE = \exp[(HDD/118.56) + 2.1244] \quad \textbf{[EQN C9.T10-4]}$$

3. Use of equations given in Notes (1) and (2) to determine other HDD-MCE combinations is allowed.
4. PTRD = 60 percent of IBD with a minimum distance equal to the IMD given in Table C9.T8. for AGS (L). For other structures as either ES or PES, see Table C9.T8.
5. ILD = 36 percent of IBD with a minimum distance equal to the IMD given in Table C9.T8. for the applicable PES-ES combination. For structures other than AGS (L) as either ES or PES, see TableC9.T8.

GENERAL COMMENTS

(a) The quantity-distance criteria for HD 1.2.1 items are based on the hazards from primary fragments. When stored in structures which may contribute to the debris hazard (secondary fragments), the IBD for HD 1.2.1 items whose MCE is greater than 31 pounds [14.1 kg] is determined by using the larger of the following two distances: those given in Table C9.T9. for the appropriate Explosive Weight or those given in this table for the appropriate MCE. Structures that may contribute to the debris hazard for storage of HD 1.2.1 AE include: (a) all earth-covered magazines (ECM) – Frontal exposure only. Side and rear exposures have fixed minimum distances for IBD; (b) all AGS—Including heavy wall (H), heavy wall/roof (H/R), and light wall (L) as defined in Table C9.T8., unless data/analyses are provided to show that the structural debris contribution is less. Note that ILD and PTRD are based on 36 percent and 60 percent respectively, of the applicable IBD as determined in this note with the following minimum distances: ILD minimum distances are given in Table C9.T8. for applicable PES-ES combinations, and PTR minimum distances are given in Table C9.T8. for AGS (L).

(b) See Table C9.T8. for a summary of IMD and minimum distances for ILD and PTRD.

TABLE C9.T11. HD 1.2.2 QD (IBD, PTR, ILD) FOR AE WITH NEWQD ≤ 1.60 lbs [0.73 kg]

EXPLOSIVE WEIGHT[1] (lbs) *[kg]*	IBD[2,3,4] (ft) *[m]*	PTRD[5] (ft) *[m]*	ILD[6] (ft) *[m]*
1	100	100	100
0.45	*30.5*	*30.5*	*30.5*
1.5	100	100	100
0.68	*30.5*	*30.5*	*30.5*
2	100	100	100
0.9	*30.5*	*30.5*	*30.5*
3	100	100	100
1.4	*30.5*	*30.5*	*30.5*
5	100	100	100
2.3	*30.5*	*30.5*	*30.5*
7	100	100	100
3.2	*30.5*	*30.5*	*30.5*
10	100	100	100
4.5	*30.5*	*30.5*	*30.5*
15	100	100	100
6.8	*30.5*	*30.5*	*30.5*
20	100	100	100
9.1	*30.5*	*30.5*	*30.5*
30	107	100	100
13.6	*32.7*	*30.5*	*30.5*
50	118	100	100
22.7	*36.1*	*30.5*	*30.5*
70	127	100	100
31.8	*38.8*	*30.5*	*30.5*
100	138	100	100
45.4	*42.1*	*30.5*	*30.5*
150	152	100	100
68.0	*46.2*	*30.5*	*30.5*
200	162	100	100
90.7	*49.5*	*30.5*	*30.5*
300	179	107	100
136.1	*54.6*	*32.7*	*30.5*
500	202	121	100
226.8	*61.7*	*37.0*	*30.5*
700	219	132	100
317.5	*66.8*	*40.1*	*30.5*

TABLE C9.T11. HD 1.2.2 QD (IBD, PTR, ILD) FOR AE WITH NEWQD ≤ 1.60 lbs [0.73 kg] (continued)

EXPLOSIVE WEIGHT[1] (lbs) *[kg]*	IBD[2,3,4] (ft) *[m]*	PTRD[5] (ft) *[m]*	ILD[6] (ft) *[m]*
1,000	238	143	100
453.6	*72.7*	*43.6*	*30.5*
1,500	262	157	100
680.4	*79.8*	*47.9*	*30.5*
2,000	279	168	101
907.2	*85.2*	*51.1*	*30.7*
3,000	306	183	110
1,361	*93.2*	*55.9*	*33.5*
5,000	341	205	123
2,268	*104.0*	*62.4*	*37.4*
7,000	366	220	132
3,175	*111.6*	*67.0*	*40.2*
10,000	394	236	142
4,536	*120.0*	*72.0*	*43.2*
15,000	427	256	154
6,804	*130.1*	*78.1*	*46.8*
20,000	451	271	162
9,072	*137.5*	*82.5*	*49.5*
30,000	487	292	175
13,608	*148.5*	*89.1*	*53.5*
50,000	535	321	193
22,680	*163.0*	*97.8*	*58.7*
70,000	568	341	204
31,751	*173.1*	*103.8*	*62.3*
100,000	604	362	217
45,359	*184.1*	*110.5*	*66.3*
150,000	647	388	233
68,039	*197.1*	*118.3*	*71.0*
200,000	678	407	244
90,718	*206.6*	*124.0*	*74.4*
300,000	723	434	260
136,077	*220.5*	*132.3*	*79.4*
500,000	783	470	282
226,795	*238.8*	*143.3*	*86.0*
>500,000	Note 4	Note 5	Note 6
>226,795	*Note 4*	*Note 5*	*Note 6*

NOTES for Table C9.T11:

1. Explosive Weight = Number of Items x NEWQD.
2. IBD in ft, NEWQD in lbs; ln is natural logarithm.

   [20 lbs < Explosive Weight]

   IBD = 101.649 - [15.934 x (ln(Number of items x NEWQD))] + [5.173 x (ln(Number of items x NEWQD))^2],

   with a minimum of 100 ft **[EQN C9.T11-1]**

   IBD in m, NEWQD in kg; ln is natural logarithm

   [9.1 kg < Explosive Weight]

   IBD = 28.127 - [2.364 x (ln(Number of items x NEWQD))] + [1.577 x (ln(Number of items x NEWQD))^2]

   with a minimum of 30.5 m **[EQN C9.T11-2]**
3. IBD in ft, NEWQD in lbs; exp (x) is e^x.

   [100 ft <IBD < 1240 ft]

   Number of items x NEWQD = exp [1.5401 + (-17.278 + 0.1933 x IBD)$^{1/2}$] **[EQN C9.T11-3]**

   IBD in m, NEWQD in kg; exp (x) is e^x.

   [30.5 m <IBD < 378 m]

   Number of items x NEWQD = exp [0.7495 + (-17.274 + 0.6341 x IBD)$^{1/2}$] **[EQN C9.T11-4]**
4. Use of equations given in Notes (2) and (3) to determine other IBD-weight combinations is allowed
5. PTRD = 60 percent of IBD with a minimum distance equal to the IMD given in Table C9.T8 for AGS (L). For other structures as either ES or PES, see Table C9.T8.
6. ILD = 36 percent of IBD with a minimum distance equal to the IMD given in Table C9.T8 for the applicable PES-ES combination. For structures other than AGS (L) as either ES or PES, see Table C9.T8.

GENERAL COMMENTS

(a) The QD criteria for HD 1.2.2 items are based on the hazards from primary fragments.

(b) See Table C9.T8. for a summary of IMD and minimum distances for ILD and PTRD.

(c) For operational necessity, limited quantities of HD 1.2.2 may be stored without regards to QD. See subparagraph C9.4.2.10.

TABLE C9.T12. HD 1.2.1, 1.2.2, AND 1.2.3 MIXING RULES

HAZARD SUB-DIVISION INVOLVED	DISTANCES TO BE APPLIED
1.2.1	Apply HD 1.2.1 distances[1]
1.2.2	Apply HD 1.2.2 distances[2]
1.2.3	Apply HD 1.2.3 distances[3]
1.2.1 + 1.2.2	Apply greater of two distances
1.2.1 + 1.2.3	Apply greater of two distances
1.2.2 + 1.2.3	Apply greater of two distances

NOTES for Table C9.T12:

1. HD 1.2.1 distances given in Tables C9.T8., C9.T9, and C9.T10.
2. HD 1.2.2 distances given in Tables C9.T8. and C9.T11.
3. HD 1.2.3 distances given in Table C9.T13. (See subparagraph C9.4.2.12.)

C9.4.2.12.1. If the AE are in a structure that can interrupt primary fragments and can contribute debris, the minimum IBD is the hazardous debris distance given in Table C9.T10. for an MCE equal to the NEWQD of a single round.

C9.4.2.12.2. If the AE are in the open or in a light structure that will not interrupt primary fragments, the minimum IBD is the HFD based on the HD 1.1 hazardous fragment areal number density criteria applied to a single HD 1.2.3 item. The HFD applicable to AE in the open is specified in hundreds of ft in parentheses as "(xx) HD 1.2.3."

C9.4.2.12.3. As an alternative to the preceding HD 1.2.3 QD criteria, when an increase in the allowable quantity or a reduction in the required distance will result, HD 1.2.3 AE may be treated as follows:

C9.4.2.12.3.1. If the single-round NEWQD is > 1.6 lbs [0.73 kg], consider the items as HD 1.2.1. Use the total NEWQD present, with an MCE equal to the NEWQD of one round to determine the maximum QD.

C9.4.2.12.3.2. If the single-round NEWQD is $\leq$ than 1.6 lbs [0.73 kg], consider the items as HD 1.2.2, based on the total NEWQD present.

C9.4.2.13. For storage of mixed Unit Risk HD 1.2 (HD 1.2.3) AE, multiply the NEWQD for the HD 1.2.3 items by the corresponding number of HD 1.2.3 rounds and use Table C9.T13. with the HFD for the mixture based on the largest HFD for the HD 1.2.3 AE in storage. Use the distances given in Table C9.T12., when HD 1.2.3 AE is located with any other HD 1.2 sub-division. The HD 1.2.3 AE is considered HD 1.2 (HD 1.2.1 or HD 1.2.2, according to NEWQD) for QD purposes, when HD 1.2.3 AE is located with any other HD AE. The mixing rules provided in paragraph C9.2.2., above then apply to the combination of the hazard divisions.

C9.4.2.14. HD 1.2 AE in the current inventory with IBD given in hundreds of feet and presented in parentheses in the format HD (xx) 1.2, need not use the QD criteria specified above. Instead, constant value QD criteria for these items may be specified as follows: IBD is the distance specified in hundreds of feet (in parentheses); PTR is computed as 60 percent of IBD; ILD is computed as 36 percent of IBD, with a minimum distance equal to the IMD given in Table C9.T8.

C9.4.3. HD 1.3. HD 1.3 includes items that burn vigorously with little or no possibility of extinguishment in storage situations. Explosions normally will be confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast overpressure beyond the magazine distance specified in Table C9.T13. A severe hazard of spread of fire may result from tossing about of burning container materials, propellant, or other flaming debris.

C9.4.4. HD 1.4.

C9.4.4.1. HD 1.4 AE present a fire hazard with minimal blast, fragmentation, or toxic hazards. Separate facilities for storage and handling of these AE shall be located IAW Table C9.T14.

C9.4.4.2. In mixed storage, the NEWQD of HD 1.4 is not additive (see subparagraph C9.2.2.1.1). However, QD criteria for each HD present, including HD 1.4, must be determined and the largest value shall be used.

C9.4.4.3. HD 1.4S AE (see paragraph C2.5.5) may be stored (including associated handling) without regard to the QD criteria in Table C9.T14.

C9.4.5. HD 1.6. QD separations for HD 1.6 AE shall be based on the storage location and configuration. This information is detailed in Table C9.T15. and its footnotes. A maximum of 500,000 lbs [226,795 kg] NEWQD shall be permitted at any one location. Any special storage configuration and siting approved for HD 1.1 AE may be used for storage of like explosive weights of HD 1.6 AE.

C9.4.6. HD 6.1.

C9.4.6.1. HD 6.1 includes items that contain only toxic chemical or riot control agents. AE containing both explosives and toxic chemical or riot control agents may be hazard classified as HD 1.1 through HD 1.4, based on testing IAW reference (e).

C9.4.6.2. Hazard zones for toxic chemical agents are determined by the relative toxicity of the agents, the amount released to the atmosphere and the rate at which they are released (that is, evaporation, pressure, or explosive dispersal), terrain features, and meteorological conditions. Hazard zone calculations are based on MCE, using DDESB TP No. 10, (reference (q)). (See chapter 11 for specific criteria associated with toxic chemical agents.)

C9.4.6.3. When siting AE containing toxic chemical agents, both the explosives and toxic chemical agent hazards shall be evaluated with the greatest QD governing siting.

TABLE C9.T13. HD 1.3 QD

NEWQD (lbs) *[kg]*	IBD & PTRD[1] (ft) *[m]*	Aboveground IMD & ILD[2] (ft) *[m]*
≤ 1000[3]	75	50
≤ 453.59[3]	*22.9*	*15.2*
1,500	82	56
680.4	*25.0*	*17.0*
2,000	89	61
907.2	*27.2*	*18.5*
3,000	101	68
1,360.8	*30.7*	*20.8*
5,000	117	80
2,268.0	*35.8*	*24.3*
7,000	130	88
3,175.1	*39.6*	*26.9*
10,000	145	98
4,535.9	*44.2*	*30.0*
15,000	164	112
6,803.9	*50.1*	*34.0*
20,000	180	122
9,071.8	*54.8*	*37.2*
30,000	204	138
13,607.7	*62.3*	*42.2*
50,000	240	163
22,679.5	*73.2*	*49.5*
70,000	268	181
31,751.3	*81.6*	*55.1*
100,000	300	204
45,359.0	*91.4*	*62.0*
150,000	346	234
68,038.5	*105.3*	*71.4*
200,000	385	260
90,718.0	*117.4*	*79.3*
300,000	454	303
136,077.0	*138.4*	*92.5*
500,000	569	372
226,795.0	*173.6*	*113.4*
700,000	668	428
317,513.0	*203.8*	*130.5*
1,000,000	800	500
453,590.0	*244.0*	*152.3*
1,500,000	936	577
680,385.0	*285.3*	*175.8*
2,000,000	1,008	630
907,180.0	*307.2*	*192.0*

NOTES for Table C9.T13:

1. (NEWQD in lbs, d in ft)

NEWQD $\leq$ 1,000 lbs

$d_{IBD,PTRD} = 75$

1,000 lbs < NEWQD $\leq$ 96,000 lbs

$d_{IBD,PTRD} = \exp[2.47 + 0.2368*(\ln(NEWQD)) + 0.00384*(\ln(NEWQD))^2]$ **[EQN C9.T13-1]**

with a minimum distance of 75 ft

96,000 lbs < NEWQD $\leq$ 1,000,000 lbs

$d_{IBD,PTRD} = \exp[7.2297 - 0.5984*(\ln(NEWQD)) + 0.04046*(\ln(NEWQD))^2]$ **[EQN C9.T13-2]**

NEWQD > 1,000,000 lbs

$d_{IBD,PTRD} = 8*NEWQD^{1/3}$ **[EQN C9.T13-3]**

(NEWQD in kg, d in m)

NEWQD $\leq$ 453.6 kg

$d_{IBD,PTRD} = 22.9$

453.6 kg < NEWQD $\leq$ 43,544.6 kg

$d_{IBD,PTRD} = \exp[1.4715 + 0.2429*(\ln(NEWQD)) + 0.00384*(\ln(NEWQD))^2]$ **[EQN C9.T13-4]**

with a minimum distance of 22.9 m

43,544.6 kg < NEWQD $\leq$ 453,590 kg

$d_{IBD,PTRD} = \exp[5.5938 - 0.5344*(\ln(NEWQD)) + 0.04046*(\ln(NEWQD))^2]$ **[EQN C9.T13-5]**

NEWQD > 453,590 kg

$d_{IBD,PTRD} = 3.17*NEWQD^{1/3}$ **[EQN C9.T13-6]**

75 ft $\leq d_{IBD,PTRD} \leq$ 296 ft

$NEWQD = \exp[-30.833 + (307.465 + 260.417*(\ln(d_{IBD,PTRD})))^{1/2}]$ **[EQN C9.T13-7]**

with a minimum NEWQD of 1,000 lbs

296 ft < $d_{IBD,PTRD} \leq$ 800 ft

$NEWQD = \exp[7.395 + (-124.002 + 24.716*(\ln(d_{IBD,PTRD})))^{1/2}]$ **[EQN C9.T13-8]**

800 ft < $d_{IBD,PTRD}$

$NEWQD = d_{IBD,PTRD}^3 / 512$ **[EQN-C9.T13-9]**

22.9 m $\leq d_{IBD,PTRD} \leq$ 90.2 m

$NEWQD = \exp[-31.628 + (617.102 + 260.417*(\ln(d_{IBD,PTRD})))^{1/2}]$ **[EQN C9.T13-10]**

with a minimum NEWQD of 453.6 kg

90.2 m < $d_{IBD,PTRD} \leq$ 243.8 m

$NEWQD = \exp[6.604 + (-94.642 + 24.716*(\ln(d_{IBD,PTRD})))^{1/2}]$ **[EQN C9.T13-11]**

243.8 m < $d_{IBD,PTRD}$

$NEWQD = d_{IBD,PTRD}^3 / 131.964$ **[EQN C9.T13-12]**

2. (NEWQD in lbs, d in ft)

NEWQD $\leq$ 1,000 lbs

$d_{IMD,ILD} = 50$

1,000 lbs < NEWQD ≤ 84,000 lbs

$d_{IMD,ILD} = \exp[2.0325 + 0.2488*(\ln(NEWQD)) + 0.00313*(\ln(NEWQD))^2]$ **[EQN C9.T13-13]**

with a minimum distance of 50 ft

84,000 lbs < NEWQD ≤ 1,000,000 lbs

$d_{IMD,ILD} = \exp[4.338 - 0.1695*(\ln(NEWQD)) + 0.0221*(\ln(NEWQD))^2]$ **[EQN C9.T13-14]**

1,000,000 lbs < NEWQD

$d_{IMD,ILD} = 5*NEWQD^{1/3}$ **[EQN C9.T13-15]**

(NEWQD in kg, d in m)

NEWQD ≤ 453.6 kg

$d_{IMD,ILD} = 15.2$

453.6 kg < NEWQD ≤ 38,101,6 kg

$d_{IMD,ILD} = \exp[1.0431 + 0.2537*(\ln(NEWQD)) + 0.00313*(\ln(NEWQD))^2]$ **[EQN C9.T13-16]**

with a minimum distance of 15.2 m

38,101.6 kg < NEWQD ≤ 453,590 kg

$d_{IMD,ILD} = \exp[3.0297 - 0.1346*(\ln(NEWQD)) + 0.0221*(\ln(NEWQD))^2]$ **[EQN C9.T13-17]**

NEWQD > 453,590 kg

$d_{IMD,ILD} = 1.98*NEWQD^{1/3}$ **[EQN C9.T13-18]**

50 ft ≤ $d_{IMD,ILD}$ ≤ 192 ft

$NEWQD = \exp[-39.744 + (930.257 + 319.49*(\ln(d_{IMD,ILD})))^{1/2}]$ **[EQN C9.T13-19]**

with a minimum NEWQD of 1,000 lbs

192 ft < $d_{IMD,ILD}$ ≤ 500 ft

$NEWQD = \exp[3.834 + (-181.58 + 45.249*(\ln(d_{IMD,ILD})))^{1/2}]$ **[EQN C9.T13-20]**

500 ft < $d_{IMD,ILD}$

$NEWQD = d_{IMD,ILD}^3/125$ **[EQN C9.T13-21]**

15.2 m ≤ $d_{IMD,ILD}$ ≤ 58.4 m

$NEWQD = \exp[-40.527 + (1309.19 + 319.49*(\ln(d_{IMD,ILD})))^{1/2}]$ **[EQN C9.T13-22]**

with a minimum NEWQD of 453.6 kg

58.4 m < $d_{IMD,ILD}$ ≤ 152.4 m

$NEWQD = \exp[3.045 + (-127.817 + 45.249*(\ln(d_{IMD,ILD})))^{1/2}]$ **[EQN C9.T13-23]**

152.4 m < $d_{IMD,ILD}$

$NEWQD = d_{IMD,ILD}^3/7.804$ **[EQN C9.T13-24]**

3. For quantities less than 1,000 lbs [453.59 kg], the required distances are those specified for 1,000 lbs [453.59 kg]. The use of lesser distances may be approved when supported by test data and/or analysis.

GENERAL COMMENTS

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

(b) ECM may be used to their physical capacity for this HD provided they comply with the construction and siting requirements of chapters 5 and 9, respectively, for HD 1.1. ECM used to store only HD 1.3 items must be sited for a minimum of 100 lbs [45.4 kg] of HD 1.1 items using Tables C9.T4. (ILD) and C9.T6. (IM). Use IBD and PTRD columns of Table C9.T13. for determining the IBD and PTRD associated with the HD 1.3 being placed in such ECM.

TABLE C9.T14. HD 1.4 QD

NEWQD (lbs) *[kg]*	IBD (ft) *[m]*	PTRD (ft) *[m]*	ILD[1] (ft) *[m]*	Aboveground IMD[1,2] (ft) *[m]*	ECM IMD[1] (ft) *[m]*
≤ 3000[3,4]	75	75	50	50	0 out the Sides & Rear; use AGM distance out the Front
≤ 1,360.8[3,4]	*22.9*	*22.9*	*15.2*	*15.2*[1,2]	
>3000	100	100	50 (100)	50 (100)	
>1,360.8	*30.5*	*30.5*	*15.3 (30.5)*	*15.3 (30.5)*	
(No upper limit specifically required for safety reasons)			(Note: Use larger distance for combustible construction)	(Note: Use larger distance for combustible construction)	

NOTES FOR Table C9.T14.

1. Magazines storing only HD 1.4 AE may be located at these IMD or ILD from all other magazines or operating buildings regardless of the HD or NEWQD authorized in those adjacent structures. Because the HD 1.4 AE may be destroyed as the result of a mishap involving the assets in those adjacent structures, the DoD Component on a case-by-case basis must accept application of this provision with consideration given to the value of HD 1.4 assets at risk.
2. HD 1.4 AE may be stored in a general supplies warehouse area rather than in an AE storage area. When storing in a general supplies warehouse area, any weatherproof warehouse structure may serve as a HD 1.4 magazine. Such a structure will be separated from all other warehouses by AGM distance.
3. For reasons of operational necessity, limited quantities of HD 1.4 AE (e.g., small arms AE and riot control munitions) may be stored within facilities (e.g., hangars, arms rooms, and operating buildings) without regard to QD. Alternatively, operationally necessary HD 1.4 AE may be stored in small magazines external to those facilities without regard to QD.
4. See subparagraph C9.2.2.1.1. for the applicability of HD 1.4 QD criteria and the determination of NEWQD when HD 1.4 and other HD AE are located in the same site.

TABLE C9.T15. HD 1.6 QD

NEWQD (lbs) *[kg]*	Aboveground		ECM		
	IBD or PTRD[1,2,4] (ft) *[m]*	IMD or ILD[1,3,4] (ft) *[m]*	IBD or PTRD (ft) *[m]*	ILD (ft) *[m]*	IMD (ft) *[m]*
≤100[5]	37	23	Note 4	Note 4	Note 4
≤453.9[5]	*11.3*	*7.0*			
150	43	27			
68.0	*12.9*	*8.1*			
200	47	29			
90.7	*14.3*	*8.9*			
300	54	33			
136.1	*16.3*	*10.2*			
500	63	40			
226.8	*19.4*	*12.1*			
700	71	44			
317.5	*21.7*	*13.5*			
1,000	80	50			
453.6	*24.4*	*15.2*			
1,500	92	57			
680.4	*27.9*	*17.4*			
2,000	101	63			
907.2	*30.7*	*19.2*			
3,000	115	72			
1,360.8	*35.2*	*22.0*			
5,000	137	85			
2,268.0	*41.7*	*26.1*			
7,000	153	96			
3,175.1	*46.6*	*29.2*			
10,000	172	108			
4,535.9	*52.5*	*32.8*			
15,000	197	123			
6,803.9	*60.1*	*37.6*			
20,000	217	136			
9,071.8	*66.2*	*41.4*			
30,000	249	155			
13,607.7	*75.8*	*47.4*			
50,000	295	184			
22,679.5	*89.8*	*56.1*			
70,000	330	206			
31,751.3	*100.5*	*62.8*			
100,000	371	232			
45,359.0	*113.2*	*70.7*			
150,000	425	266			
68,038.5	*129.6*	*81.0*			
200,000	468	292			
90,718.0	*142.6*	*89.1*			
300,000	536	335			
136,077.0	*163.2*	*102.0*			
500,000	635	397			
226,795.0	*193.5*	*121.0*			

NOTES for Table C9.T15:

1. Unit risk distance for airblast applies as a minimum;

   For IBD or PTRD:

   D in ft, NEWQD in lbs:

   $D_{IBD,PTRD} = 40W^{1/3}$ **[EQN C9.T15-1]**

   D in m, NEWQD in kg;

   $D_{IBD,PTRD} = 15.87Q^{1/3}$ **[EQN C9.T15-2]**

   For IMD or ILD, based on the NEWQD for a single round of AE

   D in ft, NEWQD in lbs:

   $D_{IMD,\,ILD} = 18W^{1/3}$ **[EQN C9.T15-3]**

   D in m, NEWQD in kg;

   $D_{IMD,\,ILD} = 7.14Q^{1/3}$, **[EQN C9.T15-4]**

2. D in ft, NEWQD in lbs

   $D_{IBD,PTRD} = 8W^{1/3}$ **[EQN C9.T15-5]**

   $NEWQD = D_{IBD,PTRD}^{3}/512$ **[EQN C9.T15-6]**

   D in m, NEWQD in kg

   $D_{IBD,PTRD} = 3.17Q^{1/3}$ **[EQN C9.T15-7]**

   $NEWQD = D_{IBD,PTRD}^{3}/31.86$ **[EQN C9.T15-8]**

3. D in ft, NEWQD in lbs

   $D_{IMD,\,ILD} = 5W^{/3}$ **[EQN C9.T15-9]**

   $NEWQD = D_{IMD,\,ILD}^{3}/125$ **[EQN C9.T15-10]**

   D in m, NEWQD in kg

   $D_{IMD,\,ILD} = 1.98Q^{1/3}$ **[EQN C9.T15-11]**

   $NEWQD = D_{IMD,\,ILD}^{3}/7.76$ **[EQN C9.T15-12]**

4. For HD 1.6 AE packed in non-flammable pallets or packing and stored in an ECM, provided it is acceptable to the DoD Component and the DDESB on a site-specific basis, the following QD apply, unless a lesser distance is permitted by Table C9.T15. for aboveground sites (NOTE: These lesser distances can be applied to ECM storage):

   $D_{IBD,PTRD}$ = 100 ft [30.5 m];

   D_{ILD} = 50 ft [15.2 m];

   D_{IMD} = no specific requirement.

5. For quantities less than 100 lbs [45.4 kg], the required distances are those specified for 100 lbs [45.4 kg]. The use of lesser distances may be approved when supported by test data and/or analyses.

C9.5. ENERGETIC LIQUIDS

C9.5.1. Scope and application.

C9.5.1.1. This section applies to the storage of energetic liquids, listed in Table C9.T16, in all types of containers, including rocket and missile tankage. Laboratory quantities shall be stored and handled as prescribed by the controlling DoD Component. (NOTE: The required QD are only based on the energetic liquids' energetic reaction (blast overpressure and container fragmentation). These QD requirements do not consider the toxicity or potential down-wind hazard. Therefore, QD may not be the only factor that needs to be considered when selecting a location for storage and operations of energetic liquids.)

C9.5.1.2. Exclusion. This section does not govern the storage or handling of energetic liquids for uses other than in space launch vehicles, rockets, missiles, associated static test apparatus, and AE.

C9.5.2. Concept.

C9.5.2.1. These QD standards were developed on the premise that the controlling DoD Component shall ensure that the materials of construction are compatible with the energetic liquids, facilities are of appropriate design, fire protection and drainage control techniques are employed, and other specialized controls (e.g., nitrogen padding, blanketing, and tank cooling) are used, when required.

C9.5.2.2. When additional hazards associated with AE are involved, the safety distances prescribed in other sections of this standard shall be applied, as required.

C9.5.2.3. These standards are based upon the estimated credible damage resulting from an incident, without considering probabilities or frequency of occurrence.

C9.5.3. Determination of energetic liquids quantity:

C9.5.3.1. The total quantity of energetic liquids in a tank, drum, cylinder, or other container shall be the net weight of the energetic liquids contained therein. Quantity of energetic liquids in the associated piping must be included to the points that positive means are provided for interrupting the flow through the pipe, or interrupting a reaction in the pipe in the event of an incident.

C9.5.3.2. When the quantities of energetic liquids are given in gallons [liters], the conversion factors given in Table C9.T17. may be used to determine the quantity in pounds [kg].

C9.5.4. Measurement of separation distances:

C9.5.4.1. Measure from the closest controlling hazard source (e.g., containers, buildings, segment, or positive cutoff point in piping).

C9.5.4.2. Measure from the nearest container or controlling sub-division, when buildings containing a small number of cylinders or drums are present or when quantities of energetic liquids are subdivided effectively.

TABLE C9.T16. Hazard Classifications and Minimum QD for Energetic Liquids

Energetic Liquid	OSHA/NFPA Fuel[1] or Oxidizer[2] Class	DoD Storage Hazard Class	Minimum QD[3]
Hydrogen Peroxide, > 60%	3 or 4[4]	5.1 (LA)	800[5] ft or Table C9.T20. *243.8[5] m or Table C9.T20.*
IRFNA (Inhibited Red Fuming Nitric Acid)	3	8 (LA)	Table C9.T20.
Nitrogen Tetroxide/MON (Mixed oxides of nitrogen)	2	2.3 (LA)	Table C9.T20.
Liquid Oxygen	N/A	2.2 (LA)	Table C9.T21.
RP-1	II	3 (LB)	Table C9.T19.
JP-10	II	3J (LB)	Table C9.T19.
Liquid Hydrogen	N/A	2.1 (LB)	Table C9.T22.
Hydrazine, > 64%	II	8 (LC)	800[5] or 300[6] ft or Note 7 *243.8[5] m or 91.4[6] m or Note 7*
Aerozine 50 (50%N_2H_4/50% UDMH) (Unsymmetric dimethylhydrazine)	I B	6.1 (LC)	800[5] or 300[6] ft or Note 7 *243.8[5] m or 91.4[6] m or Note 7*
Methylhydrazine	I B	6.1 (LC)	800[5] or 300[6] ft or Note 7 *243.8[5] m or 91.4[6] m or Note 7*
UDMH	I B	6.1 (LC)	Table C9.T19.
Ethylene Oxide	I A	2.3 (LD)	H/D 1.1 QD[8] with TNT Equiv = 100%, or 800[5] or 300[6] ft *H/D 1.1 QD[8] with TNT Equiv = 100%, or 243.8[5] or 91.4[6] m*
Propylene Oxide	I A	3 (LD)	H/D 1.1 QD[8] with TNT Equiv = 100%, or 800[5] or 300[6] ft *H/D 1.1 QD[8] with TNT Equiv = 100%, or 243.8[5] or 91.4[6] m*
Nitromethane	I C	3 (LE)	Use H/D 1.1 QD with TNT Equiv. = 100%[9] or Table C9.T19.
Hydroxylammonium Nitrate (HAN)	2	8 (LE)	800[5] ft or Table C9.T20. *243.8[5] m or Table C9.T20.*
XM-46 (HAN Monopropellant)	N/A	1.3C (LE)	800[5] ft or use HD 1.3 QD *243.8[5] m or use HD 1.3 QD*
Otto Fuel II	III B	9 (LE)	Use H/D 1.1 QD[10] with TNT Equiv. = 100%, or 150[11] ft or Table C9.T19. *Use H/D 1.1 QD[10] with TNT Equiv. = 100%, or 45.7[11] m or Table C9.T19.*
Halogen Fluorides (ClF_3/ClF_5)	4	2.3 (LE)	Table C9.T20.
Liquid Fluorine	4	2.3 (LE)	Table C9.T20.
Nitrogen Trifluoride	4	2.2 (LE)	Table C9.T20.
Nitrate esters (e.g. NG, TMETN, DEGDN, TEGDN, BTTN)	N/A	1.1 D (LE)	Use H/D 1.1 QD with TNT Equiv. = 100%

Notes for Table C9.T16

1. Flammable or combustible liquid classification index based on flash point and boiling point versus criteria as specified in 29 CFR 1910.106 (Occulational Safety and Health (OSHA) (reference (r)) and NFPA 30 Flammable and Combustible Liquids Code (reference (s)). Primary descriptor is a Roman numeral, possibly with an additional letter.
2. NFPA oxidizer classification index as described in National Fire Protection Association (NFPA) 430 Code for the Storage of Liquid and Solid Oxidizers (reference (t)). Descriptor is an ordinary number.
3. Positive measures for spill containment/control shall be taken for isolated storage of energetic liquids IAW applicable OSHA and NFPA guidance (referenced in Tables C9.T19. through C9.T21.). For flammable energetic liquids and liquid oxidizers where only minimum blast or fragment distances are specified, applicable OSHA and/or NFPA guidance referenced in Tables C9.T19. and C9.T20., respectively, should also be used.
4. Hydrogen peroxide solutions of concentration greater than 91 percent are NFPA Class 4 oxidizers.

5. Should be used as a default value, unless otherwise hazard classified, when the material is packaged in small (non-bulk) shipping containers, portable ground support equipment, small aerospace flight vehicle propellant tanks, or similar pressure vessels that provide heavy confinement (burst pressure greater than 100 psi [690 kPa]).
6. Should be used as a default value, unless otherwise hazard classified, when the material is packaged in small (non-bulk) shipping containers (DoT 5C or equivalent), portable ground support equipment, small aerospace flight vehicle propellant tanks, or similar pressure vessels providing a lower level of confinement (burst pressure less than or equal to 100 psi [690 kPa]) and if adequate protection from fragments is not provided from terrain, effective barricades, nets, or other physical means (lightweight building construction is not adequate). If protection from fragments is provided, use the IBD/PTRD "Protected" column of Table C9.T22.
7. For large ready, bulk, or rest storage tanks (as defined in subparagraphs C9.5.5.7., C9.5.5.9., and C9.5.5.10.), use Table C9.T22.
8. Where there is a reasonable risk of vapor cloud explosion of large quantities (for example, in bulk tank storage).
9. Technical grade nitromethane in unit quantities of 55 gallons (208.2 liters) or less in DoT approved containers listed in 49CFR173.202 (reference (e)) may be stored as flammable liquids (Table C9.T19.) provided the following apply:
    a. Packages are stored only one tier high.
    b. Packages are protected from direct rays of sun.
    c. Maximum storage life of two years, unless storage life tests indicate product continues to meet purchase specification. Such tests are to be repeated at one-year intervals thereafter.
10. For underwater static test stands, when operated at hydrostatic pressure above 50 psig [345 kPa], or for propellant tanks or other vessels having burst pressures of greater than 100 psig [690 kPa] without acceptable pressure relief devices (unless otherwise hazard classified). For underwater test stands, the TNT equivalence (MCE) should include the total energetic liquids weight in all pumps and plumbing, as well as the weight of energetic liquids held in tankage (under the test cell hydrostatic pressure) unless acceptable mitigation measures such as fuel line detonation arrestors and/or fuel tank isolation/barricading are used (as determined by hazard analysis).
11. Should be used as a default value, unless otherwise hazard classified, when the material is packaged in small vehicle propellant tanks, small (non-bulk) shipping containers, portable ground support equipment, or similar pressure vessels that provide relatively heavy confinement (burst pressure between 50 – 100 psig [345 – 690 kPa]) without acceptable pressure relief devices.

TABLE C9.T17. Factors to Use When Converting Energetic Liquid Densities[1]

Item	Density (lb/gal) *[kg/l]*	Temperature (°F) *[°C]*
Chlorine Pentafluoride	14.8	77
	1.77	*25.0*
Chlorine trifluoride	15.1	77
	1.81	*25.0*
Ethyl alcohol	6.6	68
	0.79	*20.0*
Ethylene oxide	7.4	51
	0.89	*10.6*
Fluorine (liquid)	12.6	-306
	1.51	*-187.8*
HAN Monopropellants	11.9	77
	1.43	*25.0*
HAN solution (25 to 95 wt %)	10.0 to 13.4	68
	1.20 to 1.61	*20.0*
Hydrazine	8.4	68
	1.01	*20.0*
Hydrogen peroxide (90 percent)	11.6	77
	1.39	*25.0*
JP-10	7.8	60
	0.93	*15.6*
Liquid hydrogen	0.59	-423
	0.07	*-252.8*
Liquid oxygen	9.5	-297
	1.14	*-182.8*
Monomethyl hydrazine	7.3	68
	0.87	*20.0*
Nitrogen tetroxide	12.1	68
	1.45	*20.0*
Nitrogen trifluoride	12.8	-200
	1.53	*-128.9*
Nitromethane	9.5	68
	1.14	*20.0*
Otto Fuel II	10.3	77
	1.23	*25.0*
Propylene oxide	7.2	32
	0.86	*0.0*
Red fuming nitric acid (IRFNA)	12.9	77
	1.55	*25.0*
RP-1	6.8	68
	0.81	*20.0*
UDMH	6.6	68
	0.79	*20.0*
UDMH/hydrazine	7.5	77
	0.90	*25.0*

Note for Table C9.T17.

1. Conversion of quantities of energetic liquids:

From gallons to lbs [*liter to kg*]:

lbs of energetic liquids = gallons X density of energetic liquids (lbs/gal). **[EQN C9.T17-1]**

kg of energetic liquids = liters X density of energetic liquids (kg/liter) **[EQN C9.T17-2]**

From lb/gallon to kg/liter: 1 lb/gal = 8.345 kg/liter **[EQN C9.T17-3]**

From kg/liter to lb/gal: 1 kg/ liter = 0.11983*lb/gal **[EQN C9.T17-4]**

C9.5.5. Hazard Classification of Energetic Liquids.

C9.5.5.1. The main UN hazard classification designators for energetic liquids are indicated below. (NOTE: The original liquid propellant Hazard Groups I - IV and CG A - F are no longer used.)

C9.5.5.1.1. Class 1: Explosives.

C9.5.5.1.2. Class 2: Compressed or liquefied gases.

C9.5.5.1.3. Class 3: Flammable liquids.

C9.5.5.1.4. Class 4: Flammable solids and self-reactive materials.

C9.5.5.1.5. Class 5: Oxidizers.

C9.5.5.1.6. Class 6: Toxic/infectious substances.

C9.5.5.1.7. Class 8: Corrosive.

C9.5.5.1.8. Class 9: Miscellaneous.

C9.5.5.2. Because two energetic liquids might each be compatible with certain explosive AE stores, but incompatible with each other, a two-part compatibility group designation is assigned to an energetic liquid. (NOTE: The design and logistics of modern weapons sometimes require that consideration be given to permitting storage or operations involving energetic liquids in a storage structure containing solid explosives. For example, it may be necessary to store hydrocarbon-fueled cruise missiles having high explosive warheads with fueled configurations not containing explosive warheads. Another example is the storage of liquid gun propellant with explosive AE components.)

C9.5.5.2.1. The first element is the standard storage and transportation CG designation. The alpha designations are the same as the CG designations for UN Class 1 as given in chapter 3. However, for storage and handling on DoD facilities, a CG may also be assigned to an energetic liquid in a Class other than Class 1. The absence of a CG indicates incompatibility with solid explosives.

C9.5.5.2.2. The second element is a new Energetic Liquid Compatibility Group (ELCG) designation. The ELCG applies to mixed storage of energetic liquids or AE containing energetic liquids. The ELCG is specified in parentheses as the last element of the hazard classification. The ELCG designations and definitions are:

C9.5.5.2.2.1. LA: Energetic liquids that are strong oxidizers, mainly of acidic character. These materials may cause or contribute to the combustion of other material, possibly resulting in serious flare fires or explosions. Includes, but is not limited to, nitrogen tetroxide and mixed oxides of nitrogen (MON), inhibited red fuming nitric acid (IRFNA), liquid oxygen (LO_2), hydrogen peroxide (H_2O_2), and gels, slurries, or emulsions of the above.

C9.5.5.2.2.2. LB: Energetic liquids that are readily combustible when exposed to, or ignited in the presence of an oxidizing agent, but that are not strong reducing agents. Some may be hypergolic with group LA materials. Includes, but is not limited to, hydrocarbons such as kerosene's and strained ring ramjet fuels; liquid hydrogen (LH_2); and gels, slurries, or emulsions of the above.

C9.5.5.2.2.3. LC: Energetic liquids that are readily combustible when exposed to, or ignited in the presence of an oxidizing agent, and are also strong reducing agents. These will likely be hypergolic with group LA substances. Includes, but is not limited to, hydrazine's and other amines; and gels, slurries, or emulsions of the above.

C9.5.5.2.2.4. LD: Energetic liquids that act mainly as combustible fuels, similar to groups LB and LC, when exposed to, or ignited in the presence of oxidizing agents but that may act as oxidizers in some combinations. They may be a monopropellant with the right catalyst, or may be pyrophoric and ignite upon release to the atmosphere. Examples are ethylene and propylene oxides, and boranes.

C9.5.5.2.2.5. LE: Energetic liquids having characteristics that do not permit storage with any other energetic liquid. They may react adversely with either fuels (reducing agents) or oxidizers. Examples are nitromethane, nitrate ester based formulations such as Otto Fuel II, liquid monopropellants containing hydroxyl ammonium nitrate (HAN), halogen fluorides (ClF_3 and ClF_5) and fluorine, and gels, slurries, or emulsions of the above.

C9.5.5.2.3. Mixing of energetic liquids.

C9.5.5.2.3.1. Different energetic liquids in the same ELCG may be stored together.

C9.5.5.2.3.2. ELCG-LE may not be mixed with other ELCG or dis-similar ELCG-LE.

C9.5.5.2.3.3. Mixed storage is prohibited between energetic liquids of different ELCG designations with one exception.

C9.5.5.2.3.3.1. ELCG-LB and -LC should not be stored together, particularly when the majority of the material stored is ELCG-LB; however, mixed storage of ELCG-LB and -LC is permitted when operationally necessary.

C9.5.5.2.4. As an example, for the 1.3C(LE) hazard classification for HAN-based liquid gun propellant XM-46:

C9.5.5.2.4.1. "C": indicates the propellant can be stored in the same magazine with CG-C solid propellants. Because CG-C and CG-D can be mixed, CG-D high explosive projectiles could also be stored with the energetic liquid gun propellant.

C9.5.5.2.4.2. "LE": indicates that hydrocarbon fuels (e.g., JP-10), which is an ELCG-LB, would not be permitted in this storage scenario, because its ELCG-LB indicates incompatibility with ELCG-LE.

C9.5.5.3. Complete DoD hazard classification assignments for current energetic liquids are shown in Table C9.T16. (NOTE: Conversions for gallons of energetic liquids to pounds is provided in Table C9.T17.)

C9.5.5.4. Each new energetic liquid, or new non-bulk packaging configuration of an energetic liquid, developed by a DoD Component or adopted for DoD use, must be examined and assigned a hazard classification per reference (d).

C9.5.5.5. A different minimum distance may be assigned during the hazard classification process when the hazards of a particular new packaging configuration are not adequately addressed. This distance shall be indicated parenthetically, in hundreds of feet, as the first element of the hazard classification. For example, if a new liquid oxidizer pressure vessel configuration is hazard classified as (04)2.2(LA), then a minimum distance of 400 ft (122 m) would apply for IBD and PTRD, otherwise the prescribed liquid oxidizer QD criteria would apply.

C9.5.5.6. Specific hazardous locations. The predominant hazard of the individual energetic liquids can vary depending upon the location of the energetic liquid storage and the operations involved. These locations are listed below in the order of decreasing hazards.

C9.5.5.6.1. Launch pads. Operations at these facilities are very hazardous because of the proximity of fuel and oxidizer to each other, the frequency of launchings, lack of restraint of the vehicle after liftoff, and the possibility of fallback with resultant dynamic mixing on impact. To compute the explosive equivalent for the launch pad, use Table C9.T18. with the combined energetic liquids weight in the launch vehicle tanks and any energetic liquids in piping that are subject to mixing, except as indicated in subparagraph C9.5.5.8.

C9.5.5.6.2. Static test stands. Operations at these facilities are less hazardous because test items are restrained and subject to better control than launch vehicles. As with launch pads, the proximity of fuel and oxidizer presents a significant hazard. To reduce this hazard, tankage should be separated and remotely located from the static test stand. Explosive equivalents of Table C9.T18. shall be used, with the combined energetic liquids weight subject to mixing as determined by hazard analysis. The amount of energetic liquids held in run tanks can be excluded from consideration if the test stand meets all the following criteria, if applicable:

C9.5.5.6.2.1. All tanks are American Society of Mechanical Engineers (ASME) certified (reference (u)) and maintained per ASME Code, section VIII, Division 1 or Division 2.

C9.5.5.6.2.2. For cryogenic propellants, all tanks are constructed with double wall jacketing.

C9.5.5.6.2.3. Run tankage is protected from fragments produced by an engine malfunction.

TABLE C9.T18. Energetic Liquid Explosive Equivalents [1,2,3,4,5]

ENERGETIC LIQUIDS	TNT EQUIVALENCE	
	STATIC TEST STANDS	RANGE LAUNCH
LO_2/LH_2	See Note 6	See Note 6
LO_2/LH_2 + LO_2/RP-1	Sum of (see Note 6 for LO_2/LH_2) + (10% for LO2/RP-1)	Sum of (see Note 6 for LO_2/LH_2) + (20% for LO2/RP-1)
LO_2/RP-1	10%	20% up to 500,000 lbs plus 10% over 500,000 lbs *20% up to 226,795 kg plus 10% over 226,795 kg*
IRFNA/UDMH [7]	10%	10%
N_2O_4/UDMH + N_2H_4 [7]	5%	10%
N_2O_4 liquid oxidizer + PBAN solid fuel (Hybrid propellants)	15% [8]	15% [8]
Nitromethane (alone or in combination)	100%	100%
Otto Fuel II	100% [9]	
Ethylene Oxide	100% [10]	100% [10]

Notes for Table C9.T18:

1. The percentage factors given in the table are to be used to determine equivalencies of energetic liquids mixtures at static test stands and range launch pads when such energetic liquids are located aboveground and are unconfined except for their tankage. Other configurations shall be considered on an individual basis to determine equivalencies.
2. The explosives equivalent weight calculated by the use of this table shall be added to any non-nuclear explosive weight aboard before distances can be determined from Tables C9.T1. and C9.T5.
3. These equivalencies apply also for the following substitutions:

   Alcohols or other hydrocarbons for RP-1.

   H_2O_2 for LO_2 (only when LO_2 is in combination with RP-1 or equivalent hydrocarbon fuel).

   MMH for N_2H_4, UDMH, or combinations of the two.
4. For quantities of energetic liquids up to but not over the equivalent of 100 lbs [45.4 kg] of AE, the distance shall be determined on an individual basis by the DoD Component. All personnel and facilities, whether involved in the operation or not, shall be protected by operating procedures, equipment design, shielding, barricading, or other suitable means.
5. Distances less than intraline are not specified. Where a number of prepackaged energetic liquid units are stored together, separation distance to other storage facilities shall be determined on an individual basis by the DoD Component, taking into consideration normal hazard classification procedures.
6. For siting launch vehicles and static test stands, explosive equivalent weight is the larger of:

   (a) The weight equal to $8W^{2/3}$ [$4.13\ Q^{2/3}$] where W is the weight of LO_2/LH_2; or

   (b) 14 percent of the LO_2/LH_2 weight.

(NOTE: For these calculations, use the total weight of LO_2/LH_2 present in the launch vehicle, or the total weight in test stand run tankage and piping for which there is no positive means to prevent mixing in credible mishaps. When it can be reliably demonstrated that the MCE involves a lesser quantity of energetic liquids subject to involvement in a single reaction, the lesser quantity may be used in determining the explosive equivalent yield. When siting is based on a quantity less than the total energetic liquids present, the MCE and associated explosive yield analysis must be documented in an approved site plan (section C5.4.).)

7. These are hypergolic combinations.
8. Explosive equivalency of the hybrid rocket system N_2O_4 liquid oxidizer combined with PBAN solid fuel was evaluated as 15 percent for an explosive donor accident scenario, 5 percent for a high velocity impact scenario, and less than 0.01 percent (negligible) for static mixing (tower drop) failures (AFRPL-TR-67-124 (reference (v)).
9. See Note 10 of Table C9.T16.
10. See Note 8 of Table C9.T16.

C9.5.5.6.2.4. Both the fuel and oxidizer lines contain two (redundant), remotely operated valves to shut off flow in the event of a malfunction.

C9.5.5.7. Ready storage. This storage is relatively close to the launch and static test stands; normally it is not involved directly in feeding the engine as in the case with run tankage, which is an integral part of all launch and test stand operations. The explosive equivalents of Table C9.T18. shall be used with the combined energetic liquids weight subject to mixing if the facility design does not guarantee against fuel and oxidizer mixing and against detonation propagation to, or initiation at, the ready storage facility when a mishap occurs at the test stand, on the ground at the launch pad, or at the ready storage areas. Otherwise, fire and fragment hazards shall govern (Tables C9.T16., C9.T19., C9.T20., C9.T21., and C9.T22.).

C9.5.5.8. Cold-flow test operations. Fire and fragment hazards govern (Tables C9.T16., C9.T19., C9.T20., C9.T21., and C9.T22.) if the design is such that the system is closed except for approved venting, is completely airtight, fuel and oxidizer never are employed concurrently, and each has a completely separate isolated system and fitting types to preclude intermixing, and the energetic liquids are of required purity. Otherwise, explosive equivalents (Table C9.T18.) shall be used with the combined energetic liquids weight.

C9.5.5.9. Bulk storage. This is the most remote storage with respect to launch and test operations. It consists of the area, tanks, and other containers therein, used to hold energetic liquids for supplying ready storage and, indirectly, run tankage where no ready storage is available. Fire and fragment hazards govern (Tables C9.T16., C9.T19., C9.T20., C9.T21., and C9.T22.) except in special cases as indicated in Tables C9.T16. and C9.T18.

C9.5.5.10. Rest storage. This is temporary-type storage and most closely resembles bulk storage. It is a temporary parking location for barges, trailers, tank cars, and portable hold tanks used for topping operations when these units actually are not engaged in the operation; and for such vehicles when they are unable to empty their cargo promptly into the intended storage container. Fire and fragment hazards govern (Tables C9.T16., C9.T19., C9.T20., C9.T21., and C9.T22.) except in special cases as indicated in Tables C9.T16. and C9.T18. The transporter becomes a part of that storage to which it is connected during energetic liquids transfer.

TABLE C9.T19. QD Criteria for OSHA/NFPA Class I – III Flammable and Combustible Energetic Liquids Storage in Detached Buildings or Tanks[1,2]

Quantity	IBD/PTRD (ft) [m]	ILD/Aboveground IMD (ft) [m]
Unlimited [3]	50 [4,5] [15.2 [4,5]]	Note 6

Notes for Tables C9.T19:

1. Other guidelines for diking, tank or container construction, tank venting, and facility construction apply (except for Class III B combustible liquids, e.g. Otto Fuel II). Refer to reference (r) and (reference (s) for further guidance on liquid storage and fire protection.
2. Refer to reference (r) and NFPA 30 Flammable and reference (s) for definition and explanation of OSHA/NFPA classification of flammable and combustible liquids.
3. Guidelines on interior storage configuration (for container storage inside buildings) also apply with the following exceptions:
   (a) If the storage building is located at least 100 ft [30.5 m] from any exposed building (under the direct jurisdiction of a fire protection organization) or property line; or
   (b) If the storage building is located at least 200 ft [61 m] from any exposed building (not under the direct jurisdiction of a fire protection organization) or property line; or
   (c) for combustible liquids that will not exhibit sustained burning in bulk form, e.g. Otto Fuel II, as determined through ASTM D 92 Standard Test Method for Flash and Fire Points by Cleveland Open Cup or comparable testing. Refer to reference (r) and reference (s) for further guidance on liquid storage and fire protection.
4. For container storage inside of a building, IBD/PTR distances may be less than 50 ft [15.2 m] (to a minimum of 10 ft [3.05 m]) if the storage building is constructed of fire resistive exterior walls having an NFPA Fire Resistance rating of two hours or more according to NFPA 251 (reference (w).
5. For large tank storage, QD may be 25 ft [7.6 m] for tank capacities up to 100,000 gallons [378,541 liters], and 37.5 ft [11.4 m] for capacities between 100,001 gallons [378,545 liters] and 500,000 gallons [1,892,706 liters].
6. For flammable liquids container storage inside of a building, ILD/Aboveground IMD is 50 ft [15.2 m] (except as in Note 4), or for adjacent incompatible oxidizer storage, distances specified for energetic liquid oxidizers (Table C9.T20.) or oxygen (Table C9.T21.). For flammable liquids storage in fixed or large portable tanks, ILD/Aboveground IMD is either (1) for compatible energetic liquids, equal to one sixth of the sum of the diameters of the two adjacent tanks, or distances specified in Note 5 for adjacent container storage inside of a building; or (2) for adjacent incompatible oxidizer storage, distances specified for energetic liquid oxidizers (Table C9.T20.) or oxygen (C9.T21.). ECM may be used to their physical capacity for storing flammable energetic liquids provided they comply with the construction and siting requirements of chapters 5 and 9, respectively for Hazard Division 1.1. ECM must be sited for a minimum of 100 lbs [45.4 kg] of HD 1.1 items using Tables C9.T4. and C9.T6.

TABLE C9.T20. QD Criteria for Energetic Liquid Oxidizer (excluding Liquid Oxygen) Storage in Detached Buildings or Tanks[1, 2]

NFPA Oxidizer Class[3]	Quantity (lbs) *[kg]*	IBD/PTRD/ILD/Aboveground IMD (ft) *[m]*
2	up to 600,000	50
	up to 227,154	*15.2*
3	up to 400,000	75
	up to 181,436	*22.9*
4[4,5]	≤ 50	75
	≤ 22.7	*15.2*
	70	76
	31.8	*23.1*
	100	79
	45.4	*24.1*
	150	84
	68.0	*25.7*
	200	89
	90.7	*27.2*
	300	98
	136.1	*29.9*
	500	114
	226.8	*34.8*
	700	128
	317.5	*39.0*
	1,000	147
	453.6	*44.7*
	1,500	175
	680.4	*53.2*
	2,000[6]	200
	907.2[6]	*60.9*
	3,000	246
	1360.8	*74.9*
	5,000	328
	2268.0	*100.0*
	7,000	404
	3175.1	*123.0*

TABLE C9.T20. QD Criteria for Energetic Liquid Oxidizer (excluding Liquid Oxygen) Storage in Detached Buildings or Tanks[1, 2] (continued)

NFPA Oxidizer Class[3]	Quantity (lbs) *[kg]*	IBD/PTRD/ILD/Aboveground IMD (ft) *[m]*
	10,000	510
	4535.9	*155.4*
	15,000	592
	6,803.9	*180.4*
	20,000	651
	9,071.8	*198.5*
	30,000	746
	13,607.7	*227.3*
	50,000	884
	22,679.5	*269.5*
	70,000	989
	31,751.3	*301.5*
	100,000	1114
	45,359.0	*339.5*
	150,000	1275
	68,038.5	*388.6*
	200,000	1404
	90,718.0	*427.8*
	300,000	1607
	136,077.0	*489.7*
	500,000	1905
	226,795.0	*580.6*

Notes for Table C9.T20:

1. QD requirements do not apply to storage of NFPA Class 2 and 3 oxidizers NFPA 50 (reference (x)) in approved fixed tanks.
2. Other requirements for interior storage configuration, building construction, diking, container materials, facility venting, etc. also apply. Refer to reference (t) for further guidance on oxidizer storage and fire protection.
3. Refer to reference (t) for definition and explanation of NFPA classification of oxidizers.
4. Multiple tanks containing NFPA Class 4 oxidizers may be located at distances less than those specified in the table; however, if the tanks are not separated from each other by 10 percent of the distance specified for the largest tank, then the total contents of all tanks shall be used to calculate distances to other exposures.

5. The equations given below may be used to determine distance/weights for other quantities:

Quantity (W) in lbs, distance in ft

W ≤ 10,000 lbs

$$\text{Distance} = 149.3*W^{(-0.41+0.059*\ln(W))} \quad \textbf{[EQN C9.T20-1]}$$

W > 10,000 lbs

$$\text{Distance} = 24*W^{1/3} \quad \textbf{[EQN C9.T20-2]}$$

Quantity (W) in kg, distance in m

W ≤4,535.9 kg

$$\textit{Distance} = 34.2*W^{(-0.317+0.059*\ln(W))} \quad \textbf{[EQN C9.T20-3]}$$

W > 4,535.9 kg

$$\textit{Distance} = 9.52*W^{1/3} \quad \textbf{[EQN C9.T20-4]}$$

Quantity (W) in lbs, distance in ft

Distance > 75 ft

$$W = \exp[-134.286 + 71.998*(\ln(\text{Distance})) - 12.363*(\ln(\text{Distance}))^2 + 0.7229*(\ln(\text{Distance}))^3] \quad \textbf{[EQN C9.T20-5]}$$

Quantity (W) in kg, distance in m

Distance > 22.9 m

$$W = \exp[-65.774 + 45.6823*(\ln(\text{Distance})) - 9.7864*(\ln(\text{Distance}))^2 + 0.7229*(\ln(\text{Distance}))^3] \quad \textbf{[EQN C9.T20-6]}$$

6. NFPA 430 requires sprinkler protection to be provided for storage of greater than 2,000 lbs (907.2 kg) of NFPA Class 4 oxidizers inside of a building (reference (t)).

TABLE C9.T21. QD Criteria for Liquid Oxygen Storage in Detached Buildings or Tanks[1, 2]

Quantity	IBD/PTRD (ft) *[m]*	ILD/Aboveground IMD (ft) *[m]*
Unlimited[3]	100 *30.5*	100 [4] *30.5* [4]

Notes for Table C9.T21

1. Per reference (w), distances do not apply where a protective structure having an NFPA fire resistance rating of at least two hours interrupts the line of sight between the oxygen system and the exposure. Refer to reference (r) and reference (x) for further guidance.

2. Additional guidelines relating to equipment assembly and installation, facility design (diking), and other fire protection issues also apply. Refer to reference (r) and reference (x) for further guidance.
3. QD is independent of oxygen quantity.
4. Minimum ILD/IMD distance between adjacent compatible energetic liquids storage is 50 ft [15.2 m].

TABLE C9.T22. QD Criteria for Liquid Hydrogen and Bulk Quantities of Hydrazines[1]

Propellant Weight (W) (lbs) *[kg]*	IBD/PTRD		ILD/Aboveground IMD[6,7] (ft) *[m]*
	Unprotected[2,3] (ft) *[m]*	Protected[4,5] (ft) *[m]*	
≤100	600	80	30
≤ 45.4	*182.9*	*24.4*	*9.1*
150	600	90	34
68.0	*182.9*	*27.4*	*10.3*
200	600	100	37
90.7	*182.9*	*30.4*	*11.2*
300	600	113	42
136.1	*182.9*	*34.4*	*12.7*
500	600	130	49
226.8	*182.9*	*39.5*	*14.6*
700	600	141	53
317.5	*182.9*	*42.9*	*15.9*
1,000	600	153	57
453.6	*182.9*	*46.5*	*17.2*
1,500	600	166	62
680.4	*182.9*	*50.7*	*19.0*
2,000	600	176	66
907.2	*182.9*	*53.7*	*19.9*
3,000	600	191	72
1360.8	*182.9*	*58.2*	*21.5*
5,000	600	211	79
2268.0	*182.9*	*64.1*	*23.7*
7,000	600	224	84
3175.1	*182.9*	*68.3*	*25.3*
10,000	603	239	90
4,535.9	*183.9*	*72.9*	*27.0*
15,000	691	258	97
6,803.9	*210.5*	*78.5*	*29.0*
20,000	760	272	102
9,071.8	*231.7*	*82.7*	*30.6*
30,000	870	292	110
13,607.7	*265.2*	*89.0*	*32.9*
50,000	1,032	321	120
22,679.5	*314.5*	*97.6*	*36.1*
70,000	1,154	341	128
31,751.3	*351.8*	*103.8*	*38.4*
100,000	1,300	364	136
45,359.0	*396.2*	*110.7*	*41.0*

TABLE C9.T22. QD Criteria for Liquid Hydrogen and Bulk Quantities of Hydrazines[1] (continued)

Propellant Weight (W) (lbs) *[kg]*	IBD/PTRD		ILD/Aboveground IMD[6,7] (ft) *[m]*
	Unprotected[2,3] (ft) *[m]*	Protected[4,5] (ft) *[m]*	
150,000	1,488	391	147
68,038.5	*453.6*	*119.1*	*44.1*
200,000	1,637	412	155
90,718.0	*499.2*	*125.5*	*46.4*
300,000	1,800	444	166
136,077.0	*548.6*	*135.1*	*50.0*
500,000	1,800	487	183
226,795.0	*548.6*	*148.2*	*54.8*
700,000	1,800	518	194
317,513.0	*548.6*	*157.6*	*58.3*
1,000,000	1,800	552	207
453,590.0	*548.6*	*168.1*	*62.2*
1,500,000	1,800	594	223
680,385.0	*548.6*	*180.8*	*67.8*
2,000,000	1,800	626	235
907,180.0	*548.6*	*190.4*	*70.5*
3,000,000	1,800	673	252
1,360,770.0	*548.6*	*204.7*	*75.8*
5,000,000	1,800	737	276
2,267,950.0	*548.6*	*224.2*	*83.0*
7,000,000	1,800	782	293
3,175,130.0	*548.6*	*237.9*	*88.0*
10,000,000	1,800	832	312
4,535,900.0	*548.6*	*253.3*	*93.7*

Notes for Table C9.T22.

1. Positive measures shall be taken to prevent mixing of hydrogen or hydrazine's and adjacent oxidizers in the event of a leak or spill.
2. Distances are necessary to provide reasonable protection from fragments of tanks or equipment that are expected to be thrown in event of a vapor phase explosion
3. W in lbs, Distance in ft

   $W \leq 10{,}000$ lbs

   Unprotected Distance = 600 ft

   $10{,}000 < W \leq 265{,}000$ lbs,

   Unprotected Distance = $28*W^{1/3}$ **[EQN C9-T22-1]**

   $W > 265{,}000$ lbs

   Unprotected Distance = 1,800 ft

   W in kg, Distance in m

   $W \leq 4{,}535.9$ kg

   Unprotected Distance = 182.9 m

4,535.9 kg < W ≤ 120,201.4 kg

*Unprotected Distance = 11.11*W^1/3* **[EQN C9.T22-2]**

W > 120,201.4 kg

Unprotected Distance = 548.6 m

W in lbs, Distance in ft

603 ft ≤ Unprotected Distance < 1,798 ft

$W = (\text{Unprotected Distance}/28)^3$ **[EQN C9-T22-3]**

W in kg, Distance in m

183.9 m ≤ Unprotected Distance < 548.2 m

W = (Unprotected Distance/11.11)^3 **[EQN C9.T22-4]**

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

5. Distances are based on the recommended IBD given in (reference (aa)), and extrapolation of the 2 cal/cm^2 data on the 1 percent water vapor curve.

W in lbs, Distance in ft

W ≤ 100 lbs

Protected Distance = 80 ft

100 lbs < W

Protected Distance = $-154.1 + 72.89*[\ln(W)] - 6.675*[\ln(W)]^2 + 0.369*[\ln(W)]^3$. **[EQN C9-T22-5]**

W in kg, Distance in m

W ≤ 45.4 kg

Protected Distance = 24.4 m

45.4 kg < W ≤

Protected Distance = $-30.62 + 19.211*[\ln(W)] - 1.7678*[\ln(W)]^2 + 0.1124*[\ln(W)]^3$ **[EQN C9.T22-6].**

W in lbs, Distance in ft

80 ft ≤ Protected Distance

$W = \exp[311.367 - 215.761*(\ln(\text{protected distance})) + 55.1828*(\ln(\text{protected distance}))^2 - 6.1099*(\ln(\text{protected distance}))^3 + 0.25343*(\ln(\text{protected distance}))^4]$ **[EQN C9-T22-7]**

W in kg, Distance in m

24.4 m ≤ Protected Distance

$W = \exp[122.38 - 108.8094*(\ln(\text{protected distance})) + 35.5517*(\ln(\text{protected distance}))^2 - 4.9055*(\ln(\text{protected distance}))^3 + 0.25343*(\ln(\text{protected distance}))^4]$ **[EQN C9.T22-8]**

6. ILD/Aboveground IMD distances in this column apply for adjacent compatible (ELCG LB or LC) storage; for adjacent incompatible (other ELCG) storage, use IBD distances shown in previous columns. ECM may be used to their physical capacity for storing hydrogen provided they comply with the construction and siting requirements of chapters 5 and 9, respectively for HD 1.1. ECM must be sited for a minimum of 100 lbs [45.4 kg] of HD 1.1 items using Tables C9.T4. and C9.T6.

7. Distances are 37.5 percent of "protected" column.

8. Extrapolations above 1,000,000 lbs [453,590 kg] extend well outside data included in reference (y) from which the original QD tables were derived; however, they are supported by independent calculations and knowledge of like phenomena.

C9.5.5.11. Run tankage (operating tankage). This consists of the tank and other containers and associated piping used to hold the energetic liquids for direct feeding into the engine or device during operation. The contents of properly separated "run tanks" (operating tankage) and piping are normally considered on the basis of the pertinent hazards for the materials involved, except for quantities of incompatible materials that are or can be in a position to become mixed. Explosive equivalents shall be used (Table C9.T18.) for quantities of such materials subject to mixing unless provisions of subparagraphs C9.5.5.6.2.1. through C9.5.5.6.2.4. are satisfied.

C9.5.5.12. Pipelines. A 25-ft (7.6 m) clear zone to inhabited buildings shall be maintained, as a minimum, on each side of pipelines used for energetic liquids (excluding flammable or combustible liquids that exhibit normal fire hazards such as RP-1, JP-10, and Otto Fuel II). Tables C9.T16., C9.T20., C9.T21., and C9.T22. apply, as appropriate.

C9.5.6. QD standards. Since many energetic liquids are not classified as UN Class 1 explosives, conventional QD storage criteria do not generally apply to these materials. At the same time, the (non-Class 1) UN transportation hazard classifications for many energetic liquids appear to be inappropriate and/or inadequate for application to storage safety (based on available accident and test data). For example, hydrazine has a UN hazard classification of 8 (corrosive), while it also is subject to dangerous fire and explosive behavior. Thus, the implementation of QD criteria for energetic liquids is based on an independent determination of the predominant hazard presented by the material in the storage environment. The following standards are applicable to energetic liquids used for propulsion or operation of missiles, rockets, and other related devices.

C9.5.6.1. Tables C9.T16., C9.T19., C9.T20., C9.T21., and C9.T22. provide minimum distance requirements for storage of bulk quantities, and in some cases, pressure vessels and other commercial packagings of energetic liquids. In general, the minimum distance required by the material requiring the greatest distance shall separate storage of different energetic liquids. In addition, positive measures shall be taken to control the flow of energetic liquids in the event of a leak or spill, in order to prevent possible fire propagation or accumulation of flammable liquids near other storage, and/or to prevent mixing of incompatible energetic liquids (except for specific hazardous locations as identified in subparagraph C9.5.5.6. above). Explosives equivalence applies for some materials as indicated in Tables C9.T16. and C9.T18. Fragment hazards govern for some materials in certain packaging configurations. For the more conventional fuels and oxidizers, and also where minimum blast and/or fragment criteria are not required due to low confinement packaging, QD standards are adopted from OSHA and NFPA guidelines to account for normal fire protection principles.

C9.5.6.2. For specific hazardous locations as defined in subparagraph C9.5.5.6. above, explosives equivalency may apply. If so, consult Tables C9.T16. and C9.T18. with the combined energetic liquids weight subject to mixing and use distances found in Table C9.T1. or C9.T5. Enter weight of explosives equivalent in Table C9.T1. or C9.T5. QD standards for other

conditions and explosive equivalents for any combination not contained in Table C9.T16. or C9.T18. shall be determined by the controlling DoD Component.

C9.5.7. Contaminated energetic liquids.

C9.5.7.1. Caution shall be exercised in the storage and handling of contaminated energetic liquids. Such contamination may increase the degree of hazard associated with the energetic liquids.

C9.5.7.2. Energetic liquids known to be contaminated or in a suspect condition shall be isolated and provided separate storage from all other energetic liquids pending laboratory analysis for verification of contamination and disposition requirements, if any.

C9.6. SITING

C9.6.1. Airfields, and Heliports.

C9.6.1.1. Scope and Application.

C9.6.1.1.1. This section:

C9.6.1.1.1.1. Applies to AE that is under the control and custody of DoD personnel at airfields and heliports. (Chapter 10 applies when these requirements cannot be met for contingencies, combat operations, and military operations other than war.)

C9.6.1.1.1.2. Does not apply to AE installed on aircraft (e.g., egress system components, squibs, and detonators for jettisoning external stores, engine-starter cartridges, fire extinguisher cartridges, and destructors in electronic equipment), contained in survival and rescue kits (e.g., flares, signals, explosives components of emergency equipment), and other such items or materials necessary for safe flight operations.

C9.6.1.1.2. Aircraft parking areas.

C9.6.1.1.2.1. Uploading and downloading of AE shall be conducted at explosives sited aircraft parking areas.

C9.6.1.1.2.2. QD is not required for the following:

C9.6.1.1.2.2.1. Aircraft loaded with AE shown below and parked in designated aircraft parking areas that meet airfield criteria when evaluated as a PES:

C9.6.1.1.2.2.1.1. HD 1.2.2: gun AE, 30 mm or less.

C9.6.1.1.2.2.1.2. HD 1.3: Captive missiles, aircraft defensive flares or chaff.

C9.6.1.1.2.2.1.3. HD 1.4 AE.

C9.6.1.1.2.2.2. Uploading and downloading AE listed above (subparagraph C9.6.1.1.2.2.1.), at a designated aircraft parking area, provided the quantity of AE involved in the operation is limited to a single aircraft load.

C9.6.1.2. Additional Siting Criteria. This section's QD criteria shall be applied with the below airfield clearance criteria that is prescribed by DoD Component and Federal Aviation Administration (FAA) regulations (reference (z)). For airfields and heliports:

C9.6.1.2.1. Used exclusively by the DoD Components and allied nations military components; combat aircraft parking areas, AE cargo areas, alert hangars, and shelters may be located within the airfield clearance zone, the exception is in AE prohibited areas (see subparagraph C9.6.1.7. below).

C9.6.1.2.2. Not used exclusively by DoD Components and allied nations military components; combat aircraft parking areas, AE cargo areas, alert hangars, and shelters shall be located as prescribed in Tables C9.T23. and C9.T24. (Refer to Table C9.T24. first.)

C9.6.1.3. Measurement of Separation Distances. In applying Tables C9.T23. and C9.T24., distances shall be measured as follows:

C9.6.1.3.1. Loaded Aircraft to Loaded Aircraft. Measure the shortest distance between AE on one aircraft to AE on the adjacent aircraft.

C9.6.1.3.2. AE Location to Taxiways and Runways. Measure from the nearest point of the AE location to the:

C9.6.1.3.2.1. Nearest point of the taxiway

C9.6.1.3.2.2. Centerline of the runway

C9.6.1.4. Helicopter Landing Areas for AE Operations. Helicopter landing areas for loading and unloading AE within storage sites and quick reaction alert sites shall be considered AGM and may be sited at IMD based only upon the NEWQD carried by the helicopter. Such helicopter landing areas shall meet the following requirements:

C9.6.1.4.1. Flight clearance criteria are met.

C9.6.1.4.2. Landing and takeoff approaches shall not be over any AE facilities.

C9.6.1.4.3. Helicopter operations are to be limited to AE support of the facilities concerned.

C9.6.1.4.4. Carrying of passengers is not permitted.

C9.6.1.4.5. During helicopter takeoff, landing, or loading or unloading, AE operations shall not be conducted at any PES located within IBD of the helicopter landing area. During landing or takeoff, PES doors shall be closed.

C9.6.1.4.6. Safety precautions normal to other modes of transportation are to be observed.

TABLE C9.T23. HD 1.1 QD for Military Aircraft Parking Areas.

NEWQD (lbs) [kg]	Distance for Specific Targets Indicated in Table C9.T24[1,2,3] (ft) [m]
50	111
22.7	33.7
70	124
31.8	37.7
100	139
45.4	42.4
150	159
68.0	48.6
200	175
90.7	53.5
300	201
136.1	61.2
500	238
226.8	72.6
700	266
317.5	81.2
1,000	300
453.6	91.4
1,500	343
680.4	104.7
2,000	378
907.2	115.2
3,000	433
1,360.8	131.9
5,000	513
2,268.0	156.4
7,000	574
3,175.1	174.9
10,000	646
4,535.9	197.0
15,000	740
6,803.9	225.5
20,000	814
9,071.8	248.2
30,000	932
13,608	284.1
50,000	1,105
22,680	336.9
70,000	1,236
31,751	376.9
100,000	1,392
45,359	424.4
150,000	1,594
68,039	485.8
200,000	1,754
90,718	534.7
300,000	2,008
136,077	612.1
500,000	2,381
226,795	725.8

NOTES for Table C9.T23.

1. D in ft, NEWQD in lbs

$$D = 30W^{1/3} \quad \text{[EQN C9.T23-1]}$$

with a minimum distance of 111 ft

D in m, NEWQD in kg

$$D = 11.9Q^{1/3} \quad \text{[EQN C9.T23-2]}$$

with a minimum distance of 33.8 m

D in ft, NEWQD in lbs

$$NEWQD = D^3/27{,}000 \quad \text{[EQN C9.T23-3]}$$

with a minimum NEWQD of 50 lbs

D in m, NEWQD in kg

$$NEWQD = D3/1{,}685.2 \quad \text{[EQN C9.T23-4]}$$

with a minimum NEWQD of 22.7 kg

2. Minimum fragment distance requirements for HD 1.1 (see subparagraph C9.4.1.2.) do not apply to targets for which this table is used.

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

TABLE C9.T24. Application of AE Separation Distances For Airfields and Heliports

(Note: Table entries refer to the key below and are not K factors)

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

NOTES For Table C9.T24.

1. Use applicable IBD.
2. Use applicable PTRD.
3. For HD 1.1, use applicable IMD. For HD 1.2, apply Note 10, below. Protects against simultaneous detonation of AE on adjacent aircraft, but does not prevent serious damage to aircraft and possible propagation of detonation due to fragments, debris, or fire
4. Use applicable ILD.
5. Use Table C9.T23. distances for mass-detonating items and applicable PTRD for nonmass-detonating items.
6. Use Table C9.T23. distances for DoD Component aircraft parking areas and applicable IBD for non-DoD Component aircraft parking areas.
7. Use applicable PTRD for locations in the open where passengers enplane and deplane; use applicable IBD if a structure is included where passengers assemble, such as a passenger terminal building.
8. No distance required to recreational areas that are used exclusively for alert personnel manning the combat-loaded aircraft. Other recreational areas where people are in the open shall be at applicable PTRD. When structures, including bleacher stands, are a part of such area, applicable IBD shall be used.
9. Recreational areas, where people are in the open, shall be at applicable PTRD. When structures, including bleacher stands are part of such area, applicable IBD shall be used.
10. Within these areas of airfields and heliports exclusively used by the DoD Components, the separation of aircraft parking areas from combat aircraft parking areas and their ready AE storage facilities and AE cargo areas are considered to be a command function. At joint DoD/non-DoD use airfields and heliports, the combat aircraft parking areas and its ready AE storage facilities and AE cargo area shall be separated from non-DoD aircraft as specified in Note 6, above.
11. Use $18W^{1/3}$ [$7.14Q^{1/3}$] distances from side or rear of ECM to taxiways; use PTRD from front of ECM or any other storage locations to taxiways; and use PTRD from all storage location to runways.

C9.6.1.5. Hardened Aircraft Shelters (HAS).

C9.6.1.5.1. HAS and associated AE facilities shall be separated according to Table C9.T25. At these distances there will be a high degree of protection against propagation of explosion when HAS doors are properly secured. However, the exposed shelter may be damaged heavily and aircraft and AE therein may be rendered unserviceable.

C9.6.1.5.2. HAS and associated AE facilities separated according to Table C9.T26. will provide a higher degree of asset preservation than those provided in Table C9.T25. An explosion in one shelter or ready storage facility may destroy it and its contents, but aircraft within adjacent shelters will be undamaged provided the doors are closed. These aircraft may not be immediately accessible due to debris.

C9.6.1.5.3. The front, side, or rear sectors of a HAS as either a PES or an ES are defined in Figure C9.F9.

C9.6.1.5.4. For a third-generation HAS containing up to 11,000 lbs (4,989.5 kg) NEWQD, use separation distances of Table C9.T27. to unhardened ES. The QD criteria given in Table C9.T27. apply to all HD 1.1 AE, regardless of any minimum fragment distance denoted by (xx) 1.1.

C9.6.1.5.5. When operational necessity dictates, as determined by the DoD Component, separation distances less than those contained in Tables C9.T25. and C9.T26. may be approved; however it must be shown that equivalent protection is being provided.

TABLE C9.T25. Minimum Hazard Factor for HAS for Propagation Prevention

To ↓	From →	1st Generation HAS			2nd & 3rd Generation HAS[3]			Ready Service ECM				Ready Service AGM	
		S	R	F	S	R	F	S	R	FB	FU	B	U
1st Generation HAS[3]	S	2 *0.79*	2 *0.79*	2.75 *1.09*	2 *0.79*	2 *0.79*	2.75 *1.09*	1.25[1] *0.50*[1]	1.25[1] *0.50*[1]	2.75[2] *1.09*[2]	2.75[2] *1.09*[2]	2.75 *1.09*	2.75 *1.09*
	R	2 *0.79*	2 *0.79*	2.75 *1.09*	2 *0.79*	2 *0.79*	2.75 *1.09*	1.25[1] *0.50*[1]	1.25[1] *0.50*[1]	2.75[2] *1.09*[2]	2.75[2] *1.09*[2]	2.75 *1.09*	2.75 *1.09*
	F	6 *2.38*	4.5 *1.79*	8 *3.17*	6 *2.38*	4.5 *1.79*	9 *3.57*	1.25[1] *0.50*[1]	2.75[2] *1.09*[2]	6[2] *2.38*[2]	9[2] *3.57*[2]	6 *2.38*	9[2] *3.57*[2]
2nd & 3rd Generation HAS[3]	S	2 *0.79*	2 *0.79*	2.75 *1.09*	2 *0.79*	2 *0.79*	2.75 *1.09*	1.25[1] *0.50*[1]	1.25[1] *0.50*[1]	2.75[2] *1.09*[2]	2.75[2] *1.09*[2]	2.75 *1.09*	2.75 *1.09*
	R	2 *0.79*	2 *0.79*	2.75 *1.09*	2 *0.79*	2 *0.79*	2.75 *1.09*	1.25[1] *0.50*[1]	1.25[1] *0.50*[1]	2.75[2] *1.09*[2]	2.75[2] *1.09*[2]	2.75 *1.09*	2.75 *1.09*
	F	4.5 *1.79*	2.75 *1.09*	5 *1.98*	4.5 *1.79*	2.75 *1.09*	6 *2.38*	1.25[1] *0.50*[1]	1.25[1] *0.50*[1]	2.75[2] *1.09*[2]	2.75[2] *1.09*[2]	2.75 *1.09*	2.75 *1.09*
Ready Service ECM	S	2 *0.79*	2 *0.79*	2.75 *1.09*	2 *0.79*	2 *0.79*	2.75 *1.09*						
	R	2 *0.79*	2 *0.79*	2.75 *1.09*	2 *0.79*	2 *0.79*	2.75 *1.09*						
	FB	2.75 *1.09*	2.75 *1.09*	5 *1.98*	2.75 *1.09*	2.75 *1.09*	6 *2.38*						
	FU	6 *2.38*	4.5 *1.79*	8 *3.17*	6 *2.38*	4.5 *1.79*	9 *3.57*						
Ready Service AGM	B	2.75 *1.09*	2.75 *1.09*	6 *2.38*	2.75 *1.09*	2.75 *1.09*	6 *2.38*						
	U	11 *4.36*	11 *4.36*	11 *4.36*	11 *4.36*	11 *4.36*	11 *4.36*						

Notes for Table C9.T25

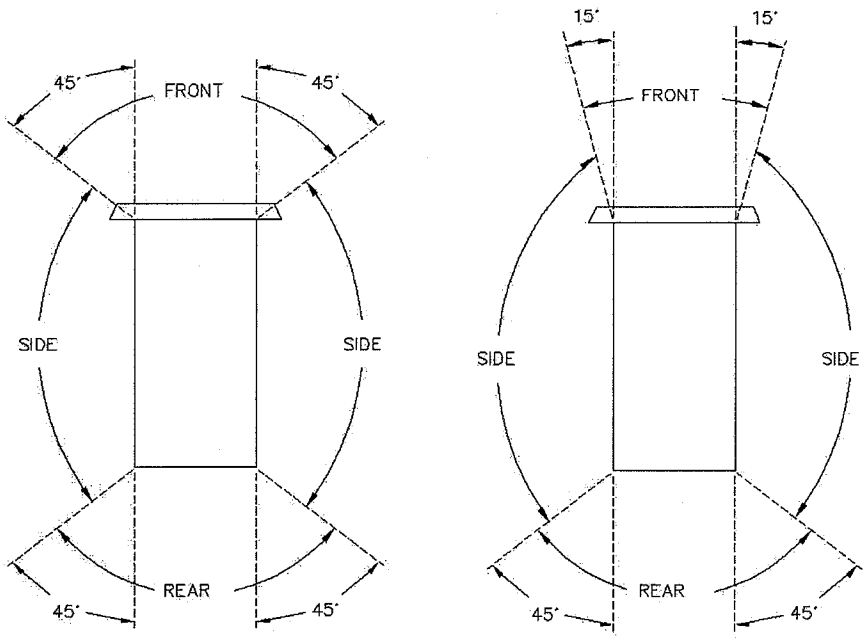
1. Use $d = 2W^{1/3}$ **[EQN C9.T25-1]** and [$d = 0.79W^{1/3}$] **[EQN C9.T25-2]** if the loading density of the ECM exceeds 1.25 lbs/ft^3 [20 kg/m^3]. Do not exceed the maximum NEWQD limit of 22,000 lbs [9,979 kg]
2. If required, use the separation shown regardless of loading density. Do not exceed the maximum NEWQD limit of 22,000 lbs [9,979 kg].
3. Second and third generation HAS are limited to a maximum of 11,000 lbs [4,989.5 kg] per shelter.

TABLE C9.T26. Minimum Hazard Factor for HAS for Asset Preservation

To ↓		From → 1st Generation HAS			2nd & 3rd Generation HAS[2]			Ready Service ECM[3]				Ready Service AGM	
		S	R	F	S	R	F	S	R	FB	FU	B	U
1st Generation HAS	S	9 *3.57*	6 *2.38*	9 *3.57*	9 *3.57*	6 *2.38*	9 *3.57*	2.75 *1.09*	2.75 *1.09*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	R	8 *3.17*	5 *1.98*	8 *3.17*	8 *3.17*	5 *1.98*	8 *3.17*	2.75 *1.09*	2.75 *1.09*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	F	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*	11 *4.36*	9 *3.57*	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*
2nd & 3rd Generation HAS	S	9 *3.57*	6 *2.38*	9 *3.57*	9 *3.57*	6 *2.38*	9 *3.57*	2.75 *1.09*	2.75 *1.09*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	R	8 *3.17*	5 *1.98*	8 *3.17*	8 *3.17*	5 *1.98*	8 *3.17*	2.75 *1.09*	2.75 *1.09*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	F	11 *4.36*	9 *3.57*	18 *7.14*	11 *4.36*	9 *3.57*	18 *7.14*	2.75 *1.09*	2.75 *1.09*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
1st Generation Maintenance HAS[1]	S	9 *3.57*	8 *3.17*	9 *3.57*	9 *3.57*	8 *3.17*	9 *3.57*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	R	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	F	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*	11 *4.36*	9 *3.57*	18 *7.14*	18 *7.14*	18 *7.14*	18 *7.14*
2nd & 3rd Generation Maintenance HAS[1]	S	9 *3.57*	8 *3.17*	9 *3.57*	9 *3.57*	8 *3.17*	9 *3.57*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	R	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*
	F	11 *4.36*	9 *3.57*	18 *7.14*	11 *4.36*	9 *3.57*	18 *7.14*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*	8 *3.17*

Notes for Tables C9.T26.

1. Maintenance HAS shall not be located closer than 300 ft [91.4 m] from any PES HAS sited for more than 500 lbs [226.8 kg] NEWQD.
2. Second and Third generation HAS are limited to a maximum of 11,000 lbs [4,989.5 kg] NEWQD per shelter.
3. Ready service ECM used to support daily loading are limited to 22,000 lbs [9,979 kg] NEWQD per magazine and loading density of not more than 1.25 lbs/ft^3 [20 kg/m^3].



HAS as an ES **HAS as a PES**

C9.F9. HAS Orientation Effects
(see subparagraph C9.6.1.5.3.)

TABLE C9.T27. QD from a U.S. Third Generation HAS PES to an Unhardened ES.[1,2,3]

NEWQD (lbs) *[kg]*	Front (ft) *[m]*	Sides (ft) *[m]*	Rear (ft) *[m]*
≤ 4.4	50	50	50
≤ 1.8	*15.2*	*15.2*	*15.2*
4.4 < NEWQD ≤ 110	230	50	50
1.8 < NEWQD ≤ 49.9	*70.1*	*15.2*	*15.2*
110 < NEWQD ≤ 500	230	50	50
49.9 < NEWQD ≤ 226.8	*70.1*	*15.2*	*15.2*
500 < NEWQD ≤ 1,100	230	394	164
226.8 < NEWQD ≤ 498.9	*70.1*	*120.1*	*50*
1,100 < NEWQD ≤ 11,000[4]	K50	K62	K40
498.9 < NEWQD ≤ 4,989.5[4]	K_m *19.84*	K_m *24.60*	K_m *15.86*

Notes for Table C9.T27.

1. Separation distances are based on shelter doors remaining closed, except for aircraft towing, fueling, servicing, run-up, or taxiing and during integrated combat turnarounds or short periods when maintenance equipment or munitions are being moved into or out of the shelter. Where doors are left open for extended periods, normal combat aircraft parking area criteria of Table C9.T24. apply.
2. Separate AE from the HAS walls by a distance sufficient to prevent breaching. For less than 1,100 lbs [498.9 kg] NEWQD a 3 ft [0.91 m] separation from the wall is sufficient.
3. These QD criteria apply to IBD, PTRD and ILD exposures for quantities ≤ 1,100 lbs [498.9 kg] NEWQD.
4. For quantities > 1,100 to 11,000 lbs [498.9 to 4,989.5 kg] NEWQD, these QD only apply to IBD exposures. Use 50 percent of the IBD criteria for PTRD exposures with a 300 ft [91.4 m] minimum distance (out the front or rear) or a 394 ft [120.1 m] minimum distance (off the sides). Use 35 percent of the IBD criteria for intraline exposures with a 300 ft [91.4 m] minimum distance (out the front and rear) or a 394 ft [120.1 m] minimum distance (off the sides).

C9.6.1.6. Combat Aircraft Support Facilities. See subparagraph C9.4.1.1.2.1.11. for separation distance criteria associated with such facilities. When operational necessity dictates, separation distances less than K18 [7.14] may be approved; however, it must be demonstrated that K18 [7.14] equivalent protection is provided.

C9.6.1.7. AE Prohibited Areas. Areas immediately beyond the ends of runways and along primary flight paths are subject to more aircraft accidents than other areas. For this reason, AE is prohibited from Accident Potential Zones (APZ) I and II and clear zones (CZ) of all aircraft landing facilities, as designated and described in detail in DoD Component airfield and airspace criteria directives.

C9.6.2. Pier And Wharf Facilities.

C9.6.2.1. Scope and Application. QD herein are for HD 1.1 AE. If only AE of other HD are involved, the applicable QD shall be applied. This section:

C9.6.2.1.1. Applies to:

C9.6.2.1.1.1. Ship and barge units, hereafter referred to as ships.

C9.6.2.1.1.2. Piers and wharf and associated facilities at which AE may be handled, or be present in ships' holds or conveyances.

C9.6.2.1.1.3. Loading, off-loading, stowing, and shifting of AE from ships' magazines.

C9.6.2.1.2. Does not apply to (i.e., no QD required):

C9.6.2.1.2.1. AE stored in ships' magazines and intended for the service of shipboard armament or aircraft.

C9.6.2.1.2.2. Handling ≤ 300 lbs NEW [136.1 kg] of combined HD 1.3 and HD 1.4 AE that are necessary for ship's security and safety-at-sea.

C9.6.2.1.2.3. Roll-on or roll-off AE operations involving ships where the requirements of C9.8.12 are met.

C9.6.2.2. Determining the Quantity of Explosives in a Ship

C9.6.2.2.1. The NEWQD on board a ship shall be determined per section C9.2., above.

C9.6.2.2.2. When ships are separated by $11W^{1/3}$ ($4.36Q^{1/3}$) distances or greater, QD shall be based individually on the quantity of each ship. Lesser separation distances require that the AE in all ships be totaled.

C9.6.2.3. Measurement of Separation Distances

C9.6.2.3.1. Moored Ships.

C9.6.2.3.1.1. Measurement of separation distances between ships or barges shall be from the nearest point of one ship's magazine (the PES) or the barge:

C9.6.2.3.1.1.1. For IMD: To the nearest point of another ship's magazine or a barge.

C9.6.2. 3.1.1.2. For IBD and PTRD: To the nearest point of another ship or a barge.

C9.6.2.3.1.2. Measurement of separation distances between ships or barges and shore ES shall be from the nearest point of a ship's magazine or the barge to the nearest point of the ES.

C9.6.2.3.2. Pier Operations. Measurement of separation distances from piers to surrounding facilities shall be from the nearest point that AE will be handled to the nearest point of an ES. (NOTE: Movement of railcars or trucks passing through the clear space between ships at a pier or between piers is considered as an operational risk. It is generally impracticable to separate berths at a single pier by enough distance to prevent mass detonation of HD 1.1. To the extent operationally feasible, the number of such exposures and total time required should be reduced to the maximum extent practicable through scheduling.)

C9.6.2.3.3. Anchorages. Measurements from anchorages generally shall be from the boundary of the area designated for the explosives anchorage. The explosives anchorage for a single ship is a circle, the radius of which is the distance from the mooring buoy or a ship's anchor to the stern of the ship or of the AE lighters alongside when riding to the full scope of the chain. For an explosives anchorage, the separation distance to an ES will depend upon whether any ships are separated properly (see subparagraph C9.6.2.2.2.).

C9.6.3. Siting Criteria and Application of QD.

C9.6.3.1. Maritime Prepositioning Ships (MPS).

C9.6.3.1.1. Reduced QD criteria may be applied to those MPS that contain up to 1,300,000 lbs [589,667 kg] NEWQD of AE stored in standard ISO shipping containers.

C9.6.3.1.2. IBD and PTRD for MPS can be determined using K = 40.85 [16.21] with a 3,700-ft [1,128 m] minimum fragment distance for IBD and K = 24.01 [9.52]for PTRD for MPS loads where no more than 52 percent of the NEWQD is HD 1.1. When the percentage of HD 1.1 is:

C9.6.3.1.2.1. Between 52 and 65 percent, use Table C9.T28.

C9.6.3.1.2.2. Above 65 percent, use Table C9.T1.

TABLE C9.T28. Variation of MPS QD Factors with Loadout.

Percent of HD 1.1	IBD	PTRD	Ship-to-Ship
up to 52	40.85	24.01	32
	16.21	*9.52*	*12.69*
53	40.97	24.08	32.1
	16.25	*9.55*	*12.73*
54	41.1	24.16	32.19
	16.3	*9.58*	*12.77*
55	41.22	24.23	32.29
	16.35	*9.61*	*12.81*
56	41.35	24.3	32.39
	16.4	*9.64*	*12.85*
57	41.47	24.37	32.48
	16.45	*9.67*	*12.88*
58	41.59	24.44	32.58
	16.5	*9.7*	*12.92*
59	41.71	24.52	32.67
	16.55	*9.73*	*12.96*
60	41.83	24.59	32.77
	16.59	*9.75*	*13*
61	41.95	24.66	32.86
	16.64	*9.78*	*13.04*
62	42.07	24.73	32.95
	16.69	*9.81*	*13.07*
63	42.19	24.8	33.05
	16.74	*9.84*	*13.11*
64	42.3	24.86	33.14
	16.78	*9.86*	*13.15*
65	42.42	24.93	33.23
	16.83	*9.89*	*13.18*

C9.6.3.1.3. The QD between applicable MPS piers, anchorages, and non-explosives loading piers, anchorages can be determined using K = 32 [12.69] with a 3,500 ft [1,067 m] minimum fragment distance for MPS loads, where no more than 52 percent of the total NEWQD is HD 1.1. When the percentage of HD 1.1 is:

C9.6.3.1.3.1. Between 52 and 65 percent, use Table C9.T28.

C9.6.3.1.3.2. Above 65 percent, use Table C9.T1.

C9.6.3.2. Scuttling Site. A properly located scuttling site will, when feasible, be provided for positioning a ship for its flooding or sinking in the event it catches fire and must be moved to avert damage to other ships or piers. The location of a scuttling site shall depend on the greatest NEWQD that may be in a single ship at any one time. (Table C9.T1. provides the applicable QD.) Additional considerations for the scuttling site include:

C9.6.3.2.1. The site should have sufficient maneuvering room and depth to permit sinking the largest vessel that may be handled at the installation so that the holds will be flooded completely at low tide.

C9.6.3.2.2. The scuttling site should provide the best available protection to other ships, piers, and shore installations in the event of a mass explosion.

C9.6.3.3. Explosives Anchorage. Explosives anchorage shall be separated from the main ship channel and from normally traversed routes of ships entering or leaving the harbor by the distances indicated below. (NOTE: Occasional watercraft passing through the arcs, while outside both the main ship channel and normally traversed routes of ships entering and leaving the harbor, are not subject to QD requirements.)

C9.6.3.3.1. The PTRD from "Other PES" column of Table C9.T1. and

C9.6.3.3.2. The turning circles and stopping distances of other ships passing the anchorage but not less than 3,000 ft [914.4 m].

C9.6.3.3.3. Separation of Ships at Explosives Anchorages. When explosives anchorages are used for both loading and unloading ships and for mooring loaded ships, they shall be separated as follows:

C9.6.3.3.3.1. Loaded ships shall be separated one from another by $18W^{1/3}$ $[7.14Q^{1/3}]$

C9.6.3.3.3.2. Loading and unloading ships shall be separated one from another by $11W^{1/3}$ $[4.36Q^{1/3}]$ and, when possible, by $18W^{1/3}$ $[7.14Q^{1/3}]$.

C9.6.3.3.3.3. Loaded ships shall be separated from ships loading and unloading by $40W^{1/3}$ $[15.87Q^{1/3}]$.

C9.6.3.3.4. Separation of Explosives Anchorages from Explosives Piers. Explosives anchorages shall be separated from explosives piers by $40W^{1/3}$ $[15.87Q^{1/3}]$, except when the anchorage is used only for the loading or unloading of ships. In that case, $18W^{1/3}$ $[7.14Q^{1/3}]$may be used.

C9.6.3.4. Separation Distances of Ships at the Same Pier.

C9.6.3.4.1. Berthing of two ships in tandem helps decrease the fragment hazard to the AE cargo of the second ship because of the additional protection afforded by the bow or stern.

C9.6.3.4.2. When two ships, which cannot be separated by $11W^{1/3}$ $[4.36Q^{1/3}]$, are being loaded through all hatches at the same time, the spotting of railcars or trucks and the loading of hatches in both ships should be planned in a manner that puts the greatest possible distance both between the open hatches, and the trucks and railcars serving the two ships. When possible, the loading of the ships shall be staggered.

C9.6.3.5. Separation of Wharf Yard from the Pier. A wharf yard shall be separated from the pier, which it serves by $11W^{1/3}$ $[4.36Q^{1/3}]$ to prevent propagation. If this separation distance cannot be met, then the wharf yard shall be considered as part of the ship or barge and added to it for computation of the total amount of explosives for QD purposes.

C9.6.3.6. Separation of Explosives Ships from Other Ships. Explosives ships being loaded or unloaded shall be separated from non-explosives carrying ships and from loaded explosives ships that are not underway by $40W^{1/3}$ [$15.87Q^{1/3}$]distances. The PTRD from "Other PES" column of Table C9.T1. shall be used for protection of ships that are underway.

C9.6.3.7. Barge Piers. Piers and wharfs used exclusively for loading or unloading AE on barges or utility craft may be sited from other shore facilities as loading docks, IAW paragraph C9.8.8. Shore facilities shall be sited under the same criteria as pier and wharf facilities, in relation to barge piers.

C9.6.3.8. Separation of Preposition Program Ships at Anchorages. The Military Sealift Command's Prepositioning Program (i.e. Combat Prepositioning Force, Maritime Prepositioning Force, Logistics Prepositioning Ships, etc.) operates both explosives-loaded and non-explosives carrying ships that are then deployed to key locations around the world. These ships are pre-loaded with military equipment and supplies necessary to support military forces on a short-notice basis and thus support a common mission. The following criteria applies to Prepositioning Program ships at anchorage:

C9.6.3.8.1. Non-explosives carrying ships shall be separated from explosives-loaded ships by a minimum of $18W^{1/3}$ [$7.14Q^{1/3}$].

C9.6.3.8.2. Non-explosives carrying ships shall be separated from non-Prepositioning Program explosives-loaded ships by $40W^{1/3}$ [$15.87Q^{1/3}$].

C9.6.3.8.3. Non-explosives carrying ships not associated with the Prepositioning Program shall be separated from all explosives carrying ships by $40W^{1/3}$ [$15.87Q^{1/3}$].

C9.6.3.8.4. All non-explosives carrying ships shall be separated from explosives ships being loaded or unloaded by $40W^{1/3}$ [$15.87Q^{1/3}$].

C9.6.4. QD Tables.

C9.6.4.1. Figure C9.F10. illustrates required hazard factors. Table C9.T7B. provides the corresponding separation distances.

C9.6.4.2. Table C9.T1. separation distances shall be maintained between explosives pier and wharf facilities and other ES (e.g., administration and industrial areas, terminal boundaries, main ship channels, and PTRD).

C9.6.4.3. As an ES, ships must be separated from AE operating and storage facilities (including holding yards) by the "Other PES IBD" column of Table C9.T1.

C9.6.4.4. As a PES, ships must be separated from AE operating facilities by either the barricaded IMD (K6 [2.38]) or unbarricaded IMD (K11 [4.36]) of Table C9.T5., as applicable. An exception (see subparagraph C9.4.1.1.2.1.10) is permitted when the ES is a container stuffing and unstuffing operation that routinely supports AE ship-loading and unloading operations. (NOTE: QD requirements of subparagraph C9.6.4.3. shall apply from such container stuffing and unstuffing operations (as a PES) to an AE ship (as an ES.)

C9.6.5. General Cargo and Vehicles at AE Terminals.

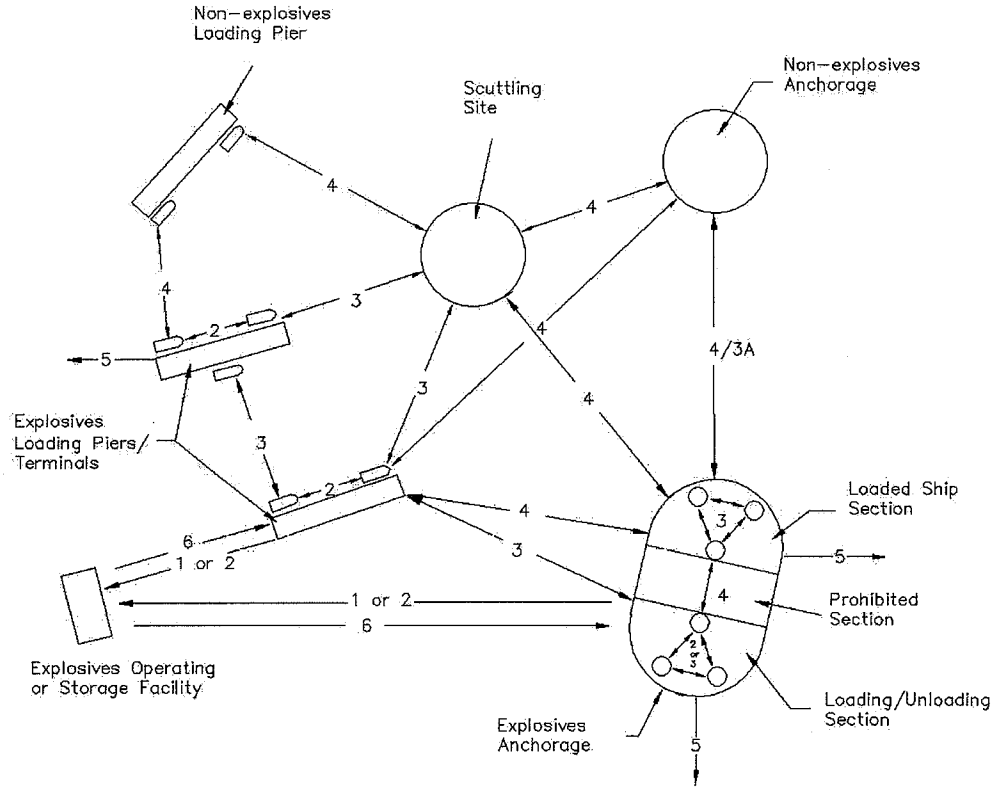
C9.6.5.1. Concurrent movements of mission-related general cargo, vehicles, and AE through a terminal may be conducted for the purpose of loading or unloading the same ship.

C9.6.5.2. Concurrent operations involving other ships shall be conducted at applicable QD separations. (See Figure C9.F10.).

C9.6.5.3. Separation of inert materials and equipment in holding areas shall be consistent with section C5.5.

C9.6.5.3.1. Personnel entering inert holding areas that are located within ESQD shall be limited both in number and time of exposure.

C9.6.5.3.2. Any labor intense activity shall take place at IBD or PTRD, as applicable.



C9.F10. Application of Separation Distances for Ship or Barge

LEGEND for Figure C9.F10

1 - $6W^{1/3}$ [$2.38Q^{1/3}$]

2 - $11W^{1/3}$ [$4.36Q^{1/3}$]

3 - $18W^{1/3}$ [$7.14Q^{1/3}$]

3A - $18W^{1/3}$ [$7.14Q^{1/3}$] (See subparagraph C9.6.3.3.9. for Prepositioning Program Ships)

Ship or Barge

4 - $40W^{1/3}$ [$15.87Q^{1/3}$]

5 – Table C9.T1. IBD or PTRD (OTHER PES columns), as applicable

6 – Table C9.T1. IBD, as applicable

C9.7. UNDERGROUND STORAGE OF AE

C9.7.1. General.

C9.7.1.1. This section provides QD standards for underground storage (e.g., natural caverns and below grade, excavated chambers) and storage facilities providing the overpressure confinement effects typically encountered in underground storage.

C9.7.1.2. These criteria are only applicable when the minimum distance from the perimeter of a storage chamber to an exterior surface exceeds $0.25W^{1/3}$ [$0.10Q^{1/3}$]. (NOTE: This minimum distance normally, but not always, equals the thickness of the earth cover.)

C9.7.1.3. Use aboveground siting criteria when minimum distance criteria of subparagraph C9.7.1.2. cannot be met.

C9.7.1.4. This section addresses explosives safety criteria both with and without rupture of the earth cover.

C9.7.1.5. QD siting requirements of this section may be determined from the applicable equations or by interpolating between the table and figure entries.

C9.7.1.6. Expected ground shock, debris, and airblast hazards from an accidental explosion in an underground storage facility depend on several variables, including the local geology and site-specific parameters. These parameters vary significantly from facility to facility. Siting distances other than those listed may be used when validated by approved experimental or analytical results showing equivalent protection to that required.

C9.7.2. External QD Determinations.

C9.7.2.1. QD Dependence on HD. (See section C9.2. to determine the explosive weight for mixed HD.)

C9.7.2.1.1. HD 1.1. Distances shall be determined from the total quantity of HD 1.1 in the individual chambers, unless the total quantity is subdivided to prevent rapid communication of an incident from one sub-division to another. Connected chambers containing HD 1.1 shall be treated as a single chamber site, unless explosion communication is prevented by adequate sub-division or chamber separation.

C9.7.2.1.2. HD 1.2. Except for primary fragments from openings to underground storage, external explosives safety hazards are not normally significant for HD 1.2. The safe distance for both IBD and PTR is the IBD distance in Tables C9.T8. through C9.T12. for locations within 10 degrees to either side of the centerline of a tunnel opening. These criteria apply only to those detonations that occur where a line-of-sight path exists from the detonation point to any portion of the tunnel opening. For detonations that do not have a line-of-sight path to the tunnel opening, or where the line-of-sight path is intercepted by a barricade beyond the opening, the IBD and PTR hazard distances are zero.

C9.7.2.1.3. HD 1.3. HD 1.3 shall be treated as HD 1.1 with an explosive equivalence of 100 percent for QD purposes. Any significant and validated differences in energy release per unit mass of HD 1.3 from that of TNT may be considered.

C9.7.2.1.4. HD 1.4. External explosives safety hazards are not normally significant for HD 1.4. Accordingly, external QD criteria do not apply for HD 1.4.

C9.7.2.1.5. HD 1.5. HD 1.5 shall be treated as HD 1.1 with an explosive equivalence of 100 percent for QD purposes.

C9.7.2.1.6. HD 1.6. HD 1.6 shall be treated as HD 1.2.

C9.7.2.2. QD Reference Points.

C9.7.2.2.1. Distances determined by blast or debris exiting from tunnel openings is the minimum distance measured from the openings to the nearest wall or point of the location to be protected. Use extended centerlines of the openings as reference lines for directional effects.

C9.7.2.2.2. Distances determined for airblast and debris produced by breaching of the chamber cover shall be the minimum distance from an exterior point defined by chamber cover thickness, on the ground surface above the storage chamber to the nearest wall or point of the location to be protected. For configurations where the storage chambers are not distinct from the access tunnel, the distance is the shortest distance from the tunnel roof directly above the charge to the surface.

C9.7.2.2.3. Distances determined for ground shock shall be the minimum distance measured from the nearest wall of the storage chamber to the location to be protected.

C9.7.2.3. IBD. IBD for HD 1.1 shall be the largest of those distances required for protection against ground shock, debris, and airblast as defined below.

C9.7.2.3.1. Ground Shock.

C9.7.2.3.1.1. For protection of residential buildings against significant structural damage by ground shock, the maximum particle velocity induced in the ground at the building site shall not exceed:

C9.7.2.3.1.1.1. 2.4 ips [6.1 cm/s] in soil

C9.7.2.3.1.1.2. 4.5 ips [11.4 cm/s] in weak rock

C9.7.2.3.1.1.3. 9.0 ips [22.9 cm/s] in strong rock.

C9.7.2.3.1.2. The above values form the basis for the following equations (NOTE: D_{ig} is in ft and W is the explosive quantity in lb [D_{ig} is in m and Q is the explosive quantity in kg]).:

C9.7.2.3.1.2.1. For sitings in moderately strong to strong rock with chamber loading densities [NEWQD/chamber internal volume] of 3.0 lb/ft^3 [48.1 kg/m^3] or less, the IBD for ground shock, D_{ig} is:

$$D_{ig} = 5.8W^{1/3} \quad \textbf{[EQN C9.7-1]}$$

$$D_{ig} = 2.30Q^{1/3} \quad \textbf{[EQN C9.7-2]}$$

C9.7.2.3.1.2.2. For higher loading densities in chambers sited in moderately strong to strong rock, and for all loading densities in other materials, the IBD for ground shock (NOTE: See C9.7.2.3.1.2.3. for values of decoupling factor, f_g) is:

$$D_{ig} = 12.5f_gW^{4/9} \text{ (Moderately strong to strong rock)} \quad \textbf{[EQN C9.7-3]}$$

$$D_{ig} = 5.41f_gQ^{4/9} \text{ (Moderately strong to strong rock)} \quad \textbf{[EQN C9.7-4]}$$

$$D_{ig} = 11.1f_gW^{4/9} \text{ (Weak rock)} \quad \textbf{[EQN C9.7-5]}$$

$D_{ig} = 4.81 f_g Q^{4/9}$ (Weak rock) **[EQN C9.7-6]**

$D_{ig} = 2.1 f_g W^{4/9}$ (Soil) **[EQN C9.7-7]**

$D_{ig} = 0.91 f_g Q^{4/9}$ (Soil) **[EQN C9.7-8]**

C9.7.2.3.1.2.3. The dimensionless, decoupling factor, f_g, depends on chamber loading density, w (lb/ft^3 [kg/m^3]), and is (NOTE: Values of D_{ig} and D_{ig}/f_g are given in Table C9.T29. Values of f_g are shown in Table C9.T30. Alternate values for D_{ig} may be used only when justified by site-specific ground shock data.):

$f_g = 0.267 w^{0.3}$. **[EQN C9.7-9]**

$f_g = 0.11604 w^{0.3}$ **[EQN C9.7-10]**

C9.7.2.3.2. Debris. (See paragraph C5.2.3. for special design considerations)

C9.7.2.3.2.1. A minimum IBD distance of 1,800 ft [548.6 m] for debris throw from an opening shall apply within 10 degrees to either side of the centerline axis of that opening, unless positive means are used to prevent or control the debris throw.

C9.7.2.3.2.2. The distance D_{id} that is required for protection of inhabited areas against the effects of debris thrown from breaching of the cover material over a detonation depends on the thickness of the cover (C) over the storage chamber. The critical cover thickness, C_c, is defined as $2.5W^{1/3}$ ($1.0Q^{1/3}$).

C9.7.2.3.2.2.1. When $C_c \geq 2.5W^{1/3}$ [$1.0Q^{1/3}$], debris from a surface breach need not be considered.

C9.7.2.3.2.2.2. When $C_c < 2.5W^{1/3}$ [$1.0Q^{1/3}$], then the debris distance, D_{id} shall be calculated using the equation:

$D_{id} = f_d * f_c * W^{0.41}$ **[EQN C9.7-11]**

$D_{id} = f_d * f_c * Q^{0.41}$ **[EQN C9.7-12]**

C9.7.2.3.2.2.3. The dimensionless, decoupling factor, f_d depends on chamber loading density, w (lb/ft^3 [kg/m^3]), and is:

$f_d = 0.6 w^{0.18}$ **[EQN C9.7-13]**

$f_d = 0.3615\ w^{0.18}$ **[EQN C9.7-14]**

C9.7.2.3.2.2.4. Values of f_d are shown in Table C9.T30. The coupling factor f_c is related to the type of rock around the storage chamber and the scaled cover thickness, C. Values of fc are given in Table C9.T31.

C9.7.2.3.3. Airblast. (See paragraph C5.2.3. for special design considerations)

C9.7.2.3.3.1. An explosion in an underground storage chamber may produce external airblast from two sources; the exit of blast from existing openings (tunnel entrances, ventilation shafts, etc.) and the rupture or breach of the chamber cover by the detonation. Required IBD is independently determined for each of these airblast sources, with the maximum IBD used for siting. If the chamber cover thickness is less than C_c given in subparagraph C9.7.2.3.2., some external airblast will be produced depending on the cover thickness. Use the following to determine IBD for airblast produced by breaching of the chamber cover:

TABLE C9.T29. Distances To Protect Against Ground Shock

NEWQD	Soil	Weak Rock	Moderately strong to strong rock	All rock $w < 3$ lb/ft^3
	D_{ig}/f_g			[$w<48.1$ kg/m^3]
(lbs)	(ft)	(ft)	(ft)	(ft)
[kg]	*[m]*	*[m]*	*[m]*	*[m]*
1,000	45	239	269	58
453.6	*13.8*	*72.9*	*82.0*	*17.7*
1,500	54	286	322	66
680.4	*16.5*	*87.3*	*98.2*	*20.2*
2,000	62	325	366	73
907.2	*18.8*	*99.2*	*111.6*	*22.3*
3,000	74	390	439	84
1,361	*22.5*	*118.8*	*133.7*	*25.5*
5,000	93	489	551	99
2,268	*28.2*	*149.1*	*167.7*	*30.2*
7,000	107	568	640	111
3,175	*32.8*	*173.2*	*194.8*	*33.8*
10,000	126	665	749	125
4,536	*38.4*	*345.3*	*228.2*	*38.1*
15,000	151	797	897	143
6,804	*46.0*	*243.0*	*273.3*	*43.6*
20,000	171	906	1,020	157
9,072	*52.2*	*276.1*	*528.4*	*48.0*
30,000	205	1,084	1,221	180
13,608	*62.6*	*330.7*	*371.9*	*54.9*
50,000	257	1,361	1,532	214
22,680	*78.5*	*414.9*	*466.7*	*65.1*
70,000	299	1,580	1,779	239
31,751	*91.2*	*481.9*	*542.0*	*72.8*
100,000	350	1,852	2,085	269
45,359	*106.8*	*564.6*	*635.1*	*82.0*
150,000	419	2,217	2,497	308
68,039	*127.9*	*676.1*	*760.5*	*93.9*
200,000	477	2,520	2,837	339
90,718	*145.4*	*768.4*	*864.2*	*103.3*
300,000	571	3,017	3,398	388
136,077	*174.1*	*920.1*	*1,034.9*	*118.3*
500,000	716	3,786	4,264	460
226,795	*218.4*	*1,154.6*	*1,298.6*	*140.3*
700,000	832	4,397	4,951	515.0
317,513	*253.7*	*1,340.8*	*1,508.1*	*156.9*
1,000,000	975	5,152	5,802	580
453,590	*297.2*	*1,571.2*	*1,767.1*	*176.7*

TABLE C9.T30. Functions of Loading Density

Loading Density, w (lb/ft^3) *[kg/m^3]*	Ground Shock f_g	Debris f_d
1 *16.0*	0.267	0.600
1.5 *24.0*	0.301	0.645
2 *32.0*	0.328	0.680
3 *48.1*	0.371	0.730
5 *80.1*	0.432	0.800
7 *112.1*	0.481	0.850
10 *160.2*	0.532	0.910
15 *240.3*	0.601	0.977
20 *320.3*	0.655	1.030
30 *480.5*	0.740	1.110
50 *800.9*	0.862	1.210
70 *1121.2*	0.954	1.290
100 *1601.7*	1.062	1.370

TABLE C9.T31. DEBRIS DISPERSAL FUNCTION

Scaled Earth Cover (C) ($ft/lb^{1/3}$) *[$m/kg^{1/3}$]*	Earth Cover Function, f_c	
	Hard Rock[1] ($ft/lb^{0.41}$) *[$m/kg^{0.41}$]*	Soft Rock[1] ($ft/lb^{0.41}$) *[$m/kg^{0.41}$]*
0.3	9.51	9.80
0.12	*4.01*	*4.13*
0.4	10.25	10.69
0.16	*4.32*	*4.51*
0.5	10.94	11.52
0.20	*4.61*	*4.85*
0.6	11.49	12.08
0.24	*4.84*	*5.09*
0.7	11.89	12.28
0.28	*5.01*	*5.17*
0.8	12.09	12.09
0.32	*5.10*	*5.10*
0.9	12.11	11.55
0.36	*5.10*	*4.87*
1	11.95	10.72
0.40	*5.04*	*4.52*
1.25	10.91	7.99
0.50	*4.60*	*3.37*
1.5	9.31	5.38
0.60	*3.92*	*2.27*
1.75	7.58	3.68
0.69	*3.20*	*1.55*
2	6.04	2.79
0.79	*2.54*	*1.18*
2.25	4.78	2.13
0.89	*2.01*	*0.90*
2.5	3.76	1.54
0.99	*1.58*	*0.65*

Notes for Table C9.T31.

1. Scaled earth cover, C in $ft/lb^{1/3}$, fc in $ft/lb^{0.41}$

   $0.25\ ft/lb^{1/3} < C \leq 2.5\ ft/lb^{1/3}$

   Hard Rock:

   $$f_c = 8.0178 - 0.1239*C + 27.1578*C^2 - 40.1461*C^3 + 21.9018*C^4 - 5.3529*C^5 + 0.4948*C^6$$

   [EQN C9.T31-1]

   Soft Rock:

   $$f_c = 10.8116 - 25.0685*C + 113.9591*C^2 - 168.1092*C^3 + 107.1033*C^4 - 31.5032*C^5 + 3.5251*C^6$$

   [EQN C9.T31-2]

   Scaled earth cover, C in $m/kg^{1/3}$, f_c in $m/kg^{0.41}$

   $0.10\ m/kg^{1/3} < C < 1.0\ m/kg^{1/3}$

Hard Rock:

$$f_c = 3.3794 - 0.1316*C + 72.7376*C^2 - 271.0478*C^3 + 372.7526*C^4 - 229.651*C^5 + 53.5115*C^6$$

[EQN C9.T31-3]

Soft Rock:

$$f_c = 4.5570 - 26.6351*C + 305.2201*C^2 - 1134.995*C^3 + 1822.82*C^4 - 1351.556*C^5 + 381.2317*C^6$$

[EQN C9.T31-4]

C9.7.2.3.3.1.1. $C \leq 0.25W^{1/3}$: ft [$0.10Q^{1/3}$ m]. Use IBD for surface burst of bare explosives charge (Table C9.T1., Note 4)

C9.7.2.3.3.1.2. $0.25W^{1/3} < C \leq 0.50W^{1/3}$: ft [$0.10Q^{1/3} < C \leq 0.20Q^{1/3}$: m]. Use 1/2 of IBD for surface burst of bare explosives charge

C9.7.2.3.3.1.3. $0.50W^{1/3} < C \leq 0.75W^{1/3}$: ft [$0.20Q^{1/3} < C \leq 0.30Q^{1/3}$: m]. Use 1/4 of IBD for surface burst of bare explosives charge

C9.7.2.3.3.1.4. $0.75W^{1/3}$ ft [$0.30*Q^{1/3}$ m] < C: Airblast hazards from blast through the earth cover are negligible relative to ground shock or debris hazards.

C9.7.2.3.3.2. Overpressure and debris hazards must be determined for each facility opening whose cross-section area is five percent or more of that of the largest opening.

C9.7.2.3.3.2.1. Distance versus overpressure along the centerline axis of a single opening is:

$$R = 149.3*D_{HYD}*((W/V_E)^{0.5}/p_{SO})^{1/1.4}$$ **[EQN C9.7-15]**

$$R = 220.191*D_{HYD}*((W/V_E)^{0.5}/p_{SO})^{1/1.4}$$ **[EQN C9.7-16]**

where:

R: Distance from opening (ft) [m],

D_{HYD}: Effective hydraulic diameter that controls dynamic flow issuing from the opening (feet) (Compute D, using the minimum, cross-sectional area of the tunnel that is located within five tunnel diameters of the opening, as D = 4A/P, where A is the area and P is the perimeter.),

P_{SO}: Overpressure at distance R (psi) [kPa].

W: MCE in lb [kg]

V_E: Total volume engulfed by the blast wavefront within the tunnel system at the time the wavefront arrives at the point of interest (ft^3) [m^3]

C9.7.2.3.3.2.2. Distance versus overpressure off the centerline axis of the opening is:

$$R(\theta) = R(\theta=0)/(1 + (\theta/56)^2)^{1/1.4}$$ **[EQN C9.7-17]**

where:

$R(\theta = 0)$ Distance along the centerline axis, and θ is the horizontal angle from the centerline (degrees).

C9.7.2.3.3.3. Equations **[EQN C9.7-15] [EQN C9.7-16]**, and **[EQN C9.7-17]** show that the distance providing protection from an overpressure exceeding P_{SO} depends on the D_{HYD}, and the angle from the centerline axis for the location of interest. Table C9.T32. gives the ratio of off-axis to on-axis distances.

C9.7.2.3.3.4. Find required IBD distances for airblast using the appropriate equations discussed above, with the criteria that the total incident overpressure at IBD shall not exceed:

$P_{SO} = 1.2$ psi	for $W \leq 100{,}000$ lbs,	
$P_{SO} = 8.27$ kPa	for $W \leq 45{,}359$ kg,	
$P_{SO} = 44.57 * W^{-0.314}$ psi	for $100{,}000 < W \leq 250{,}000$ lbs	**[EQN C9.7-18]**
$P_{SO} = 239.753 * W^{-0.314}$ kPa	for $45{,}359 < W \leq 113{,}397.5$ kg.	**[EQN C9.7-19]**
$P_{SO} = 0.9$ psi	for $W > 250{,}000$ lbs.	
$P_{SO} = 6.21$ kPa	for $W > 113{,}397.5$ kg.	

C9.7.2.3.3.5. For the overpressures of Equations 8a to 8c, on-axis IBD distances are:

$R = 131.1 * D_{HYD} * (W/V_E)^{1/2.8}$	for $W \leq 100{,}000$ lbs,	**[EQN C9.7-20]**
$R = 48.683 * D_{HYD} * (W/V_E)^{1/2.8}$	*for $W \leq 45{,}359$ kg,*	**[EQN C9.7-21]**
$R = 9.91 * D_{HYD} * W^{0.581} / V_E^{0.357}$	for $100{,}000 < W \leq 250{,}000$ lbs,	**[EQN C9.7-22]**
$R = 4.395 * D_{HYD} * W^{0.581} / V_E^{0.357}$	*for $45{,}3599 < W \leq 113{,}397.5$ kg,*	**[EQN C9.7-23]**
$R = 161.0 * D_{HYD} * (W/V_E)^{1/2.8}$	for $W > 250{,}000$ lbs	**[EQN C9.7-24]**
$R = 59.787 * D_{HYD} * (W/V_E)^{1/2.8}$	*for $W > 113{,}397.5$ kg.*	**[EQN C9.7-25]**

TABLE C9.T32. Off-Axis Distance Ratios

ANGLE OFF-AXIS (θ) (degrees)	DISTANCE RATIO[1] (R(θ)/R
0	1.000
5	0.994
10	0.978
15	0.952
20	0.918
25	0.878
30	0.835
35	0.790
40	0.745
45	0.701
50	0.658
55	0.617
60	0.579
65	0.544
70	0.511
75	0.480
80	0.452
85	0.426
90	0.402
100	0.359
110	0.323
120	0.292
130	0.266
140	0.243
150	0.223
160	0.206
170	0.190
180	0.177

Note for Table C9.T32

1. $R(\theta)/R = [1+(\theta/56)^2]^{(-1/1.4)}$ **[EQN C9.T32-1]**

C9.7.2.3.3.6. QD distances for IBD for airblast may be determined from the equations listed above or from entries in Tables C9.T33. and C9.T34.

C9.7.2.4. PTRD. PTRD for HD 1.1 is 60 percent of IBD for ground shock, debris, or airblast, whichever is greater.

C9.7.2.5. ILD. ILD for HD 1.1 is the greater of the following:

C9.7.2.5.1. Ground Shock. Does not apply.

C9.7.2.5.2. Debris. For locations within 10 degrees of either side of the centerline of a tunnel opening, site intraline facilities at IBD (see subparagraph C9.7.2.3.). QD criteria for debris are not applicable to locations outside 10 degrees of either side of the centerline axis of an opening.

C9.7.2.5.3. Airblast. Overpressure at barricaded and unbarricaded intraline distances shall not exceed 12 psi (82.7 kPa) and 3.5 psi [24.1 kPa], respectively.

C9.7.2.6. Distance to AGM for HD 1.1.

C9.7.2.6.1. Ground Shock. Does not apply.

C9.7.2.6.2. Debris. For locations within 10 degrees of either side of the centerline of an opening, site aboveground magazines at IBD (see subparagraph C9.7.2.3.). QD criteria for debris from rupture of the chamber cover are not applicable.

C9.7.2.6.3. Airblast. Overpressure at barricaded and unbarricaded AGM distance shall not exceed 27 and 8 psi [186.2 and 55.2 kPa], respectively.

C9.7.2.7. Distance to ECM for HD 1.1.

C9.7.2.7.1. Ground Shock. Does not apply.

C9.7.2.7.2. Debris. QD criteria for debris from rupture of the chamber cover are not applicable. QD criteria for debris exiting from an opening are not applicable, if the magazine is oriented for side-on or rear-on exposures to the debris; however, the criteria do apply for frontal exposures. Site ECM that are located within 10 degrees of either side of the centerline of an opening and oriented for a frontal debris exposure at IBD (see subparagraph C9.7.2.3.).

C9.7.2.7.3. Airblast. These sitings are based on the strength of the ECM's headwall and doors that are under consideration, and the overpressures calculated using equations **[EQN C9.7-15] [EQN C9.7-16]**, and **[EQN C9.7-17]**.

C9.7.2.7.3.1. Head-On Exposure Criteria:

C9.7.2.7.3.1.1. 7-Bar ECM: Site where p_{SO} is $\leq$ 29 psi [200 kPa].

C9.7.2.7.3.1.2. 3-Bar ECM: Site where p_{SO} is $\leq$ 16 psi [110.3 kPa].

C9.7.2.7.3.1.3. Undefined ECM: Site where p_{SO} is $\leq$ 3.5 psi [24.1 kPa].

C9.7.2.7.3.2. Other Than Head-On Exposure. Site all ECM where p_{SO} is $\leq$ 45 psi [310.3 kPa]

TABLE C9.T33. Values for Ratio, $D_{HYD}/V_E^{1/2.8}$

V_E	$D_{HYD}/V_E^{1/2.8}$					
	Effective Hydraulic Diameter, D_{HYD} (ft) *[m]*					
(ft^3)	10	15	20	25	30	35
[m^3]	*3.05*	*4.57*	*6.10*	*7.62*	*9.14*	*10.67*
1,000	0.8483	1.2725	1.6967	2.1209	2.5450	2.9692
28.32	*3.0298*	*4.5447*	*6.0596*	*7.5745*	*9.0894*	*10.6043*
1,500	0.7340	1.1010	1.4680	1.8349	2.2019	2.5689
42.48	*2.6213*	*3.9320*	*5.2427*	*6.5533*	*7.8640*	*9.1747*
2,000	0.6623	0.9935	1.3246	1.6558	1.9869	2.3181
56.63	*2.3654*	*3.5481*	*4.7308*	*5.9135*	*7.0962*	*8.2788*
3,000	0.5730	0.8595	1.1460	1.4326	1.7191	2.0056
84.95	*2.0465*	*3.0698*	*4.0930*	*5.1163*	*6.1395*	*7.1628*
5,000	0.4775	0.7162	0.9549	1.1937	1.4324	1.6711
141.58	*1.7052*	*2.5578*	*3.4104*	*4.2630*	*5.1157*	*5.9683*
7,000	0.4234	0.6351	0.8468	1.0585	1.2702	1.4819
198.22	*1.5121*	*2.2682*	*3.0243*	*3.7803*	*4.5364*	*5.2925*
10,000	0.3728	0.5591	0.7455	0.9319	1.1183	1.3047
283.17	*1.3313*	*1.9969*	*2.6626*	*3.3282*	*3.9938*	*4.6595*
15,000	0.3225	0.4838	0.6450	0.8063	0.9675	1.1288
424.75	*1.1518*	*1.7277*	*2.3036*	*2.8795*	*3.4554*	*4.0313*
20,000	0.2910	0.4365	0.5820	0.7275	0.8731	1.0186
566.34	*1.0393*	*1.5590*	*2.0787*	*2.5984*	*3.1180*	*3.6377*
30,000	0.2518	0.3777	0.5036	0.6295	0.7554	0.8812
849.51	*0.8992*	*1.3488*	*1.7985*	*2.2481*	*2.6977*	*3.1473*
50,000	0.2098	0.3147	0.4196	0.5245	0.6294	0.7343
1,415.84	*0.7493*	*1.1239*	*1.4985*	*1.8732*	*2.2478*	*2.6224*
70,000	0.1860	0.2791	0.3721	0.4651	0.5581	0.6511
1,982.18	*0.6644*	*0.9966*	*1.3289*	*1.6611*	*1.9933*	*2.3255*
100,000	0.1638	0.2457	0.3276	0.4095	0.4914	0.5733
2,831.68	*0.5850*	*0.8774*	*1.1699*	*1.4624*	*1.7549*	*2.0474*
150,000	0.1417	0.2126	0.2834	0.3543	0.4251	0.4960
4,247.53	*0.5061*	*0.7592*	*1.0122*	*1.2653*	*1.5183*	*1.7714*
200,000	0.1279	0.1918	0.2557	0.3197	0.3836	0.4476
5,663.37	*0.4567*	*0.6850*	*0.9134*	*1.1417*	*1.3701*	*1.5984*
300,000	0.1106	0.1660	0.2213	0.2766	0.3319	0.3872
8,495.05	*0.3951*	*0.5927*	*0.7902*	*0.9878*	*1.1854*	*1.3829*
500,000	0.0922	0.1383	0.1844	0.2305	0.2766	0.3226
14,158.42	*0.3292*	*0.4938*	*0.6585*	*0.8231*	*0.9877*	*1.1523*
700,000	0.0817	0.1226	0.1635	0.2044	0.2452	0.2861
19,821.79	*0.2919*	*0.4379*	*0.5839*	*0.7299*	*0.8758*	*1.0218*
1,000,000	0.0720	0.1080	0.1439	0.1799	0.2159	0.2519
28,316.84	*0.2570*	*0.3855*	*0.5141*	*0.6426*	*0.7711*	*0.8996*
1,500,000	0.0623	0.0934	0.1245	0.1557	0.1868	0.2179
42,475.27	*0.2224*	*0.3336*	*0.4448*	*0.5559*	*0.6671*	*0.7783*
2,000,000	0.0562	0.0843	0.1124	0.1405	0.1686	0.1967
56,633.69	*0.2007*	*0.3010*	*0.4013*	*0.5017*	*0.6020*	*0.7023*