3.5 Public Access and Recreation Mitigation Plan

The intent of the Public Access and Recreation Mitigation Plan (Access Plan) is to identify the pre-mining types of recreation and level of use by the public in and around the Project area and to identify provisions to accommodate continued recreational use to the extent practicable. The presence of the proposed mine and associated activities will require some access restrictions for safety reasons.

The Access Plan describes proposed roadway connections that will maintain public access for hiking, biking, horseback riding, rock hounding, hunting, camping, birding, and other types of recreation in all areas except the Barrel Canyon drainage. Rosemont Copper's plan includes providing a buttress to screen the mine and minimize the visual impact of the mine operations. The Access Plan describes any additional proposed roads and trails located on CNF land that connect to the existing network of roads and trails and will allow access to lands surrounding the Rosemont site. Existing roads which enter the site will be gated or blocked for the public safety.

3.5.1 Access to Public Lands

3.5.1.1 Land Ownership

As described above, the Project is comprised of private land, federal land administered by CNF and federal land administered by the BLM, wholly within Pima County in southeastern Arizona (Figure 1-2).

3.5.1.2 Existing Access Road System

A network of numerous FRs and other roads is in the project area (Figure 3-7). Most of the roads are graded, but none are paved. Helvetia Road (FR 231) provides access across the site through connections to the various FRs and unofficial roads (Figure 3-7). These roads connect Helvetia Road on the east side of the project site to Santa Rita Road (FR 505) on the west side. Through the permitting process for the Project some of the existing unofficial FS roads may become part of the authorized FR network.

3.5.1.3 Proposed Access Road System

Figure 3-7 shows the network of known roads and trails that surround the Project site. It also shows the proposed access roads that will connect to existing roads to allow full access to the land around the mine on both sides of the Santa Rita Mountains.

For safety, certain existing FRs and other unofficial roads which enter the mine site will be realigned to prevent public access. The perimeter of the active mine site will be fenced with four-strand barbed wire and mine identification signs will be posted for public safety and mine security.

Because road traffic will be interrupted by Project activities, the new roads will provide public access to the surrounding area and connect to other regional roads to reach the west side of the Santa Rita Mountains. The main access road to the mine site will be constructed from SR 83, extending west to the north entrance of the site (Figure 2-1). A new road segment will connect this road to Santa Rita Road and will allow travel from SR 83 to the west side of the Santa Rita Mountains without entering the site. In addition, four road segments will connect to other existing roads and provide access across the eastern and southern areas of the site. The access road to the south will connect to the existing network of roads on the west side of the site.

The proposed access roads will be typical of the existing FRs. In general, the new roads will be a cleared and graded path 12 ft wide with drainage controls as needed. The roads will follow natural contours to minimize land disturbance. Average grades over the total length of new road segments are about 15% or less; however, some grades are as high as 30% for short segments. The proposed access roads are described in detail below.

3.5.1.3.1 Access to the East Side from SR 83 (Roads 1A, 1B, 1C)

The series of proposed roads 1A through 1C, along with existing FRs, will provide access along the east side of the Property (Figure 3-7). The road alignments will follow low lying natural drainage areas between SR 83 and the mine site. This area is relatively undisturbed and supports healthy vegetation. It is a safe distance from the mining activities and will continue to be available for picnicking and camping and other forms of recreation. A four-strand barbed wire fence will be constructed along the eastern perimeter of the mine facilities, upon which mine identification signs will be posted for public safety and mine security

3.5.1.3.1.1 Access Road 1A

Helvetia Road (FR 231) crosses SR 83 and extends west along a natural drainage area until it approaches the proposed stormwater retention dams for the mine site. About 2,800 ft west of SR 83 on Helvetia Road, an existing unnamed road turns south for a short distance. Helvetia Road will be closed to public access just beyond this junction. Access Road 1A will extend south from this existing road, approximately 1,000 ft, to join the existing FR 4063-.80R-1 that continues south (Figure 3-7).

3.5.1.3.1.2 Access Road 1B

FR 4063-.80R-1 becomes FR 4063 as it travels south. The waste rock storage area will eventually encroach upon the current alignment of FR 4063 so a new route will be created, placing the road a safe distance from the toe of the waste rock storage area. This connection is labeled as Access Road 1B and will parallel the toe of the waste rock storage area south to the intersection with FR 4064, which continues southeast towards SR 83. This proposed Access Road 1B will be approximately 3,400 ft long and will connect FR 4063 to FR 4064 to provide access along the east side of the mine site (Figure 3-7).

3.5.1.3.1.3 Access Road 1C

An unnamed road extends south from FR 4064 approximately 300 ft west of SR 83 at mile marker 44. Access Road 1C will travel south and west from this unnamed road for approximately 6,680 ft until it intersects another existing unnamed road that runs parallel to and south of FR 4072. This existing road travels west towards the waste rock storage area, and then continues south and connects to another unnamed east-west road at the southeast corner of the waste rock storage area (Figure 3-7).

3.5.1.3.2 Access to the South and West Sides (Access Road 2)

Several existing FRs on the western side of the Santa Rita Mountains reach the ridge and continue east providing access to the Project area. Any of these existing roads that extend into the active mine area will be closed. However, Access Road 2 will connect the existing network of roads on the western side of the Santa Rita Mountains to the network of roads surrounding the project site. Access Road 2 will follow the southern end of the mine Property and will connect FR 4032, which runs north along the west side of the site, to an unnamed east-west road at the southeast corner of the waste rock storage area. This connecting road will be approximately 8,166 ft long, and will travel through steep terrain as it approaches the ridge of the Santa Rita Mountains. This road will have a maximum grade of 28% for one 60-ft long segment (Figure 3-7). The overall grade of this new road will be about 10.5%.

The western side of the mine Property lies on the eastern side of the mountain ridge. There are no known FRs that extend over the ridge in the vicinity of the open pit. Therefore, no additional roads are proposed from the southern end of the mine Property along the west side of the open pit. A foot trail will be provided, however, from an existing unnamed road west of the waste rock storage area to another existing unnamed road coming over the mountain range from the west. This area is too steep for an access road.

3.5.1.3.3 Access to the Mine and the North Side (Main Access Road and Access Road 3)

The main access road to the plant starts at SR 83 south of mile marker 47 and north of FR 231, and extends west to connect at the north entrance to the plant site. Access to the plant from Santa Rita Road (FR 505) will utilize existing roads on the west side of the Santa Rita Mountains and connecting to the main access road on the east. Furthermore, portions of Santa Rita Road will be modified to provide a more direct route to the area north of the plant site. Santa Rita Road connects to Sahuarita Road and Interstate 19 (I-19) farther to the west (Figure 3-7).

In addition to extending Santa Rita Road, a new road will connect the main access road to the existing Santa Rita Road, via an existing unnamed road located about 0.7 mi north of the plant entrance. This new Access Road 3 extends 10,489 ft to join the west access road. This will allow access from one side of the mountain ridge to the other by way of existing roads without approaching the main entrance to the plant (Figure 3-7).

3.5.1.3.4 Trails

A foot trail will be provided south of the mine to allow hiking over the summit, from one side of the range to the other. This trail will be about 1,740 ft long and will extend from an existing unnamed road west of the waste rock storage area. It will connect to another existing unnamed road on the western side of the Santa Rita Mountains (Figure 3-7).

A portion of the Arizona Trail (Passage 6) that has not yet been completed is planned for construction near the Project site. In order to protect the safety of hikers along this section of the Arizona Trail, a modification of the current plan has been proposed. The proposed Rosemont Segment of the Arizona Trail would generally follow along the east side of the proposed Access Roads 1A and 1B along the west side of the proposed Access Road 1C as shown in Figure 3-7. The trail will cross Access Road 1C as the road turns west, with the trail continuing to the south. This trail segment is about 4.5 mi long and will pass just east of the Rosemont mine site. Project plans include assistance with construction of this section of the Arizona Trail system.

3.5.1.3.5 Summary of New Roads and Trails

Table 10 contains a summary of proposed new roads and trails will allow recreational access in the Coronado National Forest around the Rosemont mine site. Also included are the east and west access roads into the plant area.

Table 10. Summary of Roads and Trails

Proposed Roads and Trails	Length (ft)	Length (mi)
Access Road 1A	1,000	0.19
Access Road 1B	3,406	0.65
Access Road 1C	6,680	1.27
Access Road 2	8,165	1.55
Access Road 3	10,489	1.99
East Access Road	19,392	3.67
West Access Road	25,264	4.78
Total New Roads	**74,396**	**14.09**
Foot Trail	1,735	0.33
Rosemont Segment of the Arizona Trail	23,788	4.51
Total Trails	**25,523**	**4.84**

3.5.2 Recreation Diversity

Within the vicinity of the Project, outdoor enthusiasts can choose from a variety of activities such as astronomy, hiking, biking, horseback riding, bird watching, hunting, and exploring on foot or using off-road vehicles (ORVs). Rosemont is sensitive to the value of tourism and to the maintenance of open space and will endeavor to return the land disturbed by mining to cattle grazing and outdoor recreation.

This Access Plan also provides several concepts designed to allow as much recreational use as practicable, including maintenance of public access in all areas except the Barrel Canyon drainage.

3.5.2.1 Existing Regional Recreational Opportunities

3.5.2.1.1 Hiking/Bird watching/Rock Hounding/Mountain Biking

The Santa Rita Mountains are well known to many hikers, bird watchers, mountain bikers, and other outdoor enthusiasts. Groups such as the Green Valley Recreation Hiking Club (GVRHC) often visit the Santa Rita Mountains and take advantage of various access roads and pathways, as well as off-trail hiking through less accessible areas (GVRHC 2007). During a site visit on January 24, 2007, several hikers were noted. A group of hikers were seen at Gunsight Pass and another couple, who indicated that they were scouting the trail for GVRHC, were hiking along FR 4051 to the west of the proposed mine site (Figure 3-7).

A portion of the Arizona Trail, the most extensive trail in the state lies near the southern boundary of the Project and is proposed to extend north through the Project. The Arizona Trail Passages 5 and 6 provide a route for hikers and mountain bikers through the Santa Rita Mountains and Las Cienegas, which are adjacent to the Project area (Figure 3-7). The 17.2 mi segment of the Arizona Trail known as Passage 5 starts at the Gardner Trailhead, which is 5.5 mi west of State Route 83 off Gardner Canyon Road, and approximately 6 mi south of the Project. It runs to Oak Tree Canyon at FR 4072 at SR 83, at the southeast corner of the Project. The official route for Passage 6 has not yet been established, but a proposed route travels north from Oak Tree Canyon, roughly following the west side of SR 83. It crosses I-10 at Sahuarita Road and travels alongside Davidson Canyon ending 0.25 mi west of the Davidson Canyon Bridge at I-10 (approximately 9 mi northeast of the Project). Parking areas are located at the beginning and ending access points of each passage, with the exception of the ending access point for the proposed Passage 6, which is not accessible by vehicle (Jones 2005).

Hikers currently utilize both Passage 5 and the proposed Passage 6 while awaiting the official construction of the latter. Mountain bikers can take advantage of moderate single-track riding through Passage 5, but are encouraged to travel along SR 83 and I-10 to reach Davidson Canyon until the construction of Passage 6 has been completed (Jones 2005).

In addition to the Arizona Trail, mountain bikers have several unimproved (dirt) roads and trails to choose from in the Santa Rita Mountains. The Southern Arizona Mountain Biking Association (SAMBA) makes use of several trails in the Gardner Canyon area, some of which stretch into the southern part of the Project area (SAMBA 2002) (Figure 3-8).

The Mount Wrightson Wilderness area, located approximately 4 mi southwest of the Project area, encompasses over 25,000 ac of terrain (Figure 3-8). This wilderness area is home to a variety of trails that support hiking and bird watching. No motorized or mechanized vehicles or equipment are allowed, which makes bird watching in this area especially popular. Local trails include Gardner Canyon, Super, Old Baldy, Florida Canyon, Crest, and Agua Caliente, among others (USFS 2006a).

Madera Canyon, located approximately nine mi southwest of the Project area, is also a popular site for hiking and bird watching (Figure 3-8). The canyon is easily accessed and is known as one of the most favorable birding areas in Arizona. Similarly, Florida Canyon and Santa Rita Lodge both offer good bird watching spots in the Santa Rita Mountains (SABO 2006).

Horseback riding and rock hounding are assumed to occur within the Santa Ritas, though no official sites exist in the area.

3.5.2.1.2 Hunting

The Rosemont Project is located within Game Management Unit 34A, which is bordered by I-19 to the west, SR 82 to the southeast, SR 83 to the east, and Sahuarita Road to the north (Figure 3-8). The area is home to various game species, including black bear, javelina, mule deer, white-tailed deer, cottontail rabbit, dove, and quail. Hunting activities are allowed seven months out of the year. Though a hunting license is required to hunt any game animal, specific permits are required to hunt more popular species. For the last five years, the Arizona Game & Fish Department (AGFD) has issued an average of 4,000 white-tailed deer permits, 240 mule deer permits, and 1,100 javelina permits per year in Unit 34A. Hunters who visit the area often camp at developed campgrounds and wildcat campsites (AGFD 2006).

Hunting would be prohibited within the active mine area for public safety and mine security reasons. However, the loss of hunting ground is not expected to have a significant impact on hunting in the area since the active mine area represents less than 3% of Game Management Unit 34A (Figure 3-8).

3.5.2.1.3 Campgrounds and Campsites

Several designated campgrounds maintained by the FS are approximately 9 mi southwest of the project area, including Bog Springs, Madera Canyon, Round Up, and Whitehouse (Figure 3-8). Madera Canyon is especially popular for hiking, camping and picnicking. These campgrounds are clustered together on the west side of the Santa Rita Mountains and are reached Madera Canyon Road and White House Canyon Road. There are no designated campsites within the Project area. However, wildcat campsites occur throughout the Santa Rita Mountains, and are often used by hunters and various other visitors (USFS 2007).

3.5.2.1.4 Off-Road Vehicle Use

The Rosemont area is a popular site for riding ORVs because of the four-wheel-drive roads that extend across the local landscape (Figure 3-8). Established parking areas and informational boards allow easy and safe access to the area for ORVs (USFS 2006b). ORV routes through Gunsight Pass are especially popular (TRR 2007) (Figure 3-7). Currently, ORV roads in the area cross through public and, where allowed, private land.

3.5.2.1.5 Scenic Drives

A designated Scenic Highway and several scenic drives are located within the vicinity of the project area, although none pass through the site.

SR 82 and SR 83 from Nogales to I-10 were designated as Scenic Highways in September 1985, under Arizona Department of Transportation's (ADOT) Scenic Highway Program (Wheat Scharf Associates 2003). The designation is based on nearby attractions, including rolling hills, high mountains, a lake, panoramic views, visible wildlife, ranching, camping, picnicking, and hiking (USFS 2004). A Corridor Management Plan (CMP) for this stretch of highway describes the existing conditions, the qualities that attract visitors, and the strategies to preserve and enhance those qualities.

A couple of criteria exist for development along Scenic Highways. For example, all vegetation with a "designated zone of influence" must be protected against destruction or unauthorized removal. In addition, all access permits requested for work within designated Parkways and Historic and Scenic Roads must be reviewed for potential negative environmental and visual impacts. The ADOT Roadside Development Section reviews permit applications, and if any negative impacts are found due to access point locations, recommendations will be made. Recommendations include alternative locations where the proposed construction would cause the least environmental and visual impact and provide adequate safety standards for traffic at the access point. Permit applications and recommendations must be reported to the Parkways and Historic and Scenic Roads Advisory Committee (PHSRAC). All permit applicants must comply with all applicable Landscape and Irrigation Design Guidelines for ADOT Encroachment Permit Applications and other appropriate department standards (ADOT Unknown[a]).

Box Canyon Road (FR 62), located at the north end of the Santa Rita Mountains (0.3 mi south of the project area), is considered a scenic drive by USFS. This roadway includes canyon views, a grassland setting, the Santa Ritas, a historic mining district, and operating cattle ranches (USFS 2004).

Madera Canyon/Madera Nature Trail #88, located nine mi southwest of the Project area, is also considered a scenic drive because of its scenery, streamside nature trail, bird watching, hiking and horseback trails, picnic areas, and campground (USFS 2004).

Mt. Hopkins Road (FR 184), located 12 mi southwest of the Project, is the only scenic drive that reaches the upper elevations of the Santa Rita Mountains. It has views to the east and west and it provides access to the Whipple Observatory, a visitor center, and amateur stargazing area (USFS 2004).

3.5.2.1.6 Other

Tourism destinations nearest the Project include the Nature Conservancy's Patagonia-Sonoita Creek Preserve (approximately 20 mi south of the Project near Patagonia), the Appleton-Whittell National Audubon Research Ranch (approximately 12 mi southeast of the Project near Elgin), and La Cienegas National Conservation Area (at SR 83 and an unnamed turnoff at Milepost 40, approximately 3 mi southeast of the Project). These areas offer a wide spectrum of outdoor experiences. In addition, the international Multiple Mirror and Whipple Observatories are located on the summit of Mt. Hopkins, which is the second highest peak in the Santa Rita Mountain Range. The Whipple Observatory operates a base camp and a visitor center at Amado (approximately 22 mi southwest of the Project) (Harvard 2003).

Other common tourist destinations in the Project region are local wineries located near the communities of Elgin and Sonoita. These wineries include Callaghan Vineyards, Sonoita Vineyards, and the Village of Elgin Wine Companies. The nearest of these to the proposed Project is approximately 30 mi away.

3.5.2.2 Prospective Recreational Opportunities

Most of the recreational opportunities mentioned above are not directly adjacent to the Project area. Those activities that currently occur within or immediately adjacent to the Project area, such as ORV riding, hiking, camping, hunting and some bird watching, will need to be shifted to the surrounding areas.

To reduce the aesthetic impact on the area, mining activities associated with the Project will be contained within a single drainage basin. A key component of the mine design is a series of perimeter buttresses which will be constructed in the initial phases of the mining operation. Reclamation of these Perimeter buttresses will proceed concurrently with the ongoing mining activities to provide a visual barrier, primarily from SR 83, to activities associated with the waste rock and tailings placement, the heap leach facility, and the mill and plant operations. A summary of the activities in the reclamation plan are provided in Section 3.3 of this document.

A modification to Passage 6 of the Arizona Trail has been proposed to prevent accommodate hikers to pass near the Project site and to protect their safety. The proposed Rosemont Segment of the Arizona Trail will generally follow along the east side of the proposed Access Roads 1A and 1B along the west side of the proposed Access Road 1C (Figure 3-7). Interpretive facilities recognizing the unique ranching and mining history of the Rosemont/Helvetia Mining District will be prepared for this section of the trail.

In addition, scenic values will be maintained through other design concepts, such as siting the mill facilities in a recessed canyon and using low-profile buildings to minimize visual impacts. Visual impacts at night will be controlled by application of dark sky technology for lighting (see Section 3.8).

3.6 Biological Resource Plan

Details of the biological resources occurring on the Property, as well as anticipated mitigation for impacts to these resources, are included in the technical report *Biological Resources and Mitigation Concept: Rosemont Project* (WestLand 2007). A summary is provided here.

3.6.1 Vegetation and Habitat Description

The Property ranges in elevation from 4,400 to 6,300 ft above msl and supports a variety of upland habitat with vegetation characteristic of Madrean Evergreen Woodlands and Semidesert Grassland. Madrean Evergreen Woodland covers the higher elevations of the Property, generally in the western and southern areas. This community is characterized by open woodlands or savanna, with trees interspersed with grasses and forbs. Semidesert grassland, characterized by open grasslands with widely scattered shrubs and cacti, covers the lower elevations of the Property.

Barrel Canyon is the principal drainage system for the east side of the Property. Wasp, McCleary, and Scholefield Canyons discharge to Barrel Canyon, which then discharges to Davidson Canyon east of the Property. The northwest side of the Property is drained by a series of unnamed headwater tributaries of Sycamore Canyon. Riparian areas are present along some of the major washes and in small patches at some of the more reliable springs. Ephemeral flow in Barrel Canyon, McCleary Canyon, and Wasp Canyon supports areas with tree and shrub species not present on drier upland ridges, including Arizona black walnut, netleaf hackberry, desert willow, and desert broom. Several springs, including Rosemont Spring, Scholefield Spring, and Figtree Spring, support a variety of trees, shrubs, and herbaceous plants not found elsewhere on the site. These species include Goodding's willow, coyote willow, common, poison ivy, seepwillow, desert false indigo, canyon grape, American brooklime, and southern cattail.

3.6.2 Special Status Species

A variety of mammals, birds, reptiles, and amphibians comprise the wildlife community on the Property. Special-status species considered to date include those covered by the Endangered Species Act (ESA) and those considered sensitive by the FS.

3.6.2.1 Endangered Species Act

A preliminary evaluation comparing habitat requirements of special-status species (including geographic and elevation ranges) with habitat occurring on the Property determined that three of the ESA-listed species known to occur in Pima County (the Huachuca water umbel, Chiricahua leopard frog, and lesser long-nosed bat [LLNB]) may be present on the Property. Several springs on the Property constitute potential (though marginal) habitat for the Huachuca water umbel and Chiricahua leopard frog. These springs were surveyed and no individuals of either species were identified. Additional surveys are not planned. Abandoned mine shafts and adits on the Property may provide roosting habitat for the LLNB, and evidence of nectar-feeding bats was identified in three of these features during the survey. However, no LLNB individuals were observed, and another nectar-feeding bat, the Mexican long-tongued bat, was positively identified during surveys. A biological assessment will be completed for the project to support the FS NEPA process, and results of consultation with the US Fish and Wildlife Service will be incorporated into the Project plan.

3.6.2.2 Forest Sensitive Species

Forty-seven plant species in Pima County are listed as sensitive by the FS. These species have no specific protection under the ESA, but because much of this site is on CNF, the FS takes special interest in their possible presence on the site. One of these sensitive species, the Arizona giant sedge (*Carex ultra*), was observed in a dense stand with some cattails (*Typha domingensis*) at Scholefield Spring. This sedge is rare, with its distribution generally limited to one location in each of several mountain ranges in southern Arizona. Three other sensitive plant species have not been confirmed in the Property but their presence is considered probable because of suitable habitat and known occurrence very close to the site (ARPC 2001). These species are the Bartram stonecrop (*Graptopetalum bartramii*), Box Canyon muhly (*Muhlenbergia dubioides*), and weeping muhly (*Muhlenbergia xerophila*).

Thirty-two animal species in Pima County are listed as sensitive by the FS. As with the sensitive plants described above, these species have no legal status, but the FS takes special interest in their possible presence on the site. Three of these species—the Chiricachua leopard frog, yellow-billed cuckoo, and lesser long-nosed bat—are also ESA-listed and have been discussed above.

Six other FS-listed sensitive species are considered possibly or probably present on the site, based on geographic range and habitat requirements. This group of species includes three insects, one amphibian, one reptile, and one bird. Three sensitive butterfly species are potentially present on site: the Arizona giant skipper (*Agathymus aryxna*), Poling's giant skipper (*Agathymus polingi*), and Arizona metalmark (*Calephelis rawsoni arizonensis*). The Western barking frog (*Eleutherodactylus augusti cactorum*) is often found in caves, crevices, and abandoned mines in limestone, and it is known to be present in the Santa Rita Mountains. The canyon spotted whiptail (*Aspidoscelis burti*) is found in valley bottoms and riparian corridors in semidesert grassland and Madrean evergreen woodland—habitats well represented on this site (Brennan and Holycross 2006). The American peregrine falcon (*Falco peregrinus anatum*) is found in a wide variety of habitats, especially those with high topographic relief and available prey. Cliffs on the western edge of the Property could provide possible nest sites.

Additional biological investigations will be carried out during the NEPA process, as necessary.

3.6.3 Noxious Weeds

As necessary, Rosemont Copper will initiate and maintain a program to control noxious weeds occurring within the boundary of the Project. Reseeding activity will use exclusively certified seed, weed-free straw, and any equipment from outside the United States will be cleaned prior to use.

CNF approval will be obtained prior to initiating any weed control program on federal land. Weed control will be limited to chemicals and procedures approved by the CNF. The purpose of the program will be to control the growth and dissemination of noxious weeds on disturbed sites and soil stockpiles. A written annual report summarizing the noxious weed control program for the previous year will be submitted to the FS.

3.6.4 Pima County Conservation Lands System

The entire Property is included within the Pima County Conservation Land System (CLS). The CLS was adopted in 2001 by the Pima County Board of Supervisors as part of its Comprehensive Plan. These designations are used by Pima County to guide development and growth and to foster the conservation objectives of the Sonoran Desert Conservation Plan (SDCP). The development of the Project is not a discretionary action subject to Pima County's jurisdiction, therefore, these designations have no regulatory or other implication in regard to the development of the Project. However, WestLand (2007) considers Project impacts to CLS lands and provides a mitigation strategy for these impacts.

3.7 Cultural Resource Plan

The Rosemont Project area has a ranching and mining past, and many relics of these enterprises remain. In addition, evidence from past archaeological surveys indicates that prehistoric sites are present as well. A preliminary records search has shown that as many as 50 archeological surveys have been conducted on or near the Project area.

As a part of the NEPA analysis, CNF, with the help of a qualified archaeological contractor, will determine the adequacy and coverage of previous archaeological work as it relates to the proposed new mine plan. A new Class III (100%) cultural resources survey will be conducted on any lands that are within the Project analysis area where previous survey coverage is determined to be inadequate or incomplete.

CNF has the responsibility of consulting with interested tribal entities and the State Historic Preservation Office (SHPO) as part of the NEPA review, as well as for compliance with the National Historic Preservation Act (NHPA) Section 106. During these consultations, SHPO and interested tribes will participate in the preparation of a plan for the treatment of the cultural resources which may be affected by the Project. Rosemont project personnel will participate in this effort as directed by CNF.

Rosemont Project planning has included efforts to reduce the overall footprint of the project to the minimum possible area, thereby avoiding cultural resources to the extent practicable.

3.8 Lighting Plan

The Project is located in Pima County where certain types of activities fall under building, construction and operations requirements. On August 21, 2000, Pima County, along with the Town of Marana and the City of Tucson, adopted Final Ordinance No. 2001-138: The Outdoor Lighting Code (OLC). The purpose and intent of the OLC is to preserve the unique desert environment and night sky by controlling the obtrusive aspects of excessive and careless outdoor lighting usage. All outdoor lighting and associated illuminating devices must be specified and installed in conformance with the provisions of the OLC of the authorizing jurisdiction as applicable and under the appropriate permit and inspection.

The OLC consists of a set of restrictions on the amount of outdoor artificial lighting allowed per unit area for various public and private property activities according to the use of the lighting; the type of lighting appliance; and the geographic location within Pima County. Specifically, the Rosemont Project is located in the two most restrictive lighting areas, defined by the OLC as E1a and E1b. Areas in E1a are around astronomical observatories and include all areas within 15 mi of the summit of Kitt Peak and 12.5 mi of the summit of Mount Hopkins. They also include those areas within any national park, monument, or forest boundary. In these areas, the preservation of a naturally dark environment, both in the sky and visible landscape, is of paramount concern. Lighting Area E1b is a circular area, 25 mi in radius, the center of which is the summit of Mount Hopkins in the Santa Rita Mountain range (Figure 3-9). The OLC states, however, that if a property is located in more than one lighting area, the entire property shall be subject to the more restrictive lighting area; therefore, the entire Property falls in Lighting Area E1a.

ARS 11-830 exempts mining operations of more than five ac from Pima County zoning ordinances. Therefore, compliance with the OLC is technically not required for the Project. However, Rosemont Copper has voluntarily elected to comply with the requirements of the OLC during the projected life of the Project, including the design, construction, and daily operation phases.

Specific Rosemont Project outdoor lighting design requirements and basis of design will address the following technical items as prescribed by the OLC.

3.8.1 Property Site Outdoor Light Output Limits

Table 5.1, "Maximum Total Outdoor Light Output Requirements," of the OLC identifies the maximum total outdoor light output in units of mean lumens (lm) per net acre (a lumen is a measure of luminous flux in SI Units). A net acre is the remaining ground area within a development, parcel, or subdivision after removing all segments for proposed and existing public streets. For reference, the Pima County OLC can be found in the Appendix D of this Plan.

The OLC limits lm output based on whether the lighting uses full cutoff optics (FCO) and if it is produced by low pressure sodium (LPS)-type lamp sources and luminaires (light fixtures). For example, the maximum output allowed in Lighting Area E1a is 18,000 lm per acre for FCO LPS, plus FCO non-LPS.

There is also a limit of 3,000 lm per acre for FCO non-LPS. Unshielded lighting using any lamp type is prohibited.

The OLC provides a definition for "Full Cutoff Light Fixture:"

> A luminaire where no candela (lm) occur at or above an angle of 90 degrees above the nadir (Horizontal Plane at centerline of luminaire). This applies to all lateral angles around the luminaire. Such candela information shall be as determined by a photometric test report from a nationally recognized independent testing laboratory and as certified by the manufacturer. Any structural part of the luminaire providing this cutoff angle shielding shall be permanently attached.

FCO outdoor type lighting fixtures are readily available from a number of lighting fixture manufacturers.

A typical FCO LPS streetlight casts 8,000 lm. The OLC would permit about one streetlight for every 20,000 sq ft on an isolated parking lot.

3.8.2 Lamp Type and Shielding Standards

Table 5.2 of the OLC, "Lamp Type and Shielding Standards," describes standards for lamp types depending on the use of the light. The three classes of use are:

- Class 1 for applications requiring good color rendition, such as commercial car lots, gas stations and swap meets
- Class 2 for general illumination
- Class 3 for decorative lighting

This plan assumes the Rosemont operations would fall in Class 2 (General Illumination). Furthermore, Rosemont does not anticipate the need for outdoor lighting to achieve color rendition or decorative type lighting.

FCO LPS is required in all E1a areas for Class 2 lighting. Lighting other than LPS is prohibited unless the output is less than 3,000 lm per luminaire.

Only FCO is required in E1b areas for Class 2.

3.8.3 Miscellaneous OLC Items

Some additional requirements of the OLC are listed below:

- Mobile/portable outdoor lighting used for flood or area lighting in support of mining operations or onsite construction activities, either permanent or temporary, shall comply with the OLC.

However, temporary lighting not complying with the OLC can be used for one thirty-day period within a calendar year, with one thirty-day extension.

- Mobile equipment lights that are low voltage, incandescent lamps are exempt from compliance with the OLC. These lights include headlights found on motorized equipment, such as haul trucks, operations vehicles, and fleet and service trucks.

- The design and specification of mercury vapor lamps and associated lighting fixtures are prohibited and shall not be considered.

Rosemont Copper operations will require adequate levels of outdoor illumination for its 24/7 operations.

3.8.4 Proposed Rosemont Mine Outdoor Lighting Design Specification

The Project, although not required to do so, will make every attempt to comply with the OLC. It should be noted, however, that federal and state laws also require Rosemont operations to give utmost attention to the safety of its employees and the public.

The outdoor artificial area lighting foot-candle (fc) design will provide a maximum of 1.0 fc at all mine process and support areas and facilities. (A ft-candle is a unit of luminance in English Units, and is equal to 1.0 lm per sq ft.) The design goal is to achieve a balance between compliance with the OLC and support for safe mine operations during the course of the 24-hour per day operating schedule.

Based on the category "Commercial and Industrial, Option 1" and the location in Lighting Area E 1a, a maximum total outdoor light requirement to be applied to the entire Rosemont Property (in mean lm per net ac) can be determined. This target number is 18,000 lm per ac from both FCO LPS plus FCO non-LPS. Of the 18,000 lm per ac, only 3,000 lm per ac can be from FCO non-LPS lamp sources and light fixtures.

The Rosemont outdoor lighting design will be based on using, to the greatest extent possible, full cutoff, low pressure, sodium type lamp sources and light fixtures. The goal is to provide 18,000 lm per acre while providing a safe, adequately lit work environment.

References

Anderson, S. R.. 1987. "Potential for Aquifer Compaction, Land Subsidence, and Earth Fissures in the Tucson Basin, Pima County, Arizona." U.S. Geological Survey Open-File Report: 86-482.

Anzalone, S.A. 1995. "The Helvetia Area Porphyry Systems, Pima County, Arizona: Porphyry Copper Deposits of the American Cordillera," *Arizona Geological Society Digest*, 20.

Arizona Game and Fish Department (AGFD). 2006. Game Management Unit 34A. http://www.azgfd.gov/h_f/hunting_units_34a.shtml, accessed February 1, 2007.

Arizona Rare Plant Committee (ARPC). 2001. *Arizona Rare Plant Field Guide.*

Brennan, T. C. and A. T. Holycross. 2006. *A Field Guide to Amphibians and Reptiles in Arizona.* Arizona Game and Fish Department: 150.

Brown, D. E. (ed.). 1982. "Biotic Communities of the American Southwest–United States and Mexico." *Desert Plants* (4): 1-4. Boyce-Thompson Arboretum, University of Arizona.

Daffron, W. et.al. 2007. *Geologic Report, Relogging Program at the Rosemont Porphyry Skarn Copper Deposit.* Augusta Resource Corporation internal company report, dated March 2007.

Davidson, E.S. 1973. "Geohydrology and Water Resources of the Tucson Basin, Arizona." U.S. Geological Survey Water Supply 1939-E, with City of Tucson, U.S. Bureau of Reclamation, and the University of Arizona.

Green Valley Recreation Hiking Club (GVRHC). 2007. "Hiking Schedules, February." http://www.gvrhc.org/BulletinPages/February07.html, accessed February 2, 2007.

Hargis and Montgomery. 1982. "Summary of Hydrologic Monitoring Program, Empire Ranch and Rosemont areas, Arizona." Prepared for Anamax Mining Company, May 12, 1982.

Harshbarger, J.W., and Hargis, D.R. 1976. Hydrology of the Rosemont Area, Pima County, Arizona. Preliminary Draft of Part 1. Prepared for Anamax Mining Company, October 15, 1976.

Harshbarger and Associates, Inc. 1980. "Summary of Hydrologic Monitoring program, Empire Ranch and Rosemont areas, Arizona." Annual report, AR-192/194-80-1. Prepared for Anamax Mining Company, March 18, 1980.

Harshbarger and Associates, Inc. 1981. "Summary of Hydrologic Monitoring Program, Empire Ranch and Rosemont areas, Arizona." Annual report, AR-192/194-81-1. Prepared for Anamax Mining Company, February 3, 1981.

Harvard. 2003. MMT Observatory Public Information, About the MMT. http://cfa-www.harvard.edu/mmt/aboutmmt.html, accessed February 8, 2007.

Jones, Tom Lorang, Rebecca Finkel, and Jerry Sieve. 2005. *Arizona Trail, the Official Guide*. The Arizona Trail Association. Westcliffe Publishers, Inc., Englewood, CO.

Montgomery and Associates. 2007. "Results of Construction, Development, and Testing for Exploration Water Well (D-17-14)17bdd[E-1]." Technical Report, April 27, 2007.

Murphy, B.A. and J.D Hedley. 1984. Maps Showing Groundwater Conditions in the Upper Santa Cruz Basin Area, Pima, Santa Cruz, Pinal and Cochise Counties, Arizona, 1982. Department of Water Resources, Hydrologic Map Series Report. Number 11, January 1984.

Pima Association of Governments. 1979. Upper Santa Cruz Groundwater Quality Baseline Report, December 1979.

_____. 1983a, Assessment of Nitrate in Groundwater of the Upper Santa Cruz Basin, September 1983.

_____. 1983b, Groundwater Monitoring in the Tucson Copper Mining District, September 1983.

_____. 1983c, Regionwide Groundwater Quality in the Upper Santa Cruz Basin. Mines Task Force Area, September 1983.

Southeastern Arizona Bird Observatory (SABO). 2006. "Guide to Birding Hotspots: The Santa Rita Mountains & Santa Cruz County." http://www.sabo.org/birding/santa.htm, accessed February 7, 2007.

Southern Arizona Mountain Biking Association (SAMBA). 2002. Gardner Canyon Area Map. http://sambabike.org/ftp/samba/MAPS/Gardner%20Canyon%20Area.pdf, accessed March 6, 2007.

Tetra Tech. 2007a. "Baseline Geochemical Characterization." Prepared for Augusta Resource Corporation, June 2007.

_____. 2007b. "Dry Tailings Facility Design Report." Prepared for Augusta Resource Corporation, June 2007.

_____. 2007c. *Geologic Hazards Assessment*. Prepared for Augusta Resource Corporation, June 2007.

_____. 2007d. *Geotechnical Study Report*. Prepared for Augusta Resource Corporation, June 2007.

_____. 2007e. *Groundwater Protection Plan*. Prepared for Augusta Resource Corporation, June 2007.

_____. 2007f. "Leaching Facility Design Report." Prepared for Augusta Resource Corporation, June 2007.

_____. 2007g. "Site Water Management Plan." Prepared for Augusta Resource Corporation, June 2007.

_____. 2007h. Viewshed Analysis. Technical Memorandum prepared for Augusta Resource Corporation, dated June 29, 2007.

_____. 2007i. "Waste Management Plan." Prepared for Augusta Resource Corporation, June 2007.

Tucson Rough Riders, Inc (TRR). 2007. "Club Activities and Events." http://www.tucsonroughriders.com/activities.htm, accessed February 7, 2007.

United States Forest Service (FS). 2007. "Coronado National Forest, Camping and Picnicking Recreation Sites." http://www.fs.fed.us/r3/coronado/forest/recreation/camping/camp_pic_list.shtml, accessed February 1, 2007.

______. 2006a. Coronado National Forest, Mt. Wrightson Wilderness. http://www.fs.fed.us/r3/coronado/forest/recreation/wilderness/wrightson.shtml, accessed February 1, 2007.

______.2006b. Santa Rita Backcountry Touring Map. http://www.fs.fed.us/r3/coronado/forest/recreation/ohv/ohv_images/santa_rita_ohv.pdf, accessed February 7, 2007.

______. 2004. Recreational Activities: Scenic Drives. http://www.fs.fed.us/r3/coronado/forest/recreation/scenic_drives/scenic.shtml, accessed March 6, 2007.

University of Arizona. 1977. "An Environmental Inventory of the Rosemont Area in Southern Arizona." Volume I: The Present Environment. Edited by Davis, R., and J.R Callahan.

Vector Arizona. 2006. "Rosemont Tailings Siting Study." Technical report, May 26, 2006.

Wardrop. 2005. Technical Report on the Rosemont Property, Pima County, Arizona. August 16, 2005.

Western Regional Climate Center. 2006. Arizona climate summaries. http://www.wrcc.dri.edu/summary/climsmaz.html, accessed May 16, 2006.

WestLand Resources, Inc. 2007. "Biological Resources and Mitigation Concept, Rosemont Project."

Wheat Scharf Associates. 2003. "Corridor Management Plan for the Patagonia-Sonoita Scenic Road." http://www.superstitionfreeway.com/highways/SWProjMgmt/enhancement/scenic_roads/PDF/cmp_patagonia_text.pdf, accessed April 5, 2007.

DoD 6055.9-STD

DEPARTMENT OF DEFENSE

DOD AMMUNITION AND EXPLOSIVES SAFETY STANDARDS

October 5, 2004
Under Secretary of Defense
for Acquisition, Technology & Logistics

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

FOREWORD

This Standard is issued under the authority of DoD Directive 6055.9, "DoD Explosives Safety Board (DDESB) and DoD Component Explosives Safety Responsibilities," July 29, 1996 (reference(a)). It establishes uniform safety standards applicable to ammunition and explosives, to associated personnel and property, and to unrelated personnel and property exposed to the potential damaging effects of an accident involving ammunition and explosives during development, manufacturing, testing, transportation, handling, storage, maintenance, demilitarization, and disposal.

DoD 6055.9-STD, "DoD Ammunition and Explosives Safety Standards," July 1999, is hereby canceled.

This Standard applies to the Office of the Secretary of Defense, the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, the Office of Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities in the Department of Defense (hereafter referred to collectively as the "DoD Components").

This Standard is effective immediately and is mandatory for use by all DoD Components. The Heads of the DoD Components may issue supplementary instructions only when necessary to provide for unique requirements within their respective Components. A copy of supplementary instructions shall be forwarded to the Chairman, DDESB.

Forward recommendations for change to this Standard through channels to:

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

This Standard is only available in electronic form. The DoD Components, other Federal Agencies, and the public may obtain copies on the worldwide web at http://www.ddesb.pentagon.mil/ddesb/. Reports Control Symbols DD-AT&L (AR) 1643 and DD-AT&L (AR) 1020 have been assigned to the reports required by this Standard.

Michael W. Wynne
Acting

TABLE OF CONTENTS

FIGURES AND TABLES

FIGURES AND TABLES

FIGURES AND TABLES

ACRONYMS AND ABBREVIATIONS

AAE	Arms, Ammunition and Explosives
ADUSD (ESOH)	Assistant Deputy Under Secretary of Defense (Environment, Safety and Occupational Health)
AE	Ammunition and Explosives
AEL	Airborne Exposure Limits
AFM	Air Force Manual
AFPAM	Air Force Pamphlet
AFR	Air Force Regulation
AFRPL	Air Force Rocket Propulsion Laboratory
AGM	Aboveground Magazine
AGS	Aboveground Structure/Site
AGS (H)	AGS, Heavy Wall
AGS (H/R)	AGS, Heavy Wall and Roof
AGS (L)	AGS, Light
ANFO	Ammonium Nitrate/Fuel Oil
APZ	Accident Potential Zone
AR	Army Regulation
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASU	Ammunition Storage Unit
B	Barricaded
BATF	Bureau of Alcohol, Tobacco and Firearms
BLAHA	Basic Load Ammunition Holding Area
BLSA	Basic Load Storage Area
BTTN	Butane-Trio-Trinitrate
CAD	Cartridge Activated Device
CALA	Combat Aircraft Loading Area
CAPA	Combat Aircraft Parking Area
CBU	Cluster Bomb Unit
CCI	Controlled, Cryptographic Item
CE	Conditional Exemption
CFR	Code of Federal Regulations
CG	Compatibility Group
CIC	Commercial Intermodal Container
CoE	Corps of Engineers
CONUS	Continental United States
CRDEC	Chemical Research Development and Engineering Center
CTF	Chlorine Trifluoride
CZ	Clear Zone
DDESB	Department of Defense Explosives Safety Board
DEGDN	Diethyleneglycoldinatrate

ACRONYMS AND ABBREVIATIONS

DLAR	Defense Logistics Agency Regulation
DoD	Department of Defense
DoDAC	Department of Defense Ammunition Code
DoE	Department of Energy
DoT	Department of Transportation
DPE	Demilitarization Protective Ensemble
DUSD	Deputy Under Secretary of Defense
DUSD(I&E)	Deputy Under Secretary of Defense (Installations and Environment)
E3	Electromagnetic Environmental Effects
ECM	Earth-covered Magazine
EED	Electro-Explosive Device
EID	Electrically Initiated Device
EIDS	Extremely Insensitive Detonating Substances
ELCG	Energetic Liquid Compatibility Group
EMC	Electromagnetic Compatibility
EMCON	Emission Control
EME	Electromagnetic Environment
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
EMV	Electromagnetic Vulnerability
EOD	Explosive Ordnance Disposal
EP	Electronic Protection
EPA	Environmental Protection Agency
EPCRA	Emergency Planning Community Right-To-Know Act
ES	Exposed Site
ESQD	Explosives Safety Quantity Distance
F	Front
FAA	Federal Aviation Administration
FAE	Fuel-air Explosive
FARP	Forward Arming and Refueling Point
FB	Front Barricaded
FSC	Federal Supply Class
FU	Front Unbarricaded
FUDS	Formerly Used Defense Site
GA	Dimethylaminoethoxy-Cyanophosphine Oxide (Nerve Agent)
GB	Isopropyl Methylphosphonofluoridate (Nerve Agent)
GD	Pinacolyl Methylphosphonofluoridate (Nerve Agent)
H	Heavy Wall
HA	Holding Area

ACRONYMS AND ABBREVIATIONS

HAN	Hydroxylammonium Nitrate
HAS	Hardened Aircraft Shelter
HC	Hexachlorethane
HD	Hazard Division
HDD	Hazardous Debris Distance
HE	High Explosive
HERO	Hazards of Electromagnetic Radiation to Ordnance
HEW	High Explosive Weight
HFD	Hazardous Fragment Distance
H/HD	2,2' Dich1orodiethyl Sulfide (Blister Agent)
H/HT	60 percent HD and 40 percent 2,2' Dichloroethylthiodiethyl Ether (Blister Agent)
HPM	High Performance Magazine
H/R	Heavy Wall/Roof
IAW	In Accordance with
IBD	Inhabited Building Distance
ILD	Intraline Distance
IMD	Intermagazine Distance
IMO	International Maritime Organization
IR	Infra-red
IRFNA	Inhibited Red Fuming Nitric Acid
ISO	International Standardization Organization
JHCS	Joint Hazard Classification System
JOERAD	Joint Spectrum Center Ordnance Electromagnetic Environmental Effect Risk Assessment Database
JTF	Joint Task Force
JP	Jet Propellant
KPa	Kilopascal
KV	Kilovolt
L	Dichloro (2-chlorovinyl) Arsine (Blister Agent)
LEPC	Local Emergency Planning Committee
LH	Liquid Hydrogen
LOX	Liquid Oxygen
LPS	Lightning Protection System
MAIS	Major Automated Information System
MCE	Maximum Credible Event
MCO	Marine Corps Order
MDAPS	Major Defense Acquisition Program
MFD	Maximum Fragment Distance

ACRONYMS AND ABBREVIATIONS

MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MILVAN	Military Van
MK	Mark
MOD	Model
MON	Mixed Oxides of Nitrogen
MOOTW	Military Operations Other than War
MPS	Maritime Prepositioning Ship
MR	Munitions Rule
MWD	Military Working Dogs
MWR	Morale, Welfare, and Recreation
NAVFAC	Naval Facilities Engineering Command
NALC	Navy Ammunition Logistic Code
NATO	North Atlantic Treaty Organization
NAVSEAINST	Naval Sea Systems Command Instruction
NEC	National Electrical Code
NEQ	Net Explosive Quantity
NEW	Net Explosive Weight
NEWQD	Net Explosive Weight for Quantity Distance
NFESC	Naval Facilities Engineering Service Center
NFPA	National Fire Protection Association
NG	Nitroglycerin
NIN	National Identification Number
NIOSH	National Institute of Occupational Safety and Health
NPW	Net Propellant Weight
NSN	National Stock Number
OCE	Office, Chief of Engineers
OCONUS	Outside CONUS
OPNAVINST	Chief of Naval Operations Instruction
OSHA	Occupational Safety and Health Administration
PAD	Propellant Actuated Device
PES	Potential Explosion Site
PETN	Pentaerythritol Tetranitrate
PBAN	Polybutadiene-Acrylic Acid-Acrolyonitrile
POL	Petroleum, Oils, Lubricants
PPE	Personnel Protective Equipment
PTR	Public Traffic Route
PTRD	Public Traffic Route Distance
PWP	Plasticized White Phosphorus
QD	Quantity Distance

ACRONYMS AND ABBREVIATIONS

R	Rear
RCRA	Resource Conservation and Recovery Act
RCS	Report Control Symbol
RDT&E	Research, Development, Test and Evaluation
RDX	Cyclotrimethylenetrinitramine
RF	Radio Frequency
RORO	Roll-on or Roll-off
RP	Rocket Propellant
S	Side
SCBA	Self-contained Breathing Apparatus
SD	Sympathetic Detonation
SDW	Substantial Dividing Wall
SG	Sensitivity Group
SOP	Standard Operating Procedure
SSD	Surge Suppression Device
TAPES	Toxicologic Agent Protective Ensemble, Self-contained
TB	Technical Bulletin
TEA	Triethyl Aluminum
TEGDN	Triethylene Glycol Dinitrate
TM	Technical Manual
TMETN	Trimethylolethane Trinitrate
TNT	Trinitrotoluene
TO	Technical Order
TP	Technical Paper
TPA	Thickened TEA
TR	Technical Report
TWA	Time-Weighted Average
U	Unbarricaded
UDMH	Unsymmetrical Dimethylhydrazine
UFC	Unified Facilities Code
UN	United Nations
U.S.	United States
UXO	Unexploded Ordnance
VX	0-ethyl S-[2-(diisopropylamino) Ethyl] Methylphosphonothioate (Nerve Agent)
WP	White Phosphorus

REFERENCES

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

(b) DoD 8910.1-M, "DoD Procedures for Management of Information Requirements," June 1998

(c) Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 17, DDESB Blast Effects Computer Version 5.0 User's Manual and Documentation, May 1, 2003, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(d) Technical Bulletin (TB) 700-2, Naval Sea Systems Command Instruction (NAVSEAINST) 8020.8B, Technical Order (TO) 11A-1-47, Defense Logistics Agency Regulations (DLAR) 8220.1, "Department of Defense Ammunition and Explosives Hazard Classification Procedures," January 5, 1998, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(e) Title 49, Code of Federal Regulations, Parts 171 to 177, "Shippers - General Requirements for Shipments and Packaging," current edition

(f) ST/SG/AC.10/Revision 12, "UN Recommendations on the Transport of Dangerous Goods Model Regulations Volumes I and II," Thirteenth Revised Edition, 2003, United Nations, New York, New York, 10017, ; Phone: 212-963-8302

(g) Technical Manual (TM)-5-1300, Naval Facilities Engineering Command (NAVFAC) P-397, Air Force Manual (AFM) 88-22, "Structures to Resist the Effects of Accidental Explosions," November 28, 1990, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(h) Military Standard (MIL-STD)-398, "Shields, Operational for Ammunition Operations, Criteria for Design and Tests for Acceptance," November 5, 1976, Defense Automated Printing, 700 Robbins Avenue, Philadelphia, PA 19111; Phone: 215-697-2179

(i) Military Standard (MIL-STD)-1474D, "Noise Limits," August 29, 1997, Defense Automated Printing, 700 Robbins Avenue, Philadelphia, PA 19111; Phone: 215-697-2179

(j) Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) No. 15, Approved Protective Construction, February 2001, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(k) U. S. Army Corps of Engineers Report HNDED-CS-S-95-01, "Guide For Evaluating Blast Resistance Of Nonstandard Magazines," U.S. Army Corps of Engineers Engineering Support Center, Huntsville, AL, January 1995, U.S. Army Engineer Division, Code: CEHNC-ED-CS-S, P.O. Box 1600, Huntsville, AL 35807-4301; Phone: 256-895-1829

REFERENCES

(l) National Fire Protection Association (NFPA) 70, "National Electric Code," current version, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471; Phone: 617-770-3000; Fax: 617-770-0700

(m) National Fire Protection Association (NFPA) 780, "Lightning Protection Code," current version, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471; Phone: 617-770-3000; Fax: 617-770-0700

(n) Sections 11001-11022 of title 42, United States Code

(o) Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) No. 13, "Prediction of Building Debris for Quantity-Distance Siting," April 1991, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(p) Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 16, Revision 1, Methodologies for Calculating Primary Fragment Characteristics, December 1, 2003, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(q) Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) No. 10, Change 3, "Methodology For Chemical Hazard Prediction," June 1980, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(r) Title 29 Code of Federal Regulations, Part 1910, Subpart H – "Hazardous Materials," current edition

(s) National Fire Protection Association (NFPA) 30, "Flammable and Combustible Liquids Code," current version, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471; Phone: 617-770-3000; Fax: 617-770-0700

(t) National Fire Protection Association (NFPA) 430, "Code for the Storage of Liquid and Solid Oxidizers," current version, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471; Phone: 617-770-3000; Fax: 617-770-0700

(u) American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels, Division 1/Division 2, current version, ASME International, 22 Law Drive, Box 2900, Fairfield, NJ 07007-2900; Phone: 800-843-2763; International: 973-882-1167; Fax: 973-882-1717

(v) Wilton, C., "Investigation of the Explosive Potential of the Hybrid Propellant Combinations N_2O_4/PBAN and CTF/PBAN," AFRPL-TR-67-124, 1967 (AD A003 595) Defense Technical Information Center, Fort Belvoir, VA; Phone: 800-225-3842

(w) National Fire Protection Association (NFPA) 251, "Standard Methods of Tests of Endurance of Building Construction and Materials," current version, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471; Phone: 617-770-3000; Fax: 617-770-0700

REFERENCES

(x) National Fire Protection Association (NFPA) 50, "Standard for Bulk Oxygen Systems at Consumer Sites," current version, NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471; Phone: 617-770-3000; Fax: 617-770-0700

(y) Zabetakis, M. G. and Burgess, D. S., "Research on the Hazards Associated With the Production and Handling of Liquid Hydrogen," US Department of the Interior, Bureau of Mines Report 5707, 1961, Chemical Propulsion Information Agency (CPIA) Accession Number 1964-0291, CPIA, The Johns Hopkins University, 10630 Little Patuxent Parkway, Sujite 202, Columbia, MD 21044-3204; Phone: 410-992-7300; Fax: 410-730-4969

(z) Title 14, Code of Federal Regulations, Part 77, "Objects Affecting Navigable Airspace," current edition

(aa) DoD 4500.9-R, "Defense Transportation Regulation - Part II, Cargo," May 2003

(ab) Military Standard (MIL-STD)-882D, "Standard Practice for System Safety", February 10 2000, Defense Automated Printing, 700 Robbins Avenue, Philadelphia, PA 19111; Phone: 215-697-2179

(ac) Whitacre, C. G., et al, "Personal Computer Program For Chemical Hazard Prediction (D2PC)," CRDEC-TR-87021, January 1987, (AD A177 622), Defense Technical Information Center, Fort Belvoir, VA; Phone: 800-225-3842

(ad) DoD Instruction 6055.1, "DoD Safety and Occupational Health (SOH) Program," August 19, 1998

(ae) DoD Instruction 6055.5, "Industrial Hygiene and Occupational Health," May 6, 1996

(af) AR 740-32/OPNAVINST 8070.1B/AFR 136-4/MCO 4030.25B, "Responsibilities For Technical Escort of Dangerous Materials," June 5, 1975, DDESB, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600; Phone: 703-325-0891; Fax: 703-325-6227

(ag) Joblove, Louis, et al, "Engineering Guide For Fire Protection And Detection systems At Army Plants," ARLCD-CR-80049, (AD A095 040), Defense Technical Information Center, Fort Belvoir, VA; Phone: 800-225-3842

(ah) Unified Facilities Code (UFC) 3-340-01, "Design and Analysis of hardened Structures to Conventional Weapons Effects," June 1, 2002, Headquarters, U.S. Army Corps of Engineers, Office of the Chief of Engineers, ATTN: CECW-EI, 441 G. Street, NW, Washington, DC 20314-1000; Phone: 202-761-0301

(ai) Adley, Mark, et al, "Methodology and Users Guide for PENCURV + Version 1.0," ERDC/GSL TR 03-2, February 2003, U.S. Army Engineer Research and Development Center, ATTN: CEERD-GM-1, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199; Phone: 601-634-4252

(aj) DoD Instruction 6055.7, "Accident Investigation, Reporting, And Record Keeping," October 3, 2000

REFERENCES

(ak) Munitions Rule (MR), Federal Register, Volume 62, page 6621, February 12, 1997

(al) Section 6901 of title 42, United States Code

(am) Title 40, Code of Federal Regulations "Protection of the Environment"

(an) MIL-HDBK-237, Electromagnetic Environmental Effects on Platforms, Systems, and Equipment, July 17, 2001, Defense Automated Printing, 700 Robbins Avenue, Philadelphia, PA 19111; Phone: 215-697-2179

(ao) MIL-HDBK-240, Hazards of Electromagnetic Radiation to Ordnance (HERO) Test Guide, November 1, 2002, Defense Automated Printing, 700 Robbins Avenue, Philadelphia, PA 19111; Phone: 215-697-2179

(ap) Joint Publication 1-02, "DoD Dictionary of Military and Associated Terms," current edition

(aq) Section 2011 et seq. of title 42, United States Code

(ar) Section 1521 (j) (1) of title 50, United States Code

(as) Section 9601 of title 42, United States Code

C1. CHAPTER 1

INTRODUCTION

C1.1. GENERAL

C1.1. These explosive safety standards (Standards) are issued under the authority of DoD Directive 6055.9 (reference (a)). These Standards are designed to manage risks associated with DoD-titled ammunition and explosives (AE) by providing protection criteria to minimize serious injury, loss of life, and damage to property. They are not intended to be so rigid as to prevent the DoD Components from accomplishing their assigned missions.

C1.2. NOTE: Criteria provided by these Standards are provided in English units (e.g., ft, lb, psi, etc.) with metric equivalents shown in brackets (e.g., [m, kg, kPa, etc.]) and highlighted.

C1.2. EXPLOSIVES SAFETY POLICY

These Standards are the minimum protection criteria for personnel and property; however, greater protection should be provided when feasible. Consistent with operational requirements, it is DoD policy to:

C1.2.1. Provide the maximum possible protection to both personnel and property from the damaging effects of potential accidents involving AE.

C1.2.2. Expose the minimum number of persons, to the minimum amount of AE, for the minimum amount of time, consistent with safe and efficient operations.

C1.2.3. Comply with these Standards:

C1.2.3.1. In thc United States (U.S.), which includes U.S. Territories, possessions, and commonwealths; and other areas over which the U.S. Government has complete jurisdiction and control or has exclusive authority or defense responsibility.

C1.2.3.2. Outside the U.S.:

C.1.2.3.2.1 When DoD-titled AE is under U.S. custody and control, except when international agreements make compliance with more restrictive local standards mandatory.

C1.2.3.2.2. When DoD-titled AE is not under U.S. custody and control, consistent with host nation agreements.

C1.3. APPLICABILITY

These Standards:

C1.3.1. Apply to DoD-titled AE wherever it is located.

C1.3.2. Apply to DoD personnel and property when hazarded by known host nation or off-installation AE hazards.

C1.3.3. Govern DoD facilities siting and construction, except as indicated below in paragraph C1.3.5.

C1.3.4. Apply to the evaluation of non-DoD explosives siting submissions on DoD installations (see section C5.5.).

C1.3.5. Do not apply for the exceptions described below in subparagraphs C1.3.5.1 through C1.3.5.3. NOTE: These exceptions must be documented per subparagraph C1.3.5.4.

C1.3.5.1. Existing facilities, or those approved for construction under previous editions of these Standards. This exception applies for the balance of the useful lives of such facilities provided:

C1.3.5.1.1. The facility continues to be used for its intended purpose.

C1.3.5.1.2. The explosives safety hazards are not increased.

C1.3.5.1.3. Redesign or modification is not feasible.

C1.3.5.1.4. The quantity of AE cannot be reduced for reasons of operational necessity.

C1.3.5.2. Those planned facilities that do not meet these Standards, but have been certified by the Head of the DoD Component (see paragraph C1.4.4.) as essential for operational or other compelling reasons.

C1.3.5.3. To other situations that, upon analysis by both the DoD Component and the Department of Defense Explosives Safety Board (DDESB), are determined to provide the required degree of safety through use of protective construction or other specialized safety features.

C1.3.5.4. <u>Records.</u> The DoD Components must document the above exceptions in permanent records. These records must include:

C1.3.5.4.1. The effective date the applicable Standards were first published.

C1.3.5.4.2. The date the deviant facility was either approved, from an explosives safety viewpoint, for use, or was first used in the deviating manner.)

C1.4. WAIVERS, EXEMPTIONS AND SECRETARIAL EXEMPTIONS OR CERTIFICATIONS

C1.4.1. <u>General.</u> When strategic or compelling operational requirements necessitate deviation from these Standards, the DoD Component shall:

C1.4.1.1. Acknowledge and accept the added risk to personnel or property.

C1.4.1.2. Document both the risk and methods used to reduce it to an acceptable level.

C1.4.2. <u>Waivers.</u> A waiver is a written authority that permits temporary deviation from these Standards for strategic or compelling operational requirements. Generally, it is granted for a period not to exceed 5 years pending cancellation or correction of the waived conditions. Exceptional situations may require a waiver to be reissued to allow either completion of the operation requiring the waiver or time for completion of the corrective action. In such cases, the next higher approval authority shall reissue the waiver; the exception is when the Head of the DoD Component or the responsible Combatant Commander has issued the waiver. Waivers shall be reviewed for applicability and currency at intervals not to exceed 2 years. Waivers may be granted by the official with both:

C1.4.2.1. The assigned responsibilities consistent with the level of risk.

C1.4.2.2. The authority to control the resources required to accomplish the corrective action.

C1.4.3. Exemptions. An exemption is a written authority that permits long-term noncompliance with these Standards for strategic or compelling operational requirements. Exemptions shall be reviewed for applicability and currency at intervals not to exceed 5 years. Exemptions may be granted by:

C.1.4.3.1. Law.

C.1.4.3.2. Congressional action.

C.1.4.3.3. The official assigned responsibilities consistent with the level of risk.

C1.4.4. Secretarial Exemptions or Certifications. A Secretarial Exemption or Certification is a written authority granted by a Secretary of a Military Department to deviate from the requirements of these Standards to allow the construction of new potential explosion sites (PES) or exposed sites (ES). To validate the strategic or compelling operational requirements and ensure the identification of risks and exposures, these exemptions or certifications shall be reviewed at intervals not to exceed 5 years.

C1.4.5. Report Control Symbol DD-AT&L(AR)1643. (See DoD 8910.1-M, reference (b)) When the DDESB requests information on exemptions and waivers, the DoD Components shall provide the following, if appropriate:

C1.4.5.1. Identification number (DoD Component-derived).

C1.4.5.2. Classification (waiver or exemption); approval authority's title; and date of approval, expiration, or cancellation, as applicable.

C1.4.5.3. Location.

C1.4.5.4. Condition waived or exempted.

C1.4.5.5. Net explosive weight (NEW) or Net Explosive Weight for Quantity Distance (NEWQD) by Hazard Division (HD) at a PES.

C1.4.5.6. Distance from the PES to any ES and a brief description of the ES to include: type, estimated value of any property involved, and location of the property (e.g., on or off installation).

C1.4 5.7. Estimated number of DoD and non-DoD personnel located at the ES.

C1.4.5.8. Calculated hazard distances (see public exclusion distance), as applicable.

C1.4.5.9. Planned corrective action, to include the expected completion date.

C1.4.5.9.1. Estimated cost to correct.

C1.4.5.9.2. Military construction project number, if assigned.

C2. CHAPTER 2
REACTION EFFECTS

C2.1. INTRODUCTION

This Chapter describes the expected effects of AE reactions.

C2.2. HD 1.1 EFFECTS

C2.2.1. Blast.

C2.2.1.1. Blast Wave Phenomena. In an incident involving HD 1.1 or HD 1.1 with any other HD (a HD 1.1 event), the violent release of energy creates a sudden and intense pressure disturbance termed the "blast wave." The blast wave is characterized by an almost instantaneous rise from ambient pressure to a peak incident pressure (P_i). This pressure increase, or "shock front," travels radially outward from the detonation point, with a diminishing velocity that is always in excess of the speed of sound in that medium. Gas molecules making up the front move at lower velocities. This velocity, which is called the "particle velocity," is associated with the "dynamic pressure," or the pressure formed by the winds produced by the shock front.

C2.2.1.1.1. As the shock front expands into increasingly larger volumes of the medium, the incident pressure decreases and, generally, the duration of the pressure-pulse increases.

C2.2.1.1.2. If the shock wave impinges a rigid surface (e.g., a building) at an angle to the direction of the wave's propagation, a reflected pressure is instantly developed on the surface and this pressure rises to a value that exceeds the incident pressure. This reflected pressure is a function of the incident wave's pressure and the angle formed between the rigid surface and the plane of the shock front.

C2.2.1.2. Partially Confined Explosions. When an explosion occurs within a structure, the peak pressure associated with the initial shock front will both be high and amplified by reflections within the structure. In addition, the accumulation of gases from the explosion will exert additional pressure and increase the load duration within the structure. This effect may damage or destroy the structure unless the structure is designed to either withstand or vent the gas and shock pressures. Structures that have one or more strengthened walls may be vented for relief of excessive gas by either frangible construction of the remaining walls or roof or through the use of openings. This type of construction will permit the gas from an internal explosion to spill out of the structure. Once released from confinement, these pressures (referred to as "exterior" or "leakage" pressures) expand radially and may affect external structures or personnel.

C2.2.1.3. Quantity Distance (QD) – K factors. Throughout this Standard, NEW is used to calculate quantity-distance by means of a formula of the type D (ft) = $K \cdot W^{1/3}$, where "D" is the distance in feet, "K" is a factor (also called K-factor) that is dependent upon the risk assumed or permitted, and "W" is the NEW in pounds. When metric units are used, the symbol "Q" denotes Net Explosive Quantity (NEQ) in kilograms. In the formula D (m) = $K_m \cdot Q^{1/3}$, the distance "D" is expressed in meters. Thus, the respective units of "K" are ft/lb$^{1/3}$ and " K_m " are m/kg$^{1/3}$ in the two systems. The value of "K" in English units is approximately 2.52 times " K_m." For example, if D (m) = 6•Q$^{1/3}$, then D (ft) = 15.12•W$^{1/3}$. Distance requirements determined by the formula with English units are sometimes expressed by the value of "K," using the terminology K9, K11, K18, to mean K = 9, K = 11, and K = 18.

C2.2.1.4. Expected Blast Pressures at QD. Table C2.T1. presents the incident pressures that would be expected at various K-factors from HD 1.1 events.

TABLE C2.T1. EXPECTED PEAK INCIDENT PRESSURES FROM HD 1.1 EVENTS

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

C2.2.1.5. General Blast Effects On Structures

C2.2.1.5.1. Conventional Structures. Conventional structures are generally designed to withstand roof-snow loads of 0-50 pounds per square foot (0-2.4 kPa) or wind loads up to 90 miles per hour (145 kilometers per hour) or both. At 90 mph (145 kph), the wind load equates to 0.14 psi (1.0 kPa). Given the pressures shown in Table C2.T1. for the selected K-factors, it is evident that, even at inhabited building distance (IBD), conventional structures may not provide complete protection from blast. Generally, the weakest portions of any conventional structure are the windows. Table C2.T2. provides the probability of breaking typical windows at various K-factors and associated incident pressures from HD 1.1 events.

TABLE C2.T2. PROBABILITY OF WINDOW BREAKAGE FROM INCIDENT PRESSURE

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

Window 1: 12" x 24" x 0.088" Float annealed (area = 2 ft^2)
30.5 cm x 61 cm x 0.0.223 cm Float annealed (area = 0.186 m^2)

Window 2: 24" x 24" x 0.088" Float annealed (area = 4 ft^2)
61 cm x 61 cm x 0.0.223 cm Float annealed (area = 0.372 m^2)

Window 3: 42" x 36" x 0.12" Float annealed (area = 10.5 ft^2)
106.7 cm x 91.4 cm x 0.0.395 cm Float annealed (area = 0.975 m^2)

C2.2.1.5.2. Above Ground Structures (AGS). These are generally considered conventional structures and provide little protection from blast or fragmentation. (See paragraph C2.2.5.).

C2.2.1.5.3. Earth-Covered Magazines (ECM). High reflected pressure and impulse produced by an explosion at an adjacent ECM can damage doors and headwalls and propel debris into an ECM so that explosion is communicated by impact of such debris upon the contents. When separated from each other by the minimum distances required by Table C9.T6., ECM (see paragraph C5.2.1.) provide virtually complete protection of AE against the propagation effects of an explosion. However, AE in adjacent ECM may be damaged and structural damage ranging from cracks in concrete, damage to ventilators and doors to complete structural failure may occur. (NOTE: When ECM containing HD 1.1 AE are sited so that any one is in the forward sector of another, the two must be separated by distances greater than the minimum permitted for side-to-side orientations. The greater distances are required primarily for the protection of door and headwall structures against blast from a PES forward of the exposed magazine, and to a lesser extent due to the directionality of effects from the source.)

C2.2.1.5.4. Underground Storage Facilities. Underground facilities sited per section C9.7. provide a high degree of protection against propagation of an explosion between chambers, and between underground and aboveground structures. An HD 1.1 explosion in an underground storage facility causes very high pressures of prolonged duration. Blast waves and the accompanying gas flows will travel throughout the underground facility at high velocity.

C2.2.1.5.5. Barricaded Open-Storage Modules. Barricaded open-storage modules (see paragraph C5.2.2.) provide a high degree of protection against propagation of explosion. However, if flammable materials are present in nearby cells, subsequent propagation of explosion by fire is possible. When an explosion occurs, AE in adjacent modules separated by K1.1 (K_m 0.44) will be thrown tens of meters, covered with earth, and unavailable for use until extensive uncovering operations, and possibly maintenance, are completed. Items at K=2.52 (K_m 1) separation distance from a donor explosion are expected to be readily accessible.

C2.2.1.5.6. High Performance Magazine (HPM). When separated from other AE storage magazines by the minimum distances required by Table C9.T6., the HPM provides virtually complete protection of AE against the propagation effects of an explosion. The HPM's 2-story transfer and storage areas are enclosd by a pre-engineered metal building, which may be severely damaged as a result of an explosion at a nearby PES. The amount of damage to be expected at various pressure levels is described in paragraph C2.2.5. Access to the AE in a HPM may require extensive cleanup and the use of a mobile crane, unless special design considerations are incorporated into the metal building design. The HPM contains multiple storage cells, which are designed to limit the maximum credible event, as discussed in subparagraph C9.3.1.1.3. In the event of an internal explosion involving the maximum credible event (MCE), the pre-engineered metal building can be expected to be completely destroyed, and AE not involved in the explosion can be expected to be significantly damaged and no longer usable.

C2.2.1.6. General Blast Effects on Personnel. Tables C2.T3. through C2.T5. describe the expected effects of blast on personnel.

C2.2.1.7. Computation of Blast Effects. Many of the blast effects described in this section were computed with the DDESB Blast Effects Computer (reference (c)), which can be used to estimate similar effects associated with various NEWs, facilities, and distances.

TABLE C2.T3. GENERAL BLAST EFFECTS ON PERSONNEL—EARDRUM RUPTURE

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

TABLE C2.T4. GENERAL BLAST EFFECTS ON PERSONNEL—LUNG DAMAGE

EFFECT	Incident Pressure (psi) *[kPa]*	Pulse Duration (ms)
Lung Damage	174 *1200*	0.5
	94 *648*	1
	31 *214*	5
	22 *152*	10
	15 *103.4*	50
	15 *103.4*	100

TABLE C2.T5. GENERAL BLAST EFFECTS ON PERSONNEL-LETHALITY DUE TO LUNG RUPTURE

EFFECT*	Weight (lbs) *[kg]*	Range (ft) *[m]*	K-FACTOR ($ft/lb^{1/3}$) *Km-FACTOR* *[$m/kg^{1/3}$]*	Incident Pressure (psi) *[kPa]*	Pulse Duration (ms)	Positive Impulse (psi-ms) *[kPa-s]*
Lethality due to Lung Rupture	8,000	35.8	1.79	386.9	8.8	412.5
	3,628.7	*10.92*	*0.71*	*2667.8*		*2,844.5*
	27,000	99.8	3.33	107.1	51.1	665.6
	12,247	*30.42*	*1.32*	*738.3*		*4,589.2*
	125,000	189.8	3.80	79.3	82.6	985.3
	56,699	*57.85*	*1.51*	*546.6*		*6,793.8*

* Lethality due to lung rupture is caused by a combination of pressure and impulse. This combination will vary with the charge weight. (NOTE: In this example, the probability of lethality is assumed to be 99.9%.)

C2.2.2. Fragments.

C2.2.2.1. General. An important consideration in the analysis of the hazards associated with an explosion is the effect of any fragments produced. Although most common in HD 1.1 or HD 1.2 (see below) events, fragmentation may occur in any incident involving AE. Depending on their origin, fragments are referred to as "primary" or "secondary" fragments.

C2.2.2.1.1. Primary fragments result from the shattering of a container (e.g., shell casings, kettles, hoppers, and other containers used in the manufacture of explosives, rocket engine housings) in direct contact with the explosive. These fragments usually are small, initially travel at thousands of feet per second and may be lethal at long distances from an explosion.

C2.2.2.1.2. Secondary fragments are debris from structures and other items in close proximity to the explosion. These fragments, which are somewhat larger in size than primary fragments and initially travel at hundreds of feet per second, do not normally travel as far as primary fragments.

C2.2.2.1.3. The earth cover of an underground facility may rupture and create a significant debris hazard.

C2.2.2.1.4. A hazardous fragment is one having an impact energy of 58 ft-lb (79 joules) or greater.

C2.2.2.1.5. A hazardous fragment density is 1 hazardous fragment per 600 ft^2 (55.7 m^2).

C2.2.3. Thermal Hazards.

C2.2.3.1. General. Generally, thermal hazards from a HD 1.1 event are of less concern than blast and fragment hazards.

C2.2.3.2. Personnel. It normally takes longer to incur injury from thermal effects than from either blast or fragmentation effects because both blast and fragmentation occur almost instantaneously. The time available to react to a thermal event increases survivability.

C2.2.3.3. Structures, Material, and AE. The primary thermal effect on structures, material, and AE is their partial or total destruction by fire. The primary concern with a fire involving AE is that it may transition to a more severe reaction, such as a detonation.

C2.2.4. Groundshock and Cratering.

C2.2.4.1. General.

C2.2.4.1.1. In an airburst, there may be a downward propagation of groundshock and cratering may be reduced or eliminated.

C2.2.4.1.2. In a surface burst, groundshock is generated and cratering can be significant.

C2.2.4.1.3. A buried or partially buried detonation produces the strongest groundshock; however, if the explosion is deep enough, no crater will be formed.

C2.2.4.2. Underground Facilities. AE protection can be achieved by proper chamber spacing. An HD 1.1 explosion will produce ground shocks that may rupture the earth cover and eject debris. (See section C9.7.).

C.2.2.5. Expected Consequences.

C2.2.5.1. Barricaded Aboveground Magazine (AGM) Distance - $6W^{1/3}$ ft ($2.38Q^{1/3}$ m) - 27 psi (186.1 kPa). At this distance:

C2.2.5.1.1. Unstrengthened buildings will be destroyed.

C2.2.5.1.2. Personnel will be killed by blast, by being struck by debris, or by impact against hard surfaces.

C2.2.5.1.3. Transport vehicles will be overturned and crushed by the blast.

C2.2.5.1.4. Explosives-loaded vessels will be damaged severely, with propagation of explosion likely.

C2.2.5.1.5. Aircraft will be destroyed by blast, thermal, and debris effects.

C2.2.5.1.6. Control. Barricades are effective in preventing immediate propagation of explosion by high velocity low angle fragments. However, they provide only limited protection against any delayed propagation of explosives caused by a fire resulting from high angle firebrands.

C2.2.5.2. Barricaded Intraline Distance (ILD) - $9W^{1/3}$ ft ($3.57Q^{1/3}$ m) - 12 psi (82.7 kPa). At this distance:

C2.2.5.2.1. Unstrengthened buildings will suffer severe structural damage approaching total destruction.

C2.2.5.2.2. Personnel will be subject to severe injuries or death from direct blast, building collapse, or translation.

C2.2.5.2.3. Aircraft will be damaged beyond economical repair both by blast and fragments. (NOTE: If the aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires.)

C2.2.5.2.4. Transport vehicles will be damaged heavily, probably to the extent of total loss.

C2.2.5.2.5. Improperly designed barricades or structures may increase the hazard from flying debris, or may collapse in such a manner as to increase the risk to personnel and equipment.

C2.2.5.2.6. Control. Barricading is required. Direct propagation of explosion between two explosive locations is unlikely when barricades are placed between them to intercept high velocity low angle fragments. Exposed structures containing high value, mission critical equipment or personnel may require hardening.

C2.2.5.3. Unbarricaded AGM Distance - $11W^{1/3}$ ft ($4.36Q^{1/3}$ m) - 8 psi (55.3 kPa). At this distance:

C2.2.5.3.1. Unstrengthened buildings will suffer damage approaching total destruction.

C2.2.5.3.2. Personnel are likely to be injured seriously due to blast, fragments, debris, and translation.

C2.2.5.3.3. There is a 15 percent risk of eardrum rupture.

C2.2.5.3.4. Explosives-loaded vessels are likely to be damaged extensively and delayed propagation of explosion may occur.

C2.2.5.3.5. Aircraft will be damaged heavily by blast and fragments; destruction by resulting fire is likely.

C2.2.5.3.6. Transport vehicles will sustain severe body damage, minor engine damage, and total glass breakage.

C2.2.5.3.7. Control. Barricading will significantly reduce the risk of propagation of explosion and injury of personnel by high velocity low angle fragments.

C2.2.5.4. Unbarricaded ILD - $18W^{1/3}$ ft ($7.14Q^{1/3}$ m) - 3.5 psi (24 kPa). At this distance:

C2.2.5.4.1. Direct propagation of explosion is not expected.

C2.2.5.4.2. Delayed propagation of an explosion may occur at the ES, as either a direct result of a fire or as a result of equipment failure.

C2.2.5.4.3. Damage to unstrengthened buildings may approximate 50 percent, or more, of the total replacement cost.

C2.2.5.4.4. There is a two percent chance of eardrum damage to personnel.

C2.2.5.4.5. Personnel may suffer serious injuries from fragments, debris, firebrands, or other objects.

C2.2.5.4.6. Fragments could damage the decks and superstructure of cargo ships and overpressure could buckle their doors and bulkheads on weather decks.

C2.2.5.4.7. Aircraft can be expected to suffer considerable structural damage from blast. Fragments and debris are likely to cause severe damage to aircraft at distances calculated from the formula $18W^{1/3}$ ($7.2Q^{1/3}$) when small quantities of explosives are involved.

C2.2.5.4.8. Transport vehicles will incur extensive, but not severe, body and glass damage consisting mainly of dishing of body panels and cracks in shatter-resistant window glass.

C2.2.5.4.9. Control. Suitably designed suppressive construction at PES or protective construction at ES may be practical for some situations. Such construction is encouraged when there is insufficient distance to provide the required protection.

C2.2.5.5. Public Traffic Route Distance (PTRD) (under 100,000 lbs of high explosives (HE)) $24W^{1/3}$ ft ($9.52Q^{1/3}$ m) - 2.3 psi (15.8 kPa). At this distance:

C2.2.5.5.1. Unstrengthened buildings can be expected to sustain damage approximately 20 percent of the replacement cost.

C2.2.5.5.2. Occupants of exposed structures may suffer temporary hearing loss or injury from blast effects, building debris and displacement.

C2.2.5.5.3. Although personnel in the open are not expected to be killed or seriously injured by blast effects, fragments and debris may cause some injuries. The extent of these injuries depends largely upon the PES structure and the amount and fragmentation characteristics of the AE involved.

C2.2.5.5.4. Vehicles on the road should suffer little damage, unless they are hit by a fragment or the blast causes a momentary loss of control.

C2.2.5.5.5. Aircraft may suffer some damage to the fuselage from blast and possible fragment penetration, but should be operational with minor repair.

C2.2.5.5.6. Cargo-type ships should suffer minor damage to deck structure and exposed electronics from blast and possible fragment penetration, but such damage should be readily repairable.

C2.2.5.5.7. Control. Barricading can reduce the risk of injury or damage due to fragments for limited quantities of AE at a PES. When practical, suitably designed suppressive construction at the PES or protective construction at the ES may also provide some protection.

C2.2.5.6. PTRD (over 250,000 lbs HE) $30W^{1/3}$ ft ($11.9Q^{1/3}$ m) - 1.7 psi (11.7 kPa). At this distance:

C2.2.5.6.1. Unstrengthened buildings can be expected to sustain damage that may approximate 10 percent of their replacement cost.

C2.2.5.6.2. Occupants of exposed, unstrengthened structures may be injured by secondary blast effects, such as falling building debris.

C2.2.5.6.3. Pilots of aircraft that are landing or taking off may lose control and crash.

C2.2.5.6.4. Parked military and commercial aircraft will likely sustain minor damage due to blast, but should remain airworthy.

C2.2.5.6.5. Although personnel in the open are not expected to be killed or seriously injured by blast effects, fragments and debris may cause some injuries. The extent of these injuries will largely depend upon the PES structure, the NEW, and the fragmentation characteristics of the AE involved.

C2.2.5.6.6. Control. Barricading or the application of minimum fragmentation distance requirements may reduce the risk of injury or damage due to fragments for limited quantities of AE at a PES.

C2.2.5.7. Inhabited Building Distance (IBD) $40W^{1/3}$ ft - $50W^{1/3}$ ft ($15.87Q^{1/3}$ - $19.8Q^{1/3}$ m) - 1.2 psi - 0.90 psi (8.3 kPa - 6.2 kPa). At this distance:

C2.2.5.7.1. Unstrengthened buildings can be expected to sustain damage that approximates five percent of their replacement cost.

C2.2.5.7.2. Personnel in buildings are provided a high degree of protection from death or serious injury; however, glass breakage and building debris may still cause some injuries.

C2.2.5.7.3. Personnel in the open are not expected to be injured seriously by blast effects. Fragments and debris may cause some injuries. The extent of injuries will depend upon the PES structure and the NEW and fragmentation characteristics of the AE involved.

C2.2.5.7.4. Control. Elimination of glass surfaces is the best control. If determined to be necessary, reducing the use of glass or the size of any glass surfaces and the use of blast resistant glass will provide some relief. For new construction, building design characteristics, to include consideration of how any required glass surfaces are oriented and use of blast resistant glass can reduce glass breakage and structural damage.

C.2.3. HD 1.2 EFFECTS

C2.3.1. Blast.

C2.3.1.1. HD 1.2, when not stored with HD 1.1 or HD 1.5, is not expected to mass detonate. In an incident involving HD 1.2, when stored by itself or with HD 1.3, HD 1.4, or HD 1.6 (a HD 1.2 event), AE can be expected to both explode sporadically and burn. Fire will propagate through the mass of the AE over time. Some AE may neither explode nor burn. Blast effects from the incident are limited to the immediate vicinity and are not considered to be a significant hazard.

C2.3.1.2. A HD 1.2 event may occur over a prolonged period of time. Generally, the first reactions are relatively nonviolent and, typically, begin a few minutes after flames engulf the AE. Later reactions tend to be more violent. Reactions can continue for some time (hours), even after a fire is effectively out. Generally, smaller AE tends to react earlier in an incident than larger AE.

C2.3.1.3. The results of an accidental explosion in an underground facility will depend on the type and quantity of munitions, the type of explosion produced, and the layout of the facility. Hazards created outside the underground facility will likely not be as severe as those produced by HD 1.1 or 1.3 material.

C2.3.2. Fragments

C2.3.2.1. The primary hazard from a HD 1.2 event is fragmentation. Fragmentation may include primary fragments from AE casings or secondary fragments from containers and structures. At longer ranges, primary fragments are the major contributors to fragment hazards.

C2.3.2.2. During a HD 1.2 event, fragmentation may extensively damage exposed facilities. However, less fragmentation damage can be expected from a given quantity of HD 1.2 than would be expected from the corresponding quantity of HD 1.1 because not all the HD 1.2 will react.

C2.3.3. Thermal Hazards.

C2.3.3.1. An incident involving a quantity of HD 1.2 poses considerably less thermal risk to personnel than an incident involving corresponding quantities of either HD 1.1 or HD 1.3 because a HD 1.2 event's progressive nature allows personnel to immediately evacuate the area.

C2.3.3.2. A HD 1.2 event's progressive nature provides an opportunity for a fire suppression system, if installed, to put out a fire in its early stages.

C2.3.4. Ejected Items. In HD 1.2 events, a reaction may eject (lob) unreacted-AE or AE components from the event site. These ejected items may subsequently react.

C2.3.5. Propelled Items. In HD 1.2 events, some AE or AE components may become propulsive and travel well beyond IBD.

C2.3.6. Firebrands. In an incident involving only HD 1.2 or HD 1.2 with HD 1.4, firebrands are considered to be a hazard only in the immediate vicinity of the incident site.

C.2.3.7. Expected Consequences.

C.2.3.7.1. The expected consequences for HD 1.2 AE are similar to those for HD 1.1. The effects of HD 1.2 AE are NEW dependent.

C2.3.7.2. The principal hazard to personnel in the open, to aircraft, and to occupied vehicles is fragments.

C2.3.7.3. Airblast, fragment, and thermal hazards to buildings and parked aircraft or vehicles cannot be predicted reliably because the effects will depend on the MCE.

C2.4. HD 1.3 EFECTS

C2.4.1. Gas Pressures. In an incident involving only HD 1.3 or HD 1.3 with HD 1.4 (a HD 1.3 event):

C2.4.1.1. Where sufficient venting is provided, gas pressures generated by the event are not a significant concern. Examples of sites with sufficient venting include open storage and structures where internal pressures do not exceed 1-2 psi (6.9-13.8 kPa) (non-confinement structure).

C2.4.1.2. Where venting is insufficient, internal gas pressures may be substantial. In such situations, these pressures may blow out vent panels or frangible walls and, in some instances, cause partial or complete structural failure.

C2.4.1.3. Where there is minimal venting and structural containment (extreme confinement), a detonation of the HD 1.3 may occur with effects similar to those of a HD 1.1

explosion. For example, HD 1.3 AE is considered as HD 1.1 (mass explosion) for QD purposes when stored in underground chambers.

C2.4.2. Fragments. In a HD 1.3 event, fragments are considerably less hazardous than those produced by HD 1.1 and HD 1.2 events. Internal gas pressures may produce fragments from the bursting of containers or the rupture of containment facilities. In general, such fragments will be large and of low velocity. (For exceptions, see subparagraph C2.4.1.3.)

C2.4.3. Thermal Hazards. In a HD 1.3 event, heat flux presents the greatest hazard to personnel and assets. HD 1.3 substances include both fuel components and oxidizers. Burning HD 1.3 emits fuel-rich flammable gases, fine particles, or both. This unburned material may ignite when it comes in contact with air and cause a large fireball. This fireball will expand radially from the ignition site and could wrap around obstacles, even those designed to provide line-of-sight protection from HD 1.1 events. Shields and walls can be designed to provide protection from thermal effects (see chapter 4).

C2.4.3.1. The nominal spherical fireball that would be expected from the rapid burning of HD 1.3 can be calculated by $D_{FIRE}=10XW_{EFF}^{1/3}$ where "D_{FIRE}" is the diameter of the fireball (ft) and "W_{EFF}" is the quantity of HD 1.3 involved (lb), multiplied by a 20% safety factor (e.g., "W" of 100 pounds = "W_{EFF}"of 120 pounds). [d_{fire} (meters) = $3.97 \times w_{eff}^{1/3}$ (w_{eff} in kilograms].

C2.4.3.2. In addition to the fireball itself, the thermal flux from the fireball can ignite fires out to intermagazine distance (IMD).

C2.4.4. Propelled Items. In a HD 1.3 event, some AE or AE components may become propulsive and travel well beyond IBD.

C2.4.5. Firebrands. In a HD 1.3 event, a severe fire-spread hazard may result from firebrands projected from the incident site. Firebrands can be expected to be thrown more than 50 ft (15.2 m) from a HD 1.3 event. Firebrands can ignite fires well beyond the distance to which a fireball poses a threat.

C.2.4.6. Expected Consequences.

C2.4.6.1 Exposed personnel may receive severe burns from fireballs or flash burning in a HD 1.3 event. The hazard distance is dependent on the quantity and burning rate of the HD 1.3 involved.

C2.4.6.2 Buildings, vehicles, and aircraft may be ignited by radiant heat, sparks, or firebrands or may be damaged by heat (searing, buckling, etc.).

C2.4.6.3 Personnel in nearby buildings, vehicles, or aircraft may be injured unless evacuated before heat conditions reach hazardous levels.

C2.5. HD 1.4 EFFECTS.

C2.5.1. Blast. There is no blast associated with an incident involving only HD 1.4 (a HD 1.4 event).

C2.5.2. Fragmentation. A HD 1.4 event will not produce fragments of appreciable energy (i.e., greater than 14.8 ft-lbs (20 joules)). (NOTE: Fragments from HD 1.4S have energies less than or equal to 5.9 ft-lbs (8 joules)).

C2.5.3. Thermal Hazard. AE given this designation are considered to provide only a moderate fire hazard. A fireball or jet of flame may extend 3 feet (1 m) beyond the location of the HD 1.4 event. A burning time of less than 330 seconds (5.5 minutes) for 220 lbs (100 kg) of the HD 1.4 AE is expected.

C2.5.4. Firebrands. No fiery projections are expected beyond 50 feet (15.2 m).

C2.5.5. Compatibility Group (CG) -S Items. HD 1.4 AE assigned a CG-S designation (see paragraph C3.2.2.1.13.) is the most benign of all AE. In a HD 1.4 event that only involves CG-S, the expected blast, thermal, and projection effects will not significantly hinder fire fighting or other emergency responses.

C.2.5.6. Expected Consequences. There may be minor consequences (projection, fire, smoke, heat, or loud noise) beyond the AE itself.

C2.6. HD 1.5 EFFECTS.

HD 1.5 effects are similar to those produced by HD 1.1, without the fragmentation effects.

C2.7. HD 1.6 EFFECTS.

HD 1.6 effects are similar to those produced by HD 1.3.

C3. CHAPTER 3 HAZARD CLASSIFICATION, STORAGE AND COMPATIBILITY PRINCIPLES, AND MIXING RULES

C3.1. HAZARD CLASSIFICATION

To ease identification of hazard characteristics for storage and transportation, the Department of Defense shall use:

C3.1.1. DoD Ammunition and Explosives Hazard Classification Procedures as a basis for assigning hazard classifications to all AE for both storage and transportation applications. (See Technical Bulletin (TB) 700-2, Naval Sea Systems Command Instruction (NAVSEAINST) 8020.8B, Technical Order (TO) 11A-1-47, Defense Logistics Agency Regulations (DLAR) 8220.1 (reference (d)).

C3.1.2. The applicable Department of Transportation (DoT) hazardous materials regulations per 49 CFR 171 to 177 (reference (e)).

C3.1.3. The United Nations' (UN) international system of classification developed for the transport of dangerous goods. See ST/SG/AC.10 (reference (f)).

C3.2. DoD HAZARD CLASSIFICATION SYSTEM

C3.2.1. The DoD hazard classification system consists of nine hazard classes plus a non-regulated category that applies when explosives and hazardous materials are present in an item, but not to the degree that criteria for assignment to one of the nine classes are met. AE is assigned to the class that represents an item's predominant hazard characteristic. Class 1 applies to AE where the explosive hazard predominates. The six Class 1 divisions, and three division 1.2 sub-divisions (sub-divisions are only applicable for storage applications), which are outlined below, are used to indicate the character and predominance of explosive hazards. In addition to the classes, divisions, sub-divisions, and the non-regulated category, thirteen Compatibility Groups (CG) are used for segregating AE on the basis of similarity of function, features, and accident effects potential. Furthermore, a parenthetical number is also used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands, when distance alone is relied on for such protection. This number is placed to the left of the hazard classification designators 1.1 through 1.3 (e.g., (18)1.1, (08)1.2.3, or (02)1.3). To simply express an item's hazard classification, this Standard uses the term "Hazard Division (HD)" to avoid repeatedly using the more cumbersome terminology "Sub-division X of Division Y of Class Z". The six Class 1 divisions and three hazard sub-divisions are:

C3.2.1.1. Mass-explosion (HD 1.1).

C3.2.1.2. Non-mass explosion, fragment producing (HD 1.2). (See C9.4.2.)

C3.2.1.2.1. HD 1.2.1. Those items with a NEWQD > 1.60 pounds (0.73 kg) or that exhibit fragmentation characteristics similar to or greater than (higher density, longer distance) M1 105 mm projectiles regardless of NEWQD.

C3.2.1.2.2. HD 1.2.2. Those items with an NEWQD ≤ 1.60 pounds (0.73 kg) or that at most exhibit fragmentation characteristics similar to high-explosive 40 mm ammunition regardless of NEWQD.

C3.2.1.2.3. HD 1.2.3. AE that does not exhibit any sympathetic detonation response in the stack test, and any reaction more severe than burning in the external fire test, bullet impact test, and slow cook-off test.

C3.2.1.3. Mass fire, minor blast or fragment (HD 1.3).

C3.2.1.4. Moderate fire, no significant blast or fragment (HD 1.4).

C3.2.1.5. Explosive substance, very insensitive (with mass explosion hazard) (HD 1.5).

C3.2.1.6. Explosive article, extremely insensitive (HD 1.6).

C3.2.2. Storage and Transportation CG.

C3.2.2.1. The thirteen CG assigned to AE based on similarity of function, features, and accident effects potential are:

C3.2.2.1.1. Group A. Initiating explosives. Bulk initiating explosives that have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples include: bulk lead azide, lead styphnate, mercury fulminate, tetracene, dry cyclonite (RDX), and dry pentaerythritol tetranitrate (PETN).

C3.2.2.1.2. Group B. Detonators and similar initiating devices not containing two or more effective protective features. Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples include: detonators, blasting caps, small arms primers, and fuzes.

C3.2.2.1.3. Group C. Bulk propellants, propelling charges, and devices containing propellant with, or without, its own means of ignition. Examples include: bulk single-, double-, or triple-base, and composite propellants, rocket motors (solid propellant), and propelled AE with inert projectiles.

C3.2.2.1.4. Group D. Bulk black powder; bulk HE; and AE without a propelling charge, but containing HE without its own means of initiation, i.e., no initiating device is present or the device has two or more effective protective features. Examples include: bulk trinitrotoluene (TNT), Composition B, and black powder; bulk wet RDX or PETN; bombs, projectiles, cluster bomb units (CBU), depth charges, and torpedo warheads.

C3.2.2.1.5. Group E. AE containing HE without its own means of initiation and either containing, or with, a solid propelling charge. Examples include: artillery AE, rockets, and guided missiles.

C3.2.2.1.6. Group F. AE containing HE with its own means of initiation, i.e., the initiating device present has less than two effective protective features, and with or without a solid propelling charge. Examples include: grenades, sounding devices, and similar items having explosive trains with less than two effective protective features.

C3.2.2.1.7. Group G. Illuminating, incendiary, and smoke (including hexachlorethane (HC)) or tear-producing AE excluding those that are water-activated or that contain WP or a flammable liquid or gel. Examples include: flares, signals, and pyrotechnic substances.

C3.2.2.1.8. Group H. AE containing white phosphorus (WP). AE in this group contains fillers that are spontaneously flammable when exposed to the atmosphere. Examples include: WP and plasticized white phosphorus (PWP).

C3.2.2.1.9. Group J. AE containing flammable liquids or gels other than those that are spontaneously flammable when exposed to water or the atmosphere. Examples include: liquid- or gel-filled incendiary AE, fuel-air explosive (FAE) devices, and flammable liquid-fueled missiles and torpedoes.

C3.2.2.1.10. Group K. AE containing toxic chemical agents. AE in this group contains chemicals specifically designed for incapacitating effects more severe than lachrymation (tear-producing). Examples include: artillery or mortar AE (fuzed or unfuzed), grenades, rockets and bombs filled with a lethal or incapacitating chemical agent. (See note 4, Table C3.T1.)

C3.2.2.1.11. Group L. AE not included in other CG. AE having characteristics that present a special risk that does not permit storage with other types of AE, or other kinds of explosives, or dissimilar AE of this group. Examples include: water-activated devices, pyrophorics and phosphides and devices containing these substances, prepackaged hypergolic liquid-fueled rocket engines, triethyl aluminum (TEA), thickened TEA (TPA), and damaged or suspect AE of any group. (NOTE: Different types of AE in CG L presenting similar hazards may be stored together.)

C3.2.2.1.12. Group N. AE containing only extremely insensitive detonating substances (EIDS). An example is HD 1.6 AE.

C3.2.2.1.13. Group S. AE that presents no significant hazard. AE packaged or designed so that any hazardous effects from accidental functioning are limited to the extent that they do not significantly hinder firefighting. Examples include: explosive switches or valves and small arms ammunition.

C3.2.3. Sensitivity Groups. For the purpose of storage within a HPM (see paragraph C3.3.7. below) or where ARMCO, Inc. revetments (see paragraph C5.3.5.) or substantial dividing walls (SDW) are utilized to reduce MCE, each HD 1.1 and HD 1.2 AE item is designated, based on its physical attributes, into one of five SG. Directed energy weapons are further identified by assigning the suffix "D" following the SG designation (e.g., SG2D). The SG assigned to an HD 1.1 and HD 1.2 AE item is found in the Joint Hazard Classification System (JHCS).

C3.2.3.1. The five SG, in relative order from least sensitive to most sensitive, are:

C3.2.3.1.1. SG 2: Non-robust or thin-skinned AE (See glossary).

C3.2.3.1.2. SG 1: Robust or thick-skinned AE. A SG 1 item meets any two of the following criteria:

C3.2.3.1.2.1. Ratio of explosive weight to empty case weight < 1.

C3.2.3.1.2.2. Minimum case thickness > 0.4 inches (1 cm).

C3.2.3.1.2.3. Ratio of case thickness to $NEWQD^{1/3}$ > 0.05 $in/lb^{1/3}$ (0.165 $cm/kg^{1/3}$)

C3.2.3.1.3. SG 3: Fragmenting AE. These items, which are typically air-to-air missiles, have warhead cases designed for specific fragmentation (e.g., pre-formed fragment warhead, scored cases, continuous rod warheads, etc.).

C3.2.3.1.4. SG 4: Cluster bombs/dispenser munitions.

C3.2.3.1.5. SG 5: Other AE (items for which HPM non-propagation walls are not effective). Items are assigned to SG 5 because they are either very sensitive to propagation or their sensitivity has not been determined.

C3.2.3.2. Item specific testing or analyses can be used to change an item's SG.

C3.3. STORAGE AND COMPATIBILITY PRINCIPLES

C3.3.1. Separate storage of AE by HD and type provides the highest degree of safety. Because such storage is generally not feasible, mixed storage—subject to compliance with these Standards—is normally implemented when such storage facilitates safe operation and promotes overall storage efficiency.

C3.3.2. The CG assigned to AE indicates what it can be stored with without increasing significantly either an accident's probability or, for a given quantity, the magnitude of an accident's effects. Only compatible AE will be stored together.

C3.3.3. AE may not be stored with dissimilar substances or articles (e.g., flammable or combustible materials, acids, or corrosives) that may present additional hazards to the AE unless they have been assessed to be compatible. Non-Regulated AE and AE assigned to Classes 2 through 9 may have a CG assigned. When so assigned, the AE may be stored in an explosives magazine in accordance with the CG. The explosive weight of non-regulated AE and AE assigned to Classes 2 through 9 is not considered for QD purposes.

C3.3.4. The DoD hazard classification system classifies articles that contain riot control substances, without explosives components, and bulk toxic chemical agents as HD 6.1.

C3.3.5. AE in damaged packaging, in a suspect condition, or with characteristics that increase risk in storage, are not compatible with other AE and will be stored separately (in CG L).

C3.3.6. If different types of CG N munitions are mixed together and have not been tested to ensure non-propagation, the mixed munition types are individually considered to be HD 1.2.1 D or HD 1.2.2 D based on their NEWQD or overriding fragmentation characteristics.

C3.3.7. High Performance Magazine. Because of its construction (see paragraph C5.2.4.), each HPM storage cell is treated as a separate magazine for the purposes of meeting compatibility and mixing requirements. Within a HPM cell, all current compatibility and mixing regulations apply. The maximum allowable NEWQD is 30,000 lbs [13,608 kg] in a HPM cell and 60,000 lbs [27,215 kg] in the loading dock with the following restraints:

C3.3.7.1. When SG 1, 2, or 3 AE is present in a HPM cell, the allowable NEWQD in all cells (adjacent, across, and diagonal) and in the loading dock remains the maximum.

C3.3.7.2. When SG 4 AE is present in a HPM cell, the allowable NEWQD in each adjacent cell and in the cell directly across from it is reduced to 15,000 lbs [6,804 kg]. The allowable NEWQD in diagonal cells and in the loading dock remains the maximum.

C3.3.7.3. When SG 5 AE is present in a HPM, the NEWQD of all cells and the loading dock must be summed for quantity-distance purposes.

C3.3.7.4. When directed energy weapons are present in a HPM, they must be oriented in such a manner that if initiation were to occur, the consequences would be directed away from any other cell. Otherwise, the NEWQD of all cells and the loading dock must be summed for quantity-distance purposes.

C3.3.7.5. When HD and SG are mixed within a HPM cell, the most sensitive SG associated with the AE in that cell controls the allowable NEWQD in each adjacent cell. For example, when HD 1.3, HD 1.4 and HD 1.6 items are stored with HD 1.1 or HD 1.2 items, the most sensitive SG of the HD 1.1 and HD 1.2 items controls the storage requirements.

C3.4. MIXED COMPATIBILITY GROUP STORAGE

C3.4.1. AE of different CG may only be mixed in storage as indicated in Table C3.T1. The exceptions are when Chapter 10 is being applied, and at specific continental United States (CONUS) locations that a DoD Component designates to store AE packaged and configured for rapid response (e.g., Rapid Deployment Force) for which the DDESB has approved the site plan. Such designated locations are authorized to mix CG, without complying with the compatibility and mixing requirements, as operationally required to achieve the optimum load needed by the intended receiving troops. The MCE allowable at any of these storage sites shall be limited to 8,818 lbs NEWQD (4,000 kg NEQ). When computing QD requirements for such sites, chapter 9 applies. However, the following AE will be excluded for NEWQD determination at such storage sites:

C3.4.1.1. Propelling charges in HD 1.2 fixed, semi-fixed, mortar, and rocket AE (See glossary).

C3.4.1.2. The NEWQD of HD 1.3 items, except at sites that contain only HD 1.3 items. At such sites, HD 1.3 Q-D applies. (NOTE: In the application of this paragraph to separate loading AE, the explosive weight of propelling charges are generally excluded when matched pairs of projectiles and propelling charges are at the site. However, if the quantity of propelling charges at the site exceeds the maximum usable for the quantity of projectiles at the site, the explosive weights of all propelling charges and projectiles at the site must be summed for NEWQD determination.)

TABLE C3.T1. Storage Compatibility Mixing Chart

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

Notes:

1 An "X" at an intersection indicates that the groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per Note 2 below.

2 A "Z" at an intersection indicates that when warranted by operational considerations or magazine non-availability, and when safety is not sacrificed, mixed storage of limited quantities of some items from different groups may be approved by the DoD Components. Such approval documentation must be kept on site. Component approval of mixed storage in compliance with Z intersections does not require a waiver or exemption. Mixed storage of items within groups where no X or Z exists at that pair's intersection beyond the prohibitions and limitations of note 7 below, however, requires an approved waiver or exemption.

Examples of acceptable storage combinations are:

a. HD 1.1A initiating explosives with HD 1.1B fuzes not containing two or more effective protective features.

b. HD 1.3C bulk propellants or bagged propelling charges with HD 1.3G pyrotechnic substances.

3 Equal numbers of separately packaged components of hazard classified complete rounds of any single type of AE may be stored together. When so stored, compatibility is that of the complete round.

4 CG K requires not only separate storage from other groups, but also may require separate storage within the group. The controlling DoD Component will determine which items under CG K may be stored together and those that must be stored separately. Such documentation must be kept on site.

5 AE classed outside Class 1 may be assigned the same CG as Class 1 AE containing similar hazard features, but where the explosive hazard predominates. Non-Class 1 AE and Class 1 AE assigned the same CG may be stored together.

6 The DoD Components may authorize AE designated "Practice" or "Training" by nomenclature, regardless of the CG assigned, to be stored with the tactical AE it simulates. Such documentation must be kept on site.

7 The DoD Components may authorize the mixing of CG, except items in CG A, K and L, in limited quantities generally of 1,000 lb (454 kg) total NEWQD or less. Such documentation must be kept on site.

8 For purposes of mixing, all AE must be packaged in its standard storage and shipping container. AE containers will not be opened for issuing items from storage locations. Outer containers may be opened in storage locations for inventorying and for magazines storing only HD 1.4 items, unpacking, inspecting, and repackaging the HD 1.4 ammunition.

9 When using the "Z" mixing authorized by Note 2 for articles of either CG B or CG F, each will be segregated in storage from articles of other CG by means that prevent propagation of CG B or CG F articles to articles of other CG.

10 If dissimilar HD 1.6N AE are mixed together and have not been tested to ensure non-propagation, the mixed AE are individually considered to be HD 1.2.1 D or HD 1.2.2 D based on their NEWQD or overriding fragmentation characteristics for purposes of transportation and storage. When mixing CG N AE with CG B through CG G or with CG S, see subparagraphs C9.2.2.1.1, C9.2.2.4, C9.2.2.10, and C9.2.2.11 to determine the HD for the mixture.

C4. CHAPTER 4
PERSONNEL PROTECTION

C4.1. SCOPE AND APPLICATION

This Chapter establishes blast, fragment, and thermal hazards protection principles. It applies to all operations and facilities within an explosives safety quantity-distance (ESQD) arc in which personnel are exposed to AE hazards. Technical Manual (TM)-5-1300, Naval Facilities Engineering Command (NAVFAC) P-397, Air Force Manual (AFM) 88-22 (reference (g)) contains design procedures to achieve personnel protection, protect facilities and equipment, and prevent propagation of explosions.

C4.2. RISK ASSESSMENT

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

C4.2.1. The risk assessment shall include:

C4.2.1.1. Initiation sensitivity.

C4.2.1.2. Quantity of materials.

C4.2.1.3. Heat output.

C4.2.1.4. Rate of burn.

C4.2.1.5. Potential ignition and initiation sources.

C4.2.1.6. Protection capabilities of shields, various types of clothing, and fire protection systems.

C4.2.1.7. Personnel exposure.

C4.4.2. New or modified facilities, located within the IBD arc of any PES, that will include glass panels and will contain personnel shall have a glass breakage personnel hazards risk assessment conducted.

C4.3. PERMISSIBLE EXPOSURES

C4.3.1. Accidental Ignition or Initiation of Explosives.

C4.3.1.1. When a risk assessment indicates that there is an unacceptable risk from an accidental explosion or a flash fire, personnel shall be provided protection from blast, fragments and thermal effects, to include respiratory and circulatory hazards.

C4.3.1.2. When required, personnel protection must limit incident blast overpressure to 2.3 psi [15.9 kPa], fragments to energies of less than 58 ft-lb [79 joules], and thermal fluxes to 0.3 calories per square centimeter per second [12.56 kilowatts per square meter].

C4.3.1.3. K24 [9.52] distance provides the required level of protection for blast and thermal effects only.

C4.3.1.4. Shields that comply with Military Standard (MIL-STD)-398 (reference (h)) provide acceptable protection for blast, thermal and fragment effects.

C4.3.2. Intentional Ignition or Initiation of AE. At operations (e.g., function, proof, lot acceptance testing) where intentional ignition or initiation of AE are conducted and where shielding is required, as determined on a case-by-case basis by the DoD Component concerned, personnel protection shall:

C4.3.2.1. Meet the requirements of subparagraph C4.3.1.2., above.

C4.3.2.2. Limit overpressure levels in personnel-occupied areas to satisfy MIL-STD-1474D “Noise Limits” (reference (i)).

C4.3.2.3. Contain or defeat all fragments.

C4.3.2.4. Limit thermal flux to: "Q" (calories/square centimeter/second) = $0.62t^{-0.7423}$ where "t" is the time in seconds that a person is exposed to the radiant heat. (NOTE: Shields that comply with reference (h) provide acceptable protection.)

C4.4. PROTECTIVE MEASURES

Personnel protection may be achieved by:

C4.4.1. Eliminating or establishing positive control of ignition and initiation stimuli.

C4.4.2. Using sufficient distance or barricades to protect from blast or fragments.

C4.4.3. Using fire detection and extinguishing systems (e.g., infra-red {IR} actuated deluge system) in those areas where exposed, thermally-energetic materials that have a high probability of ignition and a large thermal output are handled. Such systems shall maximize the speed of detection, have adequate capacity to extinguish potential flash fires in their incipient state, and maximize the speed of the application of the extinguishing agent.

C4.4.4. Using thermal shielding between the thermal source and personnel in AE operational areas, where it is essential for personnel to be present and the risk assessment indicates that an in-process thermal hazard exists. Any shielding used shall comply with reference (h). When shielding is either not possible or inadequate, to include a failure to protect exposed personnel's respiratory and circulatory systems, augmentation with improved facility engineering design and personnel protective clothing and equipment may be necessary.

C4.4.5. Using thermal protective clothing that is capable of limiting bodily injury to first degree burns (0.3 calories per square centimeter per second [12.56 kilowatts/m^2]) with personnel taking turning-evasive action, when the maximum quantity of combustible material used in the operation is ignited.

C4.4.6. Using protective clothing capable of providing respiratory protection from the inhalation of hot vapors or any toxicological effects, when the risk assessment indicates adverse effects would be encountered from the inhalation of combustion products.

C4.4.7. Minimizing the number and size of glass panels in an ES and, if possible, orienting the ES to minimize blast loads on glass panels, when a risk assessment (see section C4.2.) indicates that a glass hazard is present.

C4.4.7.1. When use of window panels is determined to be necessary and a risk assessment determines that there will be an associated glass hazard, blast resistant windows of sufficient strength, as determined by an engineering analysis, shall be used for:

C4.4.7.1.1. Existing ES, upon major modification or modified operations.

C4.4.7.1.2. New construction. (NOTE: The use of glass panels in new construction should be avoided.)

C4.4.7.2. The framing and sash of such panels shall be of sufficient strength to retain the panel in the structure for the expected blast loads from an explosion at any PES.

C5. CHAPTER 5

CONSTRUCTION CRITERIA PERMITTING REDUCED SEPARATION DISTANCES

C5.1. GENERAL

C5.1.1. This Chapter contains DoD standards for construction of ECM, barricades, barricaded open storage modules, special structures, ARMCO, Inc. revetments, and underground storage facilities. Facilities constructed per this chapter:

C5.1.1.1. Are permitted to use reduced separation distance criteria.

C5.1.1.2. Must meet the criteria of chapters 6 and 7.

C5.1.2. Construction features and location are important safety considerations in planning facilities. The effects of potential explosions may be altered significantly by construction features that limit the amount of explosives involved, attenuate blast overpressure or thermal radiation, and reduce the quantity and range of hazardous fragments and debris. (Note: Proper location of ES in relation to PES helps minimize unacceptable damage and injuries in the event of an incident.) The major objectives in facility planning shall be to:

C5.1.2.1. Protect against explosion propagation between adjacent bays or buildings and protect personnel against death or serious injury from incidents in adjacent bays or buildings. The construction of separate buildings to limit explosion propagation, rather than the use of either protective construction or separation of explosives within a single building should be considered when safety would be greatly enhanced or cost would be significantly reduced.

C5.1.2.2. Protect assets, when warranted.

C5.1.3. Protective Construction. Hardening an ES or constructing a PES to suppress explosion effects to provide an appropriate degree of protection may allow a reduction of the separation distances required by QD tables. The rationale and supporting data that justify any such QD reduction shall be submitted to the DDESB with the site and general construction plans for approval (see section C5.4.).

C5.1.4. New construction of previously DDESB-approved 7-Bar and 3-Bar ECM must meet the minimum requirements of the current revisions of the approved drawings.

C5.2. AE STORAGE FACILITIES

C5.2.1. ECM. An ECM's primary purpose is to protect AE. To qualify for the default IMD in Table C9.T6., an ECM, acting as an ES, must not collapse. Although substantial permanent deformation of the ECM may occur, sufficient space should be provided to prevent the deformed structure or its doors from striking the contents.

C5.2.1.1. ECM may be approved for storage of up to 500,000 lbs NEW [226,795 kg NEQ] of HD 1.1 in accordance with Table C9.T5. DDESB Technical Paper (TP) 15, (reference (j)) provides listings of the various types of ECM that have been constructed. These magazines are identified by their structural strength designator (i.e. 7-Bar, 3-Bar, or Undefined). Table

AP1-1. of reference (j) lists the 7-Bar and 3-Bar ECM designs that are currently approved for new construction.

C5.2.1.1.1. If an ECM's drawing number(s) are not listed in reference (j), it shall be treated as an "Undefined" ECM, until a structural analysis is performed to show that the ECM qualifies for another structural strength designation, or support documentation is provided to prove the ECM had been approved by the DDESB with a different structural strength designation.

C5.2.1.1.2. For existing, arch-shaped Undefined ECM, U. S. Army Corps of Engineers (COE) Report HNDED-CS-S-95-01 (reference (k)) may be used to determine if an Undefined ECM could qualify as a 7-Bar or a 3-Bar ECM.

C5.2.1.1.3. DDESB approval is required prior to any change in an ECM's structural strength designator.

C5.2.1.1.4. Certain ECM, aboveground storage magazines, and containers have been approved with reduced NEW and/or reduced QD and these are listed in Table AP1-4. of reference (j). Use of these structures/containers requires that their use and siting meet all conditions AND restrictions specified in the design and approval documentation, as described in reference (j).

C5.2.1.2. ECM must be designed to withstand the following: (Note: Undefined ECM must meet the criteria of subparagraphs C5.2.1.2.1 through C5.2.1.2.3 only.)

C5.2.1.2.1. Conventional (e.g., live, dead, snow) loads for the barrel of an arch-shaped ECM.

C5.2.1.2.2. Conventional (e.g., live, dead, snow) and blast-induced loads for the roof of a flat-roofed ECM.

C5.2.1.2.3. Conventional (e.g., live, dead, snow) loads for the rear wall of an arch-shaped ECM and for the rear and side walls of a flat-roofed ECM.

C5.2.1.2.4. Expected blast loads, as applicable:

C5.2.1.2.4.1. On the head wall and door of 3-Bar ES ECM is a triangular pulse with peak overpressure of 43.5 psi [3-bars, 300 kPa] and impulse of $11.3W^{1/3}$ psi-ms [$100Q^{1/3}$ Pa-s].

C5.2.1.2.4.2. On the head wall and door of 7-Bar ES ECM is a triangular pulse with peak overpressure of 101.5 psi [7-bars, 700 kPa] and impulse of $13.9W^{1/3}$ psi-ms [$123Q^{1/3}$ Pa-s].

C5.2.1.2.4.3. On the roof of a flat-roofed ES ECM is a triangular pulse with peak overpressure of 108 psi [7.5-bars, 745 kPa] and impulse of $19W^{1/3}$ psi-ms [$170Q^{1/3}$ Pa-s].

C5.2.1.3. Earth cover for ECM.

C5.2.1.3.1. Earth cover shall be reasonably cohesive and free from harmful (toxic) matter, trash, debris, and stones heavier than ten pounds [4.54 kg] or larger than six inches [152 mm] in diameter. Solid or wet clay or similar types of soil shall not be used as earth cover because it is too cohesive. Use of acceptable stones shall be limited only to the lower center of side cover. The earthen material shall be compacted and prepared, as necessary, for structural integrity and erosion control. If it is impossible to use a cohesive material (e.g., in sandy soil), the earth cover over ECM shall be finished with a suitable material (e.g., geotextiles, gunnite) that will not produce hazardous debris, but will ensure structural integrity.

C5.2.1.3.2. The earth fill or earth cover between ECM may be either solid or sloped. A minimum of 2 ft [0.61 m] of earth cover shall be maintained over the top of each ECM. (NOTE: If the specified thickness and slope of earth on the ECM is not maintained, the ECM shall be sited as an AGM.)

C5.2.2. Barricaded Open Storage Modules

C5.2.2.1. As depicted in Figure C5.F1., a module is a barricaded area composed of a series of connected cells with hard surface (e.g., concrete, packed earth, engineered materials, etc.) storage pads separated from each other by barricades. Although a light metal shed or other lightweight fire retardant cover may be used for weather protection for individual cells, heavy structures (e.g., reinforced concrete, dense masonry units) or flammable material shall not be used.

C5.2.2.2. The maximum NEW [NEQ] permitted to be stored within each cell is 250,000 lbs [113,398 kg].

C5.2.2.3. Module storage is considered a temporary expedient and may be used as the DoD Component concerned determines necessary. However, from an explosives safety and reliability standpoint, priority shall be given to the use of ECM for items requiring protection from the elements, long-term storage, or high security protection.

C5.2.2.4. Storage shall be limited to AE that will not promptly propagate explosions or mass fire between modules, and that are not susceptible to firebrands and fireballs. These restrictions allow storage at K1.1 [0.44] separation.

C5.2.2.4.1. Only the following AE are approved for modular storage:

C5.2.2.4.1.1. Robust HD 1.1 AE (e.g., HE bombs, fuzed or unfuzed, with or without fins) when stored on nonflammable pallets.

C5.2.2.4.1.2. The below items when contained in nonflammable shipping containers:

C5.2.2.4.1.2.1. 30 mm and smaller AE.

C5.2.2.4.1.2.2. CBU.

C5.2.2.4.1.2.3. Inert AE components.

C5.2.2.4.1.2.4. HD 1.4 AE.

C5.2.2.4.2. Module storage of AE items in flammable outer-packaging configurations shall be minimized. AE items in flammable outer packaging configurations must be covered with fire retardant material. Combustible dunnage or other flammable material shall not be stored either in, or within, 100 ft [30.5 m] of modules.

C5.2.2.4.3. When fire retardant materials are used to cover AE items stored in modules, ventilation shall be provided between the covers and the stored AE items to minimize the effects of solar heating upon the stored AE.

C5.2.2.4.4. AE stored in each module shall normally be limited to one type of item, unless the DoD Component concerned authorizes mixed storage.

C5.2.2.5. Barricade Requirements:

C5.2.2.5.1. All barricades used in forming the module shall meet the requirements in section C5.3. The width or length of the stack of AE (controlled by the pad size of the cell) and the distances between the stack and the top of the barricade influences the minimum barricade height requirement. The heights listed in Table C5.T1. are the minimum requirements for barricade locations. These minimum heights are based upon both the storage pad sizes and the separations shown. When feasible, barricade heights should be increased (see subparagraph C5.3.2.3.).

C5.2.2.5.2. The centerlines of barricades between cells of the module shall be located at a point halfway between adjacent AE storage pads. Back and end (outside) barricades shall be located at the same distance from the pads as those between the cells.

C5.2.2.5.3. When selecting a site for a module, maximum advantage should be taken of natural topographical barriers. When used, natural barriers shall provide the same level of protection as the barricade shown in Figure C5.F1.

C5.2.2.6. Table C5.T1. provides the minimum pad sizes necessary to store the NEWQD indicated. The pad's size may need to be adjusted to accommodate specific AE. This adjustment will impact the required barricade height (see Note 2 of Table C5.T1.).

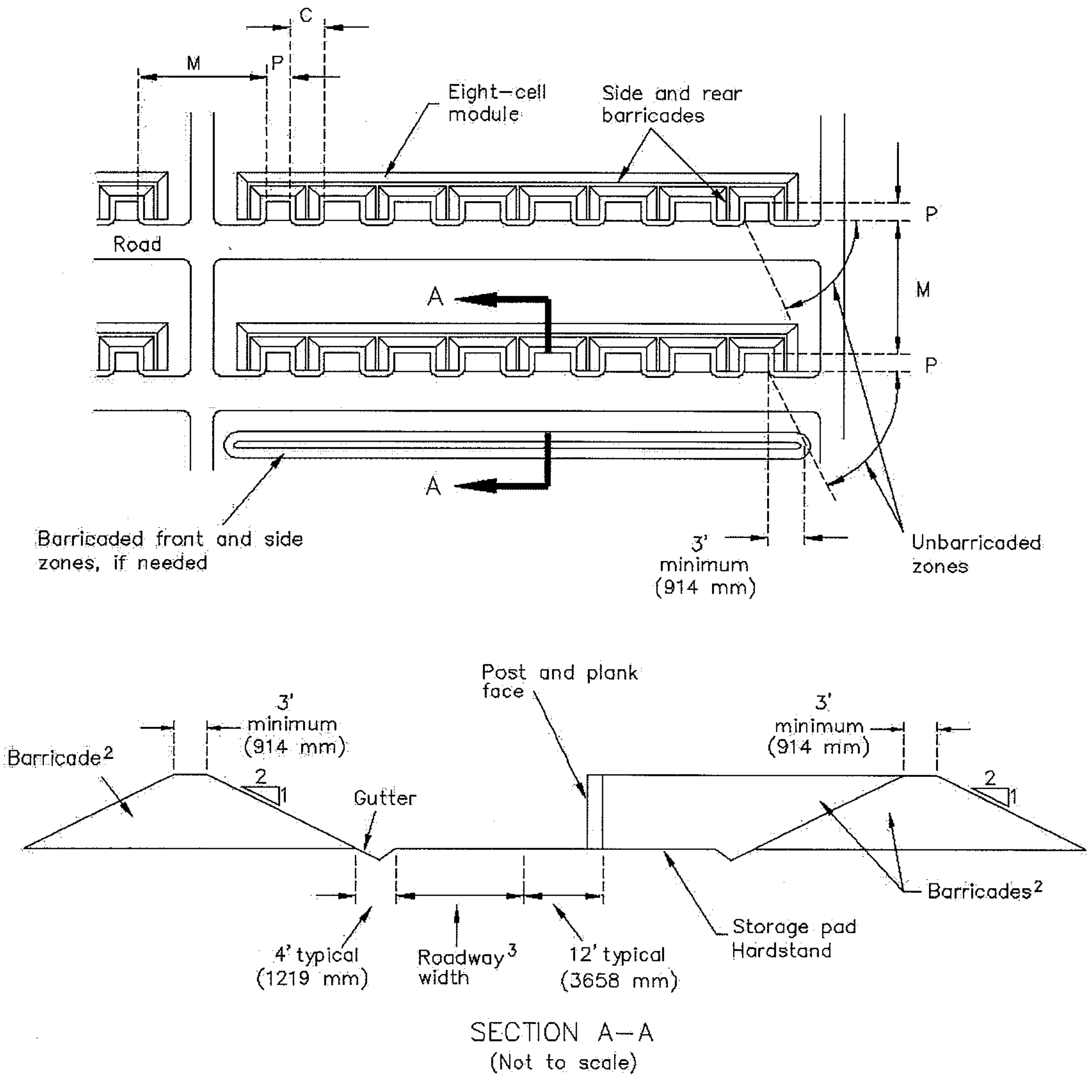
C5.2.2.7. The only restriction on the arrangement of cells within a module and of groups of modules is that cell openings may not face each other, unless they are either barricaded or meet QD criteria for an unbarricaded AGM (see Table C9.T6.).

C5.2.3. <u>Underground storage facilities</u>

C5.2.3.1. <u>General Design Considerations:</u>

C5.2.3.1.1. Underground storage facilities may consist of a single chamber or a series of connected chambers and other protective construction features. The chambers may be either excavated or natural geological cavities. Figure C5.F2. shows the layout of several typical underground facilities. To qualify as an underground facility, the minimum distance from the perimeter of a storage area to an exterior surface shall be greater than 0.25 $W^{1/3}$ [0.10 $Q^{1/3}$]. (Note: This minimum distance normally, but not always, equals the thickness of the earth cover.) If this criterion cannot be met, the facility must be sited as an AGM.

C5.2.3.1.2. Design of new underground storage facilities must takc into account site conditions, storage requirements and operational needs. Once these are established, a design may be developed based on the CoE definitive drawing, DEF 421-80-04, discussed in Chapter 5 of reference (j). Special features (e.g., debris traps, expansion chambers, closure blocks, portal barricades, and constrictions) may be incorporated in the design of underground storage facilities to reduce the IBD for both debris and airblast. The specifications for these special features are also given in CoE definitive drawing, DEF 421-80-04, and their effects are discussed below.



Notes:

1. Number of cells, cells' NEWQD, pad sizes (P), distances between cells (C) and modules (M), and minimum barricade heights can vary (see Table C5.T1.).
2. Refer to section C5.3. for barricade design criteria and for alternate barricade designs.
3. Roadway width determined by the DoD Components.

FIGURE C5.F1. Typical Eight-Cell Open Storage Module (see paragraph C5.2.2.)

TABLE C5.T1. HD 1.1 IMD FOR BARRICADED OPEN STORAGE MODULE

NEWQD	Minimum Storage Pad-to-Storage Pad Separation Distance ("C" in C5.F1)[1,2]	Maximum Pad Dimension ("P" in C5.F1) Width or Depth	Minimum Height Above Top of Stack[3]
(lbs)	(ft)	(ft)	(ft)
[kg]	*[m]*	*[m]*	*[m]*
50,000	41	30	2
22,680	*12.5*	*9.1*	*0.6*
70,000	45	30	2
31,751	*13.9*	*9.1*	*0.6*
100,000	51	30	2
45,359	*15.7*	*9.1*	*0.6*
150,000	58	30	2
68,039	*18.0*	*9.1*	*0.6*
200,000	64	30	2
90,718	*19.8*	*9.1*	*0.6*
200,000	64	40	2.5
90,718	*19.8*	*12.2*	*0.8*
250,000	69	40	2.5
113,398	*21.3*	*12.2*	*0.8*
250,000	69	50	3
113,398	*21.3*	*15.2*	*0.9*

Notes:

1. $D = 1.1W^{1/3}$ **[EQN C5.T1-1]**

   D in ft and W in lbs

   $D = 0.44Q^{1/3}$ ***[EQN C5.T1-2]***

   D in m and Q in kg

   $W = D^3/1.33$ **[EQN C5.T1-3]**

   W in lb and D in ft

   $Q = D^3/0.083$ ***[EQN C5.T1-4]***

   Q in kg and D in m

2. AE shall not be stored beyond the boundaries of the storage pad.
3. Barricade height is based upon storage pad size. When "P" exceeds 50 ft [15.2 m], then the barricade height shall be increased by 6 inches [152 mm] for each 10 ft [3.05 m] increase of "P".

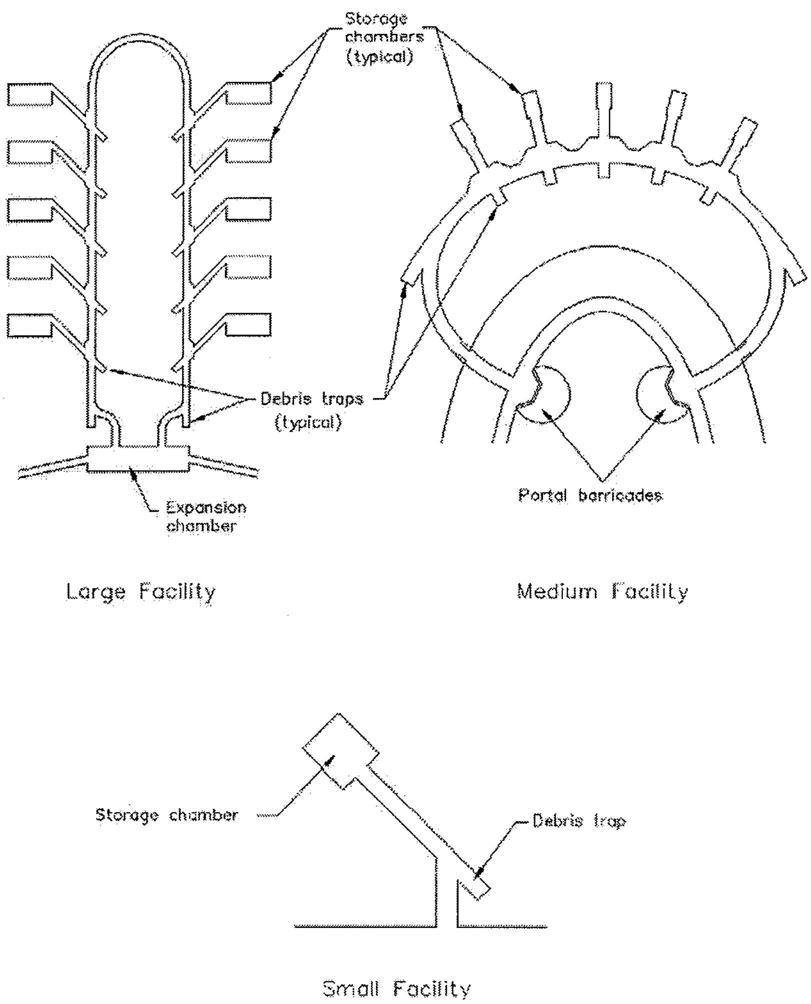


FIGURE C5.F2. Typical Underground Storage Facilities (see paragraph C5.2.3.)

C5.2.3.2. Special Design Considerations:

C5.2.3.2.1. Debris Mitigation. Debris IBD may be reduced through the use of debris traps, expansion chambers, high pressure closures, and portal barricades.

C5.2.3.2.1.1. Debris traps are pockets excavated in the rock at or beyond the end of sections of tunnel that are designed to catch debris from a storage chamber detonation. Debris traps should be at least 20 percent wider and 10 percent taller than the tunnel leading to the trap, with a depth (measured along the shortest wall) of at least one tunnel diameter.

C5.2.3.2.1.2. Expansion chambers are very effective in entrapping debris, as long as the tunnels entering and exiting the chambers are either offset in axial alignment by at least two tunnel widths, or enter and exit the chambers in directions that differ by at least 45 degrees.

C5.2.3.2.1.3. To be effective, debris traps and expansion chambers that are intended to entrap debris must be designed to contain the full potential volume of debris, based on the maximum capacity of the largest storage chamber.

C5.2.3.2.1.4. Portal barricades provide a means of reducing IBD from debris by obstructing the path of the debris as it exits the tunnel.

C5.2.3.2.1.5. High-pressure closures are large blocks constructed of concrete or other materials that can obstruct or greatly reduce the flow of blast effects and debris from an explosion from or into a storage chamber. For chamber loading density (w) of about 0.625 lb/ft^3 [10 kg/m^3] or above, closure blocks will contain 40 percent or more of the explosion debris within the detonation chamber, provided that the block is designed to remain intact. If a closure block fails under the blast load, it will produce a volume of debris in addition to that from the chamber itself. However, because the block's mass and inertia are sufficient to greatly reduce the velocity of the primary debris, the effectiveness of other debris-mitigating features (e.g., debris traps, expansion chambers, and barricades) is increased.

C5.2.3.2.1.6. Use of barricades with any other of these features will lower the debris hazard to a level where QD considerations for debris is not required.

C5.2.3.3. Airblast Mitigation. Special features that may be used in underground storage facilities to reduce airblast IBD include:

C5.2.3.3.1. Facility Layouts. A facility's layout and its volume control the external airblast effects.

C5.2.3.3.1.1. In a single-chamber facility with a straight access tunnel leading from the chamber to the portal, which is commonly called a "shotgun" magazine, the blast and debris are channeled to the external area as if fired from a long-barreled gun. In this type of facility design, airblast mitigation, given a fixed NEWQD, can be provided by increased chamber and tunnel dimensions.

C5.2.3.3.1.2. In more complex facility layouts, reflections of the explosive shock against the various tunnel walls may reduce the exit pressures. The cumulative effects of these reflections may reduce the overpressure at the shock front to that of the expanding gas pressure. In addition, the detonation gas pressure decreases as the volume it occupies increases. Therefore, larger, more complex facilities will produce greater reductions in the effective overpressure at the opening, which will reduce the IBD.

C5.2.3.3.1.3. In a more complex facility with two or more openings, the IBD will be reduced by about 10 percent.

C5.2.3.3.2. Expansion-Chambers. Expansion-chambers provide additional volume for the expansion of the detonation gasses behind the shock front as it enters the chamber from a connecting tunnel. Some additional reduction of the peak pressure at the shock front occurs as the front expands into the expansion-chamber and reflects from the walls. Although, expansion-chambers may be used as loading areas or as turn-around areas for transport vehicles servicing facilities through a single entry passage, they shall not be used for storage.

C5.2.3.3.3. Constrictions. Constrictions are short lengths of tunnel whose cross-sectional areas are reduced to one-half or less of the normal tunnel cross-section. Constrictions reduce the airblast effects passing through them. To be effective, constrictions should be placed within five tunnel diameters of the tunnel exit or to the entrances of storage chambers. As an added benefit, constrictions at chamber entrances also reduce the total loading on blast doors that may be installed to protect a chamber's contents.

C5.2.3.3.4. Portal Barricades. A barricade in front of the portal (entrance into tunnel) will reflect that portion of the shock wave moving directly outward from the portal, thereby, reducing the pressures along the extended tunnel axis and increasing the pressures in the opposite direction. The result is a more circular IBD area centered at the portal. A portal barricade meeting the construction criteria of the CoE definitive drawing discussed in subparagraph C5.2.3.1.2 will reduce the IBD along the extended tunnel axis by 50 percent. The total IBD area is only slightly reduced, but will change to a circular area, half of which is behind the portal.

C5.2.3.3.5. High-Pressure Closures. High-Pressure Closures are large blocks constructed of concrete or other materials that obstruct or greatly reduce the flow of blast effects and debris from an explosion from or into a storage chamber.

C5.2.3.3.5.1. When used to reduce QD, by restricting the blast outflow from a chamber, the block must be designed to be rapidly driven from an open to a closed position by the detonation pressures in the chamber. While this type of block will provide some protection of chamber contents from an explosion in another chamber, blast doors must also be used to provide complete protection. Tests have shown that a closure block, with sufficient mass, can obstruct the initial outflow of airblast from an explosion in a chamber to reduce pressures in the connecting tunnels by a factor of two or more, even when the block is destroyed. Blocks with sufficient strength to remain structurally intact can provide greater reductions. Because many variables influence the performance of a closing device, their design details must be developed on a site-specific basis.

C5.2.3.3.5.1.1. For loading densities (w) of 0.625 lb/ft^3 [10 kg/m^3] or higher, a 50 percent reduction in IBD may be applied to the use of a high pressure closure block provided it is designed to remain intact in the event of an explosion.

C5.2.3.3.5.1.2. For lower loading densities, use the following reductions:

C5.2.3.3.5.1.2.1. $0.0625 < w < 625$ lb/ft^3 [$1.0 < w < 10$ kg/m^3], reductions may be calculated by:

$$y(\%) = 50\log_{10}(16.02w)$$ **[EQN C5.2-1]**

$$[y(\%) = 50\log_{10}(10w)]$$ **[EQN C5.2-2]**

where y is the percent reduction in IBD, and w is loading density in lb/ft^3 [kg/m^3]

C5.2.3.3.5.1.2.2. For $w < 0.0625$ lb/ft^3 [$w < 1$ kg/m^3]:

$y(\%) = 0.$

C5.2.3.3.6. When used to protect the contents of a chamber from an explosion in another chamber, the block must be designed to move from a normally closed position to an open position when entry is required. (NOTE: Blast doors are not required for this type of closure block.)

C5.2.3.4. Chamber Separation Requirements. Minimum storage chamber separation distances are required to prevent or control the communication of explosions or fires between chambers. There are three modes by which an explosion or fire can be communicated: rock spall, propagation through cracks or fissures, and airblast or thermal effects traveling through connecting passages. Spalled rock of sufficient mass that is traveling at a sufficient velocity may damage or sympathetically detonate impacted AE in the acceptor chambers.

C5.2.3.4.1. Prevention of Damage by Rock Spall (HD 1.1 and HD 1.3). The chamber separation distance is the shortest distance (rock thickness) between two chambers. When an explosion occurs in a donor chamber (a PES), a shock wave is transmitted through the surrounding rock. The intensity of the shock decreases with distance. For small chamber separation distances, the shock may be strong enough to produce spalling of the rock walls of adjacent ES chambers. When no specific protective construction is used:

C5.2.3.4.1.1. For moderate to strong rock, with loading densities less than or equal to 3.0 lb/ft^3 [48.1 kg/m^3], the minimum chamber separation distance (D_{cd}) required to prevent hazardous spall effects is:

$$D_{cd} = 2.5W^{1/3}$$ **[EQN C5.2-3]**

$$[D_{cd} = .99Q^{1/3}]$$ **[EQN C5.2-4]**

where D_{cd} is in ft and W is in lbs [D_{cd} is in m, and Q is in kg]. (**Note**: D_{cd} shall not be less than 15 ft [4.6 m].)

C5.2.3.4.1.1.1. For loading densities greater than 3.0 lbs/ft^3 [48kg/m^3], the separation distance is:

$$D_{cd} = 5.0W^{1/3}$$ **[EQN C5.2-5]**

$$[D_{cd} = 1.98Q^{1/3}]$$ **[EQN C5.2-6]**

C5.2.3.4.1.2. For weak rock, at all loading densities, the separation distance is:

$$D_{cd} = 3.5W^{1/3}$$ [EQN C5.2-7]

$$[D_{cd} = 1.39Q^{1/3}]$$ **[EQN C5.2-8]**

C5.2.3.4.1.3. The equations above are the basis for values of D_{cd} listed in Table C5.T2.).

C5.2.3.5. Prevention of Propagation by Rock Spall (HD 1.1 and HD 1.3). Because rock spall is considered an immediate mode of propagation, time separations between donor and acceptor explosions may not be sufficient to prevent coalescence of blast waves. If damage to AE stored in adjacent chambers is acceptable, chamber separation distances from those determined to prevent damage (see subparagraph C5.2.3.2.1.) can be reduced to prevent propagation by rock spall. To prevent propagation, the separation distances between donor and acceptor chambers are calculated using the below equations. (Note: If the required separation distances defined below cannot be met, explosives weights in all chambers must be added together to determine W, unless analyses or experiments demonstrate otherwise.)

C5.2.3.5.1. When no special protective construction is used, the separation distance (D_{cp}) to prevent propagation by rock spall is:

$$D_{cp} = 1.5W^{1/3}$$ **[EQN C5.2-9]**

$$[D_{cp} = 0.59Q^{1/3}]$$ **[EQN C5.2-10]**

where D_{cp} is in ft and W is in lbs. [D_{cp} is in m and Q is in kg]

C5.2.3.5.2. When the acceptor chamber has protective construction to prevent spall and collapse, the D_{cp} to prevent propagation by impact of rock spall is:

$$D_{cp} = 0.75W^{1/3}$$ **[EQN C5.2-11]**

$$[D_{cp} = 0.30Q^{1/3}]$$ **[EQN C5.2-12]**

where D_{cp} is in ft and W is in lbs. [D_{cp} is in m and Q in kg]

C5.2.3.5.3. Separation distances, D_{cp} and D_{cd}, are listed in Table C5.T2. These distances are based on an explosive loading density of 17 lb/ft^3 [272.3 kg/m^3] and will likely be safety conservative for lower loading densities.

C5.2.3.6. Prevention of Propagation Through Cracks and Fissures (HD 1.1 and HD 1.3). Propagation between a donor and an acceptor chamber has been observed to occur when natural, near horizontal jointing planes; cracks; or fissures in the rock between the chambers are opened by the lifting force of the detonation pressure. Prior to construction of a multi-chamber magazine, a careful site investigation must be made to ensure that such joints or fissures do not extend from one chamber location to an adjacent one. Should such defects be encountered during facility excavation, a reevaluation of the intended siting is required.

C5.2.3.7. Prevention of Propagation through Passageways (HD 1.1 and HD 1.3). Flame and hot gas may provide a delayed mode of propagation. Time separations between the events in the donor chamber and the acceptor chamber by this mode will likely be sufficient to prevent coalescence of blast waves. Consequently, siting is based on each chamber's NEWQD. To protect assets, blast and fire resistant doors may be installed within multi-chambered facilities. Evaluations for required chamber separations due to this propagation mode should be made on a site-specific basis using procedures outlined in CoE definitive drawing DEF 421-80-04. For HD 1.1 and HD 1.3 materials:

C5.2.3.7.1. Chamber entrances at the ground surface, or entrances to branch tunnels off the same side of a main passageway, shall be separated by at least 15 ft [4.6 m].

C5.2.3.7.2. Entrances to branch tunnels off opposite sides of a main passageway shall be separated by at least twice the width of the main passageway.

C5.2.3.8. Chamber Cover Thickness. The chamber cover thickness is the shortest distance between the ground surface and the natural rock surface at the chamber's ceiling or, in some cases, a chamber's wall. For all types of rock, the critical cover thickness required to prevent breaching of the chamber cover by a detonation (C_c) is

$$Cc = 2.5W^{1/3}$$ **[EQN C5.2-13]**

$$[Cc = .99Q^{1/3}]$$ **[EQN C5.2-14]**

where C_c is in ft and W is in lbs. [*C_c is in m and Q is in kg*].

TABLE C5.T2. CHAMBER SEPARATION DISTANCES REQUIRED TO PREVENT DAMAGE AND PROPAGATION BY ROCK SPALL.

NEWQD	Chamber Separation to Prevent Damage by Rock Spall, D_{cd}			Chamber Separation to Prevent Propagation by Rock Spall, D_{cp}	
	Moderate-to-strong rock		Weak rock (all loading densities)	No protective construction	With protective construction
	$w \leq 3$ lbs/ft^3 *$w \leq 48.1$ kg/m^3*	$w > 3$ lbs/ft^3 *$w > 48.1$ kg/m^3*			
	(See note 1)	(See note 2)	(See note 3)	(See note 4)	(See note 5)
(lbs) *[kg]*	(ft) *[m]*	(ft) *[m]*	(ft) *[m]*	(ft) *[m]*	(ft) *[m]*
1,000	25	50	35	15.0	7.5
454	*7.6*	*15.2*	*10.7*	*4.6*	*2.3*
2,000	31	63	44	18.9	9.4
907	*9.6*	*19.2*	*13.5*	*5.8*	*2.9*
3,000	36	72	50	22	10.8
1,361	*11.0*	*21.9*	*15.4*	*6.6*	*3.3*
4,000	40	79	56	24	11.9
1,814	*12.1*	*24.1*	*17.0*	*7.3*	*3.7*
5,000	43	85	60	26	12.8
2,268	*13.0*	*26.0*	*18.3*	*7.9*	*3.9*
7,000	48	96	67	29	14.3
3,175	*14.6*	*29.1*	*20.4*	*8.8*	*4.4*
10,000	54	108	75	32	16.2
4,536	*16.4*	*32.8*	*23.0*	*9.9*	*5.0*
20,000	68	136	95	41	20.4
9,072	*20.6*	*41.3*	*29.0*	*12.5*	*6.3*
30,000	78	155	109	47	23.3
13,608	*23.6*	*47.3*	*33.2*	*14.3*	*7.2*
50,000	92	184	129	55	27.6
22,680	*28.0*	*56.0*	*39.3*	*17.0*	*8.5*
70,000	103	206	144	62	30.9
31,751	*31.3*	*62.7*	*44.0*	*19.0*	*9.5*
100,000	116	232	162	70	34.8
45,359	*35.3*	*70.6*	*49.6*	*21.4*	*10.7*
200,000	146	292	205	88	43.9
90,718	*44.5*	*89.0*	*62.5*	*27.0*	*13.5*
300,000	167	335	234	100	50.2
136,077	*50.9*	*101.8*	*71.5*	*30.9*	*15.4*
500,000	198	397	278	119	59.5
226,795	*60.4*	*120.7*	*84.8*	*36.6*	*18.3*
700,000	222	444	311	133	66.6
317,513	*67.5*	*135.1*	*94.8*	*40.9*	*20.5*
1,000,000	250	500	350	150	75.0
453,590	*76.1*	*152.1*	*106.8*	*46.1*	*23.1*

Notes:

1. $D_{cd} = 2.5W^{1/3}$ **[EQN C5.T2-1]**

   W in lbs, D_{cd} in ft with a minimum distance of 15 ft

   $D_{cd} = 0.99Q^{1/3}$ **[EQN C5.T2-2]**

   Q in kg, D_{cd} in m with a minimum distance of 4.57 m

   W=Dcd3/15.625 **[EQN C5.T2-3]**

D_{cd} in ft, W in lbs, with a minimum W of 216 lb

$Q = D_{cd}^3/0.97$ **[EQN C5.T2-4]**

D_{cd} in m, Q in kg, with a minimum Q of 98.3 kg

2. $D_{cd} = 5W^{1/3}$ **[EQN C5.T2-5]**

W in lbs, D_{cd} in ft with a minimum distance of 15 ft

$D_{cd} = 1.98Q^{1/3}$ **[EQN C5.T2-6]**

Q in kg, D_{cd} in m with a minimum distance of 4.57 m

$W = D_{cd}^3/125$ **[EQN C5.T2-7]**

D_{cd} in ft, W in lbs, with a minimum W of 216 lb

$Q = D_{cd}^3/7.762$ **[EQN C5.T2-8]**

D_{cd} in m, Q in kg, with a minimum Q of 98.3 kg

3. $D_{cd} = 3.5W^{1/3}$ **[EQN C5.T2-9]**

W in lbs, D_{cd} in ft with a minimum distance of 15 ft

$D_{cd} = 1.39Q^{1/3}$ **[EQN C5.T2-10]**

Q in kg, D_{cd} in m with a minimum distance of 4.57 m

$W = D_{cd}^3/42.875$ **[EQN C5.T2-11]**

D_{cd} in ft, W in lbs, with a minimum W of 216 lb

$Q = D_{cd}^3/2.686$ **[EQN C5.T2-12]**

D_{cd} in m, Q in kg, with a minimum Q of 98.3 kg

4. $D_{cd} = 1.5W^{1/3}$ **[EQN C5.T2-13]**

W in lbs, D_{cd} in ft

$D_{cd} = 0.60Q^{1/3}$ **[EQN C5.T2-14]**

Q in kg, D_{cd} in m

$W = D_{cd}^3/3.375$ **[EQN 5 C5.T2-15]**

D_{cd} in ft, W in lb

$Q = D_{cd}^3/0.216$ **[EQN C5.T2-16]**

D_{cd} in m, Q in kg

5. $D_{cd} = 0.75W^{1/3}$ **[EQN C5.T2-17]**

W in lbs, D_{cd} in ft

$D_{cd} = 0.30Q^{1/3}$ **[EQN C5.T2-18]**

Q in kg, D_{cd} in m

$W = D_{cd}^3/0.422$ **[EQN C5.T2-19]**

D_{cd} in ft, W in lb

$Q = D_{cd}^3/0.027$ **[EQN C5.T2-20]**

D_{cd} in m, Q in kg

C5.2.4. HPM. HPM allow a reduction in encumbered land by limiting the MCE to a quantity considerably less than that stored in the HPM. (NOTE: HPM are to be constructed per Naval Facilities Engineering Command (NAVFAC) guidance, as outlined in Table AP1-1. of reference (j), and are to be sited at the IMD provided by Table C9.T6.). HPM separation walls protect against fire propagation between internal storage areas. Although IMD provides nearly complete asset protection between HPM (MCE = 60,000 lbs [27,216 kg] maximum), AE damage may occur to about K9 [3.57] from a donor NEW > 350,000 lbs [158,757 kg].

C5.2.5. AGM. There are no DDESB construction criteria for AGM. However, such structures must meet the criteria of chapters 6 and 7.

C5.2.6. Special Structures. The DDESB has approved reduced QD for structures and containers listed in Table AP1-4. of reference (j).

C5.3. BARRICADES

C5.3.1. General

C5.3.1.1. Properly constructed and sited barricades, and undisturbed natural earth have explosives safety applications for both protecting against low-angle fragments and reducing shock overpressure loads very near the barricade. Barricades provide no protection against high-angle fragments or lobbed AE. If the barricade is destroyed in the process of providing protection, then secondary fragments from the destroyed barricade must also be considered as part of a hazards analysis.

C5.3.1.2. To reduce hazards from high-velocity, low-angle fragments, the barricade must be placed between the PES and the ES so that the fragments of concern impact the barricade before the ES. The barricade must both be thick enough so that it reduces fragment velocities to acceptable levels and high enough so that it intercepts the ballistic trajectories of the fragments of concern.

C5.3.1.3. A barricade placed between a PES and an ES interrupts the direct line-of-sight motion of the shock wave. If the barricade has sufficient dimensions and is located close enough to the ES, significant reductions in shock loading to selected areas of the ES may be realized.

C5.3.2. Barricade Designs.

C5.3.2.1. Chapter 6 of reference (j) lists DDESB approved designs and construction materials for barricades. Use of these barricades satisfies barricading criteria.

C5.3.2.2. Alternate barricade designs (e.g., earth filled steel bin) may be approved by the DDESB provided that testing or analysis demonstrates their effectiveness in stopping high velocity, low angle fragments.

C.5.3.2.3. Barricade Size and Orientation for Protection Against High-Speed, Low-Angle Fragments. The location, height, and length of a barricade shall be determined as follows:

C5.3.2.3.1. Location. The barricade may be placed anywhere between the PES and the ES. The location shall determine the barricade's required height and length.

C5.3.2.3.2. Height. To determine the required barricade height:

C5.3.2.3.2.1. Establish a reference point at the top of the far edge of one of the two AE stacks between which the barricade is to be constructed. When both stacks are of equal height, the reference point may be established on either stack. If the tops of the two stacks are not of equal height (elevation), the reference point shall be on the top of the lower stack. (NOTE: To preclude building excessively high barricades, the barricade should be located as close as possible to the stack on which the reference point was established (see Figure C5.F3.))

C5.3.2.3.2.2. Draw a line from the reference point to the highest point of the other stack.

C5.3.2.3.2.3. Draw a second line from the reference point forming an angle of two degrees above the line.

C5.3.2.3.3. Length. The barricade's length shall be determined per Figure C5.F3.

C5.3.2.4. Barricade Size and Orientation for Protection Against Overpressure. General procedures to predict pressure mitigation versus barricade design and location have not been developed. However, based on direct-experimental work, the overpressure loading on a surface area shielded by a barricade is reduced by approximately 50 percent when the following conditions are met:

C5.3.2.4.1. Location. The barricade's standoff is within two barricade heights of the protected area.

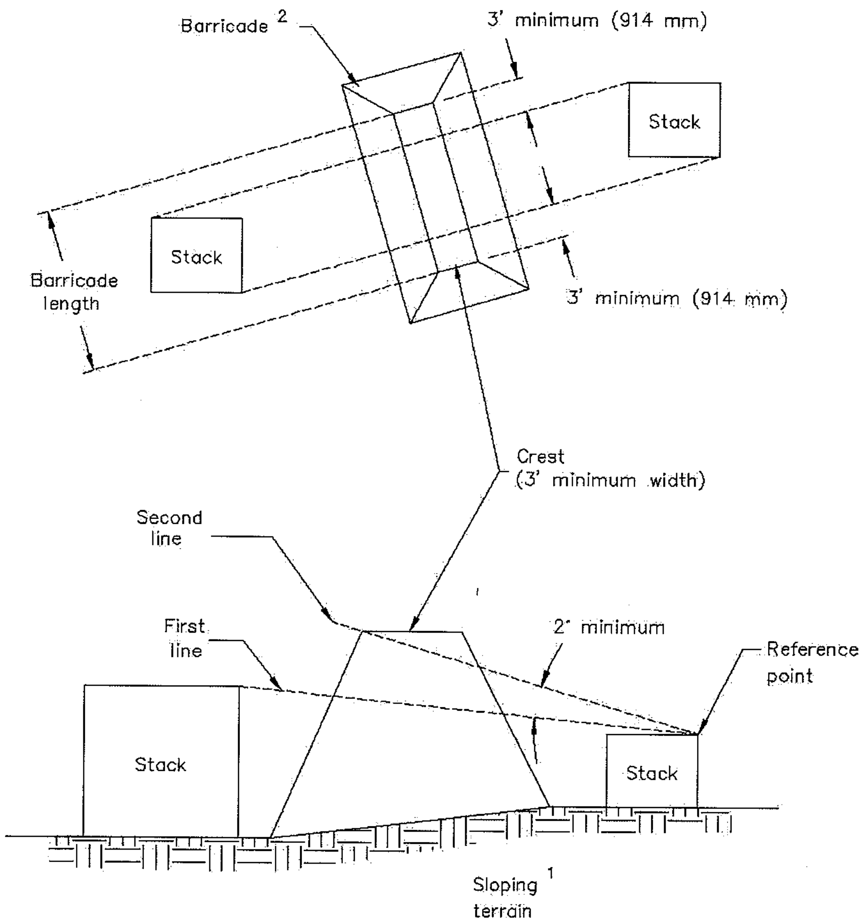
C5.3.2.4.2. Height. The top of the barricade is at least as high as the top of the protected area.

C5.3.2.4.3. Length. The length of the barricade is at least two times the length of the protected area.

C5.3.3. Barricade Construction Materials.

C5.3.3.1. Materials for earthen barricades shall be reasonably cohesive and free from harmful (toxic) matter, trash, debris, and stones heavier than ten pounds [4.54 kg] or larger than six inches [152 mm] in diameter. The larger of acceptable stones shall be limited to the lower center of fills. Earthen material shall be compacted and prepared, as necessary, for structural integrity and erosion control. Solid or wet clay or similar types of soil shall not be used in barricades because they are too cohesive. If it is impossible to use a cohesive material (e.g., in sandy soil) the barricade shall be finished with a suitable material (e.g., geotextiles, gunnite) that shall not produce hazardous debris, but shall ensure structural integrity.

C5.3.3.2. The slope of an earthen barricade must be two horizontal to one vertical, unless erosion controls are used. Earthen barricades with slopes no greater than one and one half horizontal to one vertical that were approved prior to 1976 may continue to be used. However, renovations to these facilities shall meet the above criteria, when feasible.



Notes:

1. This illustration is for sloping terrain; however, a similar approach is used for level terrain.
2. Barricade must meet construction and siting criteria of section C5.3.

FIGURE C5.F3. Determination of Barricade Length and Height (see subparagraph C5.3.2.3)

C5.3.4. Portal Barricades for Underground Storage Facilities. Portal barricades allow reduction in IBD for underground magazines. Criteria for the location and construction of portal barricades are illustrated in Figure C5.F4. and include:

C5.3.4.1. Location. Portal (entry or exit) barricades shall be located immediately in front of an outside entrance or exit to a tunnel leading to an explosives storage point. The portal barricade should be centered on the extended axis of the tunnel that passes through the portal and shall be located a distance of not less than one and not more than three tunnel widths from the portal. The actual distance should be no greater than that required (based on the turning radius and operating width) to allow passage of any vehicles or materials handling equipment that may need to enter the tunnel.

C5.3.4.2. Height. The height of the barricade, along its entire width, shall be sufficient to intercept an angle of 10 degrees above the extended height of the tunnel.

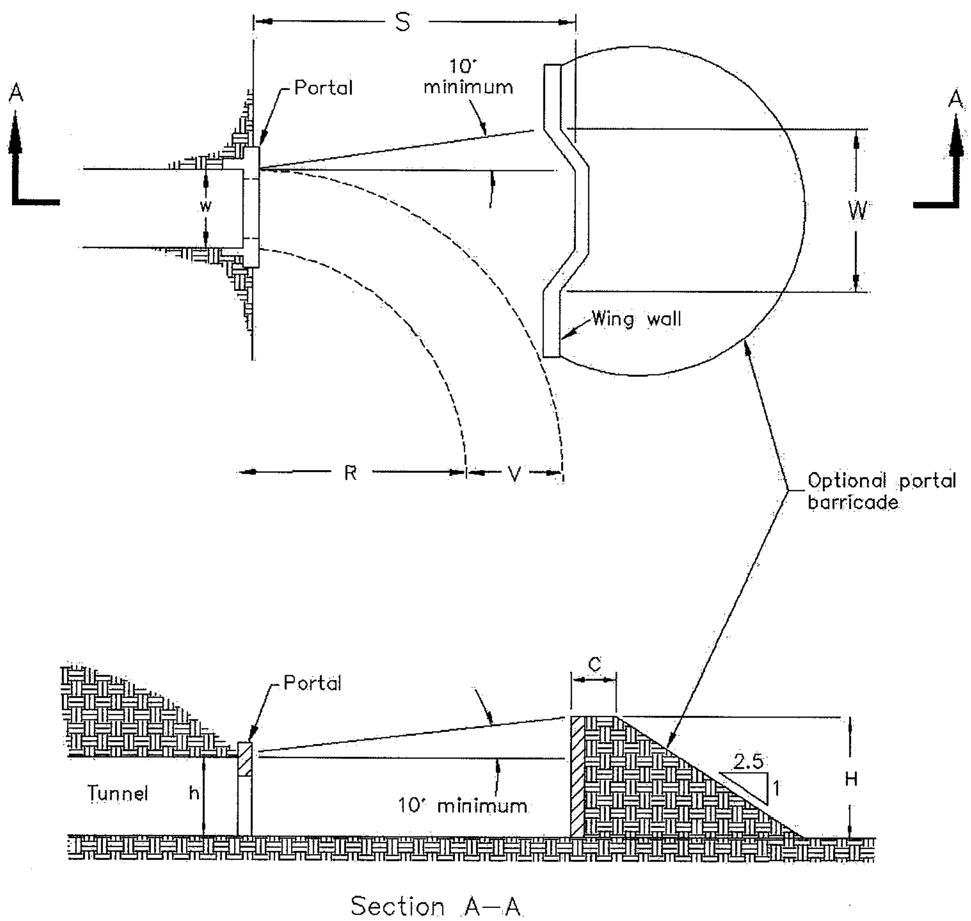
C5.3.4.3. Width and Length.

C5.3.4.3.1. The width of the central face typically equals the width of the tunnel at the portal.

C5.3.4.3.2. The front face (i.e., the face toward the entry or exit) shall be vertical and concave in plan view, consisting of a central-face oriented perpendicular to the tunnel axis, and wing walls.

C5.3.4.3.3. The wing walls shall be of sufficient width so that the entire barricade length intercepts an angle of 10 degrees (minimum) to the right and left of the extended tunnel width.

C5.3.4.4. Construction. To withstand the impact of debris ejected from the tunnel; the front face (including wing walls) shall be constructed of reinforced concrete, with a minimum thickness equal to 10 percent of the barricade height, but in no case less than 12 inches [30.5 cm]. The concrete wall shall have a spread footing of sufficient width to prevent significant settlement. In addition, the central wall, wing walls, and footing shall be structurally tied together to provide stability. The backfill behind the concrete wall may be composed of any fill material, to include rock rubble from the tunnel excavation, with a maximum particle size of 6 inches [15.2 cm] within the area extending out to 3 feet [0.9 m] from the rear face of the wall.



LEGEND:

S = Barricade standoff distance from portal
W = Width of barricade (excluding wing walls)
H = Height of barricade
V = Width of munitions transport vehicles
R = Turning radius of munitions transport vehicles
C = Crest width
w = Tunnel width at portal
h = height of tunnel

FIGURE C5.F4. Portal Barricade Location, Height, and Width (see paragraph C5.3.4)

C5.3.5. <u>Earth-Filled, Steel Bin-Type Barricades (ARMCO Revetments or Equivalent) for Outside Storage</u>

C5.3.5.1. These barricades, also known as ARMCO, Inc. revetments, are earth-filled steel bins used to separate AE awaiting scheduled processing (e.g., AE on a flight line associated with aircraft parking or loading operations; or the temporary positioning of AE awaiting transfer to preferred, long-term storage). These barricades, which are also used to separate explosive-loaded aircraft, are normally used to form a series of cells. They are designed to limit the MCE, for QD siting purposes, of AE properly positioned in separate cells by preventing prompt detonation transfer to adjacent cells.

C5.3.5.2. ARMCO, Inc. Revetment Cells (see paragraph C6.2.3 of reference (j)):

C5.3.5.2.1. Armco Inc. revetments cells are approved for storage of any HD 1.1 and HD 1.2 AE assigned to SG 1 through 4, as discussed in paragraph C3.2.3. In addition, storage of HD 1.3, HD 1.4, or HD 1.6 items is approved.

C5.3.5.2.2. When properly sited, these cells prevent prompt detonation transfer; however; all assets in the series of cells are at risk of loss. Although a revetment is effective in limiting the blast loading of an adjacent ES to that produced by the largest contents of a single cell, there is a significant probability that the contents of many of the cells will be damaged or destroyed by the initial and subsequent fire and explosion events. The extent of such losses increases with the amount of explosives present.

C5.3.5.3. <u>Types of ARMCO, Inc. Revetments</u>

C5.3.5.3.1. Type A revetments, which must be a minimum of 7 feet [2.1 m] thick, can be used to limit a MCE in a series of cells to the largest quantity in a single cell, provided the quantity in the single cell does not exceed 30,000 pounds NEW [NEQ]. [13,608 kg]

C5.3.5.3.2. Type B revetments, which must be a minimum of 5.25 feet [1.6 m] thick, can be similarly used to limit the MCE, provided no cell contains more than 5,000 pounds NEW [2,268 kg NEQ].

C5.3.5.4. For ARMCO revetments to be used effectively, the following conditions must be met:

C5.3.5.4.1. The criteria shown in Figure C5.F3.

C5.3.5.4.2. AE shall be positioned no closer than 10 feet [3.1 m] from cell walls, no closer than 3 feet [0.9 m] from the end of the wing walls, and no higher than 2 feet [0.6 m] below the top of cell walls.

C5.3.5.4.3. AE shall be distributed over the available area within the cell, rather than being concentrated in a small area.

C5.3.5.4.4. AE stored in a cell in quantities near the maximum NEW limit shall not be configured into a single row of pallets, stacks, or trailers.

C5.3.5.4.5. The storage of AE in flammable outer-pack configurations shall be minimized.

C5.4. <u>SITE AND GENERAL CONSTRUCTION PLANS REVIEW</u>

C5.4.1. The following site and general construction plans shall be submitted to the DDESB for review and approval:

C5.4.1.1. New construction of:

C5.4.1.1.1. AE facilities. (NOTE: See Appendix 1 (AP1) for the definition of AE facility).

C5.4.1.1.2. Non-AE related facilities within QD arcs.

C5.4.1.2. Facility modifications, change of mission, or change of operations that increase explosive hazards (e.g., personnel exposures, NEW, change in HD, nature of operation, etc.).

C5.4.1.3. Change of use of non-AE related facilities that require application of more stringent explosives safety criteria. (For example, an airfield restricted to DoD use only, changed to joint DoD and non-DoD use.)

C5.4.2. Vulnerable facility construction. Although site plans for construction of vulnerable facilities (e.g., schools, high-rise buildings, restaurants, etc.) located on a DoD installation that are outside but near QD arcs are not required, it is recommended that they be submitted to the DDESB for review and comment.

C5.4.3. Site and general construction plans need not be submitted to the DDESB for facility modifications, change of mission, or change of operations that do not introduce additional explosives hazards or do not increase NEW, chemical agent hazards, or personnel exposure.

C5.4.4. Site Plan Submission Requirements.

C5.4.4.1. Preliminary. When required by the DoD Component, Preliminary Site Plan submissions shall include, at a minimum, the information specified below in subparagraphs C5.4.4.3.1. to C5.4.4.3.6. and C5.4.4.3.12. (NOTE: If sufficient detail is available, the Preliminary and Final Site Plan Submissions can be combined into a Final Site Plan Submission).

C5.4.4.2. Final. Final Site Plan submission shall include the information in subparagraphs C5.4.4.3.1. to C5.4.4.3.12., below.

C5.4.4.3. Site Plan Contents. A Site Plan should consist of:

C5.4.4.3.1. The DoD Component's approval, in the transmittal document, of the proposal, along with any changes, modifications, or specific precautionary measures considered necessary.

C5.4.4.3.2. Drawings, at a scale of 1 in equals not more than 400 ft or metric equivalent. (NOTE: Smaller scale drawings may periodically be necessary to properly reflect certain distance and structure relationships within the area surrounding a given project.) When standard drawings exist for a building or group of buildings that the DDESB has reviewed and declared acceptable (the Definitive Drawing), the drawing does not need to be resubmitted. In such cases, the site plan must note the Definitive Drawings for each building or structure to be constructed.

C5.4.4.3.3. The distances between the facility to be constructed or modified and all ES within QD arcs impacted by the project, to include on- and off-installation power transmission and utility lines; the installation's boundary; public railways; and public highways.

C5.4.4.3.4. A description of use and occupancy of each ES within IBD of the facility to be constructed or modified.

C5.4.4.3.5. The NEW and HD of the AE that will be stored or handled in the facility to be constructed or modified or that will impact the project.

C5.4.4.3.6. Anticipated personnel limits for the new or modified facility, to include a breakdown by room or bay, when appropriate.

C5.4.4.3.7. Approved drawings or, when approved drawings are not used, general construction details to include: materials used, dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, hazardous waste disposal systems, lightning protection system, static grounding systems, process equipment, and auxiliary support structures.

C5.4.4.3.8. A summary of the design procedures for any engineering protections, which the DDESB has not already approved, that are to be used. The summary shall include: a statement of the design objectives in terms of protection categories to be obtained (see reference (j)), the explosives quantities involved, the design loads applied, any material properties and structural behavior assumptions made, references, and the sources of methods used. (NOTE: Only engineers who are experienced in the field of structural dynamics and who use design procedures accepted by professionals, in that field, may design explosion resistant facilities.)

C5.4.4.3.9. Information on the type and arrangement of explosives operations or chemical processing equipment.

C5.4.4.3.10. A topography map, with contours (when terrain features are considered to provide natural barricading) or topography that otherwise influence the facility's layout, as in some chemical operations.

C5.4.4.3.11. When chemical agents are involved, also provide information on:

C5.4.4.3.11.1. Personnel protective clothing and equipment to be used.

C5.4.4.3.11.2. Treatment of all effluent and waste materials and streams.

C5.4.4.3.11.3. The adequacy of medical support.

C5.4.4.3.11.4. The average wind speed and direction.

C5.4.4.3.11.5. Other support facilities pertinent to chemical safety.

C5.4.4.3.11.6. The warning and detection systems to be used.

C5.4.4.3.11.7. Any hazard analysis performed.

C5.4.4.3.12. An indication of any deviations from pertinent safety standards that local conditions cause.

C5.4.4.4. Records.

C5.4.4.4.1. The installation that submits the site plan shall maintain a copy of:

C5.4.4.4.1.1. The complete site plan and the final safety submission.

C5.4.4.4.1.2. A copy of the DDESB approval.

C5.4.4.4.2. Installations shall develop and maintain current (with the latest site plan approval) installation maps, and drawings that show QD arcs.

C5.4.4.4.3. Installations shall ensure that site plans are reconciled with the installation's Master Planning Documents.

C5.5. Criteria for Non-DoD, Explosives Activities (AE Operations and Storage) on DoD Installations

C5.5.1. Non-DoD explosives activities shall only be conducted on DoD property per Table C5.T3. These non-DoD explosives activities must also comply with Bureau of Alcohol, Tobacco, and Firearms (BATF), Federal Aviation Administration (FAA), and other Federal, State, and local regulations. Definitions for the terminology used in Table C5.T3. can be found in the Glossary.

C5.5.2. For these types of non-DoD explosives activities, the Department of Defense shall be responsible for ensuring that IMD requirements only, as outlined in explosives site plan submissions, are met. DoD oversight of these non-DoD explosives activities is not intended.

C5.5.3. Non-DoD, explosives activities shall be evaluated based on IMD between multiple PES to ensure non-propagation. Where IMD is not met, then the NEW at each site not meeting IMD separation requirements shall be added together to determine the basis for the applicable IMD or IBD to use for separation of DoD sites.

C5.5.4. In Table C5.T3., "Check for IM" means if IMD is not maintained between each PES, explosives quantities shall be totaled.

C5.5.5. IBD shall be determined based on this Standard.

C5.5.6. The DoD site approval for non-DoD, explosives activities is limited to the area encumbered by the IBD arcs.

C5.5.7. Review of building design, lightning protection, etc., is not necessary unless design features are used as justification to reduce the IBD arc.

TABLE C5.T3. CRITERIA FOR NON-DoD EXPLOSIVES ACTIVITIES ON DoD INSTALLATIONS

To ➔ From ➘	Non-DoD Storage	DoD/Joint Storage	Non-DoD Operations	DoD Operations	Shared Launch Facilities	DoD Non-Explosives Facilities/Operations Non Related
Non-DoD Storage	Check for IMD	IMD	Check for IMD	IBD	IBD	IBD
Non-DoD Operations	Check for IMD	IBD	Check for IMD	IBD	IBD	IBD
Shared Launch Facilities	IBD	IBD	IBD	IBD	ILD	IBD
DoD/Joint Storage	IMD	IMD	IBD	ILD	IBD	IBD
DoD Operations	IBD	ILD	IBD	ILD	IBD	IBD

C5.6. Site Plans Not Required

Site plans are not required to be submitted to the DDESB for the specific situations listed below (Note: DoD Components shall specify siting and documentation requirements for these situations):

C5.6.1. Storage and associated handling of HD 1.4S (see subparagraph C9.4.4.3.).

C5.6.2. Interchange yards limited to those operations described in paragraph C9.8.6.

C5.6.3. Inspection stations where only the operations described in paragraph C9.8.10. are performed.

C5.6.4. Transportation mode change locations, which involve roll-on/roll-off operations where no lifting is involved, and for off-installation MILVAN/ISO container inter-/intramodal transfers (involving highway and rail modes only) where containers are not stored or other operations are performed (see paragraph C9.8.12.).

C5.6.5. Parking of aircraft loaded with specific munitions (see subparagraph C9.6.1.1.2.2.), while in designated aircraft parking areas that meet airfield criteria, and associated handling of these munitions, provided the quantity of munitions involved in the operation is limited to a single aircraft load.

C5.6.6. The handling of HD 1.3 and HD 1.4 material (≤ 300 lbs NEW) [≤ 136.1 kg] necessary for ships' security and safety-at-sea (see subparagraph C9.6.2.1.2.2.).

C5.6.7. Storage of limited quantities of HD 1.2.2, HD 1.3, or HD 1.4, for reasons of operational necessity, as permitted by subparagraph C9.4.2.10. and applicable notes of Tables C9.T13. and C9.T14.

C5.6.8. Certain contingency and combat training operations as described in section C10.3.

C5.6.9. Inert storage accessed by personnel related to the explosives mission.

C5.6.10. Locations used for a demilitarization processing operation of expended .50-caliber and smaller cartridge casings that meet subparagraphs C9.8.19.1. and C9.8.19.2., and are located outside of IBD from all PES.

C6. CHAPTER 6

ELECTRICAL STANDARDS

C6.1. GENERAL

This Chapter establishes safety standards for the design and installation of electrical equipment and wiring for explosives environments.

C6.1.1. For this purpose, the Department of Defense adopts Article 500 of the Code "Hazardous (Classified) Locations" of the National Fire Protection Association (NFPA) 70 (reference (l)) (a.k.a., National Electrical Code (NEC)). This Code establishes standards for the design and installation of electrical equipment and wiring for atmospheres containing combustible dusts, flammable vapors or gasses that are comparably hazardous.

C6.1.2. This Chapter does not address extraordinarily hazardous situations (e.g., nitroglycerin manufacturing) that will require special consideration and design features. In these situations, the DoD Components shall develop site-specific design criteria.

C6.2. HAZARDOUS LOCATIONS

NEC definitions of Class I, Division 1, and Class II, Division 1, hazardous locations are modified as follows for DoD explosives applications:

C6.2.1. Areas containing explosives dusts or explosives that may through handling produce dust capable of being dispersed in the atmosphere shall be regarded as Class II, Division 1.

C6.2.2. Areas in which explosives sublimation or condensation may occur shall be regarded as both Class I, Division 1 and Class II, Division 1.

C6.3. SPECIAL OCCUPANCIES

To ensure assignment to the proper hazardous location, class and group, it is necessary to have knowledge of the properties of explosives involved. Minimum requirements include sensitivity to heat and spark and thermal stability.

C6.3.1. If the properties of an explosive are such that Class I or Class II, or both, provide inadequate protection under prevailing conditions, use of any of the following approaches is acceptable:

C6.3.1.1. Intrinsically safe equipment.

C6.3.1.2. Purged or pressurized and suitably temperature-limited equipment.

C6.3.1.3. Exclusion of electrical equipment from the hazardous atmosphere.

C6.3.1.4. Isolation of equipment from the hazardous atmosphere by means of dust, vapor, or gas-free enclosures with surface temperatures positively maintained at safe levels.

C6.3.2. Underground Storage Facilities. All wiring and electrical equipment in underground storage facilities shall, in addition to any other requirements of this Chapter, be of moisture and corrosion resistant materials and construction unless a site specific analysis indicates that such construction is not necessary. Underground facilities shall have emergency lighting systems to provide minimum illumination in the event of a power failure.

C6.4. STATIC ELECTRICITY

Personnel and equipment in hazardous locations (section C6.2.) and locations where static sensitive electro-explosive device (EED) are exposed shall be grounded in a manner that effectively discharges static electricity and prevents static electricity accumulations that may be capable of initiating dusts, gases, vapors, or exposed EEDs. Permanent equipment in contact with conductive floors and tabletops shall not be considered grounded. Static grounds shall be bonded to the facility's grounding system (see chapter 7).

C6.5. ELECTRIC SUPPLY SYSTEMS

There may be mutual hazards when PES are located near electric supply lines. To protect against these hazards, the following separation requirements apply to all new construction (NOTE: PTRD and IBD specified in paragraphs C6.5.3. and C6.5.4. are based on airblast overpressure only; fragment distances do not apply):

C6.5.1. Electric lines serving explosives operating facilities shall be installed underground from a point not less than 50 ft [15.3 m] away from such facilities.

C6.5.2. Overhead electric service lines shall be no closer to combustible PES or to an open PES than the length of the electric lines between the nearest service poles and the length of the nearest service pole. An exception is when an effective means (e.g., line spacers, weights, etc.) is provided to ensure that energized lines on breaking cannot come into contact with the facility or its appurtenances.

C6.5.3. Electric distribution lines carrying less than 69 kilovolt (kv), the tower or poles supporting those lines, and unmanned electrical substations shall be no closer to PES than PTRD. (NOTE: Lesser distance permitted by section C9.4. for the placement of electrical substations and transformers that support explosives areas.)

C6.5.4. Electric transmission lines carrying 69 kv or more and the tower or poles supporting them shall be located no closer to the PES than:

C6.5.4.1. IBD, if the line in question is part of a grid system serving a large off-base area.

C6.5.4.2. PTRD, if loss of the line does not create serious social or economic hardships.

C6.5.5. Electric transmission lines which can be interrupted without loss of power (i.e., power is rerouted through existing lines or networks) shall be separated from explosives sites in accordance with paragraph C6.5.2.

C6.6. HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO)

Military Munitions (at times also referred to as ordnance or AE) containing electrically initiated device (EID) shall be designed or protected such that electromagnetic radiation (EMR) does not cause their inadvertent initiation, degradation or disablement. Both direct radio frequency (RF) induced actuation of the EID or electrical coupling to and triggering of the associated firing circuits can occur, especially in a tactical radiated electromagnetic environment (EME). Examples of EID include: exploding foil initiators, laser initiators, burn wires, fusible links, and EED, such as, hot bridge wires, carbon bridges, and conductive compositions.

C6.6.1. During acquisition, HERO testing and certification shall be accomplished, both for routine employment mission profiles, and for any anticipated joint- or combined-operational employment to include transshipment exposures through EME differing from the employment environment.

C6.6.2. During subsequent phases of life cycle munitions management, additional HERO testing and certification shall be accomplished when legacy munitions are redesigned or before they are employed through EME for which they where not previously HERO certified.

C6.6.3. Minimally, HERO certification shall involve exposure, without adverse effects, of the munitions to the EME relevant to all life cycle configurations, including packaging, handling, storage, transportation, checkout, loading and unloading, and launch.

C6.6.4. All HERO test and certification data shall be compiled in a centralized data repository to support the Joint Spectrum Center Ordnance Electromagnetic Environmental Effects (E3) Risk Assessment Database (JOERAD), for subsequent use in information applications supporting Combatant Commands and the DoD Components.

C6.6.5. The DoD Components shall take measures (e.g., identifying susceptibilities, quantifying electromagnetic environments, evaluating risks associated with operating procedures, and establishing tailored emission control (EMCON) instructions) to ensure that HERO effects on munitions are resolved during the planning of joint or combined operations or training exercises.

C7. CHAPTER 7

LIGHTNING PROTECTION

C7.1. POLICY

This Chapter defines minimum explosives safety criteria for the design, maintenance, testing and inspection of lightning protection systems (LPS). Properly maintained LPS are required (with exceptions) for AE facilities. If other LPS for these facilities are used, they shall offer equivalent protection to the types prescribed in this Chapter.

C7.2. LPS DESIGN

C7.2.1. Design and installation of a LPS used to protect DoD AE must meet, at a minimum, the requirements of NFPA 780 Lightning Protection Code (reference (m)). LPS must feature air terminals, low impedance paths to ground, sideflash protection, surge suppression or grounding of all conductive penetrations into the protected area, and earth electrode systems. Structural elements of the building may serve as air terminals, down conductors, or the earth electrode. LPS used to protect DoD AE must be designed to intercept lightning at a 100 ft [30.5 m] or less striking distance arc in accordance with reference (m).

C7.2.1.1. Air Terminals. An air terminal is a component of an LPS that is able to safely intercept lightning strikes. Air terminals may include overhead wires or grids, vertical spikes, or a building's grounded structural elements. Air terminals must be capable of safely conducting a lighting strike.

C7.2.1.2. Down Conductors. Down conductors (flat or round) provide low impedance paths from the air terminals described above to the earth electrode (ground) system. Structural elements having a high current capacity and a low impedance to ground need not be augmented with wires. Where wires are used as down conductors, these shall meet the requirements of reference (m).

C7.2.1.3. Sideflash Protection. Protection from side flash caused by lightning shall be obtained by either separation distance or bonding in accordance with reference (m), except as modified herein.

C7.2.1.3.1. Fences and railroad tracks located within six feet of a structure's LPS shall be bonded to the structure's LPS.

C7.2.1.3.2. The reinforcing bars in adjacent structural elements must be joined in a manner to provide electrical bonding between the elements. This is an absolute requirement for facilities that are used to store AE. Techniques commonly used and approved in the construction industry to join reinforcing steel are acceptable for this purpose. The steel arch of an ECM must be similarly joined to the rebar in the floor.

C7.2.1.4. Surge Protection for Incoming Conductors. A LPS shall include surge protection for all incoming conductors. The surge protection must include suppression at the entrance to the building from each wire to ground. Shielded cabling, power cabling, communication lines, and electrical conduit shall be buried underground in conduit for a minimum of 50 feet [15.3 m] before entering the structure. All other metallic utility lines and pipes must be electrically connected to the LPS or the structural steel of the building just before they enter the building.

C7.2.1.5. Earth Electrode System. Earth electrode systems dissipate the current from a lightning strike to ground. Earth electrode systems may be Ufer grounds, ground loop conductors, radials, grounding rods, ground plates, a cable immersed in nearby salt water, chemical grounds that are installed for the purpose of providing electrical contact with the earth, or combinations of these.

C7.2.2. Underground Storage Facility. An underground storage site normally requires designed protection against lightning only for exposed or partially exposed parts. Metal and structural parts of the site that have less than 2 feet [60 cm] of earth cover shall be protected as for an aboveground site. Lightning protection requirements shall be considered on a site specific basis.

C7.3. INSPECTION, TESTING, AND TRAINING

C7.3.1. Visual inspection. LPS shall be periodically inspected at a frequency determined by each DoD Component. Visual inspections shall be conducted at least yearly.

C7.3.2. Electrical tests. LPS shall be periodically tested electrically as specified in paragraphs C7.3.2.1. and C7.3.2.2., below. Electrical testing shall be accomplished at least every 2 years.

C7.3.2.1. Bonding (Resistance) Tests. Bonding (resistance) tests shall be conducted periodically (or after facility modification that may affect bonding). A maximum resistance value of one ohm is permitted across all bonds.

C7.3.2.2. Resistance to Earth Tests. Resistance to earth tests of LPS shall be conducted periodically during the same season of the year (or after facility modification that may have affected the system).

C7.3.3. Records. Records of resistance to earth tests shall be kept on file for the last six inspection cycles. These records shall be reviewed for trend analysis.

C7.3.4. Training. Personnel responsible for maintenance, inspection and testing must be familiar with the fundamentals described in reference (m) and herein as they relate to AE facilities to ensure requirements of paragraphs C7.3.1. and C7.3.2., above, are met.

C7.4. LIGHTNING PROTECTION EXCEPTIONS

Properly maintained LPS are required for AE facilities, with the follow exceptions:

C7.4.1. Explosives operations served by a local lightning warning system to permit operations to be terminated before the incidence of an electrical storm, if all personnel are provided with protection equivalent to PTRD, and the damage from a lighting strike is acceptable to the DoD Component.

C7.4.2. Facilities containing only AE that cannot be initiated by lightning, as determined by the DoD Component concerned and approved by DDESB, and where no fire hazard exists.

C7.4.3. Facilities where personnel are not expected to sustain injury and at the same time, the resulting economic loss of the structure, its contents and/or surrounding facilities is minimal.

C8. CHAPTER 8
HAZARD IDENTIFICATION FOR FIRE FIGHTING AND EMERGENCY PLANNING

C8.1. SCOPE AND APPLICABILITY

C8.1.1. This Chapter establishes standard firefighting hazard identification measures to ensure a minimum practicable risk in fighting fires involving AE. These identification measures are based on the classification of AE fires into four fire divisions according to their predominant hazard. Guidelines are provided to DoD Components for the development of emergency plans, which include safety, security, and environmental protection. These plans shall be coordinated with local authorities.

C8.1.2. The following are outside the scope of this chapter and are the responsibility of the DoD Component:

C8.1.2.1. Firefighting procedures.

C8.1.2.2. Training of firefighting personnel.

C8.1.2.3. Use and maintenance of firefighting equipment and vehicles.

C8.1.2.4. Provision of water supply and alarm systems.

C8.1.2.5. First aid measures.

C8.1.2.6. Other measures required in firefighting.

C8.1.3. AE hazard symbols and supplemental symbols including chemical agent symbols (see section C8.4.) are for firefighting situations.

C8.2. FIRE DIVISIONS

There are four fire divisions. Fire division 1 indicates the greatest hazard. The hazard decreases with ascending fire division numbers from 1 to 4 and are related to HD as shown in Table C8.T1.

C8.T1. Fire Divisions

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

C8.3. FIRE DIVISION SYMBOLS

C8.3.1. The four fire divisions are represented by four distinctive symbols so that firefighting personnel can recognize the hazards. A fire division number is shown on each symbol. For the purpose of identifying these symbols from long range, the symbols differ in shape as shown in Table C8.T2.

C8.T2. Fire Division Symbols

Shape	Fire Division Symbol
Octagon	1
Cross	2
Inverted triangle	3
Diamond	4

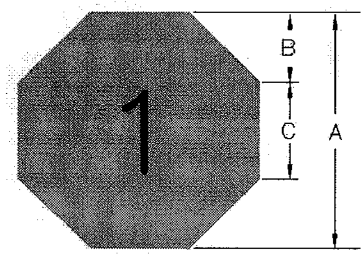
C8.3.2. The shape and dimensions of the symbols are shown in Figure C8.F1. This shape and color scheme is consistent with UN, North Atlantic Treaty Organization (NATO), and International Maritime Organization (IMO) requirements. For application on doors or lockers inside buildings, half-sized symbols may be used.

C8.3.3. At the discretion of the DoD Components, circumstances (e.g., security, etc.) may make it undesirable to post fire symbols at an AE storage site.

C8.4. CHEMICAL AGENT AND CHEMICAL MUNITION HAZARD SYMBOLS

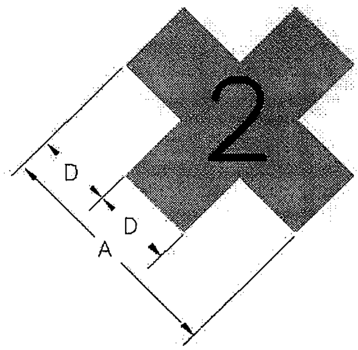
C8.4.1. The storage of chemical agents and chemical munitions requires the use of chemical hazard symbols. These symbols (see Figures C8.F2. and C8.F3.) shall be used in conjunction with fire symbols, where appropriate. Some of the common chemical agents used in AE, the CG of that AE, and the chemical hazard symbols required in storage are specified in Table C8.T3.

C8.4.2. The following sections describe these symbols, the hazards indicated by the symbols, and the recommended protective clothing and equipment to be used for fighting fires involving these chemical agents and chemical munitions. The DoD Components shall determine protective clothing requirements for other than firefighting situations.



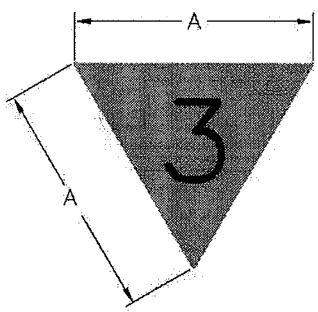
Fire Division 1 or 5

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



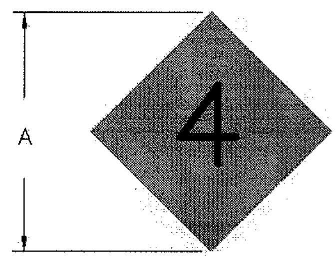
Fire Division 2 or 6

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



Fire Division 3

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



Fire Division 4

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

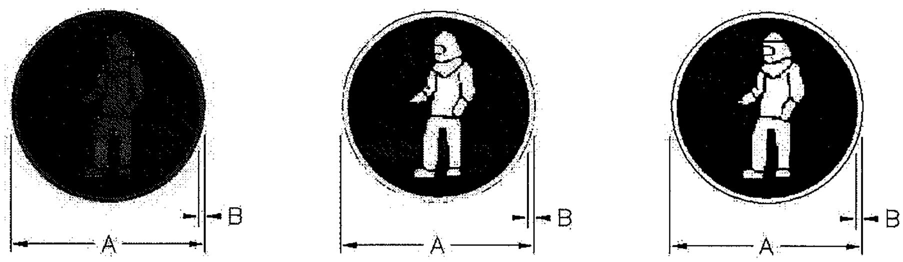
Dimensions	Large Symbol		Small Symbol	
	inches	metric (mm)	inches	metric (mm)
A	24	610	12	305
B	7	178	3.5	89
C	10	254	5	127
D	8	203	4	102
Letters (height)	10	254	5	127
Letters (thickness)	2	51	1	25

Colors (per Federal Standard 595A or GSA Catalog)

Background: Orange #12246

Letters: Black # 17038

FIGURE C8.F1. Fire Division Symbols

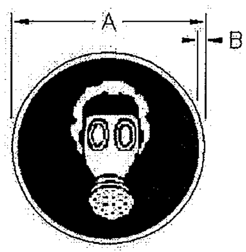


Symbol 1. Wear full protective clothing.
Background is blue, and figure and rim are as follows:

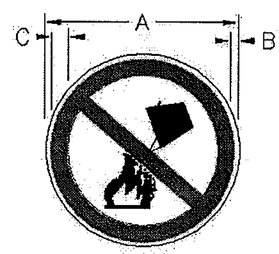
Red for Set 1 Protective Clothing:
24-inch: NSN 7690-01-081-9586
12-inch: NSN 7690-01-081-9585

Yellow for Set 2 Protective Clothing:
24-inch: NSN 7690-01-081-9587
12-inch: Not available

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



Symbol 2. Wear breathing apparatus.
Background is blue.
Figure and rim are white.
24-inch: NSN 7690-01-081-9589
12-inch: NSN 7690-01-082-0291



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

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

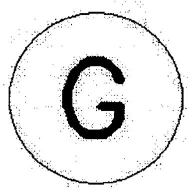
Colors (per Federal Standard 595A or GSA Catalog)

Red #11105 White # 17875

Blue #15102 Black #17038

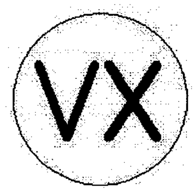
Yellow #13538

FIGURE C8.F2. Chemical Hazard Symbols



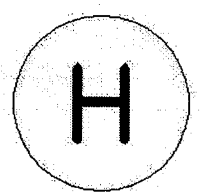
G–Type Nerve Agents

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



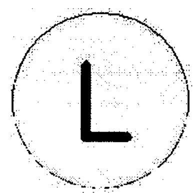
VX Nerve Agents

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



H–Type Mustard Agents

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



Lewisite

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

Colors (per Federal Standard 595A or GSA Catalog)

Background: Yellow #13538

Letters: Black # 17038, as follows:

(a) 12 inches [305 mm] high and 2 inches [51 mm] thick on a 24-inch [610 mm] diameter circle.

(b) 6 inches [152 mm] high and 1-inch [25 mm] thick on a 12-inch [305 mm] diameter circle.

FIGURE C8.F3. Supplemental Chemical Hazard Symbols

Table C8.T3. Compatibility Group and Chemical Hazard Symbols Required for Storage of Chemical Ammunition and Substances.

Chemical Agents and Munitions	CG [2]	Full Protective Clothing			Breathing Apparatus	Apply No Water
		Set 1	Set 2	Set 3		
Toxic Agents[1]	K	X				
Tear Gas, O-Chlorobenzol	G		X			
Smoke, Titanium Tetrachloride	G		X			
Smoke, Sulphur trioxide-chlorosulphonic acid solution	G		X			
Smoke, Aluminum-zinc oxide-hexachloroethane	G				X	X
White Phosphorous	H			X		
White Phosphorous plasticized	H			X		
Thermite or Thermate	G				X	X
Pyrotechnic Material	G				X	X
Calcium Phosphide	L				X	X
Signaling Smokes	G				X	
Isobutyl methacrylate with oil	J				X	
Napalm (NP)	J			X	X	X
Triethylaluminim	L			X		X

Notes:

1. Toxic Agents without explosives components that normally would be assigned to HD 6.1 may be stored as CG K.
2. See Chapter 3 for information pertaining to CG.

C8.4.2.1. Set 1 of Chemical Hazard Symbol 1 requires full protective clothing (see Figure C8.F2. and Table C8.T3.) and indicates the presence of highly toxic chemical agents that may cause death or serious damage to body functions. The following full protective clothing shall be used:

C8.4.2.1.1. Service-certified protective gas mask.

C8.4.2.1.2. Impermeable suit.

C8.4.2.1.3. Impermeable hood.

C8.4.2.1.4. Impermeable boots.

C8.4.2.1.5. Impermeable undergarments.

C8.4.2.1.6. Impermeable coveralls.

C8.4.2.1.7. Impermeable protective footwear.

C8.4.2.1.8. Impermeable gloves.

C8.4.2.2. Set 2 of Chemical Hazard Symbol 1 requires full protective clothing (see Figure C8.F2. and Table C8.T3.) and indicates the presence of harassing agents (riot control agents and smokes). The following protective clothing shall be used:

C8.4.2.2.1. Service-certified protective gas masks or self-contained breathing apparatus (SCBA).

C8.4.2.2.2. Permeable coveralls

C8.4.2.2.3. Protective gloves.

C8.4.2.2.4. Firefighting personnel equipped with normal heat-resistant clothing (e.g., bunker suit) and gas mask or SCBA do not require the set 2 protective clothing.

C8.4.2.3. Set 3 of Chemical Hazard Symbol 1 requires full protective clothing (see Figure C8.F2. and Table C8.T3.) and indicates the presence of WP or other spontaneously combustible material. The following protective clothing shall be used:

C8.4.2.3.1. Service-certified protective gas masks or SCBA.

C8.4.2.3.2. Flame-resistant coveralls.

C8.4.2.3.3. Flame-resistant gloves.

C8.4.2.3.4. Firefighting personnel equipped with normal heat-resistant clothing (e.g., bunker suit) and gas mask or SCBA do not require the set 3 protective clothing.

C8.4.2.4. Chemical hazard symbol 2 requires the wearing of breathing apparatus (see Figure C8.F2. and Table C8.T3.) and indicates the presence of incendiary or readily flammable chemical agents that present an intense radiant heat hazard. Protective masks shall be used to prevent inhalation of smoke from burning incendiary mixtures.

C8.4.2.5. Chemical hazard symbol 3 warns against applying water (see Figure C8.F2. and Table C8.T3.) and indicates a dangerous reaction will occur if water is used in an attempt to extinguish fire.

C8.5. Firefighting Measures

C8.5.1. Firefighters should have a thorough knowledge of the hazards associated with AE fires and expected AE reactions. The DoD Component shall brief the firefighting forces and other essential personnel before approaching the scene of the fire. They shall be informed of the known hazards and conditions existing at the fire scene prior to proceeding to the fire location.

C8.5.2. Fires involving AE will be fought according to the HD, fire division, the progression of the fire, and the procedures specified by the DoD Component. Special firefighting instructions addressing AE hazards will be developed according to the needs of the DoD Component.

C8.5.3. All fires in the vicinity of AE shall be immediately reported and:

C8.5.3.1. Shall be fought if not involving AE.

C8.5.3.2. Shall not be fought if the fire involves AE, or is supplying heat to the AE, or is so large that it cannot be extinguished with the equipment at hand. Personnel shall be evacuated per paragraph C8.5.4.

C8.5.4. Emergency withdrawal distances. Commanders are responsible for developing evacuation plans that include the applicable withdrawal distances as part of the installation's emergency planning (see section C8.6.).

C8.5.4.1. Non-essential personnel. These emergency withdrawal distances are intended for application in emergency situations only and are not used for facility siting.

C8.5.4.1.1. The initial withdrawal distance for non-essential personnel shall be at least IBD for the PES involved. If the fire involves AE, AE involvement is imminent, or the fire is or may become uncontrollable, then use the emergency withdrawal distances listed in Table C8.T4. The emergency withdrawal distances depend on fire involvement and on whether or not the HD, fire division and quantity of explosives are known. If fire is not affecting AE or involvement is not imminent, then emergency authorities shall determine the withdrawal distance based on the situation at hand.

C8.5.4.1.2. Structures or protected locations offering equivalent protection for the distances in Table C8.T4. may be used in lieu of relocating personnel from the structure or location to the specified emergency withdrawal distance

C8.5.4.2. Essential personnel. Emergency authorities on-site shall determine the withdrawal distance for essential personnel at accidents. Emergency authorities shall determine the essential personnel.

C8.5.5. AE containing both explosives and chemical agents (see Table C8.T3.) requires special attention and precautions in firefighting. Fires involving such AE shall be fought in accordance with their fire division characteristics. Responding personnel must consider the additional hazards and precautions discussed in chapter 11 for the chemical agents involved.

C8.5.6. Entry to underground storage facilities following a fire or explosion requires special precautions. Emergency personnel shall monitor for the presence of toxic fumes or oxygen depleted atmospheres and evaluate structural damage during initial entry following an accident. Commanders shall develop written procedures that define actions to be taken in such emergency situations.

C8.6. Emergency Planning

C8.6.1. Installations or responsible activities shall develop standard operating procedures (SOP) or plans designed to provide safety, security, and environmental protection for accidents involving AE. Plans shall be coordinated with the applicable Federal, State, and local emergency response authorities (e.g., law enforcement, fire departments, and hospitals, etc.) and any established Local Emergency Planning Committees (LEPC). The SOP or plans shall include the following:

C8.6.1.1. Specific sections and guidance that address emergency preparedness, contingency planning, and security. (NOTE: For security, the SOP or plans shall limit access to accident sites to trained and authorized personnel.)

C8.6.1.2. Procedures that minimize the possibility of an unpermitted or uncontrolled detonation, release, discharge, or migration of AE out of any storage unit when such release, discharge, or migration may endanger human health or the environment.

Table C8.T4. Emergency Withdrawal Distances for Non-essential Personnel[1]

HD	UNKNOWN QUANTITY (ft) [m]	KNOWN QUANTITY (ft) [m]
Unknown, located in facility, truck and or tractor trailer	4,000 *[1,219]*	4,000 *[1,219]*
Unknown, located in railcar	5,000 *[1,524]*	5,000 *[1,524]*
1.1^2 and 1.5	Same as unknown facility, truck,trailer, or railcar as appropriate	For Transportation: NEWQD ≤ 500 lb D = 2,500 ft *NEWQD ≤ 226.8 kg* *D = 762 m* NEWQD > 500 lb D = 5,000 ft for railcars D =4,000 ft for other modes *NEWQD > 226.8 kg* *D = 1,524 m for railcars* *D =1,219 m for other modes* For bombs and projectiles with caliber 5-in [127 mm] or greater D = 4,000 ft D = 1,219 m For Facilities: NEWQD ≤ 15,000 lb D = 2,500 ft *NEWQD ≤ 6,804 kg* *D = 762 m* 15,000 lbs < NEWQD ≤ 55,285 lbs D = 4,000 ft *6,804 kg < NEWQD ≤ 25,077 kg* *D = 1,219 m* NEWQD > 55,285 lbs $D = 105W^{1/3}$ *NEWQD > 25,077 kg* $D = 41.65Q^{1/3}$
1.2^2 and 1.6	2,500 *[762]*	2,500 *[762]*
1.3	600 *[183]*	Twice IBD with a 600 ft (183 m) minimum (C9.T13)
1.4	300 *[91.5]*	300 *[91.5]*