CHAPTER 18 - EXPLOSIVES, PROPELLANTS, AND PYROTECHNICS

Table of Contents:

18.1 SCOPE

This chapter sets forth the minimum requirements, both for Government and contractor personnel, for the safe use, handling, and control of explosives at NASA Glenn Research Center (Cleveland and Plum Brook Station). This Chapter represents is an adaptation for GRC of the 1993 version of NSS 1740.12 as pertains to Explosive Safety Standards. *Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12*

It provides directives for protecting personnel and property involved in explosive operations at all levels from the hazards of explosives and explosive materials. Such materials include all types of explosives, propellants (liquid and solid), oxidizers, pyrotechnic devices, and electroexplosive devices.

18.2 DEFINITIONS AND TERMINOLOGY

a. Certification: Confirmation that an individual has been trained in the extensive knowledge and skills to safely and accurately handle a designated explosive and has passed the prescribed physical examination (see Glenn Safety Manual, Chapter 2, 18.2 (a)).
b. Certified personnel (CP): Those who meet the requirements set forth by the authority responsible for certification. CP are not associated with safety permits, as for the operation of a test rig or facility. All personnel engaged in Category I (Hazardous operations) operations, as determined by line management, will be certified as capable to operate or perform their jobs in a safe manner if they meet the following standards set forth here.

    1. physical exam
    2. OTJ training
    3. classroom training

4. written exam
5. issuance of a certification card or listing on a CP roster
6. annual retraining
7. periodic cat I recertification not to exceed 4 years

c. Qualified: Persons employed on a merit basis to demonstrate extensive technical training, education and experience to satisfy the immediate supervisor, who demonstrates capable safe operations. A qualified person has the responsibility and the authority to control the operations.
d. Essential personnel: Personnel trained in the recognition of the hazards associated and designated as such by the CP.
e. Authorized: Personnel designated to have the authority to control operations.
f. Electroexplosive device (EED). A device containing some reactive mixture (explosive or pyrotechnic) that is electrically initiated. The output of the initiation is heat, shock, or mechanical action.
g. Explosives. Term "explosive" or "explosives" includes any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

The following table shows, briefly, the type of potential hazard and some examples of explosives in each of the DOT classes.

Class/Division	**Type of Hazard**
1.1 (class A)	Explosives that have a mass explosion hazard.
1.2 (class A or B)	Explosives that have a projection hazard, but are not a mass explosion hazard.
1.3 (class B)	Explosives that are a fire hazard, minor blast or fragment hazard, but not mass explosion.
1.4 (class C)	Explosives present only a minor fire or explosion hazard. Fire must not cause a mass explosion.
1.5 (Blasting agents)	Explosives consists of insensitive explosives. Items with very little chance for initiation under normal operating conditions. The probability is greater when transported in large quantities.

h. Explosive Equivalent Weight: The amount of a standard high explosive, which when detonated, will produce a blast effect comparable to the amount of material (solid or liquid propellant or gas) whose performance is being evaluated. It is usually expressed in equivalent weight of TNT.
i. Inhabited Building Distance: Minimum allowable unbarricaded distance between an inhabited building and an explosive facility.
j. Intraline Distance: Distance to be maintained between any two operating buildings or sites within an operating line, of which at least one building

contains, or is designed to contain explosives, except that the distance from a service magazine for the line to the nearest operating building may be not less than the intraline distance required for the quantity of explosives contained in the service magazine. Note: The intraline distance is determined by the explosive hazard classification and quantity and is specified in the QD tables in this chapter.

k. Laboratory Operations: Any operation in a laboratory where the total quantity of explosives (equivalent explosive weight) does not exceed 500 grams.
l. Magazine: A structure designed or specifically designated for the storage of explosives. There are two types of magazines 1.) Aboveground and 2.) Earth Covered Igloo (located at Plum Brook Station)
m. Magazine Distance: Minimum distance permitted between any two storage magazines. The distance is determined by the amount and classification of explosives stored therein.
n. Quantity-Distance (QD): Explosive quantity and distance separation relationships based on levels of risk considered acceptable for the stipulated exposures for explosive operations. These values are shown in the 8 series QD tables contained at the end of this chapter and in NSS 1740.12.
o. Pyrotechnics: Any combustible or explosive combinations or manufactured articles designed and prepared for the purpose of producing audible or visible effects. These are commonly referred to as fireworks.

18.3 POLICY

It is the policy of Glenn Research Center to administer its operations involving explosives at the Center so as to ensure that they are controlled from acquisition through disposal by qualified personnel. Only individuals who are trained and certified in hazardous operations in accordance with NASA's policies, who understand the potential hazards, and who have acquired the skills necessary to carry out their individual responsibilities safely will be involved in the use and handling of explosives.

18.4 RESPONSIBILITIES

18.4.1 User

It is the user's responsibility to insure that prior to conducting any operation involving explosives, that all the following requirements are met:

a. Insure the center (GRC or PBS) has adequate facilities to store, handle, or test devices or materials that are considered to be explosives, which are classified as 1.1, 1.2, 1.3, 1.4, or 1.6.
b. Insure that the Area Safety Committee is contacted first to discuss the nature and extent of the hazard to center personnel, facilities, equipment, the community and the environment prior to ordering or taking delivery of any explosive material.

c. Insure that during the safety permit application process that the Area Safety Committee is provided with all necessary documentation to insure compliance with NASA HQ requirements for handling explosives including: Site and Construction Plans (required if more than laboratory scale quantities are involved), any written Deviations or Waivers to existing procedures for handling explosives, hazard assessment form (NASA C- 923 A), applicable drawings, technical documentation or specifications, Standard Operating Procedures (SOPs) and Standard Test Procedures (STPs) to insure that explosives are received, stored, handled, tested and disposed in a safe manner.
d. Insure that GRC organizations having over sight are properly informed of the expected delivery date. This includes GSO, EMO, and Security Management Office.

18.4.2 Employees

Only essential personnel (those necessary to perform operations) shall be present in areas where explosives are handled, stored, or placed.

The two-person buddy system (see Chapter 22) shall be used where explosives are handled so that one person may give assistance to the other if any emergency occurs. The two-person system is not required when the only use of ammunition is for small arms or tools.

Supervisor Responsibilities

It is the responsibility of the area supervisor to insure that the following requirements are met:

a. Insure that facilities exist to safely store, handle or test explosives or explosive devices.
b. Insure that employees handling explosives are knowledgeable, receive adequate training on explosives and are certified to handle explosives by the NASA Safety Training Center.
c. Insure that adequate personal protective equipment is available.
d. Insure that all personnel handling explosives are trained on specific Standard Operating Procedures and Standard Test Procedures unique to the explosives being handled.
e. Insure that an up-to date copy of the explosives inventory is available in their area of responsibility.

18.4.3 Area Safety Committee

The cognizant Area Safety Committee shall be notified of the use of explosives. The Committee shall require written Standard Operating Procedures (SOP's) or Standard Test Procedures (STP's) and checklists to define proper use, handling, and storage of explosives for the system as it may pertain to the safety permit system. A copy of the approved SOP/STP will be forwarded to GSO. In addition, the requester shall route all

Purchase Requests (PR's) for explosives through the GSO and the Environment Management Office for approval.

18.4.4 Environmental Management Office

The Environmental Management Office (EMO) shall maintain an inventory of hazardous materials, including explosives. It is the User's responsibility to periodically notify the EMO/ Chemical Management Team Leader when changes occur to the inventory, such as, receipt or destruction of explosives. Disposal of any bulk explosive material must be coordinated with the EMO/Waste Management Team Leader. Arranging for the disposal of any electrically initiated devices, military or space hardware containing explosives are the responsibility of the User.

18.4.5 Glenn Safety Office

The GSO shall review all Purchase Requests (PR) for explosives, in accordance with NSS 1740.12, and shall ensure the safe use, handling, training, certifications, inventory, transportation calculated clear zones and storage of explosives.

18.4.6 Procurement Division and Transportation Management Branch

This office will ensure that contracts for the purchase of explosives contain instructions to vendors about how to properly describe, package, and transport said items in accordance with 49 CFR 500 and 29 CFR 1910. 109, 1926.900.

18.5 PROCURING EXPLOSIVES

18.5.1 Hazards Assessment Form

A Hazards Assessment Form (NASA C-923A) approved by the chairman of the cognizant Area Safety Committee must accompany every PR (Form NASA C- 923 A) for explosives. Any PR for explosives that is not accompanied by an approved NASA C-923 A shall not be processed. The requester must arrange for suitable storage for explosives prior to forwarding a PR for them.

Before approving the Hazard Assessment Form (NASA C- 923 A), the chairman of the cognizant Area Safety Committee, in consultation with the GSO, shall verify that the requested explosive is compatible with and has a net explosive weight (NEW) acceptable by the proposed storage location.

18.5.2 Purchase Request

Every (PR) for explosives shall include this instruction:

"Package shall be boldly marked as follows: **CAUTION UPON RECEIPT CALL CHEMICALS MANAGEMENT TEAM AND REQUESTOR (DO NOT OPEN)"**

In addition, every PR for explosives shall require an Explosives Description Clause, except when ammunition for small arms or tools is involved. The Explosives Description Clause shall state that the explosives vendor shall provide the following: a sectioned assembly drawing of the device, showing all electrical circuitry and general dimensions; a list of the explosive chemicals involved and the location where they are used; the total weight of the explosives in the individual loads, such as the primer mix and the main charge mix; and a current Material Safety Data Sheet (MSDS).

18.6 SYSTEM SAFETY

In general, explosives, when properly controlled and handled, are safe. However, electrical and magnetic circuits or physical abuse can cause premature firing. To minimize such hazards, a system safety approach to design is essential. The rules listed here are to be followed during design and operation of systems using explosives:

a. All designs or operations that use explosives must have the prior approval of the cognizant Area Safety Committee. Such approval must be indicated by specific wording on the Safety Permit covering the use of the explosive, its function, and the quantity authorized.
b. Each situation shall be analyzed by a hazard analysis to determine the Maximum Credible Event (MAE) possible at the site or operation. The MAE in a hazard evaluation is the worst single event that is likely to occur from a given quantity and disposition of explosives, chemical agents, or reactive material. The event must be realistic with a reasonable probability of occurrence considering the explosive characteristics and physical protection given to the item.
c. Special electrical bridge test equipment for EED's shall be limited to 10 milliamps.
d. All initiation systems (such as electrical or mechanical) shall be carefully inspected.
e. Initiating circuits shall be electrically isolated from all other circuits and ground systems, shall be physically isolated as far as possible from power lines and electrical equipment, shall be shielded from electrostatic and electromagnetic interference, and shall have fail-safe logic. Circuit design shall include provisions for isolating and grounding the firing leads at a remote location prior to installing or removing EED's.
f. Two or more functions or devices shall be required to initiate EED's.
g. All detailed SOP's and Standard Transfer Procedures (STP) with signoff sheets must be signed by two people (the performing technician and one other person, such as another technician, supervisor, cognizant engineer, or designated safety, reliability, and quality assurance representative). Standard Operating Procedures and Standard test Procedures shall state the title, scope, responsible persons, location, personal protective equipment, any personnel limits, barriers, emergency and waste disposal procedures and concise steps on how to perform explosive related operations.

h. There shall be approved procedures to cover storage, transportation between storage and use locations, installation, use, and removal of explosives (including back out procedures).
i. Only personnel on authorized-personnel lists may access/handle explosives. Authorized NASA personnel are to be listed on the safety permit indicating extent of authorization.

18.7 OPERATIONS AND HANDLING

Operations that use explosives require a valid Safety Permit and shall be accomplished by approved SOP's or STP's.

Only personnel who are listed on an authorized access roster shall have access to explosives. Of these, only personnel listed as certified handlers of a specific explosive or as certified handlers of general explosives shall be permitted to handle an explosive.

The cognizant Area Safety Committee, after reviewing evidence of contractor personnel certification and ascertaining that such persons know and understand the potential hazards involved and have acquired the skills necessary to handle specific explosives, may authorize the contractor personnel to access and handle explosives. Exception: authorization for contractor personnel to access and handle ammunition in small arms and tools may be granted after review of certification by the Security Officer and Contracting Officer's Technical Representative, respectively.

Personnel who operate with or handle explosives should note the following:

a. Smoking is not permitted in areas where explosives are handled or used.
b. The materials being used and the result intended must be understood prior to beginning work.
c. Explosives operations are to be conducted only with proper use of approved safety equipment and clothing.
d. Appropriate warning devices shall be used to alert other persons prior to the start of potentially hazardous operations.
e. Operations involving EED explosives shall be suspended whenever an electrical storm (thunderstorm) is in the near vicinity.
f. Static discharge between personnel, devices, materials, and supporting equipment shall be prevented by bringing all to the same potential.
g. Radio transmission shall not be permitted in or near EED explosives storage and operation sites. Limiting distances shall be determined for the individual EED's and conditions involved.
h. Blasting galvanometers and Alinco circuit testers (101-58F6), or other appropriate test devices with output limited to 10 milliamps, shall be used for resistance tests of EED's. Resistance tests shall be made only at an approved location (not in a magazine), and results are to be recorded.
i. A "NO-VOLTAGE TEST" (10.0 millivolts maximum allowable) shall be made at the connector on each EED firing circuit just prior to hookup to an

EED. The measurements shall be made between conductors, and between each conductor and the equipment ground.

j. EED's, on removal from standard packing, will be placed in and remain in metal or metal-clad containers (for RF shielding) until actual installation. The container shall be prominently marked "EXPLOSIVES" while it contains explosives; the marking shall be removed or covered when the explosives are removed.

18.7.1 Laboratory Operations

Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12

Facilities involved in experimental or laboratory type operations involving explosive quantities of 500 grams or less are exempt from general explosive site plan requirements specified in paragraph 18.7.2, however, adequate distance must be provided between the laboratory and other buildings containing explosives, as specified in Quantity Distance Tables 5-3 and Table 5-4. Facilities utilizing 10 grams or less of explosives are exempt from any Q-D criteria. In all cases, consideration must be given to safe laboratory practice standards for compatible storage, handling, personal protective equipment and must be conducted under approved Standard Operating Procedures and Standard Test Procedures.

18.7.2 Facility Siting Requirements for Explosives

Any facility, which plans to engage in storage, handling or testing of explosives in excess of laboratory scale operations (500 grams) must prepare and submit explosive safety site plans and general construction details for facilities containing explosives, pyrotechnics, and propellants. The facility site plan shall show protection provided against explosion propagation between adjacent bays or buildings as well as protection of personnel against death or serious injury from incidents in adjacent bays or buildings. Scaled drawings showing quantity and type of explosive being stored must demonstrate compliance with minimum separation distance in the QD tables of this chapter or the rationale on operational barriers, substantial dividing walls or shields that justify reduction in distance. The Site Plan must show the relationship of the explosive facility to other facilities containing flammable, oxidizers, cryogenic or toxic materials. Site Plans must be reviewed and approved by the Area Safety Committee and NASA Headquarters Safety Office prior to commencing the operation. Commencing an explosive operation without approved Facility Site Plans requires a Deviation/Waiver approved by the NASA Headquarters Safety Office. A Deviation/Waiver shall contain the following information:

Description of the condition

a. Safety Standard requiring deviation/waiver.
b. Reason why compliance can not be achieved.
c. Step taken to provide protection.

d. Statement of whether equivalent safety is provided and if not, assessment of residual risk (attach copy of hazard analysis/risk assessment)
e. Any proposed corrective action and schedule.
f. Duration of deviation/waiver
g. Comments from affected employees or their representative.

18.7.3 Facility Planning

Explosive Facilities, except storage magazines, containing explosives shall be constructed based on the following principles:

a. Explosive facilities' roofs and walls shall be designed for protection of personnel and equipment by fire walls, fire protection systems, operational shields, substantial dividing walls, blast resistant roofs, containment structures, and earth covered magazines. However, if an ordinary building is utilized and not specifically designed for explosive use, bays containing explosives must be separated by substantial dividing walls with each bay designed and constructed so that it will vent an internal explosion with the formation of a minimum number of fragments.
b. Explosive facilities shall have emergency exits meeting NFPA 101 (Life Safety Code) and ANSI A.156.3 (Building Exits).
c. Facilities having exposed bulk explosives or low energy initiators or electroexplosive devices must be equipped with electrostatic discharge (ESD) controls. ESD controls may consist of conductive floor tile and legstats or conductive work shoes. Alternately, ESD wriststats and grounded workbench can be used. Legstats, wriststats and conductive footwear must have a resistance to ground of 25,000 ohms to 1 megohm minimum
d. Buildings containing exposed explosives must have lightning protection. Resistance of 25 ohms or less to ground for lightning protection is the desired optimum using a copper ground rod and cable. Metallic surfaces containing explosives must a GSO be bonded and grounded. The resistance of any metallic object bonded to the static grounding system shall not exceed 1 ohm. Ground faults are not permitted. Static grounds shall not be made to gas, steam, or air lines, dry pipe sprinkler systems, or air terminals for lightning systems. Static grounds can be made to water pipes that are continuous, buried copper plates, driven ground rods, or to down conductors of lightning protection systems as close to the ground rod as possible.
e. Building or magazines used to store explosives must be placarded with the appropriate fire symbol for the explosives being used. Fire symbols shall reflect the highest rating for which the building is sited. The fire symbol for each of the classifications is as follows:

Class 1.1 (Mass Explosion Material)- 24 inches wide X 24 inches high, Octagon shape, Bright orange background, with a 10 inch high X 3inch wide , Black numeral "1" in the center.

Class 1.2 (Fragment Producing Material)- 24 inch high X 24 inch wide X 8 inch cross member ,"X" shaped sign, Bright orange background with a 10" high X 3" wide, black numeral "2" in the center.

Class 1.3 (Mass Fire Material)- 24 inch, Equilateral Triangle with point oriented downward. Bright orange background with a 10 " high X 3" wide , Black numeral 3 in the center.

Class 1.4 (Moderate Fire, No Blast Material)- 24 inch high X 24 inch wide, Diamond shaped sign. Bright orange background with a 10" high X 3" wide, Black numeral "4" in the center.

18.8 TRANSPORTATION

To ensure that full compliance with DOT regulations is accomplished prior to movement, proposed shipments of explosives (including shipments between Cleveland and Plum Brook) shall be brought to the attention of the Glenn Transportation Officer. The Security Branch and the GSO shall be notified of any shipments within, into, or out of the Glenn Research Center (Cleveland or Plum Brook).

Government-owned vehicles used for transporting explosives shall be specifically approved for such use by the Glenn Transportation Officer. Only approved vehicles and equipment, in good condition, shall be used for transportation of explosives. The condition of vehicles shall be verified before each use, in accordance with 49 CFR Sub ch. C and 29 CFR 1910.109.

Vehicle approval by the Glenn Transportation Officer shall not relieve the operator of responsibility for inspection on the day of use. Before transporting explosives, the operator must ensure that the exhaust, electrical, and braking systems are in first-class condition and that required extinguishers are on board and charged. The operator must a GSO turn off the engine of the vehicle while loading and unloading explosives and while the magazine is open.

Unless a vehicle has been specifically approved for the explosives operation, explosives shall be transported at Glenn by personnel on foot.

18.9 STORAGE, ACCOUNTABILITY, AND DISPOSAL

18.9.1 Storage

There are limitations on where explosives may be stored and the quantities that may be stored at a given location. The requester of explosives is therefore required to arrange forsuitable storage before a Purchase Request for explosives is processed.

All explosive materials will be stored in magazines, buildings, or areas designated and cited as explosives storage. Quantity-distance standards applicable to storage of

explosives are contained in DOD 6055.9. Approval for overnight and short-term storage deviations shall be in writing from the cognizant Area Safety Committee and the GSO. Long-term storage deviations require advance written approval from NASA Headquarters.

Three general types of explosives storage may be considered by the requester:

The dedicated Glenn Explosives Locker Magazine - This magazine was established as limited quantity storage for mixed groups of compatible explosives classified as DOD Class 1, Division 3 and Division 4. Total net explosive weight (NEW) of all items in the magazine may not exceed 100 pounds, and because of the limited quantity, class-division rules on quantity-distance may be disregarded. The GSO has cognizance of the magazine. Access and storage and withdrawal records shall be controlled by the Aircraft Operations Office personnel at the Hangar (Bldg. 4).

Specifically approved magazines - These magazines may be established and approved for limited quantities of a single type of explosive in each magazine. Examples of such magazines are those for security ammunition and those for tool ammunition. Such magazines shall be locked and under cognizance of a designated individual who will be responsible for control of access and for keeping continuous records of accountability for the explosives. Specific approval by the Glenn GSO and the cognizant Area Safety Committee is required.

Plum Brook igloo magazines - These magazines classify as Army igloo magazines meeting the requirements of Chapter 5, DOD 6055.9, when they have been properly prepared for explosives use and when quantity-distance requirements are met. The Plum Brook Management Office has cognizance of these igloos.

18.9.2 Explosives Storage Compatibility Groups

a. Storage Principles

1. All explosives and explosive items are assigned to storage compatibility groups (SCGs) for storage, maintenance, and transportation at and between NASA facilities.
2. Different types of explosives may be mixed in storage if they are compatible by item and division. Explosives are assigned to an SCG when they can be stored together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

b. Compatibility Groups - In development, these various factors are considered but are not limiting:

1. Chemical and physical properties.
2. Design characteristics.
3. Inner and outer packaging configuration.
4. Hazard classification.
5. Net Explosive Weight (NEW).
6. Rate of deterioration.
7. Sensitivity to initiation.
8. Effects of deflagration, explosion, or detonation.

NOTES: Subject to application of these standards and particularly to compatibility as defined herein, mixing of explosives in storage facilities is allowable only when such mixing will facilitate safe operations and promote overall storage efficiency.

As used in these standards, the phrase "with its own means or initiation" indicates that the explosive item has its normal initiating device assembled to it that presents a significant risk during storage. The phrase does not apply, however, when the initiating device is packaged to eliminate the risk of detonating the explosive in the event of accidental functioning of the initiating device, or when fuzzed end items are so configured and packaged as to prevent inadvertent arming of the fuzzed end items. The initiating device may even be assembled to the explosive item provided its safety features preclude initiation or detonation of the explosive filler of the end item in the event of an accidental functioning of the initiating device.

c. Compatible Explosives and Explosive Items. Listed below are items which may be stored together within their groups:

    1. Various kinds of initiating explosives
    2. Various kinds of propellants, regardless of hazard classification.
    3. Various kinds of high explosives.
    4. All types of initiating devices.
    5. All pyrotechnics and explosives containing pyrotechnic items except:

        a. Water activated pyrotechnics.
        b. Explosives containing flammable liquids or gels.

    6. Explosive items in any one of the above groups are not generally compatible with items in any other groups.
    7. Explosives and explosive items in substandard or damaged packaging, in a suspect condition, or with characteristics which increase the risk in storage are not compatible with other explosives and shall be stored separately.

18.9.3 Storage Compatibility Groups

Following explosives storage principles and considerations for mixed storage, explosives are assigned to one of the following 12 SCGs.

a. Group A. Initiating explosives - Bulk initiating explosives which have the necessary sensitivity to heat, friction, or percussion to make them suitable for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, and dry PETN.
b. Group B. Detonators and similar initiating devices - Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and safe/arm without two or more safety features.
c. Group C. Bulk propellants, propelling charges, and devices containing propellant with or without their own means of ignition. Items that upon initiation will deflagrate, explode or detonate. Examples are single, double, triple-base, and composite propellants, rocket motors (solid propellant).
d. Group D. Black powder, high explosives (HE), or a device containing an initiating explosive and containing two or more independent safety features. Explosives that can be expected to explode or detonate when any given item/component thereof is initiated.
e. Group E. Not normally found in NASA installations.
f. Group F. Devices (fuzzed) with or without propelling charges. Examples are sounding devices and similar items having an in-line explosive train in the initiator.
g. Group G. Fireworks, illuminating, incendiary, and smoke (including HC), or tear-producing devices other than those which are water activated or which contain white phosphorus (WP) or flammable liquid or gel. Functioning of these devices results in an incendiary, illumination, lachrymatory, smoke, or sound effect. Examples are flares, signals, incendiary or illumination devices, igniters, and other smoke producing devices.
h. Group H. Not normally found in NASA installations.
i. Group J. Not normally found in NASA installations.
j. Group K. Not normally found in NASA installations.
k. Group L. Devices not included in other compatibility groups. Devices having characteristics that do not permit storage with other types of material. Examples are water activated devices, prepackaged hypergolic liquid fueled rocket engines, fuel-air explosive devices (FAE), TPA (thickened TEA), and damaged or suspect items of any group. Types preventing similar hazards (i.e., oxidizers with oxidizers, fuels with fuels, etc.) may be stored together but not mixed with other groups.
l. Group S. Items presenting no significant hazard. Devices so designed or packed that when in storage all hazardous explosive effects are confined and self contained within the item or package. An incident may destroy all items in a single pack but must not be communicated to other packs so all are destroyed. Examples are thermal batteries, explosive switches or valves, Safe

and Arming (S&A) devices, and other items packaged to meet the criteria of this group.

18.9.4 Mixed Storage

a. Mixing of SCGs is permitted as indicated in Figure 6-1 and Table 6-1.
b. Items from SCGs C, D, F, G, and S may be combined in storage provided the net quantity of explosives in the items or in bulk does not exceed 1000 pounds per storage site. These items must be packaged in accordance with approved drawings.

Figure 6.1 Storage Compatibility Mixing Chart

Group	A	B	C	D	E	F	G	L	S
A	X	Z							Z
B	Z	X							X
C			X	Z	Z		Z		X
D			Z	X	X				X
E			Z	X	X				X
F						X			X
G			Z				X		X
L								X	
S	Z	X	X	X	X	X	X		X

NOTES: An "x" in a block of the above chart indicates that these groups may be combined in storage; otherwise, mixing is either prohibited or restricted according to the following paragraphs.

A "z" in a block of the above chart indicates that when warranted by operational considerations or magazine unavailability, and when safety is not sacrificed, these groups may be combined in storage.
No mark in a block indicates that combined storage is not permitted.

Table 6-1 Storage Compatibility Groups for Explosives and Explosives Containing Devices

Group A - Initiating Explosives

- Black powder
- CP (5-Cyanotetrazolpentaamine Cobalt III Perchlorate) (pellets)
- Lead azide
- Lead styphnate
- Mercury fulminate
- Nitrocellulose (dry)
- Tetracene
- TATNB (Triazidotrinitrobenzene)

Group B - Detonators and similar initiating devices

- Blasting caps
- Booster pellets (when packaged in nonpropagating arrays)
- Detonators including EBWs and slappers
- Explosive bolts
- Fragmenting actuators
- Igniters MDF (mild detonating fuse) detonator assemblies)
- Pressure cartridges
- Primers
- Squibs

Group C - Bulk propellant, propellant charges, and devices containing propellants with or without their own means of initiation

- Smokeless powder
- Pistol and rifle powder
- Rocket motor solid propellants

Group D - High explosives (HE and devices containing explosives without their own means of initiation

- Ammonium Picrate
- Baratol
- Boracitol
- Compositions A, B, and C (all types)
- Cyclotols (not to exceed a maximum of 85X RDX)
- DATB (diaminotrinitrobenzene)
- Detonating cord (primacord or mild detonating fuse)
- bis-Dinitropropyl adipate
- bis-Dinitropropyl glutarate
- bis-Dinitropropyl maleate
- Dinitropropane
- Dinitropropanol
- Dinitropropyl acrylate monomer (DNPA)
- Dinitropropyl acrylate polymer (PDNPA)
- Elastomeric plastic bonded explosives
- Explosive D
- HMX (Cyclotetramethylene tetranitramine) (wet)
- HMX/wax (formulated with at least 1% wax)
- HNS (Hexanitrostilbene)
- Linear shaped charge
- Nitrocellulose (wet)
- Nitroguanidine
- Octol

- Pentolite
- PETN (Pentaerythritol tetranitrate) (wet)
- PETN desensitized (dry)
- PETN/extrudable binder
- Plastic Bonded explosives, PBX (a Group D explosive formulated with desensitizing plastic binder)
- Potassium picrate
- RDX (Cyclotrimethylene trinitramine) (wet)
- TATB (Triamino trinitrobenzene)
- TATB/DATB mixtures
- Tetryl
- TNT (Trinitrotoluene)

Group E - Explosives devices without their own means of initiation and with propelling charge.

- Artillery ammunition
- Rockets (e.g., M66 LAW)

Group F - Explosives devices with detonators and detonating trains assembled to the devices.

Group G - Devices that produce an incendiary, illumination, lachrymatory, smoke, or sound effect

- Smoke pots (when in lots of 50 or more)
- Flares
- Incendiary ammunition.

Group L - Explosives or ammunition not included in other compatibility groups

- Damaged or suspect explosives devices or containers
- Explosives that have undergone severe testing.

Group R - High explosives materials more sensitive than Group D but less sensitive than Group A

- CP (5-Cyanotetrazolpentaamine Cobalt III Perchlorate) (powder)
- HMX (Cyclotetramethylene tranitramine) (dry)
- PETN (Pentaerythritol tetranitrate) (dry)
- RDX (Cyclotrimethylene trinitramine) (dry).

Group S - Explosives, explosives devices, or ammunition presenting no significant hazard

- Propellant, cartridge actuated devices (which yield a nonfragmenting, nonflame producing controlled reaction). Examples include the following:

Cable cutters Cartridge actuated valves Linear actuators (e.g., dimple, piston, bellows motors) Safety fuse Small arms ammunition Smoke pots or similar smoke devices (when in lots of less than 50).

Group X - Experimental explosives, explosives of temporary interest, newly synthesized compound, new mixtures, and some salvaged explosives.

Group Y - Material and systems that need not be stored or labeled as explosives unless they are near other explosives that could initiate them.

When near explosives, Group Y material becomes Group D unless otherwise indicated.

- FEFO/SOL(35 wt% or less FEFO in ethyl acetate)
- FEFO/solution
- Group D explosives in inert solvents (explosive concentration not exceeding 25 wt%)
- Nitrates; treat as Group C when with other explosives
- Perchlorates; treat as Group C when with other explosives
- Picric acid (containing at least 10 wt% water and in less than 11 kg lots)
- Small arms ammunition classified for shipment by DOT as ORMÄD (Other Regulated Material Class D) rather than Class C Explosives. Normally consists of ammunition not exceeding 50 caliber for handguns and rifles and 8 gauge for shotguns.

18.9.5 Color Coding

As various explosive components in NASA's inventory are manufactured according to specifications of other agencies and used for other than Flight Hardware, they may be color coded for use; e.g., "Red" designates live explosives or "Blue" for inert explosives. Note that this system of coloring code is not the only one in use; e.g., Flight Hardware will not be painted. This requires that, in addition to training in color coding differences, Operating Procedures will contain information pertaining to color coding where applicable.

18.9.6 Accountability

Only personnel designated on the Safety Permit shall be permitted to place or withdraw explosives at storage locations. They shall enter each placement or withdrawal action on the continuous inventory record at the storage location.

The cognizant authority at each storage location shall ensure that a physical inventory is taken at least semiannually, thereby confirming that storage does not exceed authorization and that utilization records are accurate. A copy of the inventory shall be forwarded to the GSO and the Environmental Management Office.

18.10 LIQUID PROPELLANT

Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12

a. Scope and Application. This section applies to the storage of liquid propellants in all types of containers, including rocket and missile tankage, in quantities greater than single minimum size shipping container such as one 55-gallon drum or one 500-pound (net weight) cylinder.
b. Determination of Propellant Quantity.

    1. The total quantity of propellant in a tank, drum, cylinder, or other container shall be the net weight of the propellant contained therein. Where the storage containers are not separated one from the other by the appropriate distance or are not so subdivided as to prevent possible accumulative involvement, the quantity shall be considered as the total of all such storage containers. Quantity of propellant in the associated piping must be included to the points that positive means are provided for interrupting the flow through the pipe, or interrupting a reaction in the pipe in the event of an incident.
    2. When incompatible propellants are not separated by the required distances or provisions are not made to prevent their mixing, the combined quantity of the two shall be used. See Table 7-1 (Section 18.10.3 below) to determine if explosive equivalents apply.
    3. Table 7-2 lists conversion factors (gallons to pounds) for the various liquid propellants.
    4. When propellants (compatible or incompatible) at a specific location are subdivided so that the possibility of accumulative involvement is limited positively to the quantity of propellant in any one of the divided segments. Quantity Distance (QD) separation does not apply between such segments. However, the propellant content of the segment requiring the greatest distance shall be used to determine the separation to be maintained between the propellant location and other targets.
    5. Separation distances shall be measured from the closest hazard source (containers, buildings, segments, or positive cutoff point in piping, whichever is controlling).

18.10.1 Liquid Propellant Hazard Groups

Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12

a. Liquid propellant presents various types and degrees of hazards. Based on these hazards, the following propellant groupings are established:

b. Group I (Fire Hazard). Materials in this group are considered to be the least hazardous. They have a fire-hazard potential and require separation distances specified in Table 7-3. When group I materials are stored with more hazardous materials, under conditions described in Section 18.10.3, Tables 7-1 (Section 18.10.3 below) and 7-6 will be used to determine TNT equivalency.
c. Group II (Serious Fire Hazard). Materials in this group are strong oxidizers. Serious fires may result when they come in contact with materials such as organic matter due to the vigorous oxidation or rapid combustion. Table 7-4 specifies quantity limitations and minimum distance requirements for this group. When group II materials are stored with more hazardous materials under conditions described in Section 18.10.3, Tables 7-1 (Section 18.10.3 below) and 7-6 will be used to determine TNT equivalency.
d. Group III (Pressure Rupture, Vapor Phase Explosion, Fragments). Hazards with this group are primarily from pressure rupture of the storage container, resulting from fire, deflagration or vapor-phase explosion. Hazardous fragmentation of the container, its protective structure, or other nearly material may be produced by pressure rupture of the storage container or a vapor-phase explosion. Table 7-5 specifies quantity limitations and minimum distance requirements for this group. When group III materials are stored with more hazardous materials, under conditions described in Section 18.10.3, Tables 7-1 (Section 18.10.3 below) and 7-6 will be used to determine TNT equivalency.
e. Group IV (Mass Detonating, Severe Fragments). The hazards from materials in this group are the same as for mass-detonating explosives (e.g., blast overpressure and fragments from the container and surrounding equipment and material). Table 7-6 will be used to determine QD requirements.

18.10.2 Specific Hazardous Locations

The major hazard of the individual propellant can vary depending upon the location of the propellant storage and the operations involved. In order of decreasing hazard, these conditions are:

a. Range Launch Pads. These pads involve research, development, testing and space exploration launchings. Operations at these facilities are very hazardous because of the close proximity of fuel and oxidizer to each other, the frequency of launches, lack of restraint of the vehicle after liftoff, and the possibility of fallback with resultant dynamic mixing on impact. Launch vehicle tankage is involved here and explosive equivalents (Table 7-1(Sect**ion** 18.10.3 below) shall be used to determine QD (Table 7-6).
b. Static Test Stands. Although these can involve experimental operations, the units remain static and are subject to better control than dynamic ones. Except where run tankage for fuel and oxidizer are mounted one above the other, it is possible to separate the tankage, or to provide larger margins of safety, to reduce the hazard over that for a rocket or missile on a launch pad. These

larger margins of safety are provided when using tankage heavier than flight weight tankage. Except as provided in Section 18.10.3b, explosives equivalents (Table 7-1(Section 18.10.3 below) must be used to determine QD (Table 7-6).

c. Ready Storage. Ready storage may be located at a minimum of intraline distance from launch and static test stands, based on the propellant requiring the greater distance (Tables 7-3**,**7-4,and 7-5). Normally, the propellant from ready storage is not fed directly into an engine, as is the case with run tankage (see f below). As stated in Section 18.10.3 c explosive equivalents must be used for propellants, in ready storage if the facility design does not guarantee against fuel and oxidizer mixing and against detonation propagation to, orientation at, the ready storage facility when a mishap occurs at the test stand or launch pad.

d. Cold-Flow Test Operations. Fire and fragment hazards (Tables 7-3**,** 7-4, and 7-5) govern if the design is such that the system is closed (except for approved venting); is completely airtight; fuel and oxidizer are never employed concurrently and each has a completely separate isolated system; and propellants are of required purity. Otherwise, as stated in Section 18.10.3 c explosive equivalents must be used to determine QD.

e. Bulk Storage. This is the most remote storage with respect to launch and test operations, never being directly connected to any of them. It consists of the area, tanks and other containers therein used to hold propellants for supplying ready storage and, indirectly, run tankage where no ready storage is available. Individual bulk storage facilities must be separated from each other and from unrelated exposures in accordance with Tables 7-3,7-4, 7-5, and 7-6. If positive measures are not taken to prevent mixing as stated in Section 18.10.3c, explosive equivalents as stated in Section 18.10.3c must be used to determine QD.

f. Run Tankage. Run tankage (operating tankage) consists of the tank and/or other containers and associated piping used to hold the propellants for direct feeding into the engine or device during operations (see c above).

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

18.10.3 Liquid Propellant Storage

Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12

a. Compatible Storage. Compatible storage of propellants of different hazard groups will be separated from other exposures by the greater intragroup storage distance. For propellants that may be mixed together without increasing the hazard, see Table 7-2.

b. Incompatible Storage. Separation distance between propellants of different compatibility groups will be the inhabited building distance for the propellant quantity and group that requires the greater distance, except where they are effectively subdivided by intervening barriers or where other positive means; e.g. shut-off valves, for preventing mixing is provided. Where prevention of mixing is assured, incompatible storage will be separated from each other by intragroup distance. If different hazard groups are involved, the group requiring the greater distance will be the controlling one.
c. Where incompatible mixing is not prevented by intervening barriers or positive means, the TNT equivalency, using Table 7-1 (below), of the mix will be calculated and the distances of Table 7-6 apply.

Table 7-1 Liquid Propellant Explosive Equivalents 2, 3, 4, 5, 6, 7, 8

Notes:

a. These are hypergolic combinations.
b. The percentage factors given in the table are to be used to determine the equivalencies of propellant mixtures at static test stands and range launch pads when such propellants are located aboveground and are unconfined except for their tankage. Other configurations shall be considered on an individual basis to determine the equivalencies.
c. The explosive equivalent weight calculated by the use of this table shall be added to any nonnuclear explosive weight aboard before distances can be determined for Table 8-1 and 8-2
d. These equivalencies apply a GSO when the following substitutions are made:

    1. Alcohols or other hydrocarbons may be substituted for LO
    2. BrF5, C1F3, F, H, H2O2, OF2 or O2F2 may be substituted for LO2
    3. MMH may be substituted for N2H4 or UDMH.
    4. C2H4O may be substituted for any propellant
    5. NH3 may be substituted for any fuel if a hypergolic combination results.

e. Use LO_2/RP-1 distances for pentaborane plus a fuel and LO_2/LM_2 distances for pentaborane plus an oxidizer.
f. For quantities of propellant up to but not over the equivalent of 100 lbs of explosives, the distance shall be determined on an individual basis by the Safety Office. All personnel and facilities, whether involved in the operation or not, shall be adequately protected by proper operating procedures, equipment design, shielding, barricading, or other suitable means.
g. Distances less than intraline are not specified. Where a number of prepackaged liquid propellant units are stored together, separation distance to other storage facilities shall be determined on an individual basis, taking into consideration normal hazard classification procedures.
h. This is currently being investigated by a joint AF and NASA program.

18.11 QUANTITY - DISTANCE REQUIREMENTS

18.11.1 General Principals

Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12

This outlines explosives quantity-distance (QD) criteria and related standards for storing and handling explosives at NASA explosive facilities.

a. The QD criteria and tables prescribe acceptable minimum separation distances for storing and handling explosives. They state GSO's state maximum quantities of the various class/division of explosives allowed at a location. Explosives limits set up locally will not be greater than needed for a safe and efficient operation. Operations and personnel will be located to minimize exposure to hazards.
b. Where explosions are to be deliberately initiated, a greater degree of protection is required. This may include maximum possible containment of the explosion at the source, barricades adjacent to the explosives or exposed sites, greater separation distances, etc. GSO may require "operational shielding" for personnel involved in evacuation of unprotected personnel from the area.
c. Separation of explosive locations is needed to minimize explosive hazards.

Locations that contain explosives will be separated from the following:

a. Other locations that contain explosives and propellants
b. Inhabited buildings, including structures or other places not directly related to explosives operations where people usually assemble or work.
c. Public traffic routes.
d. Operating lines or buildings, including structures or other places where people usually assemble or work that are directly related to explosive operations.
e. Petroleum, Oil, and Lubricant (POL) storage.
f. Utilities, buildings, and facilities.
g. Aircraft parking and storage areas, runways and approach zones, and taxiways.
h. Facility boundaries.

18.11.2 Quantity – Distance Determination

a. The location of explosives facilities with respect to each other and to other exposures shall be based on the total quantity of explosives in each facility. When the total quantity is so subdivided that any incident involving any of the subdivisions will not produce simultaneous initiation of others, the Net Explosive Weight (NEW) of the mass-detonating explosives in the largest subdivision shall apply.

b. Separation distances shall be measured from the closest hazard source (containers, buildings, segments, or positive cutoff point in piping, whichever is controlling).
c. Where rail cars, motor vehicles, or any other transport vehicles containing explosives are so located with respect to an explosives facility that simultaneous detonation can occur, the total quantity of explosives in the facility and the transportation vehicles must be considered as a unit for QD purposes.

18.11.3 Quantity of Explosives Determination

The total quantity of explosives in a magazine, operating building, or other explosives facility shall be the net weight of the explosives calculated upon the following bases (such calculations are intended for use with the tables in this standard):

a. Mass-Detonation Explosives.

    1. Net Explosive Weight (NEW).

b. Non Mass-Detonation Explosives.

    1. Propellants - The net propellant weight.
    2. Pyrotechnic Items - The sum of the weight of the pyrotechnic composition and the explosives involved.
    3. Bulk Metal Powders and Pyrotechnic Composition - The sum of the net weights of metal powders and pyrotechnic composition in containers.

c. When Class/Divisions 1.1 and 1.2 are located in the same site, determine the distance for the total quantity considered first as Division 1.1 and then as Division 1.2. The required distance is the greater of the two. When Division 1.1 requirements are controlling, the HE equivalence of the Division 1.2 items may be added to the total explosive weight of Division 1.1 items to determine the NEW for Division 1.1 distance determination.
d. When Class/Divisions 1.1 and 1.3 are located in the same site, determine the distances for the total quantity considered first as Division 1.1 and then as Division 1.3. The required distance is the greater of the two. When Division 1.1 requirements are controlling and the equivalence of the Division 1.3 is known, the HE equivalent weight of the Division 1.3 items may be added to the total explosive weight of 1.1 items to determine the NEW for Division 1.1 distance determinations.
e. When Class/Divisions 1.2 and 1.3 are located in the same site, determine the required distance for each separately. The two quantities do not need to be added together for QD purposes.
f. When Class/Divisions 1.1, 1.2, and 1.3 are located in the same site, determine the distances for the total quantity considered first as Division 1.1, next as

Division 1.2, and finally as Division 1.3. The required distance is the greatest of the three. As permitted above by paragraphs 18.11. 2 d and e above, HE equivalence for Divisions 1.2 and 1.3 items may be used in NEW determinations for QD purposes.

g. The QDs for Class/Divisions 1.1, 1.2 or 1.3, individually or in combination, are not affected by the presence of Class/Division 1.4.

NOTE: Where testing has shown that 1.1 components installed on 1.3 items, e.g., Solid Rocket Motors (SRM) in operational configuration, in storage and will not initiate the 1.3, the QD is determined by the NEW of the 1.3.

18.11.4 Inhabited Building Distance

a. Inhabited Building Distance (IHBD) is the minimum allowable distance between an unrelated inhabited building and an explosives facility. Inhabited building distances will be used between explosives facilities and administrative areas, adjacent operating lines with dissimilar hazards, and explosive locations and other nonexplosive exposures. IHBD will be provided between explosive facilities and Center boundaries.
b. IHBD will be applied to the following locations:

    1. Main power houses providing vital utilities to critical operations/facilities.
    2. Functions that could cause an immediate hazard because of their failure to operate.

c. IHBDs in Table 8-1 provide a high degree of protection to frame or masonry buildings from structural damage and to their occupants from death or serious injury. The table provides reasonable protection from parts of window frames, doors, porches, and chimneys.

18.11.5 Public Traffic Route Distance

Public Traffic Route (PTR) distance is the minimum permitted between a public traffic route, within the installation for fragments and firebrand hazards. This is applied when the traffic route is within the boundaries and access and use of route is controlled. These distances are 60 percent of the incremental IHBD.

18.11.6 Intraline Distance

a. Intraline Distance (ID) is the minimum permitted between any two buildings consisting of one operating line. ID distances a GSO are used for separating certain specified areas, buildings, and locations so arranged to permit performance of consecutive operations (part of the same operation) even though actual line operations are not involved. Administrative functions are not part of the consecutive operations and are to be at IHBD from the

operating building/site. ID distances are expected to protect buildings from propagation of explosion due to blast effects but not against the possibility of propagation due to fragments. Buildings separated by ID will probably suffer substantial structural damage.

b. A service type magazine shall be located at ID, based on the quantity of explosives within the magazine, from the nearest operating building of the line it services. Service type magazines shall be separated from each other by a minimum of magazine distance.
c. There are two types of ID distances, barricaded and unbarricaded.

18.11.7 Magazine Distance

Magazine Distance is the minimum distance permitted between any two storage magazines. Distance required is determined by the construction (type) of magazine and also the type and quantity of explosives stored. Magazine Distance is expected to prevent propagation between magazines and provides a reasonable degree of protection against propagation of explosion due to fragments. It does not protect magazines from severe structural damage, except possibly for Earth covered magazines.

18.11.8 Minimum Fragment Distances

a. Minimum fragment distances are to protect personnel in the open; firebrand distance minimums are to protect facilities. These distances will be applied to:

    1. Installation boundaries
    2. Administration and housing areas.
    3. Athletic and other recreation areas except as described below.
    4. Main powerhouses providing vital utilities to a major portion of the installation.
    5. Storehouses and shops that by reason of their vital, strategic nature or the high intrinsic value of their contents should not be placed at risk.
    6. Functions that, if momentarily put out of action, will cause an immediate secondary hazard by reason of their failure to function.

b. Examples when minimum fragments and firebrand distances need not be applied are:

    1. Recreation or training facilities if these facilities are for the exclusive use of personnel assigned to the PES.
    2. Between facilities in an operating line; between operating lines; and between operating lines and storage locations that normally are separated by inhabited building distances to protect workers and ensure against interruption of production.

c. The minimum distance for protection from hazardous fragments will be that distance at which fragments, including debris from structural elements of the

facility or process equipment, will not exceed a hazardous fragment density of one hazardous fragment per 600 square feet (56m2). If this distance is not known, the following shall apply:

1. For 100 lbs NEW (45 kg NEQ) or less of demolition explosives, thin-cased or low fragmentation explosive items, bulk high explosives, pyrotechnics, and in-process explosives of Class/Division 1.1, the minimum distance to exposure listed above will be 670 feet (204 m).
2. For all types of Class/Division 1.1 in quantities of 101 to 30,000 lbs NEW (46 to 13,600 Kg NEQ), the minimum distance will be 1250 feet (380m), unless it can be shown that fragments and debris from structural elements of the facility or process equipment will not present a hazard beyond the distance specified in Table 8-1. (Facilities sited at 1,235 or 1,245 feet in accordance with past standards will be considered to be in compliance with the 1,250 foot Minimum requirement.)

18.11.9 Fragment Distance

a. The fragment distance for a particular explosive is based on the range to which a hazardous fragment density may be created by an explosion of the item involved. A hazardous fragment is one having an impact energy of 58 ft lbs and a hazardous fragment density is constituted by at least one hazardous fragment impacting in an area of 600 square feet or less. Fragment distances do not indicate the maximum range to which fragments may be projected.
b. Fragment distance for 1.1 through 1.3 is indicated by a numerical figure in parentheses placed to the left of the division designators 1.1 through 1.3, such as (18) 1.1, (08) 1.2, (06) 1.3 when required. This number is used to indicate the fragment distance in hundreds of feet.

For items in Classes 1.1 and 1.3, a minimum distance number will be used where separation distances greater than specified for inhabited buildings by the applicable QD tables are necessary for specific hazards (projection of debris, fragments, or firebrands). These minimum fragment distances are to protect personnel in the open and will be applied to center boundaries, administrative and housing areas, athletic fields, and other recreation areas.

a. If a minimum distance number is not shown for explosive items of Class 1.1 from which primary fragments would constitute a hazard, the minimum distance will be 1250 feet. For these items, the minimum distance or that required by the QD table will be used, whichever is greater.
b. For bulk high explosives, propellant ingredients, pyrotechnics, other in process materials, and explosive items of Class 1.1 from which primary fragments would not constitute a hazard, a minimum distance of 670 feet for NEW less than or equal to 100 lbs and 1250 feet for NEW of 101 to 30,000

lbs will be used unless it can be shown that debris from structural elements of buildings or process equipment will not present a hazard beyond the distances specified in Table 8-1, for the quantity involved.

c. Rationale for using fragment distances less than 670 and 1250 foot requirements for Class 1.1 shall be included in all site plans and safety reviews. Where there are no existing test data to substantiate lesser distances, analogies to similar items or facilities, fragment dispersions from previous accident, or analytical modeling of the debris spread should be investigated (see Figure 8-1).

18.11.10 Class/Division Quantity – Distance Tables

Figure and Table numbering/designation in this chapter corresponds to that used in NSS 1740.12

a. Class/Division 1.1 (Tables 8-1 through 8-4 (below). Items in this division are primarily a blast hazard and may be expected to mass-detonate when a small portion is initiated by any means.

1. Inhabited Building and Public Traffic Route Distance - Separation distances required from standard earth covered magazines and other types of PESs to inhabited buildings and public traffic routes are listed for various quantities of Class/Division 1.1 in Table 8-1. Specified separations from standard earth-covered magazines take into account reductions in blast over-pressure attributable to the earth cover of the magazines.
2. Intraline Distance - Separation distances required between explosives and nonexplosive buildings and sites within an explosives operating line are listed for various quantities of Class/Division 1.1 in Table 8-2.
3. Intermagazine Distance - Magazines for Class/Division 1.1 shall be separated one from another in accordance with DoD 6055.9.
4. Public Traffic Route Distance - Public traffic route distances give consideration to the transient nature of the exposure in the same manner as for Class/Division 1.1.
5. Intraline Distance - Intraline distances take account of the progressive nature of explosions involving these items (normally resulting from fire spread) and the ability to evacuate personnel from endangered areas before this progression involves large numbers of items. Exposed structures may be extensively damaged by projections and delayed propagation of explosion may occur due to ignition of combustibles by projections.
6. Aboveground Magazine Distance Aboveground magazine distance provides a high degree of protection against any propagation of explosion. There is some degree of risk, however, in delayed propagation when the Exposed Site (ES) contains combustible

dunnage or packing materials that may be ignited by projected firebrands.

b. Class/Division 1.3 (Table 8-3). Class/Division 1.3 includes items that burn vigorously with little or no possibility of extinguishments in storage situations. Explosions normally will be confined to pressure ruptures of containers and will not produce propagation shock waves or damaging blast overpressure beyond the magazine distance specified in Table 8-3. A severe hazard or spread of fire may result from tossing about of burning container materials, propellant, or other flaming debris.

Table 8-4 Quantity Distance for Hazard Division 1.4 [1]

a. Items in this division present a fire hazard with no blast hazard and virtually no fragmentation hazard beyond the fire hazard clearance ordinarily specified for high risk materials. Separate facilities for storage and handling of this division should not be less than 100 feet from other facilities, except those of ire resistive construction, which may be 50 feet from each other.
b. This division includes items such as small arms ammunition without explosive projectiles, fuse lighters, and squibs, colored smoke grenades, and explosive valves or switches.

QUANTITY DISTANCE

Net Explosive Wt. (pounds)	Inhabited Building Distance (feet)	Public Traffic Route (feet)	Intraline Distance (feet)	Magazine Distance (feet)
Limited Quantities 2	not applicable	not applicable	not applicable	not applicable
Large Quantities no limit specifically required for safety reasons	100	100	50 (100 ft. if combustible construction)3	No specified separation requirement