Ministry of Defence
Defence R&D Organisation

STEC PAMPHLET - 5

QUANTITY DISTANCE REGULATIONS FOR LIQUID PROPELLANTS

2025

Issued by

Storage & Transport of Explosives Committee
Centre for Fire, Explosive & Environment Safety (CFEES)
Brig. S. K. Mazumdar Marg, Delhi – 110054

CONTENTS

PREFACE

The provisions of these regulations apply to all types of liquid propellant storage areas, including missiles, rockets and multi-compartment tanks in which both liquid fuels and oxidizers are stored. It covers Quantity Limitations and Distance standards, Storage Compatibility Groupings, Explosive equivalents for liquid propellant mixtures, Hazards of the propellants when in the gaseous as well as the liquid state.

It is hoped that users will find this revised STEC Pamphlet 2025 simpler, easier to understand and implement, thereby promoting the safe storage and transportation of military explosive. This publication supersedes STEC Pamphlet, 2017 on the subject.

QUANTITY DISTANCE STANDARDS FOR LIQUID PROPELLANTS

Scope

1. The provisions of these regulations apply to all types of liquid propellant storage areas, including missiles, rockets and multi-compartment tanks in which both liquid fuels and oxidizers are stored. It covers:

   (a) Quantity Limitations and Distance standards

   (b) Storage Compatibility Groupings

   (c) Explosive equivalents for liquid propellant mixtures

   (d) Hazards of the propellants when in the gaseous as well as the liquid state

2. However, this does not apply to toxic hazards or distances for protection there from.In some cases, the toxic hazard may be the controlling factor in siting and storage of liquid propellants. Relevant regulations concerning toxic hazards should be applied in conjunction with these standards.

Determination of Propellant Quantity

3. 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 subdivided so 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 point(s) where positive means are provided for interrupting the flow through the pipe or interrupting a reaction in the pipe in the event of an accident.

4. Where incompatible propellants are not separated by the required distance or provisions are not made to prevent their mixing, the combined quantity of the two will be used. Table-5 should be consulted to determine if explosive equivalents apply.

5. When propellants (compatible or incompatible) at a specific location are sub-divided so that the possibility of accumulative involvement is positively limited to the quantity of propellant in any one of the divided segments, quantity distance 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.

Measurement of Quantity Distances

6. Quantity distances shall be measured from the closest hazard source (containers, buildings, segment, or positive cut-off point in piping, whichever is controlling).Where buildings containing a small number of cylinders or drums are present or where quantities of propellant are effectively subdivided, distances may be measured from the nearest container or controlling sub-division.

Incompatible Storage

7. Separation distances between propellants of different Compatibility Groups will be the Inhabited Building Distance(IBD) for the propellant quantity and the group which requires the greater distance.

Compatible Storage

8. Compatible storages of different propellants will be separated by the Intra-Group Storage Distances required by the more hazardous groups.

Hazard Groupings

9. Liquid propellants present various types and degrees of hazards. Based on these hazards, the following groupings have been assigned (Refer Table 1):

(a) *Group-I:* Comprises those assigned materials which are considered to Bethe least hazardous. They have a fire hazard potential.

(b) *Group-II:* Comprises those assigned materials which are strong oxidizers.They exhibit properties such as vigorous oxidation of or rapid combustion in contact with materials such as organic matter. Such contact may result in serious fires. These hazards necessitate use of the prescribed minimum spacing of storages and quantity limitations to restrict the loss of valuable property.

(c) *Group-III:* Presents hazards primarily from the pressure rupture of the storage container resulting from fire, deflagration, or vapour phase explosions. Either pressure rupture of the container or vapour phase explosion can cause a fragment hazard from the container and its protective structure, or other adjacent material.

(d) *Group-IV:* Presents hazards which are the same as those of massdetonating explosives. Incidents may create both blast overpressures and severe fragment hazards from the containers and surrounding equipment and material.

Specific Hazardous Locations

10. Apart from the fact that the propellants differ from each other, as explained for the above groups, the predominant hazard of the individual propellant can vary depending upon the location of the propellant storage and the operation(s) involved. In order of decreasing hazards, the conditions are:

(a) *Range Launch Pads:* These involve research, development, testing andspace exploration launchings. Operations at these facilities are very hazardous because of the proximity of fuel and oxidizer to each other, the frequency of launchings, lack of restraint of the vehicle after takeoff and the possibility of fall back with resultant dynamic mixing on impact. Launch vehicle tankage is involved here and explosive equivalents must be used.

(b) *Operational Launch Pads*: Activity here is similar to that at range launchpads except the frequency of firing is much less at the operational launch pads; the latter are defence or combat type operations and can be one time event. Launch vehicle tankage is involved and explosive equivalents must be used except as provided in para 7 above. When an operational pad is used for training launches, it shall be considered as a range launch pad.

(c) *Static Test Stands:* Although these can involve experimental operations, theunits remain static and are subject to better control than launch vehicles except where run tankage for fuel and oxidizer are mounted one above the other, it is possible to separate the tankage to reduce the hazard over that for the rocket or missile on the launch pad. Explosive equivalents must be used except as provided in para 7 above.

(d) *Ready Storage:* The storage is relatively close to the launch and static teststands; normally it is not directly involved in feeding the engine as in the case with run tankage which is an integral part of all launch and test stand operations. The explosive equivalents must be used if the facility design does not guarantee against fuel and oxidizer mixing and against detonation propagation or initiation at, the ready storage facility if there are chances of a mishap at the test stand during launch or at Ready Storage Area. Otherwise, fire and fragment hazards will govern.

(e) *Cold-Flow Test operations* : Fire and fragment hazards govern if thedesign 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 fitting types to preclude intermixing, and the propellants are of required purity. Otherwise, explosive equivalents must be used.

(f) *Bulk Storage:* This is the most remote storage with respect to launch

andtest operations. It consists of the area, tanks, and other containers therein, used to hold propellant for supplying ready storage and, indirectly, run tankage where no ready storage is available. The fire and fragment hazards govern. If positive measures are not taken to prevent mixing of fuel and oxidizer or to prevent detonation propagation, the explosive equivalents must be used.

(g) *Rest Storage:* This is temporary type storage and most closely resemblesbulk storage. It is a temporary parking location for barges, trailers, tank cars, and portable hold tanks used for topping operation when these units are not actually engaged in the operation; and for such vehicles when they are unable to empty their cargo promptly into the intended storage container. Fire and fragment hazards govern. The transporter becomes a part of that storage to which it is connected during propellant transfer.

(h) *Run Tankage (Operating Tankage):* This consists of the tank and othercontainers and associated piping used to hold the propellants for direct feeding into the engine or device during operation. The contents of properly separated 'run tanks' (operating tankage) and piping are normally considered on the basis of the pertinent hazards for the materials involved, except for quantities of incompatible materials that are or can be in a position to be mixed. High explosive equivalents will be used for quantities of such materials subject to mixing.

(i) *Pipelines*: A 8 meter clear zone to Inhabited Buildings Distance shall bemaintained on each side of pipeline used for Group II or III propellants.

Liquid Propellants Hazard and Compatibility Groupings

11. Liquid propellants have been divided into four hazard groups for assessing Quantity-Distances and five Compatibility Groups for the purpose of storage and Table 1 may be referred for details.

Quantity-Distance Standards

12. The following standards are applicable to liquid propellants used for propulsion or operation of missiles, rockets and other related devices :

(a) *Group I:* Table 2 is applicable. However, when Group I materials arestored with more hazardous materials, under conditions prescribed in para 10 above, the quantity of liquid propellant is to be converted into explosive equivalents as given in Table 5 and quantity distances as applicable to UN Hazard Div. 1.1 should be used.

(b) *Group II:* Table 3 is applicable. However, when Group II materials

arestored with more hazardous materials under conditions prescribed in para 10, the quantity of liquid propellant is to be converted into explosives equivalents as given in Table 5 and quantity distances as applicable to UN Hazard Division 1.1 should be used.

(c) *Group III:* Table 4 is applicable. However, when Group III materials arestored with more hazardous materials under conditions prescribed in para 10, the quantity of liquid propellant is to be converted into explosives equivalents as given in Table 5 and Quantity Distances as applicable to UN Hazard Division 1.1 should be used.

(d) *Group IV*: Quantity Distances as applicable to UN Hazard Division 1.1 and Table 5 should be used.

Contaminated Liquid Propellants

13. Caution shall be exercised in the storage and handling of liquid propellants which are contaminated. Such contamination may increase the degree of hazard associated with the propellant.

14. Liquid propellants known to be contaminated or in a suspect condition awaiting laboratory analysis for verification of contamination and disposition requirements if any shall be isolated from all other propellants.

TABLE 1

LIQUID PROPELLANT HAZARD AND COMPATIBILITY GROUPINGS

Propellant	Hazard Group	Compatibility Group /Storage Group*
The alcohols CH_3 OH, C_2H_5OH, $(CH_3)_2CHOH$	I	C
Anhydrous ammonia NH_3	I	C
Aniline $C_6H_5NH_2$	I	C
Hydrocarbon fuels JP-4, JP-5, RP-1	I	C
Monopropellant NOS-58-6	I	G
Otto fuel II	I	G
Nitrogen tetraoxide N_2O_4	II	A
Red fuming nitric acid HNO_3	II	A
Mixed Oxides of Nitrogen	II	A
Bromine pentafluoride BrF_5	II	A
Chlorine Trifluoride CIF_3	II	A
Hydrogen peroxide (H_2O_2) greater than 52%	II**	A
Liquid fluorine LF_2	II	A
Liquid Oxygen LO_2	II	A
Perchloryl fluoride CIO_3F	II	A
Oxygen difluoride OF_2	II	A
Ozone difluoride O_3F_2	III	A
Ethylene Oxide C_2H_4O	III	D
Hydrazine N_2H_4	III	C
Hydrazine UDMH mixtures	III	C
Liquid hydrogen LH_2	III	C
Mixed amine fuels	III	C
Monomethlhydrazine CH3NHNH2	III	C
Pentaborane B_5H_9	III	D
Triethyl Boron B $(C_2H_5)_3$	III	D
UDMH $(CH_3)_2NNH_2$	III	C
Xylidine	III	C
Triethylamine	III	C
G Fuel	III	C
Nitromethane CH_3NO_2	IV	F
Tetranitromethane $C(NO_2)_4$	IV	F

Notes : * Propellants with the same Compatibility Group letter are considered as compatible propellants and unlike letters incompatible. It is to be noted that these Compatibility Groups are not to be confused with UN Hazard divisions.

** Under certain conditions concentrated hydrogen peroxide greater than 90% can detonate. However, its sensitivity to detonation is no greater than that of a standard energetic double base solid propellant under the same conditions.

TABLE 2
HAZARD GROUP – I

Weight of Propellant (kg)	Inhabited buildings, Public Traffic Routes and Incompatible Group I storage distance (meters)	Compatible Group storage and IQDs (meters)
50	10	8
100	11	10
200	14	12
300	17	13
400	18	14
500	19	14
600	19	15
700	20	15
800	20	16
900	20	16
1000	21	17
2000	24	18
3000	26	20
4000	28	22
5000	28	22
6000	29	23
7000	29	23
8000	30	24
9000	31	25
10000	32	25
15000	34	26
20000	36	28
25000	38	29
30000	39	29
35000	40	31
40000	41	31
45000	42	32
50000	43	33
60000	44	34
70000	45	35
80000	46	35
90000	47	36
100000	48	36
125000	50	38
150000	52	40
175000	53	40

Weight of Propellant (kg)	Inhabited buildings, Public Traffic Routes and Incompatible Group I storage distance (meters)	Compatible Group storage and IQDs (meters)
200000	54	41
225000	55	41
250000	57	43

NOTES :

1. Values in Column 2 are one-half the group II inhabited buildingdistances.
2. Values in Column 3 are three-fourths the Group II and group III (IQD) distances

TABLE 3
HAZARD GROUP - II

Weight of Propellant (kg)	Inhabited buildings, Public Traffic Routes and Incompatible Group II storage distance (meters)	Compatible Group II storage and IQDs (meters)
50	19	10
100	23	11
200	29	14
300	32	17
400	35	18
500	38	19
600	38	19
700	39	20
800	39	20
900	40	20
1000	41	21
2000	49	24
3000	52	26
4000	54	28
5000	56	28
6000	58	29
7000	60	29
8000	62	30
9000	63	31
10000	65	32
15000	69	34
20000	72	36
25000	76	38
30000	78	39
35000	79	40
40000	81	41
45000	83	42
50000	86	43
60000	88	44
70000	91	45
80000	93	46
90000	95	47
100000	97	48
125000	100	50
150000	103	52

TABLE 3 Contd.

HAZARD GROUP - II

Weight of Propellant (kg)	Inhabited buildings, Public Traffic Routes and Incompatible Group II storage distance (meters)	Compatible Group II storage and IQDs (meters)
175000	106	53
200000	108	54
225000	110	55
250000	112	57

NOTE: - Distances of column 2 were selected as three-fourths the Group IIIinhabited building distance and considered reasonable due to the lesser hazard.

TABLE -4
HAZARD GROUP - III

Weight of Propellant (kg)	Inhabited buildings, Public Traffic Routes and Incompatible Group II storage distance (metres)		Compatible Group II storage and IQDs (metres)
	Unprotected	Protected	
50	183	25	10
100	183	31	11
200	183	38	14
300	183	42	17
400	183	46	18
500	183	47	19
600	183	49	19
700	183	51	20
800	183	53	20
900	183	54	20
1000	183	56	21
2000	183	63	24
3000	183	69	26
4000	183	72	28
5000	366	74	28
6000	366	77	29
7000	366	80	29
8000	366	82	30
9000	366	84	31
10000	366	87	32
15000	366	91	34
20000	366	96	36
25000	366	99	38
30000	366	103	39
35000	366	106	40
40000	366	110	41
45000	366	112	42
50000	549	114	43
60000	549	117	45
80000	549	124	46
90000	549	127	47
100000	549	129	48
125000	549	132	50
150000	549	138	52

TABLE 4 Contd.

HAZARD GROUP - III

Weight of Propellant (kg)	Inhabited Buildings, Public Traffic Routes and Incompatible Group II storage distance (metres)		Compatible Group II storage and IQDs (metres)
	Unprotected	Protected	
175000	549	142	53
200000	549	145	54
225000	549	148	55
250000	549	151	57

NOTES: 1. Column 2 distances are necessary to provide reasonable protection from fragments to tanks or equipment which are expected to be Thrown in event of a vapour phase explosion.

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

TABLE 5
LIQUID PROPELLANT EXPLOSIVE EQUIVALENTS

Propellant Combinations	Static Test Stands	Range Launch Pads
LO_2/LH_2 or B_5H_9 + an oxidizer	60%	60%
LO_2/LH_2 +LO_2/RP-1	Sum of 60% for LO_2LH_2 10% for LO_2/RP-1	Sum of 60% for LO_2LH_2 20% for LO_2/RP-1
LO_2/RP-1, LO_2/NH_3 or B_5H_9 + a fuel	10%	20% upto 227000 kg +10% over 227000 kg
IRFNA/Aniline*	10%	10%
IRFNA/UDMH*	10%	10%
IRFNA/UDMH + JP-4 *	10%	10%
N_2O_4/UDMH + N_2H_4 *	15%	10%
N_2O_4/UDMH + N_2H_4 * + Solid propellants	5% + Explosive equivalent of the solid propellant	10% + explosive equivalent of the solid propellant
Tetranitro methane (alone or in combination)	100%	100%
Nitro methane (alone or in combination)	100%	100%

Notes:

* These propellant combinations are hypergolic.

1. The percentage factors given in the table are to be used to determine the equivalence of propellant mixtures at static test stands and range launch pads when such propellants are located above ground and are unconfined except for their tankage.
2. The explosive equivalent weight calculated by the use of this table, shall be added to any non-nuclear explosives weight aboard before distances can be determined from Table 1.1 of Hazard Div. (1.1)
3. These equivalences also apply when the following substitutions are made :
   a. Alcohols or other hydrocarbons may be substituted for RP-1
   b. BrF_5, CIF_3, F_2, H_2, H_2O_2, OF_2 or O_2F_2 may be substituted for LO_2.
   c. MMH may be substituted for N_2H_4 or UDMH.
   d. C_2H_4O may be substituted for any propellant.
   e. NH_3 may be substituted for any fuel if a hypergolic combination results.
   Use LO_2/RP-1 distance for pentaborane plus a fuel and LO_2/LH_2 distances for pentaborane plus an oxidizer.