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Flammable & Combustible Liquids in
Ordinary Plastic IBC's

A Users Perspective

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Spectrum of Flammable & Combustible Liquids

- Uncategorized & Class I, II, or III - Exempted Liquids
- Class IIIB Combustible Liquids - Flashpoint ≥ 500 °F (260 °C)
- Class IIIB Combustible Liquids - Flashpoint ≥ 200 °F (93 °C) & < 500 °F (260 °C)
- Class I Flammable Liquids and Class II & IIIA Combustible Liquids Except Alcohols
- Alcohol and alcohol/water blends having a fire and flash point with concentration $\geq 20\%$ and up to and including 100% alcohol by vol.

Uncategorized & Class I, II, or III - Exempted Liquids

Liquids with *no flash or fire point* – **NFPA & FM Global**

Liquids that have a *flash point* but no *fire point*

- **FM Global** D.S. 7-27 – Not “ignitable” & therefore not covered by D.S. 7-29.
- **NFPA** 30 Liquid Classification - Class I, II, or III, but Chapter 9, “Storage of Liquids in Containers – General Requirements” not applicable to these types of liquids.

Class IIIB Combustible Liquids - Flashpoint ≥ 500 °F (260 °C)

NFPA

- Permitted in plastic IBC's but subject to certain provisions (Unprotected, Chap. 16 Tables plus Listed & Labeled – UL 2368, or fire tests subject to AHJ approval)

FM Global

- Provide ceiling sprinklers and design to protect the surrounding occupancy (≥ 7 psi using twenty-five K8 sprinklers if standard spray sprinklers are provided. Other provisions also apply & applicable to only blow-molded plastic bottles in a wire cage with a wooden or steel pallet.

NFPA Chap. 16 Tables 16.5.2.9 & 16.5.2.10 plus Listed & Labeled Plastic IBC

The financial support and time invested in the fire testing done thus far was characterized by a number of NFPA 30 Storage and Warehousing Committee (SWC) members as not providing a practical means of protection.

Chapter 16 tables 16.5.2.9 & 16.5.2.10 based on fire tests using water-filled containers.

Class IIIB Combustible Liquids - Flashpoint ≥ 200 °F (93 °C) & < 500 °F (260 °C)

NFPA

- Permitted in plastic IBC's but subject to certain provisions (Unprotected, Chap. 16 Tables plus Listed & Labeled – UL 2368, or fire tests subject to AHJ approval)

FM Global

- Rack storage array; IBC's on 1st tier only; other storage above OK
- Sprinkler system design criteria under a 30 ft. ceiling * using Ord. Temp. & barrier every level & IRAS :
 - 30 K11.2, SR, @ 13 psi (Den.=.4 gpm/ft²)
 - 30 K14, SR, @ 8 psi (Den.=.4 gpm/ft²)
 - 30 \geq K16.8, SR, @ 7 psi (Den. \geq .44 gpm/ft²)
 - 16 K25.2 EC, QR, @ 10 psi (Den.=.8 gpm/ft²)

* Operating area can be reduced under certain conditions in cut-off rooms.

FM Global “D.S 7-29 Table 13” & “Scheme D” Layout

2.4.6 Composite (blow molded bottle in a wire cage on a wood or steel pallet) IBC Storage of Liquids with a Flash Point At or Above 200°F (93°C) or Alcohol in Racks

2.4.6.1 Use Table 13 to protect rack storage of liquids with a flash point at or above 200°F (93°C) or alcohol (isopropyl alcohol, ethyl alcohol, methyl alcohol) in composite IBCs consisting of a blow molded bottle in a wire cage on a wood or steel pallet. Protect all tiers of the rack with the same level of fire protection.

2.4.6.2 Limit IBC storage to the first tier of the rack. Upper tiers may be used for storage of other liquid-packaging combinations that are 60 gal (230 L) or less in size and that can be protected by the provided level of protection.

2.4.6.3 Arrange the room to ensure all storage is kept in the racks and not staged or stored on the floor. The provided ceiling protection will not prevent failure of any IBC not stored in the racks and will only provide limited protection for large pool fires.

Table 13. Rack Storage of Liquids in Composite IBCs (blow molded bottle in a wire cage on a wood or steel pallet)

Liquid Type, Flash Point	Container Size gal (L)	Maximum Ceiling Height ft (m)	Maximum Storage Height	Minimum Aisle Width ft (m)	Rack Width ft (m)	Ceiling Sprinkler Protection			In-Rack Sprinkler Protection
						Response/Nominal Temperature Rating/ Orientation	K-factor gpm/psi ^{1/2} (L/min/bar ^{1/2})	Design, # of Sprinklers @ Pressure psi (bar) (Note 2)	
≥200°F (93°C) or Alcohol	≤300 (1150)	30 (9.1)	1 IBC high in bottom tier of rack	8 (2.4)	≤9 (2.7)	SR/Ordinary/ Any	11.2 (181)	30 @ 13 (0.9)	Scheme D
							14.0 (202)	30 @ 8 (0.6)	
							≥18.8 (236) (Note 1)	30 @ 7 (0.5)	
						QR/Ordinary/ Any	25.2EC (360 EC)	18 @ 10 (0.7)	

Notes: 1. The K19.6 (K280) sprinkler is not acceptable for use in this protection table.
 2. In cutoff rooms where on-floor storage is impossible, i.e., only rack storage and transport aisles, the ceiling sprinkler operating area can be reduced to 20 sprinklers for non-EC sprinklers and 10 sprinklers for the K25.2 EC (360 EC) sprinkler.

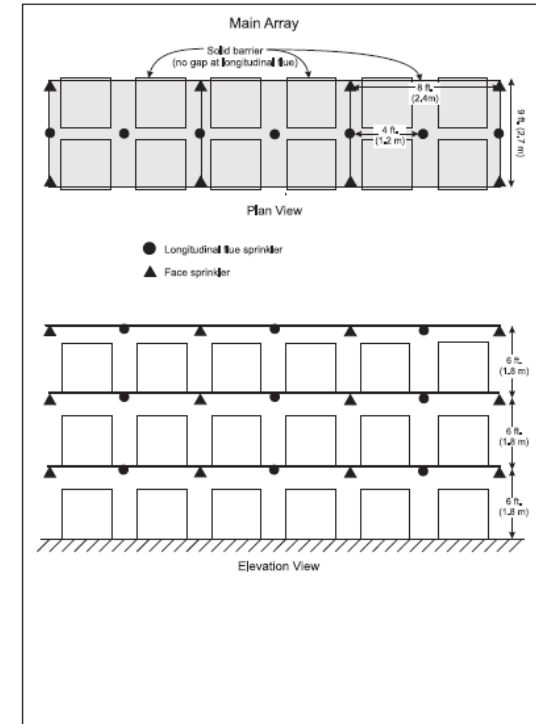


Fig. 16c. Double row rack sprinkler layout - fire protection scheme D

Class IB & IC Flammable Liquids and Class II & IIIA Combustible Liquids Except Alcohols

NFPA

Class I not Permitted

Class II & IIIA permitted in plastic IBC's but subject to certain provisions (Unprotected, Chap. 16 Tables plus Listed & Labeled – UL 2368, or fire tests subject to AHJ approval)

Class IB & IC Flammable Liquids and Class II & IIIA Combustible Liquids Except Alcohols

FM Global

D.S. 7-29, Table 12, Uses a fire mitigation approach whereby the fire is essentially a "free-burn" within the room/building enclosure, Table 12 has various storage and sprinkler system design criteria for these liquids in plastic containers.

Consumption of much of the liquids by fire can be expected with the sprinkler system reducing the likelihood of structural failure.

A large volume of liquid run-off from the sprinkler system can also be expected.

Alcohol and alcohol/water blends having a fire and flash point with concentration $\geq 20\%$ and up to and including 100% alcohol by vol.

NFPA

- NFPA 30 Classification: Class IB, IC, & II
- Class I Liquids Not Permitted in plastic IBC's
- Class II Liquids are permitted in plastic IBC's but subject to certain provisions (Unprotected, Chap. 16 Tables plus Listed & Labeled – UL 2368, or fire tests)

Alcohol and alcohol/water blends having a fire and flash point with concentration $\geq 20\%$ and up to and including 100% alcohol by vol. (Wood or Steel Pallet)

FM Global

- Methyl, ethyl, or propyl alcohol w/ or w/o water
- Rack storage array IBC's on 1st tier only; other storage above OK
- Sprinkler system design criteria under a 30 ft. ceiling * using Ord. Temp. & barrier every level & IRAS :
 - 30 K11.2, SR, @ 13 psi (Den.=.4 gpm/ft²)
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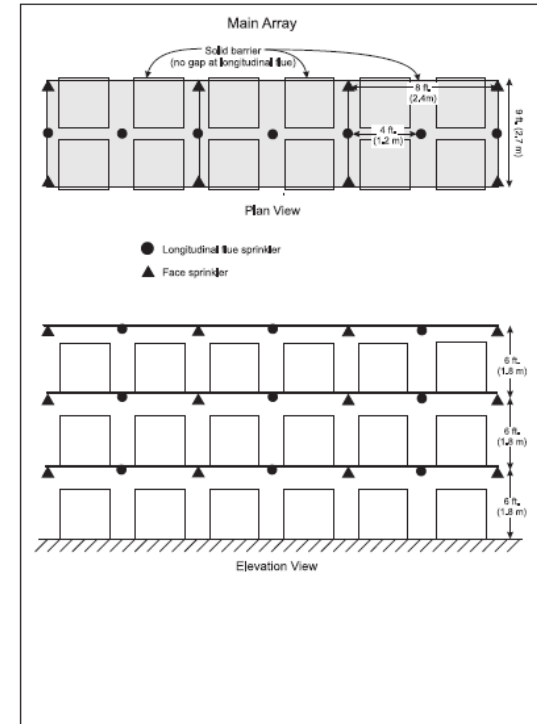


Fig. 16c. Double row rack sprinkler layout - fire protection scheme D

NFPA 30 Quantity Limitations for Unprotected Storage

Table 12.6.2.2 Quantity Limitations for Unprotected Liquid Warehouses

Liquid Class	Containers			Metal Portable Tanks and Metal IBCs			Rigid Nonmetallic IBCs and Composite IBCs		
	Maximum Storage Height (ft)	Maximum Total Quantity per Pile or Rack Section (gal)	Maximum Total Quantity (gal)	Maximum Storage Height (ft)	Maximum Total Quantity per Pile or Rack Section (gal)	Maximum Total Quantity (gal)	Maximum Storage Height (ft)	Maximum Total Quantity per Pile or Rack Section (gal)	Maximum Total Quantity (gal)
IA	5	660	660	NP	NP	NP	NP	NP	NP
IB	5	1,375	1,375	7	2,000	2,000	NP	NP	NP
IC	5	2,750	2,750	7	4,000	4,000	NP	NP	NP
II	10	4,125	8,250	7	5,500	11,000	7	4,125	8,250
IIIA	15	13,750	27,500	7	22,000	44,000	7	13,750	27,500
IIIB	15	13,750	55,000	7	22,000	88,000	7	13,750	55,000

For SI units, 1 ft = 0.3 m; 1 gal = 3.8 L.
 NP: Not permitted.

Why Should More Tests Be Conducted?

A number of manufacturers produce materials containing various soluble solvent mixtures and water.

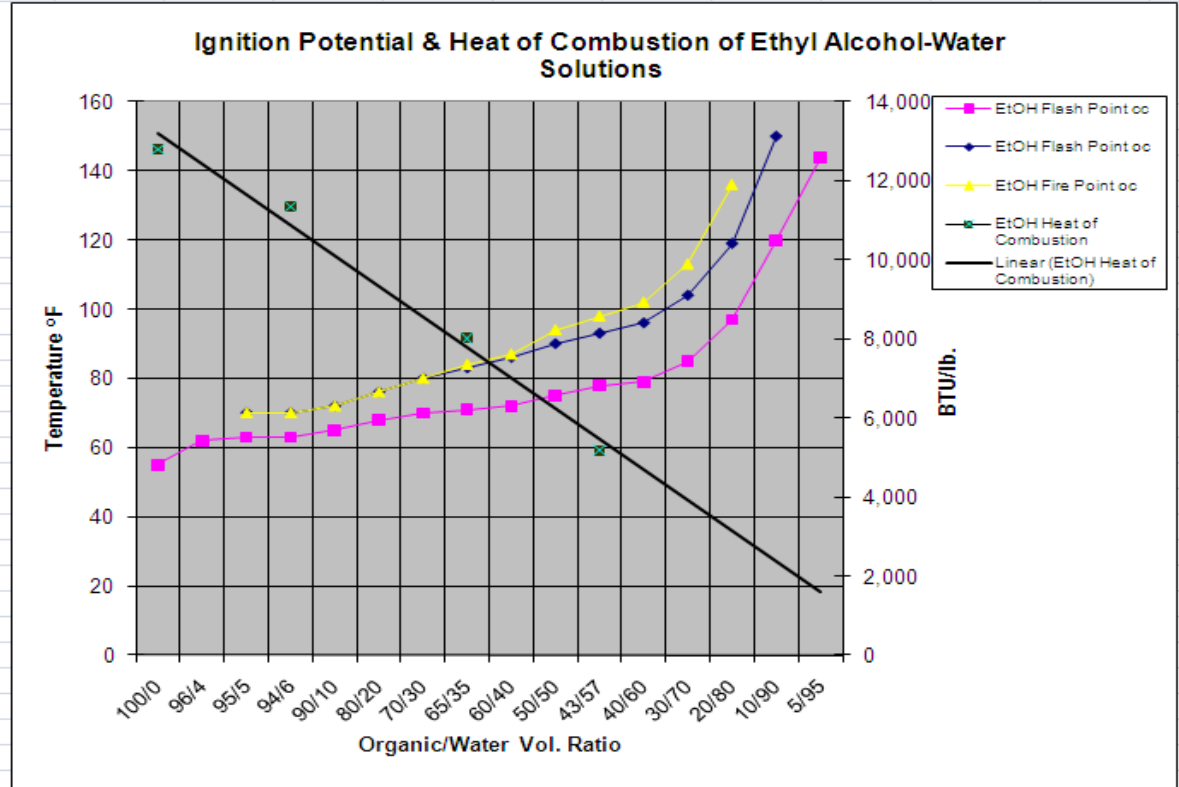
- Class I liquids not permitted by NFPA
- Storage of Class II & III Liquids are treated as “unprotected” by NFPA when not using Listed & Labeled – UL 2368 & following Chapter 16 tables 16.5.2.9 & 16.5.2.10
- Can these blends be treated as “less-hazardous” liquids allowing us to develop effective and reliable sprinkler system design criteria?

Ethyl Alcohol & Water

Organic/ Water Vol. Ratio	EtOH Fl. Pt. °F cc	EtOH Fl. Pt. °F oc	EtOH Fi. Pt. °F oc	BTU/lb.
100/0	55			12,800
96/4	62			
95/5	63	70	70	
94/6	63	70	70	11,350
90/10	65	72	72	
80/20	68	76	76	
70/30	70	80	80	
65/35	71	83	84	8,020
60/40	72	86	87	
50/50	75	90	94	
43/57	78	93	98	5,180
40/60	79	96	102	
30/70	85	104	113	
20/80	97	119	136	
10/90	120	150		
5/95	144			

Source: DISCUS

Interpolated



FPRF Phase I Tests – Liquids Used

Solvent List	Flash Point cc °C *	NFPA Class	
Acetone	-20	IB	Flammable
Methyl Ethyl Ketone	-9	IB	Flammable
Isopropyl Alcohol	13	IB	Flammable
Propylene Glycol Monomethyl Ether	33	IC	Flammable
N-butyl Alcohol	36	IC	Flammable
Acetic Acid	39	II	Combustible
Ethylene Glycol Monopropyl Ether	49	II	Combustible
Propionic Acid	53	II	Combustible
Ethylene Glycol Monobutyl Ether	62	IIIA	Combustible
N-butyric Acid	72	IIIA	Combustible
Ethylene Glycol	111	IIIB	Combustible
Dipropylene Glycol	121	IIIB	Combustible
Water		N/A	
* MSDS			

FPRF Phase I Tests – Blends Used

Blend #	Composition (%wt./wt. in water)	Total Organic Liquid %	Water %	Flash Point cc °C	NFPA Class		Flash Point oc °C	Fire Point oc °C
14	50% Acetone	50%	50%	-12	IB	Flammable	< 20	< 20
16	25% Methyl Ethyl Ketone	25%	75%	-4	IB	Flammable	< 20	< 20
15	25% Acetone	25%	75%	-2	IB	Flammable	< 20	< 20
17	75% 2-Propanol	75%	25%	19	IB	Flammable	32	32
12	50% Propanol	50%	50%	21	IB	Flammable	35	35
11	25% Propanol	25%	75%	27	IC	Flammable	35	43
1	20% Propanol, 12% Ethylene glycol, 30% Propylene glycol monomethyl ether	62%	38%	32	IC	Flammable	39	46
2	20% 1-Butanol, 20% 2-Propanol, 30% Ethylene glycol monobutyl ether	70%	30%	36	IC	Flammable	46	50
27	10% Propanol, 30% Ethylene glycol	40%	60%	38	II	Combustible	52	70
3	15% 1-Butanol, 15% 2-Propanol, 30% Ethylene glycol monobutyl ether	60%	40%	39	II	Combustible	52	52
6	10% 1-Butanol, 10% 2-Propanol, 20% Ethylene glycol monobutyl ether	40%	60%	41	II	Combustible	56	58
4	10% 1-Butanol, 10% 2-Propanol, 30% Ethylene glycol monobutyl ether	50%	50%	43	II	Combustible	58	60
13	90% Butanol	90%	10%	44	II	Combustible	59	59
8	5% 1-Butanol, 5% 2-Propanol, 10% Ethylene glycol monobutyl ether	20%	80%	44	II	Combustible	60	72
24	75% Propylene glycol monomethyl ether	75%	25%	45	II	Combustible	59	61
9	90% Acetic Acid	90%	10%	48	II	Combustible	66	92
7	5% 1-Butanol, 5% 2-Propanol, 20% Ethylene glycol monobutyl ether	30%	70%	50	II	Combustible	64	80
5	5% 1-Butanol, 5% 2-Propanol, 30% Ethylene glycol monobutyl ether	40%	60%	51	II	Combustible	66	84
22	50% Propylene glycol monomethyl ether	50%	50%	53	II	Combustible	73	77
23	25% Propylene glycol monomethyl ether	25%	75%	65	IIIA	Combustible	95	95
18	90% Butyric Acid	90%	10%	No Flash	N/A	Not Categorized	96	104
25	75% Ethylene glycol monobutyl ether	75%	25%	No Flash	N/A	Not Categorized	No Flash	71
29	70% Dipropylene glycol *	70%	30%	No Flash	N/A	Not Categorized	> 122	> 122
10	70% Acetic Acid *	70%	30%	No Flash	N/A	Not Categorized	> 104	> 104
19	70% Butyric Acid	70%	30%	No Flash	N/A	Not Categorized	106	110
26	70% Propionic acid	70%	30%	No Flash	N/A	Not Categorized	57	57
28	40% Ethylene glycol monobutyl ether, 20% Ethylene glycol monopropyl ether	60%	40%	No Flash	N/A	Not Categorized	No Flash	79
20	50% Ethylene glycol monobutyl ether	50%	50%	No Flash	N/A	Not Categorized	67	67
30	20% Ethylene glycol monobutyl ether, 10% Propylene glycol monomethyl ether	30%	70%	No Flash	N/A	Not Categorized	No Flash	91
21	25% Ethylene glycol monobutyl ether	25%	75%	No Flash	N/A	Not Categorized	No Flash	73

* Fire Point Occurred at Boiling Point

Empty Plastic IBC's

FM Global - Palletized 3 high tests & design criteria under 30 ft. (9.1 m) ceiling

Pallet Type	Fire Test Parameters	Discharge Density, gpm/ft. ²	No. Sprinklers Activated	No. Design Sprinklers & Discharge Pressure (psi)
Plastic	K14; 165 F, QR; @ 75 psi	1.2	1	See below
	K14; 165 F, QR; @ 32 psi	0.8	1	12 sprinklers @ 32
	K14; 165 F, QR; @ 18 psi	0.6	6	Not Allowed
Wood		0.6	1	12 sprinklers @ 18 *
	K11.2; 155 F , SR; @ 28 psi	0.6	17	Not Allowed

• OK for steel also

Sources:

Sienkiewicz, S, "Fire Protection Requirements of Empty Intermediate Bulk Containers (IBC's)", FM Global Research Division, Norwood, MA, July 2012

Factory Mutual Insurance Company, "Ignitable Liquid Storage in Portable Containers", Data Sheet 7-29, Johnston, RI, April 2012

Possible Phase II Full-Scale Testing

Explore which aqueous solvent mixtures stored in ordinary, non-listed IBC's can be protected with conventional sprinkler systems considering these options:

- Water
- Foam-water
- Palletized using ceiling sprinklers
- Rack using in-rack sprinklers with and without barriers

Possible Phase II Full-Scale Testing

These aqueous solvent mixtures stored in ordinary, non-listed IBC's need to be compared against:

- Empty, ordinary, non-listed IBC's
- Ordinary, non-listed IBC's filled with non-ignitable liquids
- Ordinary, non-listed IBC's filled with pure oxygenated hydrocarbons

Questions?

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