High Challenge Warehouse Fire Protection Strategies

Flammable and Combustible Liquids in Ordinary, Non-listed, Nonmetallic Intermediate Bulk Containers (IBC's)

Industry Perspective

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There are a number of critical issues to consider when utilizing IBC's:

- Type of IBC used
- Type of liquid - physical, ignition and combustion properties
- Can sprinkler system mitigate a fire for a given combination?
- If sprinkler system can not mitigate, what exposures are you are creating?

Statement of Problem

Ordinary, non-listed and non-metallic IBC's (plastic or composite) containing flammable and combustible liquids continue to present a serious fire risk (life safety and property/business interruption) to industry.

NFPA Liquid Classifications

- Flammable Liquid
  - Class IA – Flash Point < 22.8 °C & Boiling Point < 37.8 °C
  - Class IB – Flash Point < 22.8 °C & Boiling Point ≥ 37.8 °C
  - Class IC – Flash Point ≥ 22.8 °C & < 37.8 °C

- Combustible Liquid
  - Class II – Flash Point ≥ 37.8 °C & < 60 °C
  - Class IIIA – Flash Point ≥ 60 °C & < 93 °C
  - Class IIIB – Flash Point ≥ 93 °C

* Based upon Closed Cup Test

Some Definitions:

Flash Point: The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with air and when ignited will produce a flash fire, **and not continuous flaming combustion**, over the surface of the fuel.

Fire Point: The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with air and when ignited will produce **continuous flaming combustion**, over the surface of the fuel. The fire point is typically a few degrees higher than the flash point. Liquids that have a flash point and not a fire point are not considered flammable or combustible liquids.

Some Additional Liquid Properties

- Flash Point, open cup (^oC)
- Fire Point (^oC)
- Heat Release Rate (kW/m^2)
- Total Heat Released (MJ/m^2)
- Solubility (Polar vs. Non-Polar)

Ordinary, Non-listed and Non-metallic IBC's

Permeation

IBC's using a Polyethylene bottle are subject to softening or “plasticizing" when filled with hydrocarbons.

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

Can these blends be treated as “less-hazardous” liquids allowing us to develop effective and reliable sprinkler system design criteria?

Fire Test Program

Phase I – Ignition & combustion properties of various aqueous organic solutions

Phase II – Additional testing including large-scale sprinklered fire tests

Sponsors

- 3M Corporation
- American Coatings Association
- Dow Corning Corporation
- Eastman Chemical Corporation
- Property Insurance Research Group
- Rigid Intermediate Bulk Container Association
- Sherwin Williams
- Silicon Environmental Health and Safety Council
- Valspar Corporation

Fire Risks Issues

- Electrostatic Ignition Potential
  - Not Addressed in Project

- Ignition, Combustion Properties, & Fire Mitigation
  - Primary Focus of Project

Aqueous Solutions

Thirty aqueous blends of flammable / combustible solvents were selected and subjected to small scale testing:

- flash point
- fire point
- cone calorimetry

Aqueous Solutions

Stable one phase systems with 2 or more components

- Polar (hydrophilic) & partially non-polar (hydrophobic) solvents
- No hydrocarbons due to permeation and protection issues
- Co-solvents used to enhance solubility
- Vary concentrations and number of components
- Possibly representative of a broader range of materials
- Partially diluted with water having a lower heat of combustion than pure materials

Various Organic Families

- Carboxylic acids (C_2, C_3, & C_4)
- Alcohols (C_3 & C_4)
- Ketones (C_3 & C_4)
- Glycols (C_2 & C_6)
- Glycol ethers (C_4, C_5, & C_6)

Test Methods

- Closed Cup Flash Point, Seta Flash Rapid Equilibrium Method (BS EN ISO 3679:29004, equivalent to ASTM 3828)

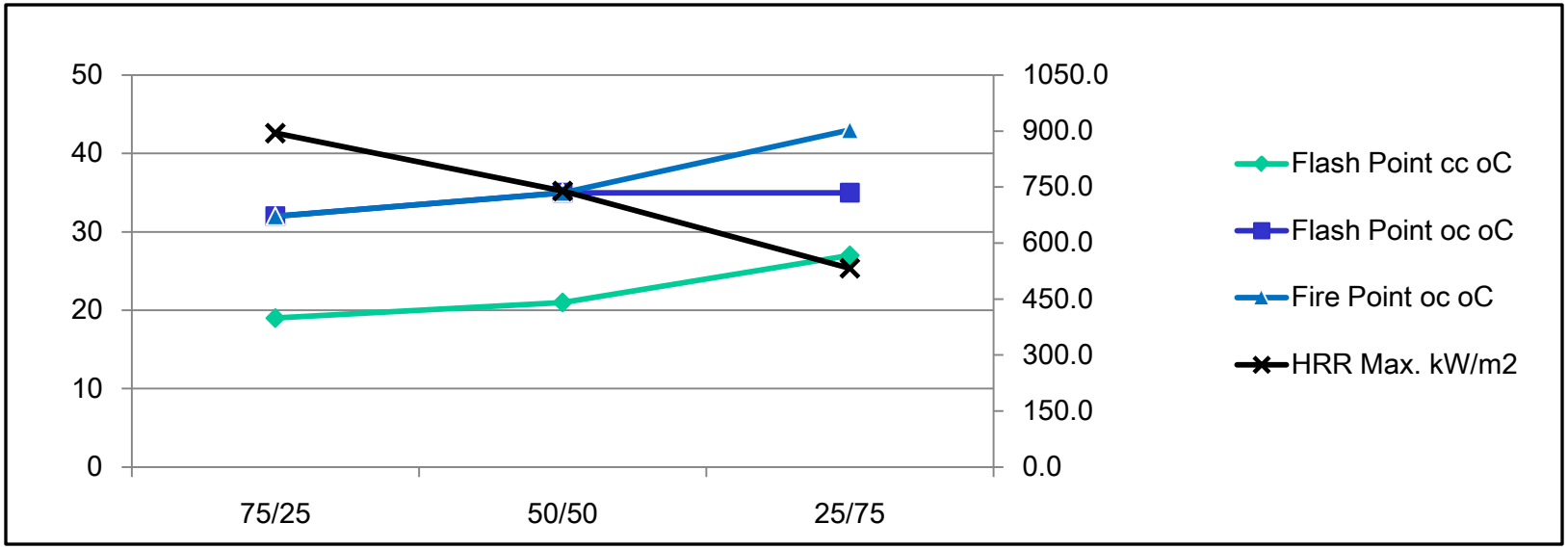
- Cleveland Open Cup Flash Point and Fire Point (ASTM D92)

- Cone calorimetry (ASTM E1345)
  - 100 X 100 X 10 (LWD)
  - Incident heat flux 35 kW/m^2

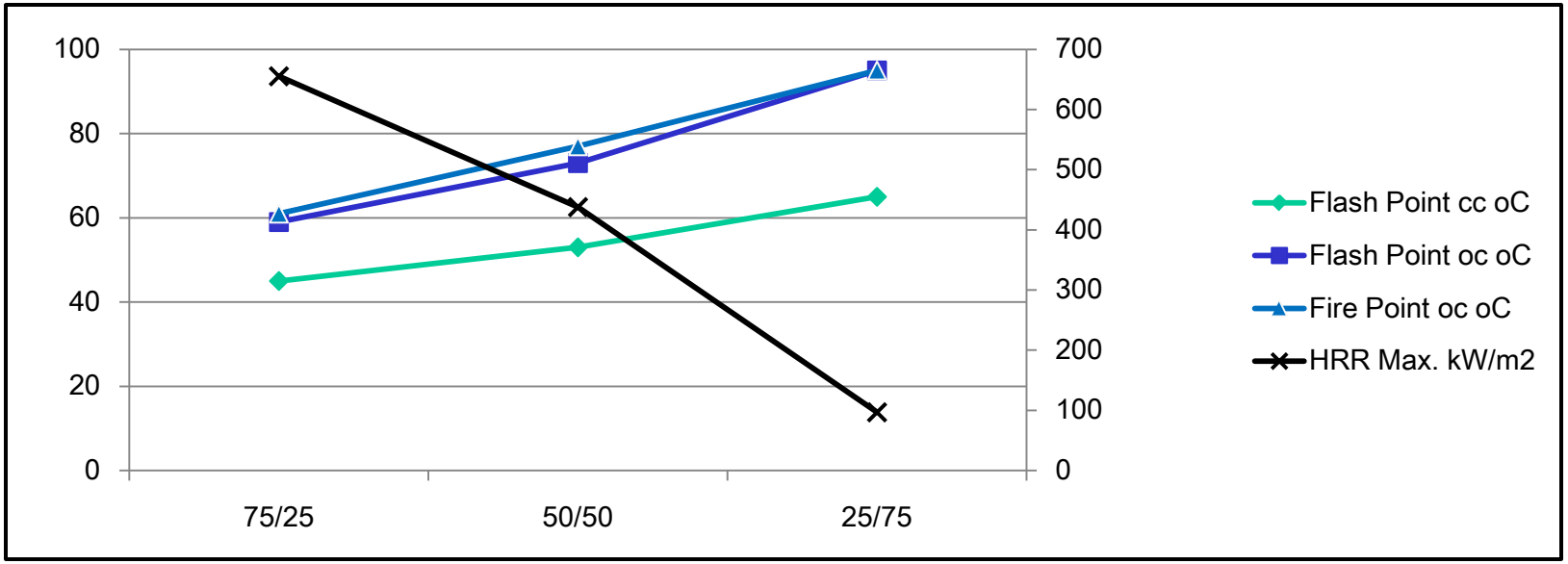
Solvent List	Flash Point cc °C *	NFPA Class	
Acetone	-20	IB	Flammable
Methyl Ethyl Ketone	-9	IB	Flammable
Isopropyl Alcohol	13	IB	Flammable
Propylene Glycol Monomethyl Ether	33	IC	Flammable
N-butyl Alcohol	36	IC	Flammable
Acetic Acid	39	II	Combustible
Ethylene Glycol Monopropyl Ether	49	II	Combustible
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			

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

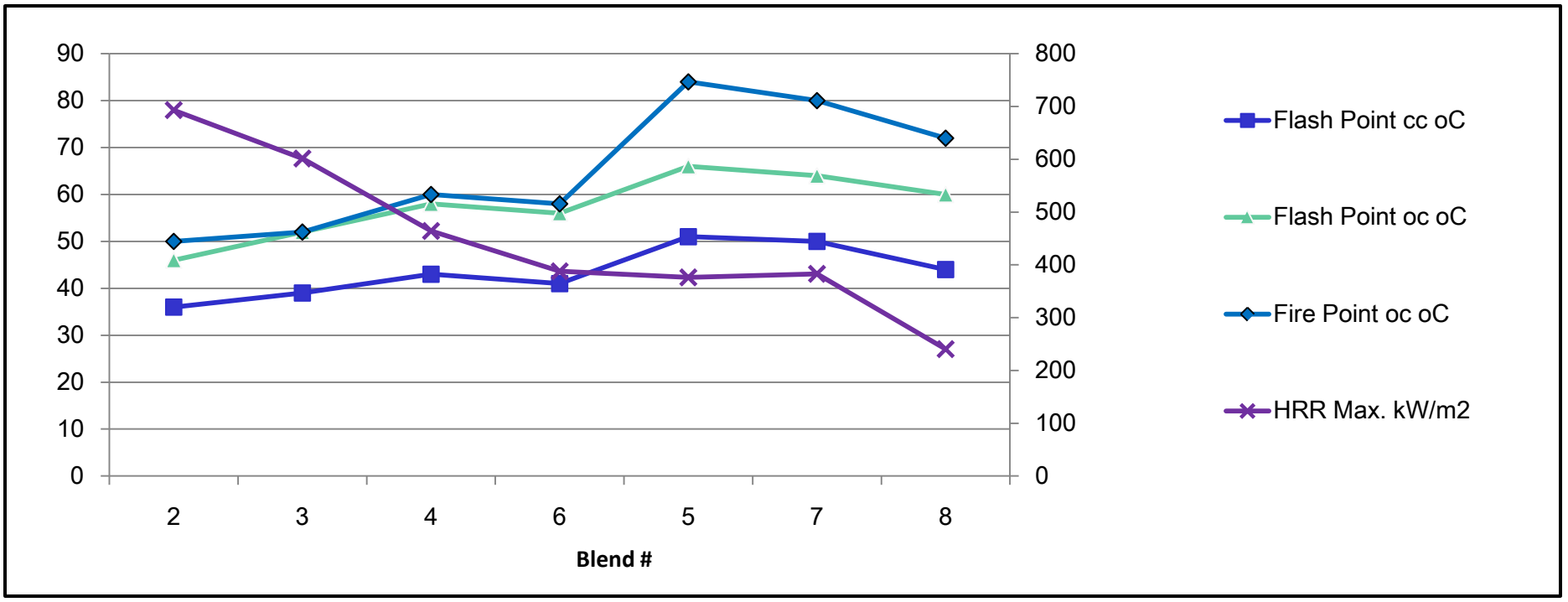
* Fire Point Occurred at Boiling Point



Blend	IPA/ Water %	**Flash Point cc °C**	**Flash Point oc °C**	***Fire Point oc °C***	**Total Heat Released MJ/m²**	**HRR Max. kW/m²**
17	75/25	19	32	32	218.5	894.4
12	50/50	21	35	35	175.7	739.4
11	25/75	27	35	43	76.8	532.5



Blend	Propylene Glycol Monomethyl Ether/Water %	**Flash Point cc ^{o}C**	**Flash Point oc ^{o}C**	**Fire Point oc ^{o}C**	**Total Heat Released MJ/m^2**	**HRR Max. kW/m^2**
24	75/25	45	59	61	212.2	655.3
22	50/50	53	73	77	145.9	437.8
23	25/75	65	95	95	6.6	96.7



Blend #	Butanol	Isopropyl Alcohol	Ethylene Glycol Monobutyl Ether	Total Organic	Water	ROH/Glycol Ether Ratio	**Flash Point cc °C**	**Flash Point oc °C**	**Fire Point oc °C**	**Total Heat Released MJ/m²**	**HRR Max. kW/m²**
2	20%	20%	30%	70%	30%	1.33	36	46	50	223.3	693.2
3	15%	15%	30%	60%	40%	1.00	39	52	52	195.6	601.5
4	10%	10%	30%	50%	50%	0.67	43	58	60	164.7	464.2
6	10%	10%	20%	40%	60%	1.00	41	56	58	136.5	387.8
5	5%	5%	30%	40%	60%	0.33	51	66	84	134.5	376.3
7	5%	5%	20%	30%	70%	0.50	50	64	80	87.6	383
8	5%	5%	10%	20%	80%	1.00	44	60	72	45.7	240.4

Phase I Test Report

Fire Performance of Ordinary, Non-listed and Non-metallic IBCs with Aqueous Solutions of Flammable and Combustible Liquids Phase 1: Small Scale Testing of Solutions

Health & Safety Laboratory

Harpur Hill, Buxton

Derbyshire, UK

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

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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