MARSH RISK CONSULTING

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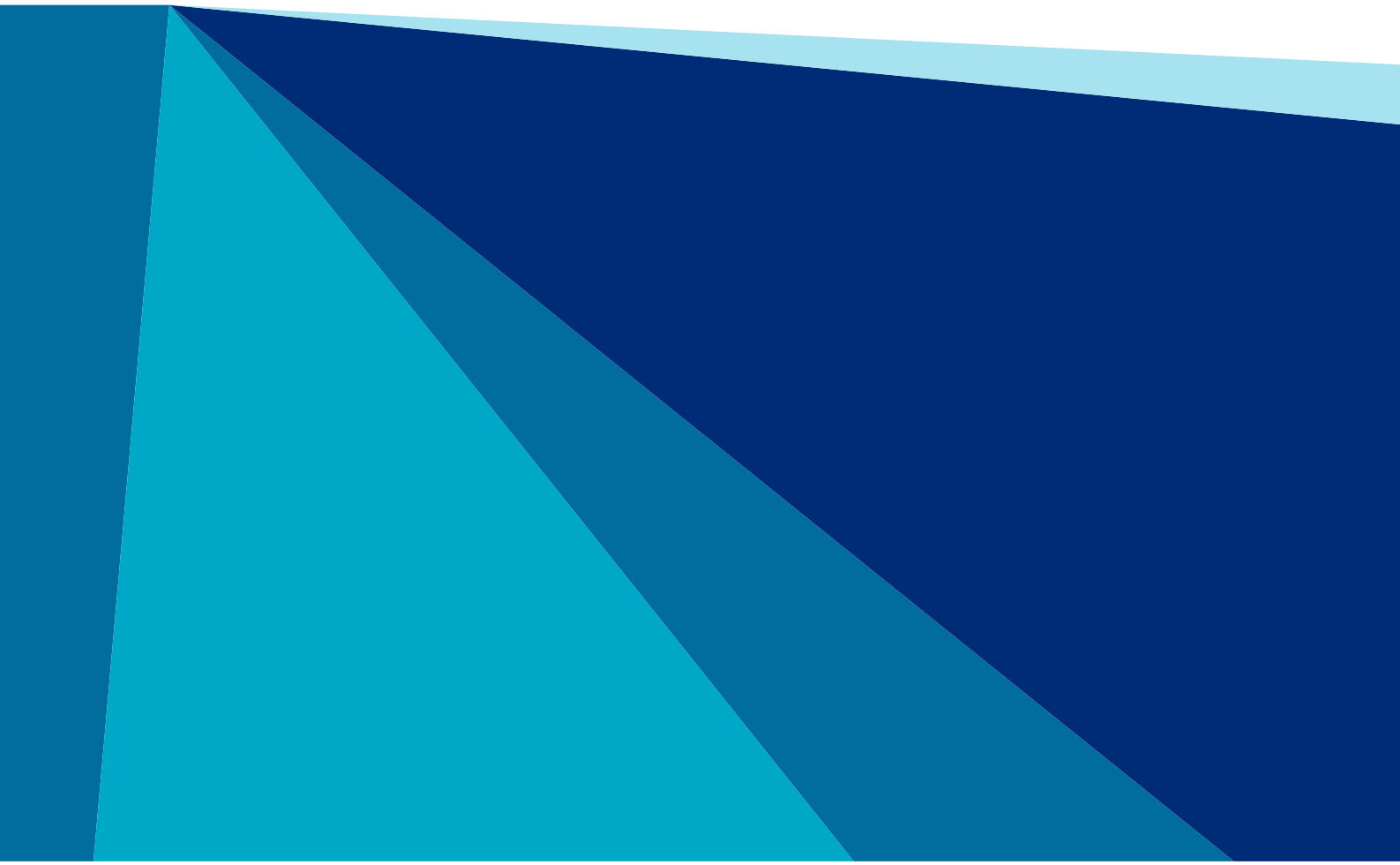
WHITE PAPER

FIRE PROTECTION COMPOSITE IBCs AND METAL IBCs

FEBRUARY 2020



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WHITE PAPER
Fire protection CIBCs and Metals IBCs

February 2020

The information in this publication provides general information and should not be considered as tailor made advice for specific problems or storage location.

Status white paper

This paper describes the best available techniques known at the time it was written for the fire protection of IBCs in storage configurations and other location addressed in this document.

The information in this document together with site specific information and legal requirements can be used as guidance to describe the intended fire protection design concept.

CONTENTS

1

Introduction

This paper provides information for the fire protection of Composite Intermediate Bulk Containers (CIBCs) containing flammable or combustible liquids.
For many years there is general consensus within the fire protection industry that a fire in warehouses storing flammable and combustible liquids in composite CIBCs is difficult to control and extinguish. Tests with CIBC's show that they fail in 1 to 11 minutes when exposed to 3D fires, pool fires and spill fires. This results in loss of containment of ≥1,000 litres of flammable or combustible liquids which, depending on the drainage provisions, can flow over the full surface of the warehouse floor causing further spread and escalation of the fire. Traditional water based sprinkler systems will be overwhelmed, when ≥1,000 litres of burning liquids spread over the warehouse's floor.

Loss of containment from a metal IBC, fitted with composite or plastic taps can also occur when the IBC's tap is exposed to a spill fire on the floor of the warehouse. Instantaneous failure of metal IBCs is less likely, however build-up of pressure in the IBC, due to the exposure to the fire, can cause major risks of escalation of the incident.

The National Fire Protection Research Foundation is involved in research which is used to update the provisions in chapter 16 of NFPA 30: Flammable and Combustible Liquids Code.
This NFPA code and other NFPA standards are frequently used to define the fire protection scheme for various storage configurations and other uses of CIBCs containing flammable or combustible liquids in this White Paper.

Fore storage of these CIBCs, NFPA 30 relies on early control of the fire before this fire can spread to the full surface of the warehouse.

CIBCs that have UL 2368 listing or FM Class 6020 approval have been submitted to tests by UL or FM Global will also fail when exposed to a fire, but this can occur slightly later than non-listed or non-approved CIBCs.

FM Global describes the conditions for storage of CIBCs in Datasheet FM 7-29: Ignitable Liquid storage in Portable Containers (latest version https://www.fmglobal.com/research-and-resources/fm-global-data-sheets).

CIBCs have become increasingly popular resulting in widespread irreversible use in many industrial activities. Users of CIBC's do not like to replace CIBCs with metal IBCs due to the increase of costs. The liquid level in the container connected to process installation is visible, which makes the it easy to monitor. They are rectangular and stackable, which means efficient use of floor space. The price of a metal IBC is 2 to10 times more than of a new and recycled CIBC. In addition the weight of a metal IBC is 2.5 to 4 times heavier than that of a CIBC, which means less CIBCs can be transported at the same time. Furthermore the carbon foot print of a company increases considerable due to use of metal IBCs.

This factsheet is a stand-alone document that describes Good Practices in the provisions for constructions of installations fitted to control and extinguish the fire and organisational measures to be taken to store flammable and combustible liquids in IBCs under safe conditions.

Information from existing references like: NFPA 11, NFPA 16, NFPA 30, FM 7-29, FM 7-83 and UN approvals were used to describe the Good Practice Examples formulated in this Factsheet. This Factsheet does not intend to replace these references and should not be considered as a supplement for and/or amendment of these references.

2

Some types of IBCs

According to the Hazardous Materials Regulations in the US a CIBC, as considered in this factsheet, consists of a rigid outer packaging enclosing a plastic inner receptacle, together with any service or structural equipment. A CIBC must have a volumetric capacity between 0.45 cubic meters (450 litres, 119 gallons, or 15.9 cubic feet) and not more than three cubic meters (3,000 litres, 793 gallons, or 106 cubic feet) or a maximum net mass of not less than 400 kg (882 pounds).

5.1 Categories of CIBCs based on UN approval

There are many types of IBCs. The main focus of this White Paper is on the behaviour of CIBCs shown in figure 1, when it is exposed to a fire.

A non-exhaustive enumeration of UN approvals for various types of IBCs is shown below:

- UN 31A, steel;
- UN 31B, aluminium;
- UN 31N, other metal than steel or aluminium;
- UN 31H1, rigid plastic IBC fitted with a frame;
- UN 31H2, rigid plastic IBC with no frame;
- UN 31HZ1, composite IBC consisting of a rigid outer packaging, usually metal, and
- UN 31HZ2, composite IBC consisting of a rigid outer packaging, usually metal, with a rigid plastic inner vessel.

Image 1: Rigid CIBC in metal cage, with composite or plastic butterfly or ball valve

Image 2: Rigid CIBC with composite or plastic butterfly or ball valve, fitted on composite pallet

Image 3: Rigid CIBC with 300 litre volume

Image 4: Rigid CIBC with solid light weight steel cove & composite butterfly or ball valve

Image 5: Rigid CIBC with solid cover made of zinc, with composite or plastic butterfly or ball valve

Image 6: Stainless steel IBC on fitted stainless steel pallet & composite butterfly or ball valve

3

Storage of empty CIBCs and used uncleaned CIBCs

The FM Global has published the Technical Report: *Fire Protection Requirements of Empty Intermediate Bulk Containers (IBCs),* July 2012.

The fire tests with empty clean CIBCs, which were described in this report, showed that their fire behavior is more severe than that of exposed unexpanded plastics. This means that there is a risk that fire protection provisions for exposed unexpanded plastics may not be able to control a fire in an area with empty CIBCs. Therefore additional measures listed below should be implemented when storing empty CIBCs in warehouse with a maximum height of 9.1 meter.

- It is strongly recommended not to store empty CIBCs in a warehouse which is also used for storage of flammable liquids;
- Stockpiling of 3 empty CIBCs is allowed with a sprinkler protection that complies with the following criteria:
  - The sprinklers have a K-factor of 202 l/min/bar^{½};
  - Pendent, quick response sprinklers with an activations temperature of 74°C should be used, and
  - The operating pressure of the sprinkler system should be no less than 2.2 bar.

It is recommended to read the FM Technical Report: *Fire Protection Requirements of Empty Intermediate Bulk Containers (IBCs),* July 2012 for more details about storage of empty CIBCs on wooden pallets.

The image below is of an empty non-cleaned CIBC, which is exposed to a pool fire of flammable liquid.
The flammable liquid has a viscosity similar to that of water.
The liquids layer of the pool is 1.1 – 1.5 cm.[1]
The vapours of the liquid were ignited soon after the liquid was put in the tray below the CIBC, using a torch

CIBCs which still contain residual quantities of flammable liquids because they were not cleaned, can contribute to escalation when exposed to an existing fire.

The images below are from the CIBC training organised by H2K Brandweeropleidingen & Marsh, where CIBCs are exposed to various fire scenario, to demonstrate the risks.

[1] Images one day training course Marsh Risk Consulting & H2K Brandweeropleidingen.

Image 7: after liquid was ignited in tray

Image 8: Within few minutes CIBC wall becomes translucent

Image 9: Translucent spot CIBC weakens and fails

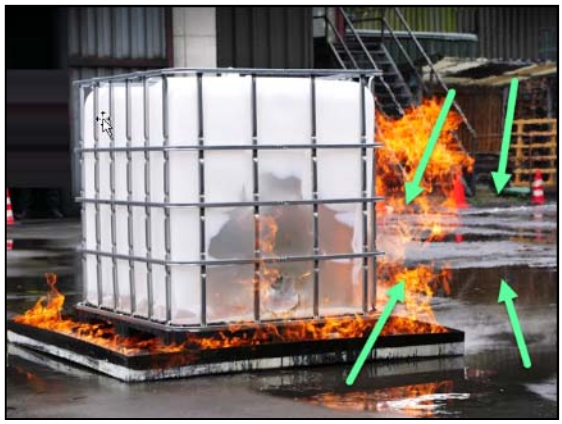

Image 10: Release of flammable vapour and aerosols

The images above, show how unclean empty CIBCs can contribute to the spread of a fire.
As far as we know, no tests were executed to identify the effect of this fire scenarios of the performance of the sprinkler protection schemes as described in chapter 16 of NFPA 30.

4

NFPA classes of flammable and combustible liquids

NFPA uses *class designations to* differentiate between liquids. An overview of the various classes and their properties is provided in table 1.

Class liquid	Flash point °C	Boiling point °C
Flammable liquids		
IA	<22.8	<37.8
IB	<22.8	≥37.8
IC	≥22.8 and <37.8	Not applicable
Combustible liquids		
II	≥37.8 and <60	Not applicable
IIIA	≥60 and <93	Not applicable
IIIB	≥93	Not applicable

Table 1: Liquids classification as defined by NFPA[2]

[2] Storage of class IA, IB and IC in CIBCs is not permitted according to Table 9.4.3 Maximum Allowable Size — Containers, Intermediate Bulk Containers (IBCs), and Portable Tanks, of NFPA 30.

5

Hazards and risks of CIBCs – containing flammable and combustible liquids during a fire

Tests used to list CIBCs for transport of liquids are aimed at the integrity of the CIBC during transport and transport incidents. It is important to note that these tests do not address the behaviour of a CIBC during a fire. There is no correlation between the UN ranking of these containers and fire protection characteristics of these containers.

In 2007 the Health and Safety Executive in England published a report with the title *Fire Performance of Composite IBCs*[3]. Extensive fire test were performed with CIBCs. These tests showed that various CIBCs rapidly lose their integrity when exposed to a fire in general and specifically when the CIBC is placed in a spill or pool fire. The two reasons for this are that the composite of the IBC wall and/or the composite ball or butterfly valve of the CIBC quickly weakens and deteriorates during flame impingement, even if the fire is small. This results in loss of containment of the ≥1,000 litres of liquid present in the CIBC.
These 1,000 – 3,000 litres liquid can spread over the full surface of the warehouse if the spill is not drained to a safe location.

Even when this scenario starts with no more than a puncture of the CIBC without a fire being present, the risk of the liquid being ignited is considerable due to the fact that CIBCs accumulate static electricity during filling, unloading, and movement and thus may hold and release static charge with any change in state or condition.

Some videos showing fire tests with a CIBC and metal IBC can be found on the following websites:

a. http://www.youtube.com/watch?v=_pfbHGxyHNc (video fire test CIBC)
b. http://www.youtube.com/watch?v=8HX3iraAyRo (video stainless steel IBC)

It is assumed that the IBC in the test shown under b is fitted with a metal butterfly or ball valve.
If the IBC was fitted with a composite valve, the valve would probably fail when exposed to a spill or pool fire, enabling loss of containment of the liquid in the IBC.

[3] http://www.hse.gov.uk/research/rrhtm/rr564.htm

5.1 Credible incident scenarios with CIBCs

Implementing good housekeeping, hot work permit procedures and other good practices can prevent incidents with CIBCs or limit the effect of the loss of containment and with it the size of a potential fire scenario.

Combustible liquids in CIBCs require nearby fire before they can contribute to pose a risk. The saying "an ounce of prevention is worth a pound of cure" is specifically for preventing fires with flammable and combustible liquids in CIBCs.

The most credible incident scenarios that can occur in a storage facility with CIBCs addressed in this factsheet are:

1. A CIBC which is stored on the floor of the warehouse. The CIBC is filled with a flammable liquid (flashpoint < 38°C).

   There is a small leak from the tap of the CIBC, or the CIBC is punctured due to an external force (e.g. the forks of a forklift truck).
   CIBCs in the warehouse containing either flammable or combustible liquid are exposed to flame impingement and radiation heat caused by this fire. These CIBCs will rapidly fail (2 - 3 minutes) after first exposure, resulting in the discharge of their contents over the floor of the warehouse and causing a full surface warehouse spill fire. Such a fire will overwhelm traditional sprinkler protection systems.

2. Leaking CIBCs at height (indoor and outdoor rack storage)
   The following two scenarios for elevated storage of CIBCs are addressed:
   A CIBC containing flammable liquids is stored in-rack at approximately 5 meters above the floor.

   The in-CIBC stored at the top of the racks suffers from a leak from the tap or the CIBC is punctured by the fork of the forklift truck.

   The distance between the floor and the spill (>4 meter) results in the flammable liquid splashing on the floor of the storage are. This supports the evaporation of the liquid and generation of flammable vapour. The vapour is ignited causing a three dimensional running fire. 3D-fires cannot be extinguished nor controlled by sprinkler installations.

   The integrity of the construction of the rack is compromised and the rack collapses, causing the spread of more products over the floor. A domino effect can occur – depending the distance and location of other storage rack. A domino collapse of other storage rack (images blow) and rapid spread of the fire can be the result depending the location of the other racks.

Image 11: collapse storage rack

Image 12: racks against wall causing loss of containment outside storage compartment

3. 4 CIBCs are stacked on the floor of the storage area. The UN listing shows that these CIBCs are suitable for this type of storage.

The in-CIBC stored at the top of the racks suffers from a leak from the tap or the CIBC is punctured by the fork of the forklift truck.
Tests performed with stacked CIBCs showed that the behaviour of the stack depends on the material of the pallet below the CIBC.
Stacks with a wooden pallet stay upright, because the wood of the pallets is charred in the fire, which makes it them stick to frames of the CIBC. This is shown in image 11 on the left.

Compare this with the images below of CIBCs with integrated composite pallets. The burning liquids causes local degradation of the pallets. The stack becomes unstable and falls over, spilling the contents of all CIBC on the storage location surface and beyond. It is difficult if not impossible to control, let alone extinguish such a fire with a sprinkler installation.

Image 13: stack of CIBCs on wooden pallets after fire

Image 14: stack four CIBCs with integrated composite pallets. Burning liquid from top CIBC at early stage of fire

Image 15: fire on surface below stack is kept under control with foam

Image 16: composite pallets weaken at location of the leak

Image 17: stack crashed spilling residual content of four CIBC over the storage area

4. Combustible liquids (flashpoint ≥ 38°C) are stored in CIBCs in-rack, or on the floor of a warehouse.

   Other products or materials stored in the same warehouse cause a fire.
   A CIBC with combustible liquid fails rapidly after exposure to the radiant heat or due to flame impingement caused by the fire.
   The fire will spread due to the spilled combustible liquid which is also ignited causing a full surface warehouse fire.

5. Metal IBCs fitted with a composite or plastic valve, containing flammable or combustible liquids are stored in a warehouse.

   Other products or materials stored in the same warehouse cause a fire. The composite valve of the IBC fails due to the radiant heat and/or flame impingement of this fire. The fire will spread as the spilled flammable/combustible liquid is ignited and spreads over the floor of the warehouse.

Summary

CIBCs rapidly fail when exposed to a fire even if the fire is small.

A spill of flammable liquids can generate sufficient ignitable vapours. The static electricity accumulated by the CIBC, a hot surface, sparks, and other ignition sources can ignite these vapours.

CIBCs exposed to the fires in the storage facility or radiant heat from this fire, rapidly lose their integrity too. Depending on the drainage provision in the storage area, this will cause a full surface pool or spill fire. This fire will overwhelm traditional sprinkler systems.

Stacked CIBCs, fitted with integrated composite pallets, exposed to a fire running from the top CIBC, will collapse minutes after the started, spilling the contents of all CIBCs involved.

The composite valve of a metal IBC can also fail when exposed to a pool fire. The contents of this IBC will spread over the surface of the storage area.

CIBCs containing combustible liquids are susceptible to integrity failure when exposed to flames and/or intense radiant heat. The combustible liquid can be ignited when exposed to the flames and radiant heat.

The fire will spread over the full surface of the warehouse floor, unless measures are in place to minimise the size of the spill. This is a credible fire scenario for storage facilities CIBCs and metal IBCs fitted with plastic or composite valves, containing flammable and/or combustible liquids.

5.2 Reducing the risk by controlling the size of the spill

A CIBC can contain ≥1,000 litres flammable or combustible liquid. This amount of liquid can spread over the full surface of the warehouse when no additional measures are in place.

Structural provision to reduce the size of the spill can effectively be used to control fires. Also strategically placed LEL-detection (preferably at locations where the liquid is collected) for spills of flammable and combustible liquids provide an early warning of the release of the before it can be ignited.

Article 16.3 of NFPA 30 [2018] and FM Data Sheet 7-83: Drainage and containment systems for ignitable liquids can be used for guidance and designing drainage and containment provisions for storage locations of CIBCs containing flammable and combustible liquids.

It is recommended to limit the gross surface area of any storage facility for CIBCs and metal IBCs with plastic/composite valves containing flammable and combustible liquids to 2,500 m^2.
This area should be divided in storage areas of 300 m^2. Spill measure control is preferred. Each storage area should be surrounded by 3 fire walls with a fire resistance of at least 30 minutes.

Drainage of the spill towards tertiary containment at a distance for the storage facility should be fitted with a flame arresting gauche in the gutter or other similar provision.

Images 16 – 18 show three trench drainage options for rack storage of CIBCs

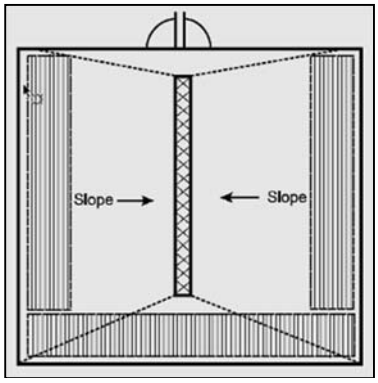

Image 18

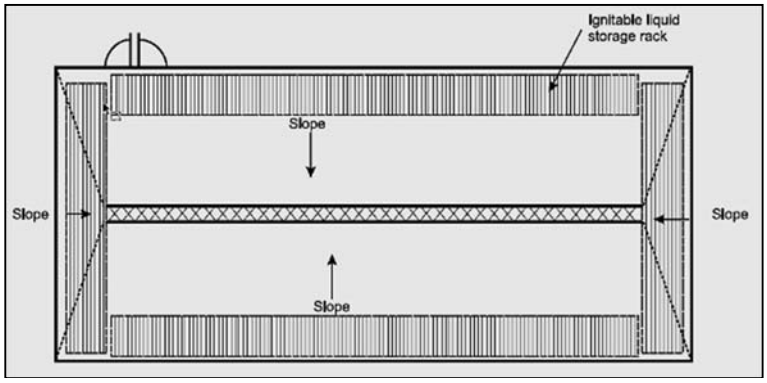

Image 19

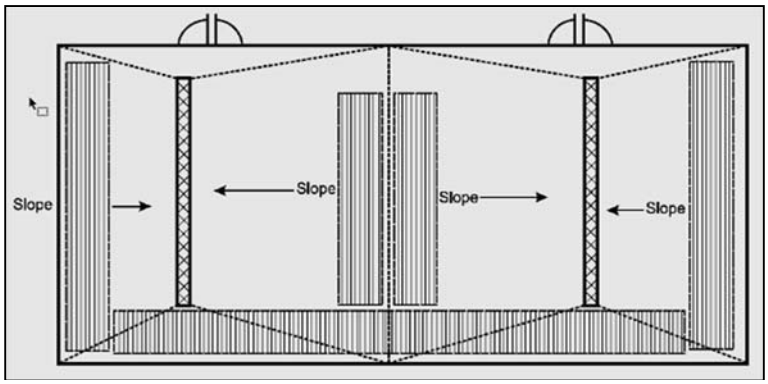

Image 20

Imgages below show two options for cicular drainage rack storage

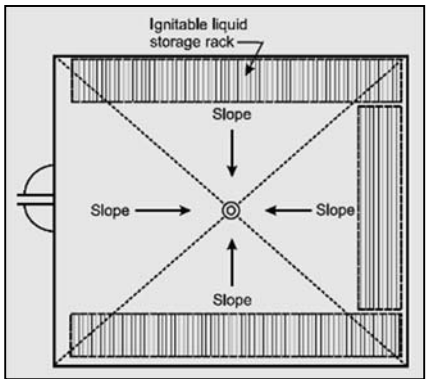

Image 21

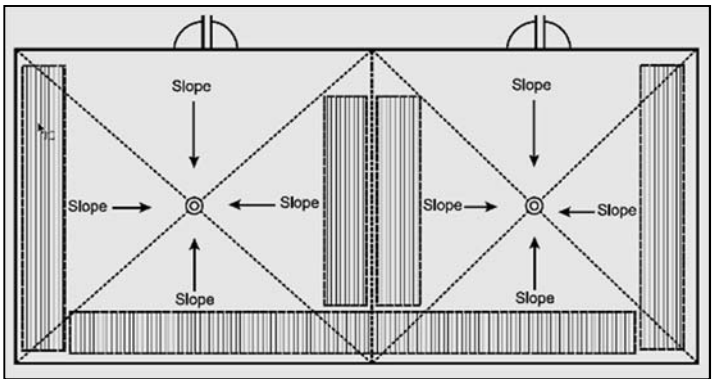

Image 22

These drainage provisions support early detection of spills and/or fires as the position of the LEL- and/or fire detectors should be located near the location towards which they are directed.
It is important that the size of drainage is is suitable for the expected flow.

When using rack storage – attention should be given to the (domino) effects of falling racks, including the potential breach if integrity of the fire compartment for light weight constructions. An example is shown in the photos above.

Storage of product which cause adverse reactions in the same containment/catchment area, should be prohibited.

5.3 Sprinkler Design Area

Controlling the size of the spill – and with it the size of the fire – for storage of stockpiled or in-rack storage of CIBCs requires a performance based design of drainage and/or containment provisions taking into account the sprinkler design area(s) (designed maximum area of operation). The water supply for a sprinkler system in of the storage facility shall be based on the water demand of all sprinklers in one sprinkler protection design area.

The size of the spill should not exceed the sprinkler design area (storage box , storage section) unless floor foam sprinklers (i.e., berm-mounted nozzles, or foam pourers intended to apply foam close to the floor) are installed. Further explanation on the use of floor foam sprinklers or floor foam pourers can be found in chapter 8.
Expertise about the development of a spill and the spill fire is required for designing performance based fire extinguishing systems.

Constructions, like storage racks and objects that are exposed to flames and/or radiant heat must be cooled. This cooling should be done by fire fighting foam discharged from ceiling and rack sprinklers. The foam makes the water sticks to vertical surfaces, enabling the water to evaporate and increasing the cooling effect of water >500 times.

Flowing burning liquids, like the liquid spilling from an elevated punctured CIBC, cannot be extinguished by fire fighting foam as it is not possible to seal the liquid with a foam blanket.

6

Performance based fire protection design

There is an array of variables which have to be considered when designing fire protection systems for storage of CIBCs containing flammable or combustible liquids. These liquids can be miscible with water, non-miscible with water, viscus, thixotropic, or have other properties which can affect the incident scenario.

The potential large quantities of liquid which can be released from an CIBC in the storage facility require a dedicated approach for the design of the fire protection system.

NFPA 1: Fire Code Handbook Chapter 5: Performance-Based Option describes this in detail.
With the performance option, acceptable levels of fire risk control for warehouses storing CIBCs can be established. Whilst the performance option does contain goals, objectives, and performance criteria necessary to provide for an acceptable level of risk control, it does not describe how to meet these goals, objectives, and performance criteria. The SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings and the Risk-Informed Performance Based Industrial Fire Protection, An Alternative to Prescriptive Codes book by Thomas F. Barry, P.E., provides the framework to accomplish this by going through a 12 step process. This process is shown on the page below.

It is recommended to go through this process for the design of each fire protection system of storage facilities for CIBCs containing flammable and combustible liquids.

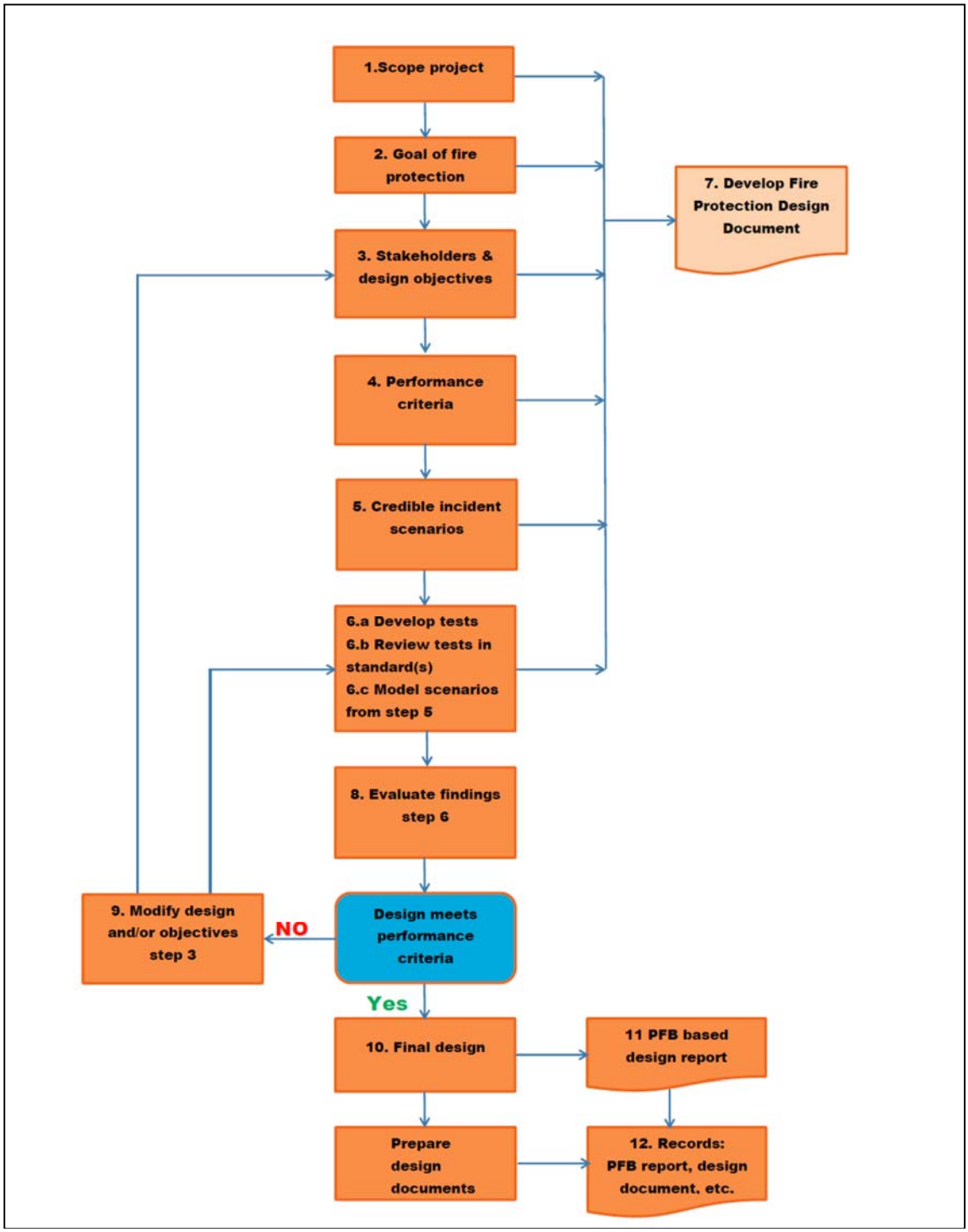

Image 23: Performance Based (PFB) process for fire protection design

7

CIBC storage location and fire protection options

Safe storage of CIBCs at outdoor storage locations and in warehouses requires stakeholders to follow the performance based process in chapter 6. The requirements for the construction of the outdoor storage locations and the warehouses and the various options for fire protection are discussed in this chapter. Examples of sprinkler protection configurations for warehouses are discussed in chapter 9.

7.1 Size storage location

The risks of rapid spread of a fire with flammable or combustible liquids stored in of CIBCs were identified and described in § 5.1 of this white Paper. The best option to control and extinguish these fires is by limiting the actual storage area of the outside storage location and warehouse to a maximum of 2,500 m^2.

7.2 Outdoor storage

Outdoor facilities for storing more than 10,000 kg flammable and/or combustible liquids in CIBCs should be located at a distance of 10 meters from any other building and activity or be fitted with fire walls from this building or activity if the separation distance is less than 10 meters. These walls should have a fire resistance of a minimum of 60 minutes. Light weight roofs, and weather shields, should be designed in a way that they do not contribute to the fire and/or adversely affect the fire fighting.

Fire rated storage cabinets which can store less than 10,000 litres of flammable liquids can also be used for outdoor storage. The FBM fire rated storage container by Denios is mentioned as an example in this White Paper for illustration purposes, without excluding any other cabinets with similar properties.

7.3 Construction storage location

Warehouses, should be built as an independent box as a fire compartment. This box shall have a fire resistance of 60 minutes (walls, including any (overhead) doors, roof, floor and load bearing construction) or more as required by local standards and codes used for the design of the fire protection system. The 60 minutes fire resistance should be based on the hydrocarbon fire curve.
Non-combustible materials, including insulating materials used in the construction, should be used when building the warehouse.
Warehouses built side by side require parapet walls, which extend at minimum of 50 cm above the roof.
Ventilation openings in the wall and/or roof and ducts in the walls should be provided with suitable shutters which comply with the 60 minutes (or more) fire resistance of the wall or roof.

7.4 Storage sections

The storage location should be divided in storage sections of maximum of 300 m^2. The drawings listed below show a non- exhaustive suggestion of storage configurations. Storage sections should be separated by aisles of 3.5 meter wide or 30 minutes fire resistant walls of non-combustible material. The walls should reach at

least 50 cm above the highest stored material in the section. Automatic spill barriers[4] can be used to allow forklift access to the storage section without compromising the containment and or drainage provisions of the storage section.

The aisles between storage sections for CIBCs with flammable and or combustible liquids should (preferably) be sloping towards the middle of the aisle. Other options which have shown to be effective through tests can also be used. The liquid should flow away from the storage section and be collected through a grate or other provision fitted with flame arresters, which is connected to the tertiary containment provision.
Images 24 – 28 below show various examples of storage configurations.

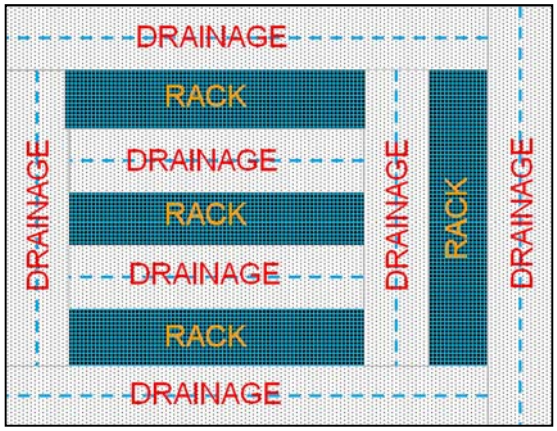

Image 24: Single rack storage with aisles

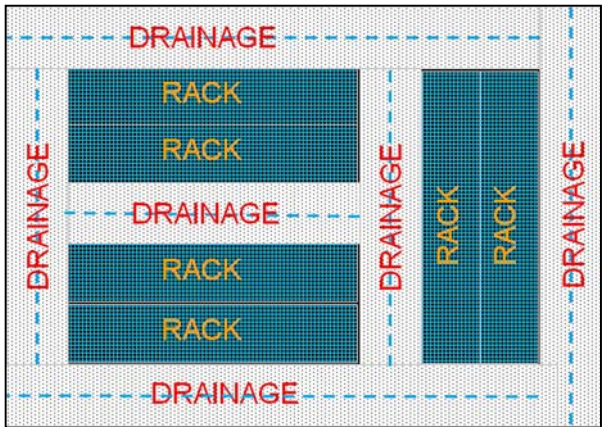

Image 25: double rack storage with aisles

[4] https://www.youtube.com/watch?v=3kuXNKmPmeI

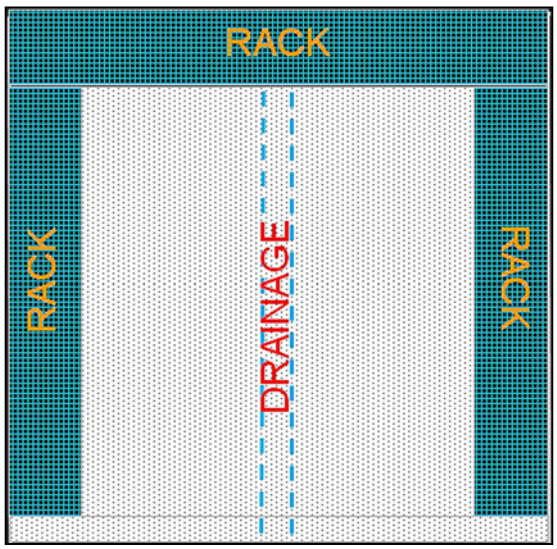

Image 26: rack storage in max 300 m² section

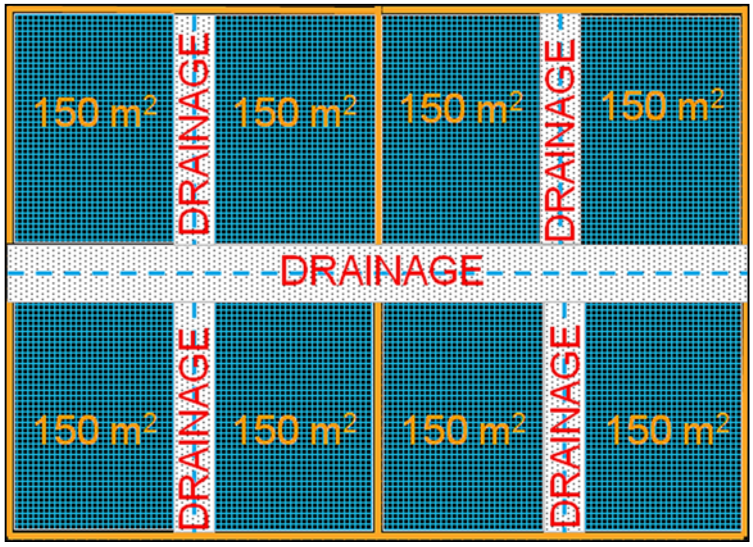

Image 27: 300 m² sections separated by 30 min fire walls

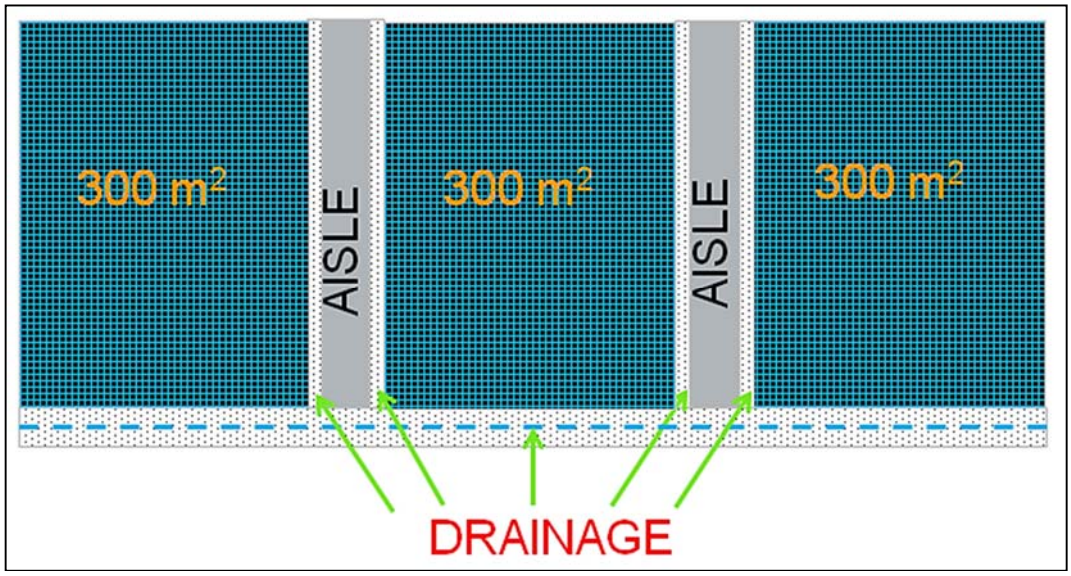

Image 28: 300 m² storage sections separated by aisles

8

Fire protection options

There are various fire protection options for protecting outdoor storage facilities and warehouses storing CIBCs containing flammable and/or combustible liquids. These options are discussed in this chapter.

8.1 Outdoor storage locations

The two water based fire protection systems for the protection of outdoor storage of CIBCs containing flammable and combustible liquids are discussed below.

8.1.1 Mobile[5] or fixed[6] monitors

Compliance with the following requirements is necessary to extinguish the fire:

a. Storage areas should not exceed 2500 m^2;
b. The storage area should be divided in sections with a maximum of 300 m^2. The separation between the sections should comply with paragraph 7.4.
   Drainage and containment provisions should be designed in accordance with NFPA 30: 16.3 [2018] and FM 7-83: drainage and containment systems for ignitable liquids;
c. CIBCs are to be stacked on the floor no higher than two CIBCs, even when the CIBC is approved for higher stacking;
d. Strategic selected locations should be provided with fast response LEL-detectors and fire detectors that generate an audible alarm for early detection of spills;
e. Empty new CIBCs and uncleaned used CIBCs should not be stored in the same section as CIBCs containing flammable or combustible liquids;
f. There should be at least 4 foam monitors per storage area, each with a minimum capacity of 4,200 litres/minute, which can be used simultaneously. It is not allowed to use monitors without foam suppletion.
   Do not use monitors without foam suppletion for the storage area;
g. Personnel operating the foam monitors have to be trained in the use of monitors for fighting these types of fires to avoid the risk of escalation of the fire;
h. The foam concentrate should be suitable for extinguishing fires with the types of products stored in the CIBCs, and
i. The water supply and foam concentrate should be sufficient for 60 minutes of fire fighting.

[5] Radiant heat exposure for responders should be taken into account for physical feasibility of a mobile response in the preplanning phase of the incident response

[6] Fixed monitors are remotely operated from a safe distance or from behind a fixed fire resistant construction which is fitted with a fire resistant view panel

8.1.2 Deluge installation with foam suppletion

Water and foam should be applied to full storage area when it is protected with a deluge installation.

Compliance with the requirements below is necessary for extinguishment of the fire:

- Fast response detection of any spill by LEL-detectors and fast fire detection by detectors reliable for outdoor use are conditional;
- Suitable low expansion foam should be used;
- Application time should be determined using article 6.3.2 of NFPA 16 [2019]: Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, and
- The use of a dry deluge or pre-action system, as described in NFPA 30 [2018]:16. 1.4.2, is not permitted

8.2 Fire protection options CIBC storage in warehouses

Various fire options may be considered following the performance based process for selecting fire protecting systems of warehouse storing composite CIBCs containing flammable or combustible liquids.
Six systems are listed below, of which four systems are discussed in more detail.

8.2.1 Examples automatically activated sprinkler system with foam suppletion

Sprinkler installations are suitable for controlling fires in warehouses storing flammable and combustible liquids in CIBCs. Sprinklers can be designed and installed as described in NFPA 30: Flammable and Combustible Liquids Code [2018].

This White Paper can be used for the storage of flammable and combustible liquids in CIBCs with UN/DOT approval.

The CIBCs, as listed in NFPA 30 are considered to be non-metallic intermediate bulk containers to be listed and labelled in accordance with UL 2368, or Standard for Fire Exposure Testing of Intermediate Bulk Containers for Flammable and Combustible Liquids; FM Class 6020, Approval Standard for Intermediate Bulk Containers; or an equivalent test procedure.
FM CIBCs are suitable for storage of combustible liquids only.

Listed composite CIBCs are made of a specific material and wrapped in a blanket of ceramic material or fitted with an additional metal covered and hinged plate to cover the tape (doghouse) of the CIBC. This plate should protect the tape from fire exposure during a fire. This hinge is sensitive to being damaged during operations.

Image 29: CIBC with doghouse cover plate

Image 30: Doghouse cover plate

Fires in warehouses storing flammable and combustible liquids in plastic and composite IBCs and metal IBCs with composite or plastic valves can be controlled or extinguished using the general provisions below in combination with one of the three dedicated protection packages on top of the requirements described in NFPA 30. This suggestion is based on:

1. A spill fire caused by ≥1,000 litres of hydrocarbons released from CIBCs. This extensive fire will overwhelm the sprinkler system described in NFPA 30
   Measures to control the size of the spill should be implemented. NFPA 30: 16.[2018] and FM 7-83: drainage and containment systems for ignitable liquids can be used for guidance.

2. By adding a fire fighting foam suitable for the products in the warehouse to the sprinklers the fire can be extinguished and the cooling capability of the water flowing over vertical surfaces is significantly increased, as foam makes the water stick to the surface generating maximum cooling by the water evaporating.[7]

8.2.1.1 General provisions

The following general provision should always be in place for the storage of CIBCs protected with sprinklers

- Early detection of spills with fast response LEL-detection that generates an alarm;
- Fast fire detection;
- Containment provision in place to reduce spill surface area;
- Provision to minimise spill when leaking CIBC is stacked or stored in-rack;
- Cooling of objects with foam when exposed to radiant heat and flame impingement from a spill fire of stacked CIBC or in-rack CIBC;
- Water fire fighting foam mixture must be discharged from all activated sprinkler heads, and

[7] Evaporating water results provides >500 times more effective cooling than a water flow.
Evaporating 1 liter of water requires 2260 kJ.
Increasing the temperature of 1 liter of water with 1 degree Celsius requires only 4.2 kJ

- The foam concentrate must have passed an appropriate EN 1568 test for compatibility with the products involved in the fire.

8.2.1.2 Provisions package 1: storage of Class liquids IB, IC, II, IIIA & IIIB in CIBCs

When Class liquids IB, IC, II, IIA and IIIB are stored in CIBCs the following provisions should be in place.

- All CIBCs used in the storage facility must have a UN/DOT listing for the product contained in the CIBC even when the CIBC is not subjected to any transport activity;
- Class IA liquids in plastic and/or composite CIBCs is prohibited from storage under provision package 1; These products must be stored in full metal CIBCs that are fitted with a metal valve and approved pressure relief mechanism;
- All sprinkler heads (ceiling and in rack sprinklers when racks are present) that have to be present according to NFPA 30 [2018] § 16.5.1.6 must be supplied with a water/foam mixture;
- Calculations for the water/foam supply requirements should always be based on the ceiling and in-rack sprinklers together that will be activated according to NFPA 30 [2018], § 16.6.1.4 or § 16.6.2.4;
- Containment provisions must secure the size of the spill within the storage section of 300 m^2, or the area of the aisle where the spill occurred.
  Spread of the spill shall be controlled within the scope of the sprinkler design area for NFPA liquids classification (NFPA 30 [2018], §. 16.8.2);
- CIBCs are to be stacked on the floor no higher that two CIBCs, even when the CIBC is approved for higher stacking, and
- Adequate containment measures to minimise the size of the spill, as well as reducing spreading of the spill, carbon steel (or other suitable material) barriers can be applied when water supply is not sufficient to meet the requirement for existing storage facilities. These measures are subject to approval by the AHJ.

Note:
Additional floor foam pourers described in provision package 3 should be installed when review of the credible CIBC incident scenarios shows that control of spread of the liquid, and therefore the size of the spill cannot be guaranteed.

8.2.1.3 Provisions package 2: dedicated storage of Class liquids IA in composite/plastic CIBCs

When class IA liquids are stored in CIBCs the following provisions should be in place.

- Storage in a cut-off room[8];
- All IBCs used in the storage facility must have a UN/DOT listing for the Class IB Products;
- All sprinkler heads that have to be present according to NFPA 30 [2018], § 16.5.1.6 must be supplied with a water/ foam mixture;
- Calculations for the water/foam supply requirements should always be based on ceiling and in-rack sprinklers that will be activated according to NFPA 30 [2018], § 16.6.1.4 or § 16.6.2.4;

[8] Cut-off rooms have either one or two exterior walls. The floor surface is limited to 30 m^2, For a 60 minute fire resistant construction including the load bearing construction, but can be any size up to 2500 m^2 for a 2-hour fire resistant construction including the load bearing construction when provisions are in place to control the spill to a maximum of 300 m^2.

- Containment provisions must secure that the size of the spill and spread of the spill will remain within the scope of the sprinkler design area for NFPA Class liquids NFPA 30 [2018], § 16.8.2;
- CIBCs are to be stacked on the floor no higher that two CIBCs, even when the CIBC is approved for higher stacking;
- Containment provision must ensure that the spill and spread of the spill is always contained within the sprinkler design area, and
- Restrict the total fire load of the products and material stored in the cut-off room to 16 MW.

Note:
Additional floor foam application described in provision package 3 should be installed when review of the credible CIBC incident scenarios shows that control of spread of the liquid, and therefore the size of the spill, cannot be guaranteed.

8.2.1.4 Provisions package 3: floor foam pourers for existing CIBC storage warehouse with containment in warehouse

The following additional measures should be in place when an analysis of the incident scenarios shows that the spill of Class liquids IB, IC, II, IIA & IIIB liquids in CIBCs cannot be restricted to the sprinkler design area, NFPA 30 [2018], 16.8.2:

- Storage in a cut-off room with a maximum floor surface of 2500 m^2;
- All CIBCs used in the storage facility must have a UN/DOT listing for the product contained in the CIBC even when the CIBC is not subjected to any transport activity;
- Storage of Class IA liquids in CIBCs are prohibited;
  These products must be stored in full metal IBCs fitted with a metal valve and approved pressure relief mechanism;
- No in-rack storage is allowed;
- IBCs are to be stacked on the floor no higher that two IBCs, even when the IBC is approved for higher stacking. Storage type: floor storage (stock piled);
- All sprinkler heads have to comply with NFPA 30 [2018], § 16.5.1.6 and should be fed with a water/foam mixture suitable for the products involved[9];
- Apply floor surface foam pourers (see examples images 15.a -15.c);
- Application rate for floor foam pourers for hydrocarbons is 6.5 l/min/m^2 NFPA 16 [2019], 7.2.2.1, or more when suppliers recommend this for water soluble liquids, like alcohols.

  Minimum expansion rate for water soluble foam should be 5:1 or 6:1 to cover the water soluble product, and to extinguish the fire.

  Gentle application of the foam should be used for water miscible products to avoid destruction of the foam.

  Application time floor foam pourers should be 30 minutes NFPA 11 [2019], 7.2.2.1.

  Activation of the floor foam pourers by the fire detection system. System can stop automatically after 30 minutes.

[9] For water miscible products the foam concentrate shall be alcohol resistant foam.

All floor foam pourers need to be activated from the moment the fire is detected;

- Calculations for the water/foam supply requirements should always be based on combined flow of the ceiling sprinklers that will be activated according to NFPA 30, and the floor foam pourers;
- Containment provisions must guarantee size of the spill and spread of the spill will always remain within the scope of the sprinkler design area for NFPA Class liquids, NFPA 30 [2018], § 16.8.2, and
- The full surface area of the storage facility should be covered with foam after activation of the floor foam pourers within 5 minutes of activation.

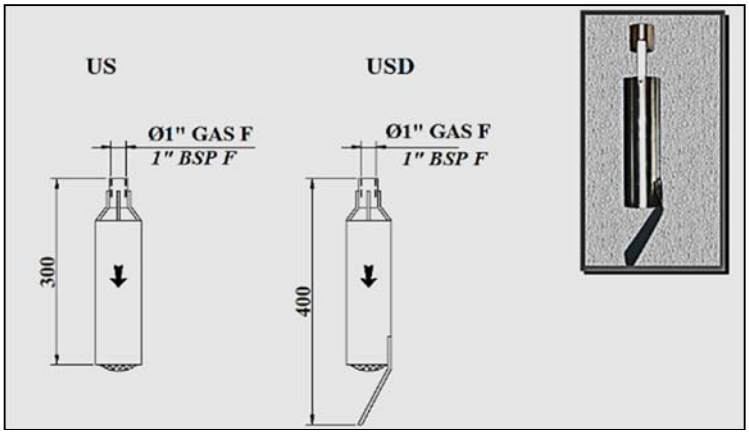

Image 31: Floor foam application device

Image 32: Air foam deflector for foam chamber

Image 33: Foam pourer

8.2.2 Automatically activated deluge system

The deluge system described in paragraph 8.1.2 for fire protection of outdoor storage can also be used for the protection of warehouses storing flammable and/or combustible liquids.

8.2.3 Hi-ex foam outside air

A hi-ex outside air fire protection system (NFPA 11) can be applied for non-water miscible liquids in CIBCs. The hi-ex installation should be quickly activated after the liquid is ignited. Therefore rapid response fire detectors should be used.

More foam may be required than anticipated for a similar warehouse where no IBCs are stored. This is due to potentially large spill area, which can cause foam to be destroyed.

Also fast response LEL-detectors should be used as delayed ignition of spills of ≥1000 litres of flammable liquid can affect this integrity of the hi-ex installation as well as the construction of the warehouse.

High temperature resistance Hi-ex foam concentrate should be used as the ceiling temperature can quickly reach ≥1000 degrees Celsius when the contents of one CIBC is spilled on the warehouse floor and is ignited.

There are no alcohol resistant hi-ex foam concentrates. An alcohol resistant low expansion foam floor system, which operates independently from the hi-ex installation, has to be installed if flammable or combustible products which are water miscible are stored in het warehouse. The floor foam pourers have to be activated immediately after detection of the fire, well before the hi-ex outside air system is activated. The alcohol resistance low expansion foam on the floor will extinguish the spill fire on the floor. The hi-ex foam on top of the alcohol resistant foam will not be affected by the water miscible liquids on the floor of the warehouse.

Design of hi-ex outside foam systems and the floor foam system for warehouses storing flammable and combustible liquids in CIBCs requires considerable knowledge of and experience with the design scenarios. The projection of the floor foam monitors has to be able to cover the full floor surface area before the hi-ex installation is activated.
Consider usage of 1% low viscosity alcohol resistant foam which has passed EN 1568-4 test.

8.2.4 Gaseous extinguishing systems

The fire compartment shall be airtight for effective operation of gaseous extinguishing systems. Unidentified loss of containment of flammable liquids in the warehouse will result in a vapor cloud. Ignition of this vapor cloud causes a pressure wave which can affect the integrity of the fire compartment. Early detection of the loss of containment by the LEL-detectors can prevent this scenario. Therefore fast response LEL-detectors that generate an alarm should always be present in warehouses with flammable liquids.

There are two types of gaseous extinguish agents:

- Gases that repel the atmosphere in the warehouse and replace it with an inert gas
  These are known as inert gas fire suppression systems.
  Argon, Argon/Nitrogen mixture, Argon/Nitrogen/Carbon dioxide mixtures, Nitrogen and Carbon dioxide high or low pressure systems are used in inert gas fire suppression systems.

  Note:
  NFPA 12 and VdS 2093 are standards which can be used for the design of Carbon dioxide extinguishing systems. These standards list products which should not be stored when using a Carbon dioxide extinguishing system and states that any materials which can have a reaction with the Carbon dioxide should not be stored in a warehouse protected with this type of extinguishing system. Therefore liquids containing Sodium hydroxide, Potassium hydroxide, Ammonium hydroxide and organic amine solutions

like Trimethylamine, even if they are not flammable, should not be stored in a warehouse protected with a Carbon dioxide extinguishing system. The Carbon dioxide dissolves rapidly in these materials when spilled on the floor, making the Carbon dioxide ineffective.

This aspect should be addressed in the analysis of credible scenarios during the performance based process for designing the gaseous fire extinguishing system.

- Chemical/Synthetic gas fire suppression systems
  The chemical/synthetic gases fight fires in two ways different ways. The molecules of the gas withdraw thermal energy from the fire. This reduced the intensity of the fire. The energy form the fire causes the molecules of the extinguishing agent to split. These split molecules 'absorb' the reactive Oxygen atoms (also known as free radicals) present in the storage area atmosphere. The fire can no longer be supported in the absence of the reactive Oxygen atoms.
  These chemical/synthetic fire suppression gases are also known as anti-catalytic gases.

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