FM Global Protection Criteria for (Ignitable Liquids) Storage and Handling Occupancies

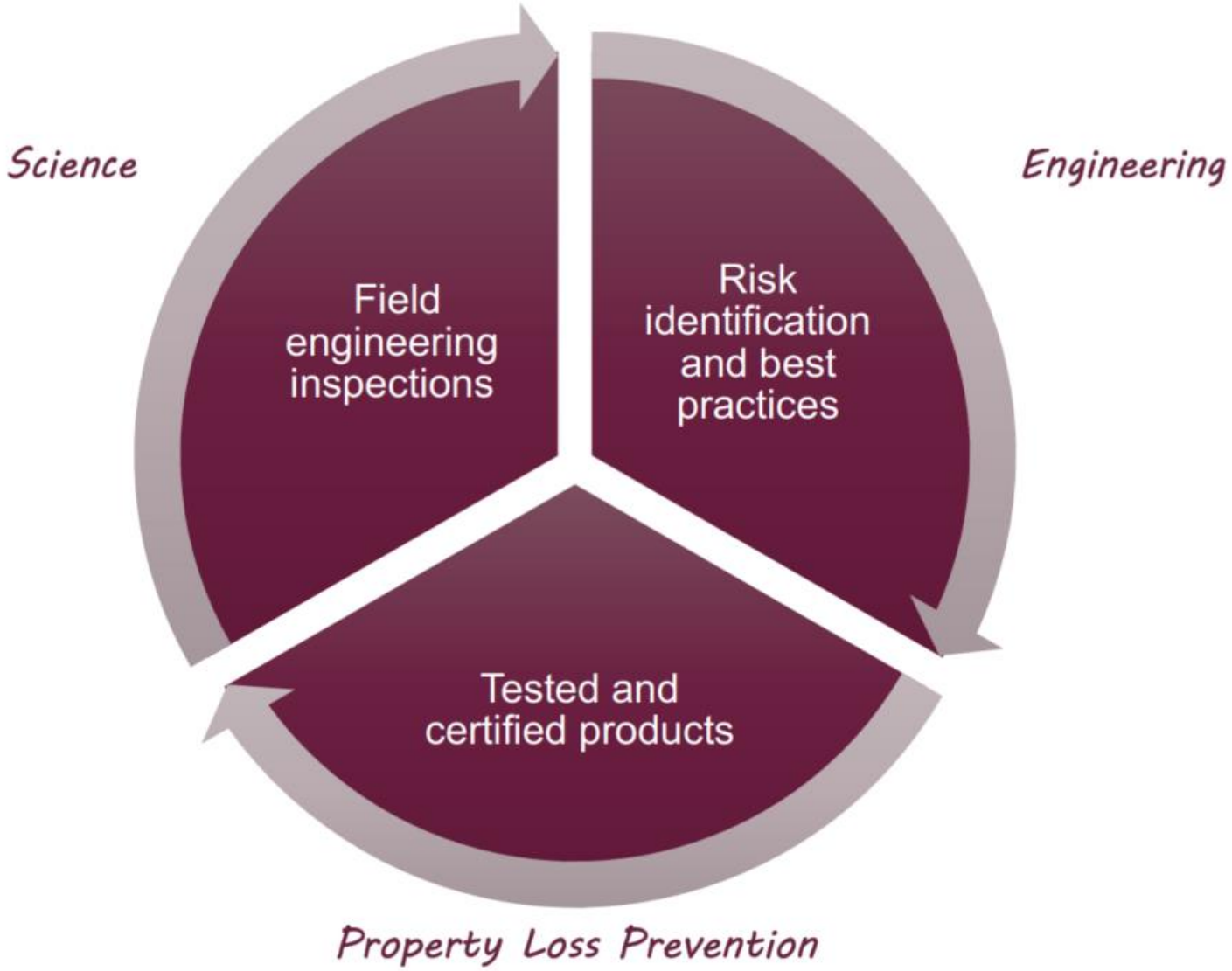
Frank Liserio, P.E.
Operations Vice President
Operations Chief Engineer

We protect today
for a better tomorrow.

Agenda

- FM Global
- The Paradigm of Ignitable Liquids
- Protection Strategies
- FOAM
- Q&A

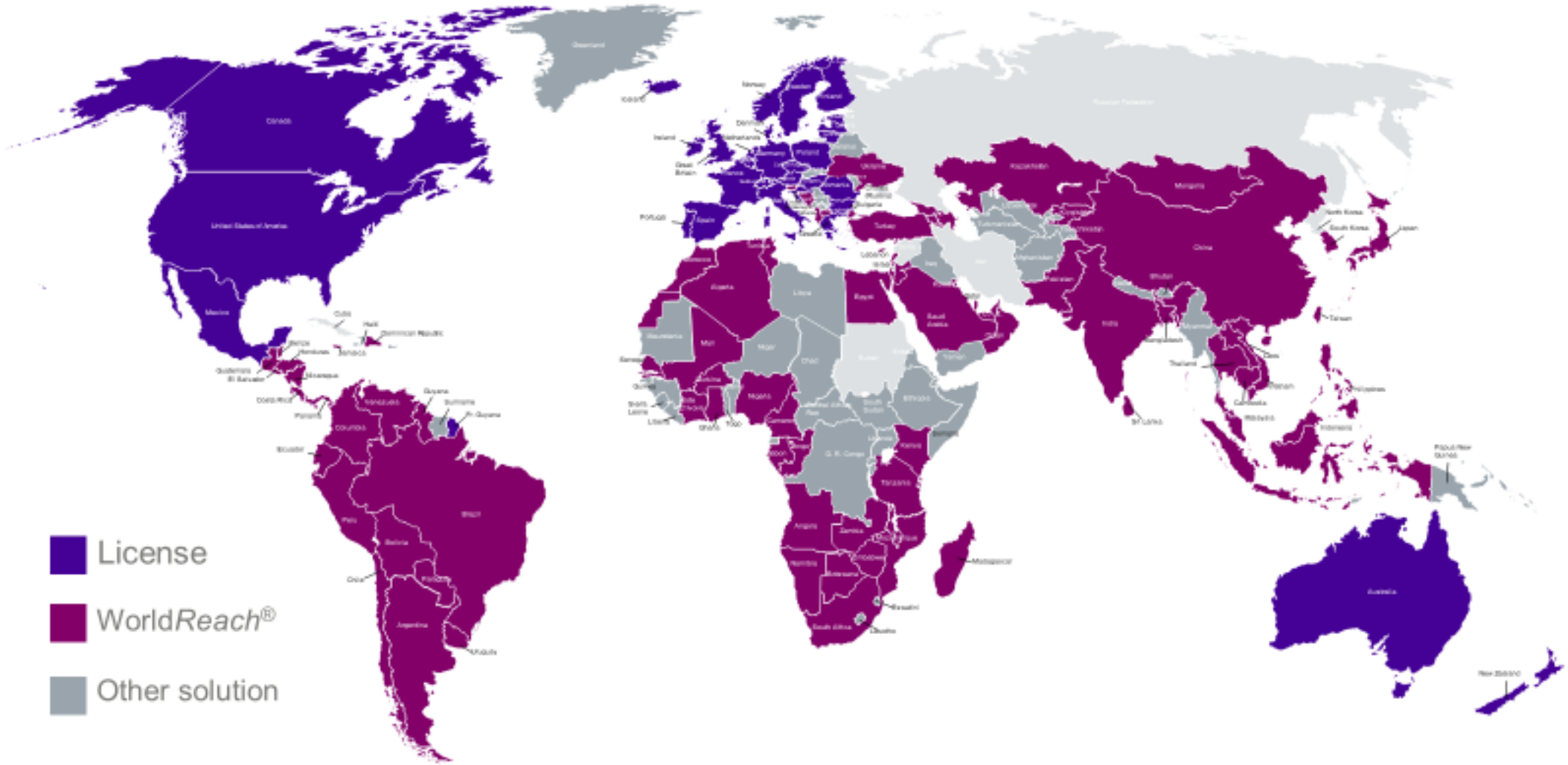
Linking Science, Engineering and Property Loss Prevention



FM Global

Property Loss Prevention

Contribute to reducing the risk of property loss around the globe.



Per U.S .Law and FM Global underwriting requirements:
excluding Cuba, Iran, North Korea, Russia, Syria, Sudan and Crimea Region of Ukraine

Worldwide Consistency

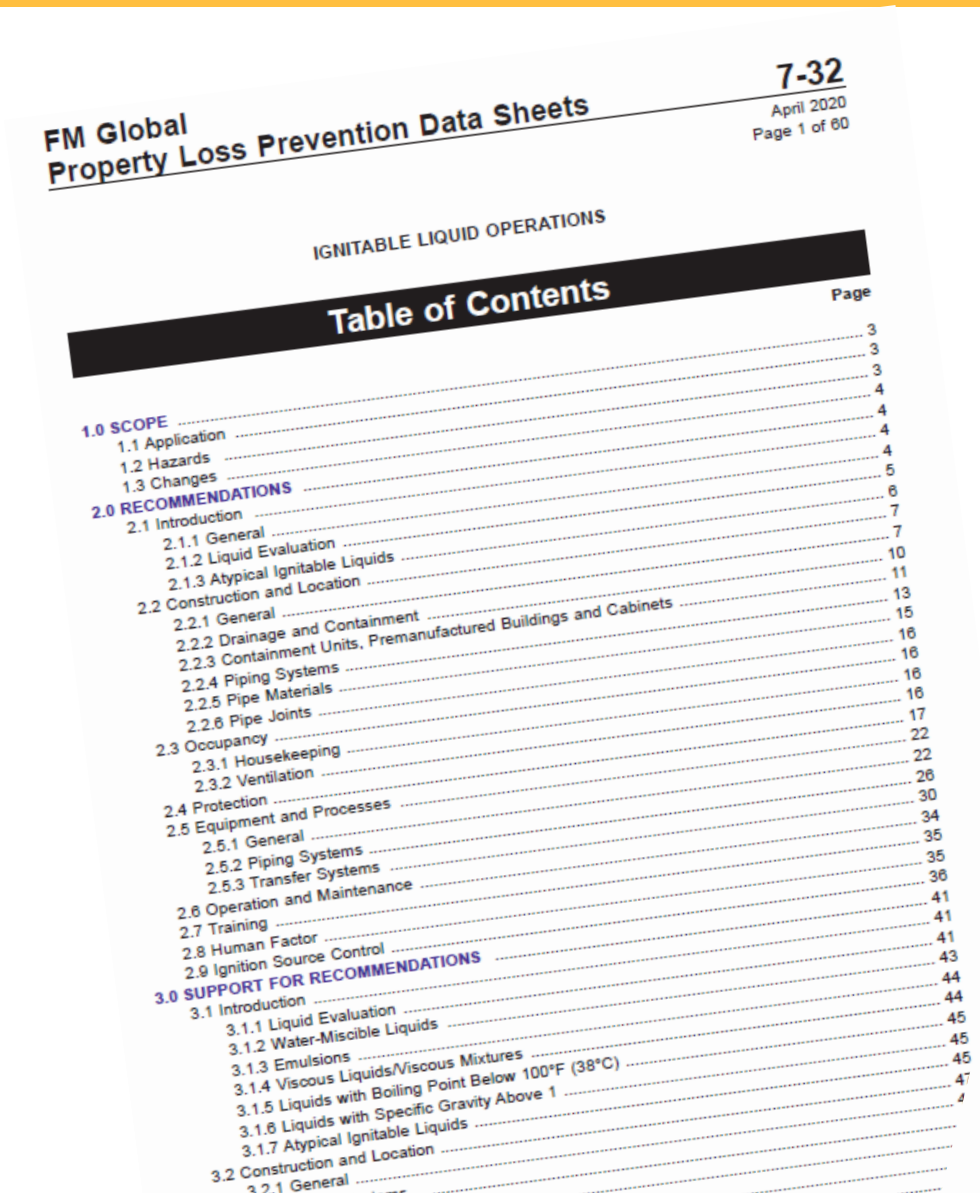
30+
Global Services Staff

1,900+
Loss Prevention Engineers

165+
Loss Adjusters

- **59,500+** serviced locations in **145+** countries
- **110,600+** Engineering visits per year
- Over **7,000+** loss opportunities each year

FM Global Standards



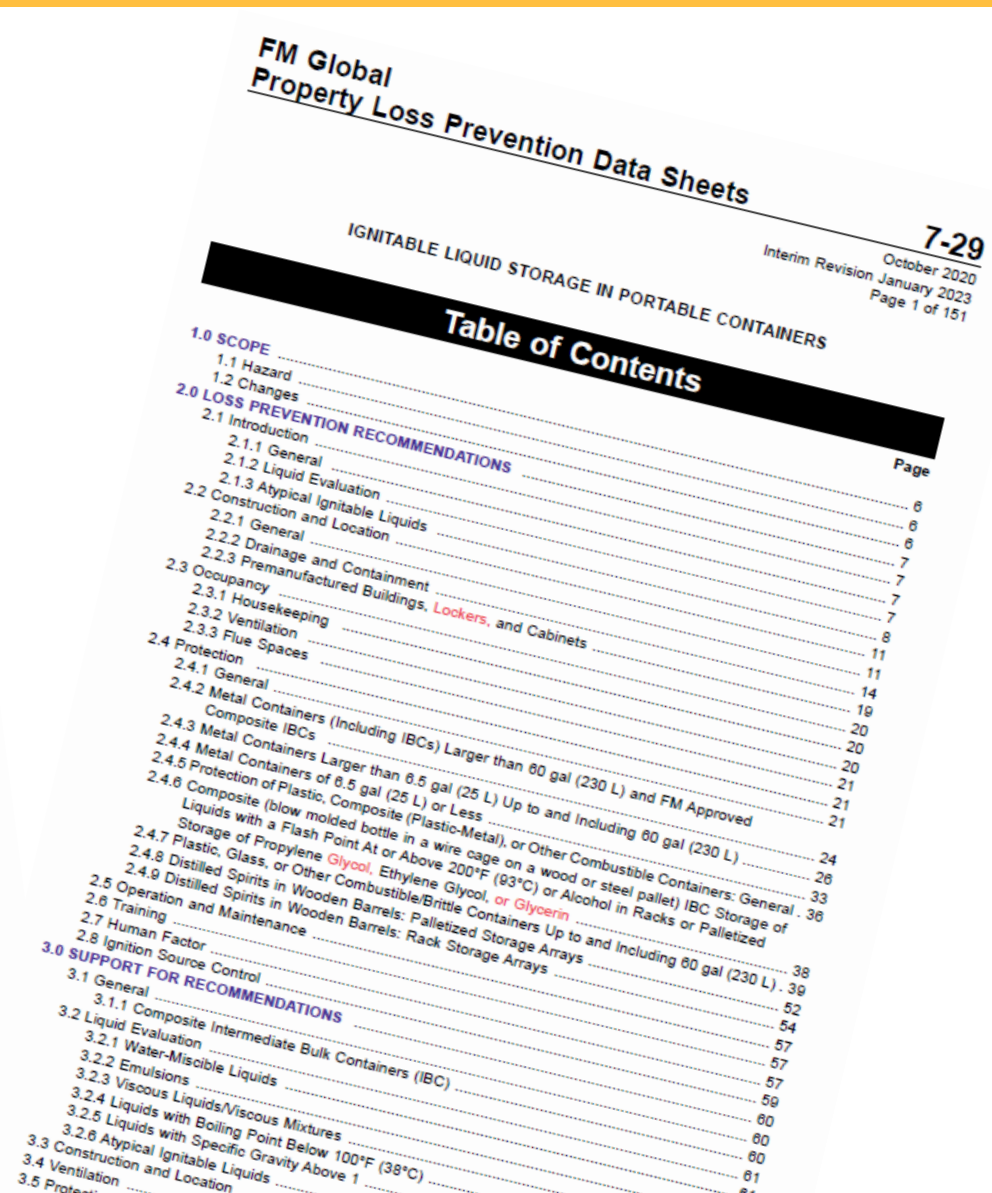
FM Global
Property Loss Prevention Data Sheets

7-32
April 2020
Page 1 of 60

IGNITABLE LIQUID OPERATIONS

Table of Contents

Page



FM Global
Property Loss Prevention Data Sheets

7-29
October 2020
Interim Revision January 2023
Page 1 of 151

IGNITABLE LIQUID STORAGE IN PORTABLE CONTAINERS

Table of Contents

Page

Large Loss activity

FM Global

Negative Factors

41 Fire/Explosion Losses

Sprinkler Systems

- 14 Automatic Sprinkler Protection
- 8 Alarm/Detection & Interlocks
- 6 Sprinklers Inside Enclosures/Special Protection

Ignitable Liquid Exposures

- 18 Handling
- 3 Storage

Emergency Response

- 9 Emergency Response Team
- 7 Fire Department / Pre-Fire Plan

Over 50% involved Ignitable Liquids

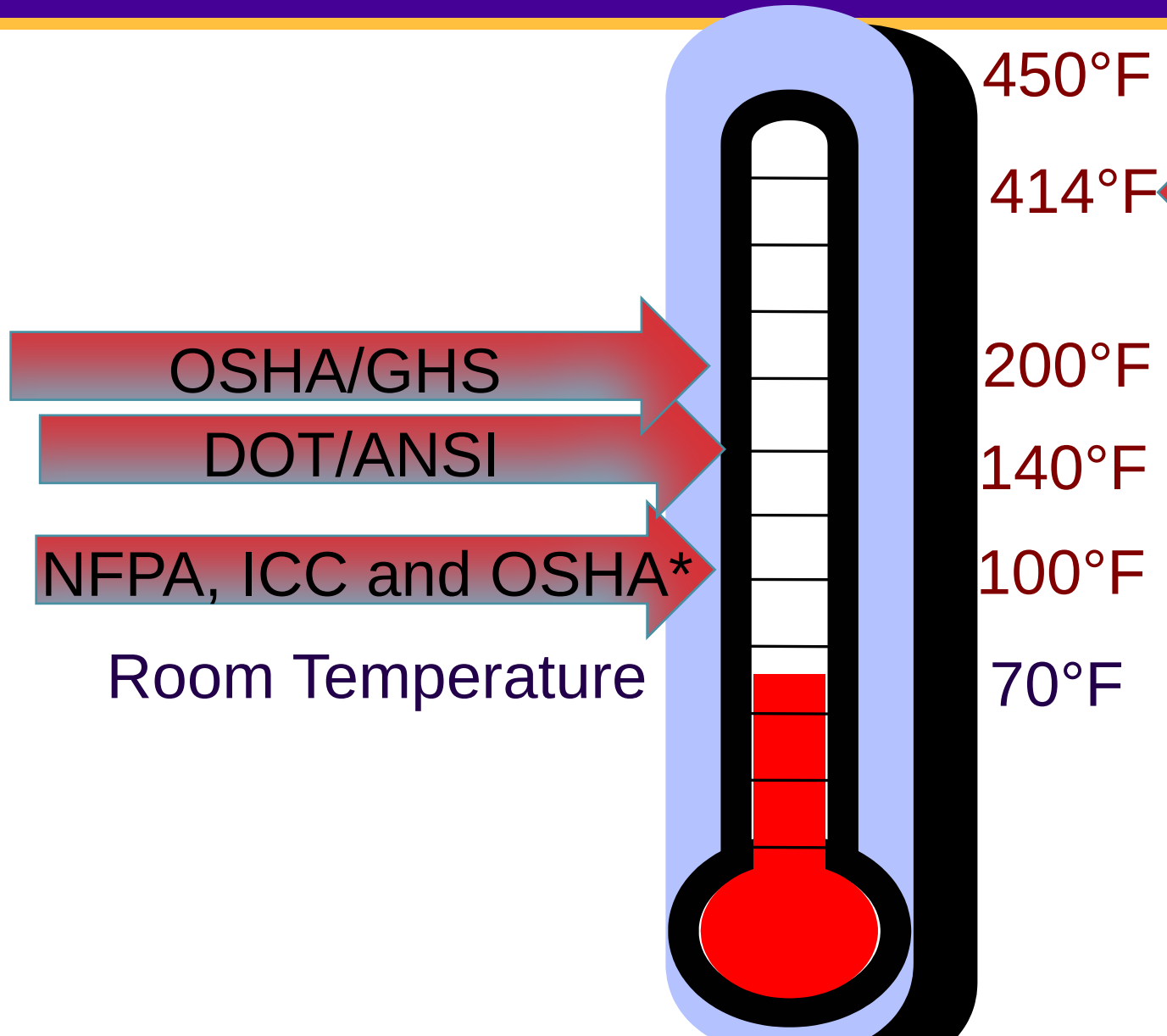
2021 KEY FINDING

The Paradigm of Ignitable Liquids

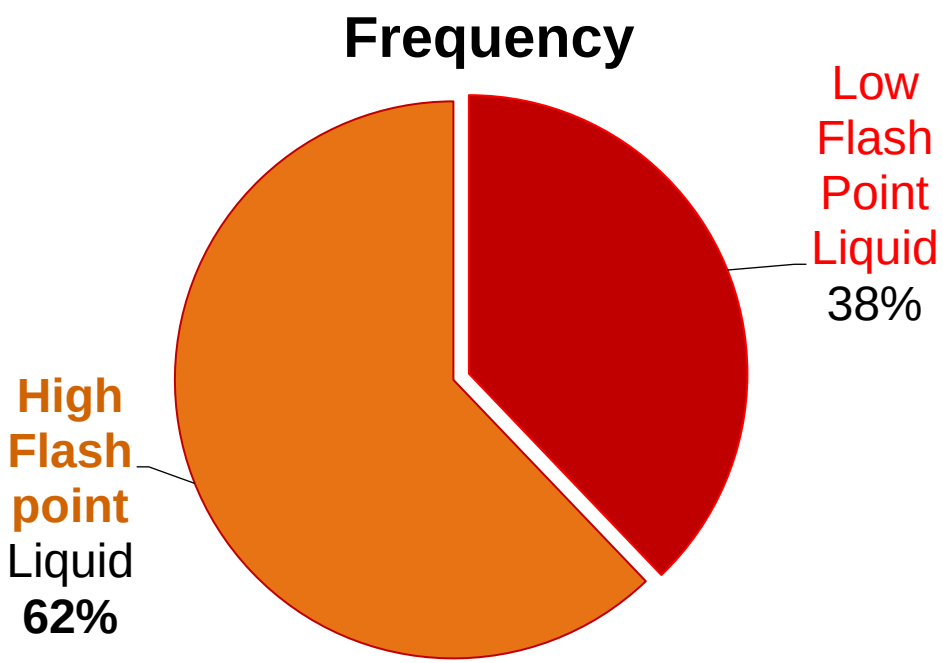
Is the Liquid Flammable or Combustible?....

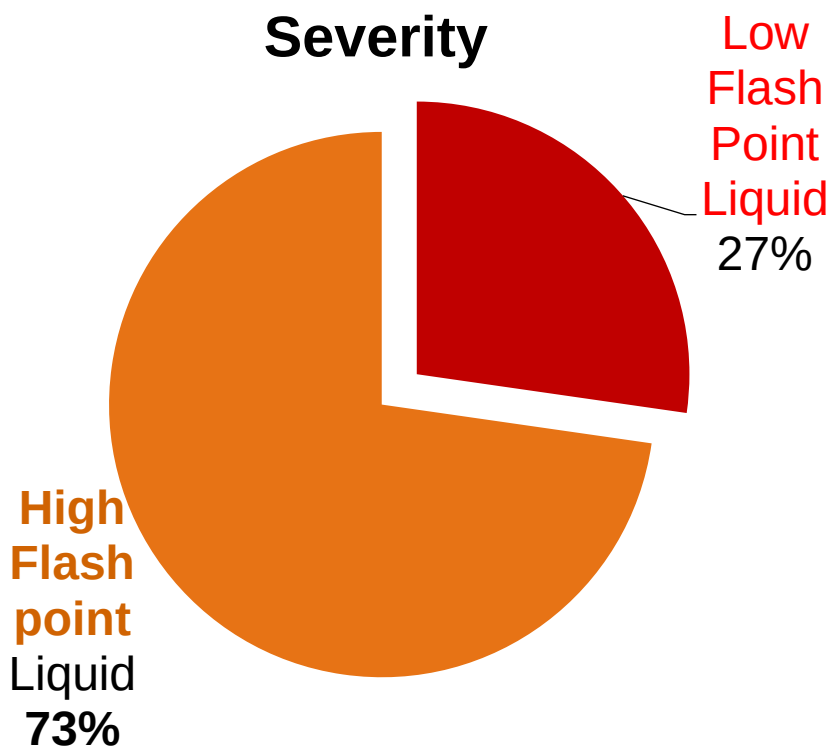
- Combustible
  - liquids that needed additional heat to vaporize sufficiently to ignite.
- Flammable
  - liquids that vaporized sufficiently to ignite at ambient temperature.

Is the Liquid Flammable or Combustible



Fire Losses by Ignitable Liquid Type

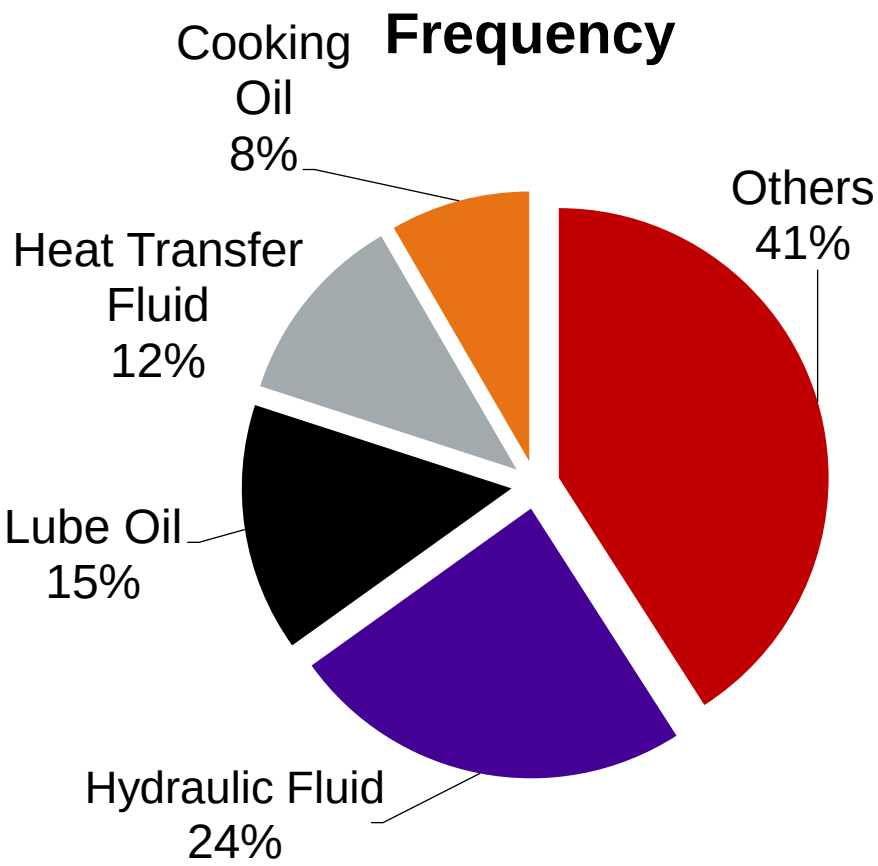


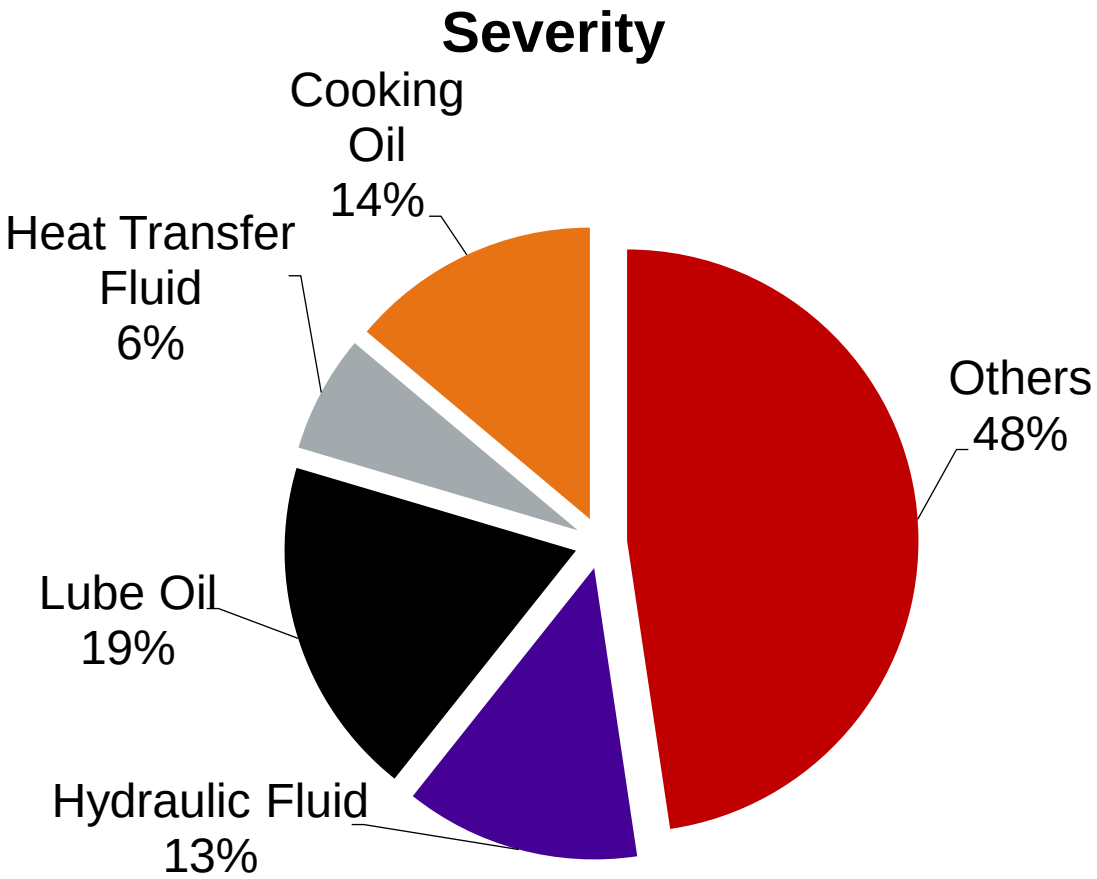


Low Flash point: FP < 200ºF

High Flash point: FP ≥ 200ºF

High Flash Point Liquid Fire Losses



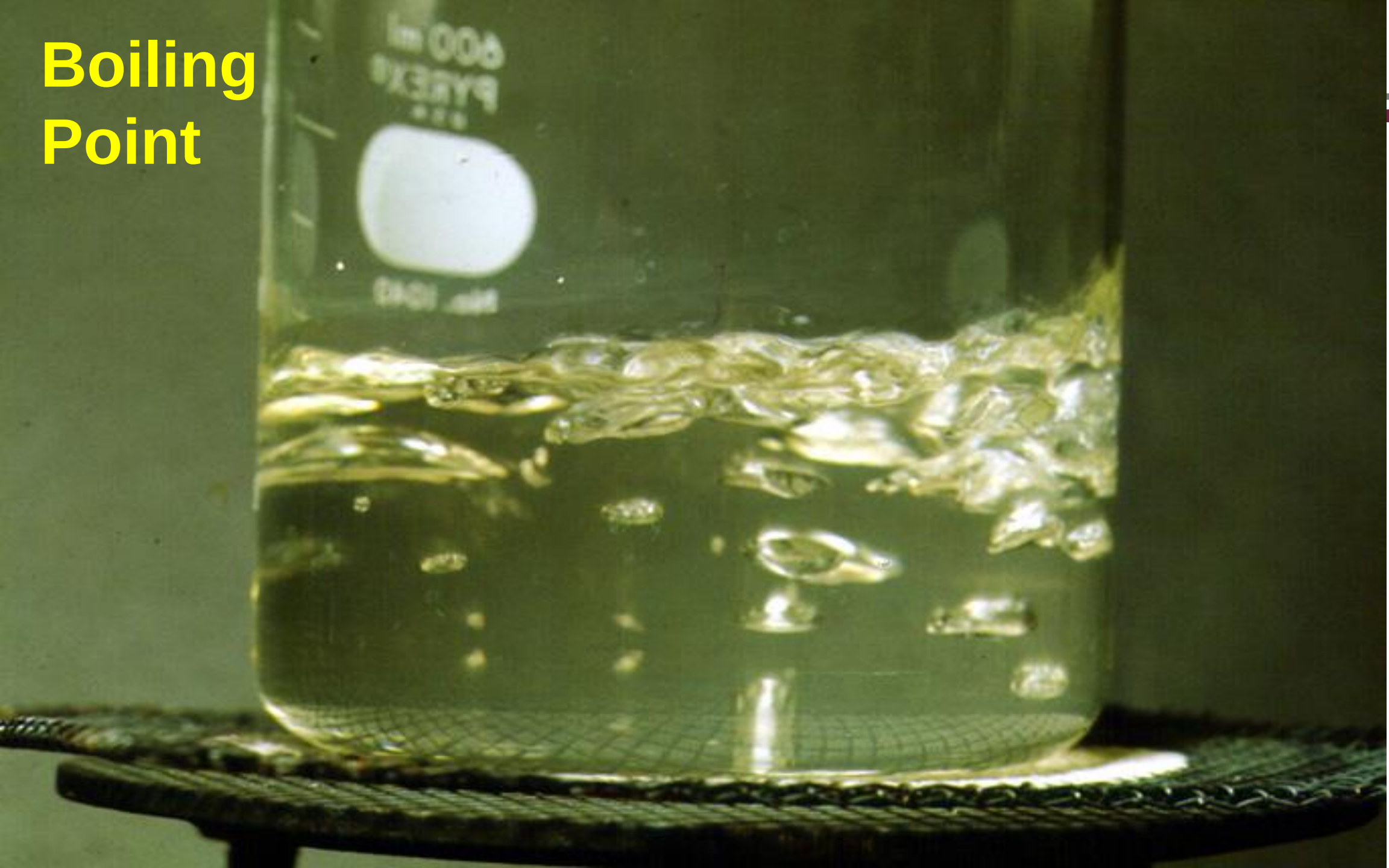


High Flash point: FP $\geq$ 200°F

Low vs. High Flash Point Liquids

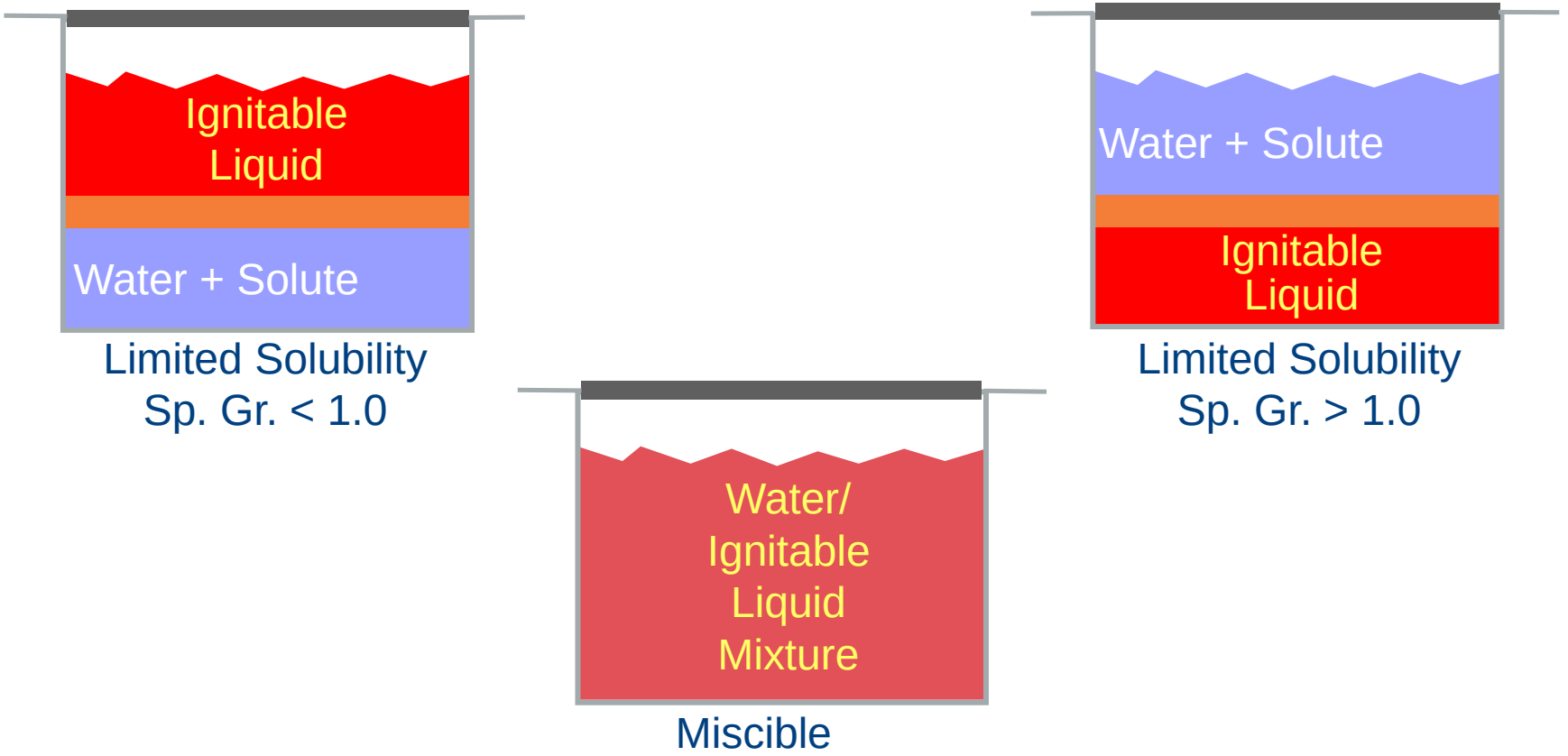
Characteristic	Low Flash Point Ignitable Liquids	High Flash Point Ignitable Liquids
Heat of combustion	Very high heat of combustion	Very high heat of combustion
HRR	Very high	Very high
Surface area	Can form large surface areas	Can form large surface areas
Ignition at room temp.	Easily ignited at room temperature	Difficult to ignite at room temperature
Ease of ignition when sprayed	Easy to ignite when sprayed	Easy to ignite when sprayed
Ease of fire spread	Fast spread across surface	Slower spread across surface
Vapor generation	High vapor generation rate = high vapor spread	Low vapor generation rate (as long as not heated)
Extinguishment with sprinkler discharge	**Cannot extinguish with sprinklers (cannot cool below fire point)**	**Pool fire can be extinguished with sufficient sprinkler discharge**

Boiling Point



Specific Gravity

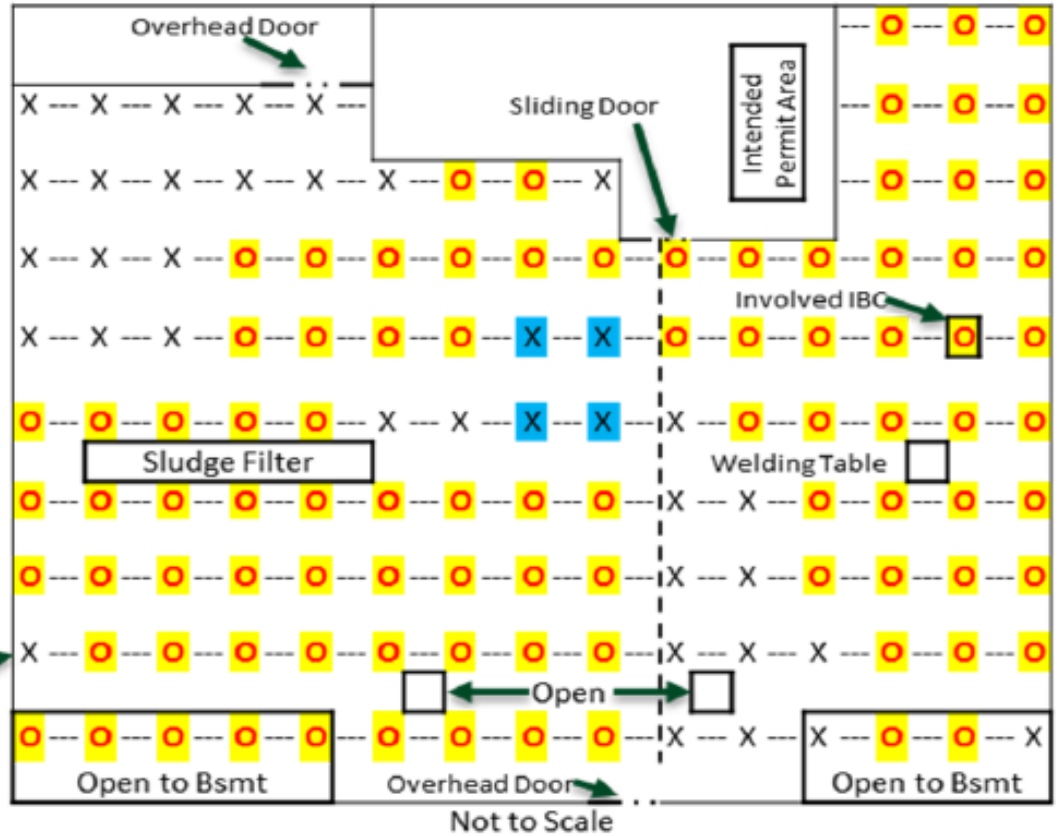
Miscibility vs. Solubility



Miscible = 100% soluble

Single IBC in sprinklered machine shop

Sprinkler installed in pendant position



O Sprinkler that operated
X Sprinkler that did not operate
X Sprinkler that did not operate, installed pendant with heat collector

Quantity, Storage and Use

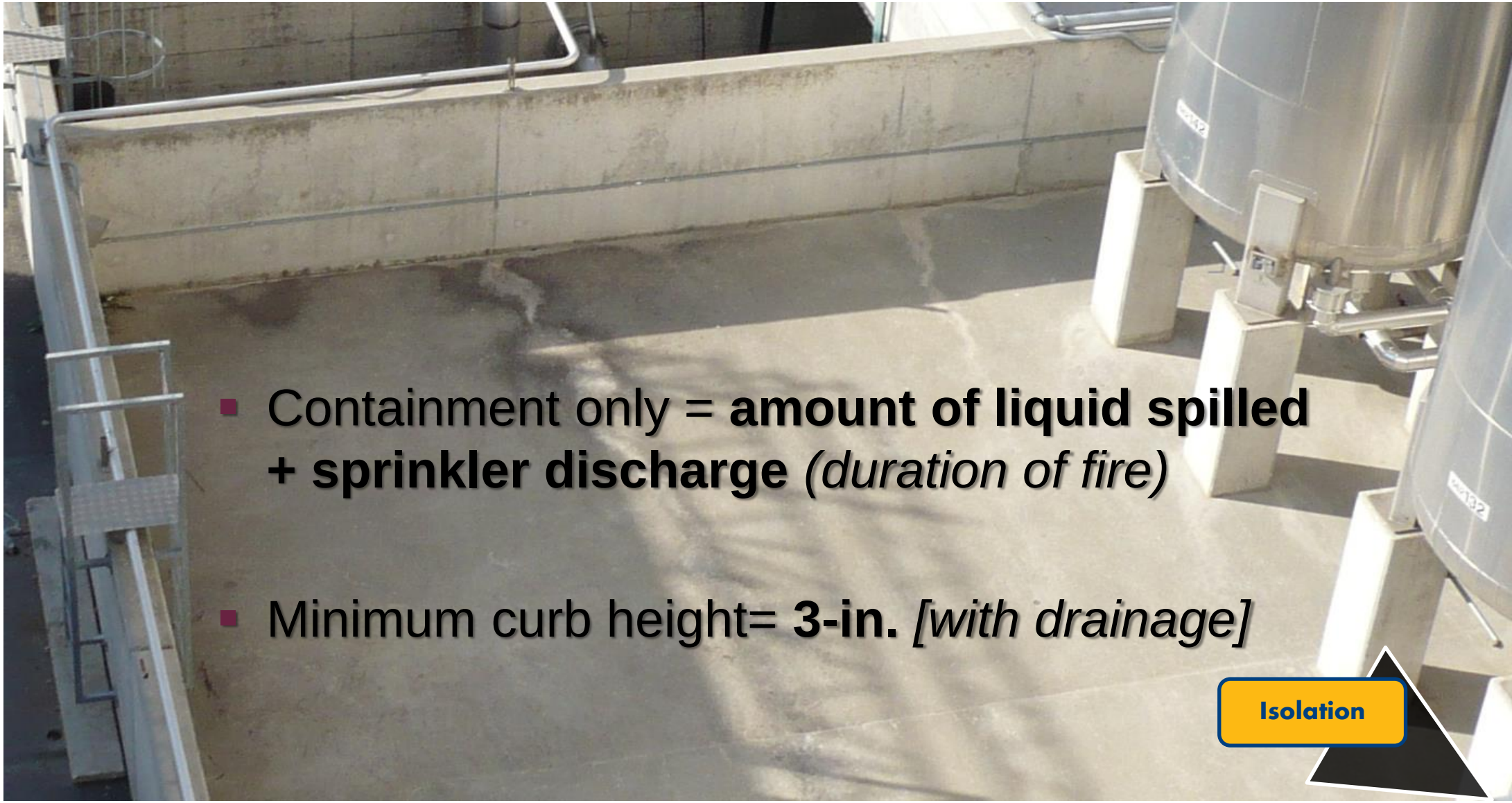
Pool Fire

Spray Fire

Three Dimensional Spill Fire

Pool Fire

Containment



- Containment only = **amount of liquid spilled + sprinkler discharge** *(duration of fire)*
- Minimum curb height= **3-in.** *[with drainage]*

Isolation

Containment

Depth of spill	6 in.	8 in.	10 in.	18 in.
Area of spill	74 sq.ft.	55 sq.ft.	44 sq.ft.	25 sq.ft.
Heat Release	10,216 BTU/sec	7,231 BTU/sec	5,543 BTU/sec	2,764 BTU/sec
	11 MW	8 MW	6 MW	3 MW
Duration	49.18 min	66.17 min	82.71 min	145.57 min
Flame Height*	18 ft	16 ft	15 ft	13 ft
# of Package Boilers**	15 boilers	10 boilers	8 boilers	4 boilers

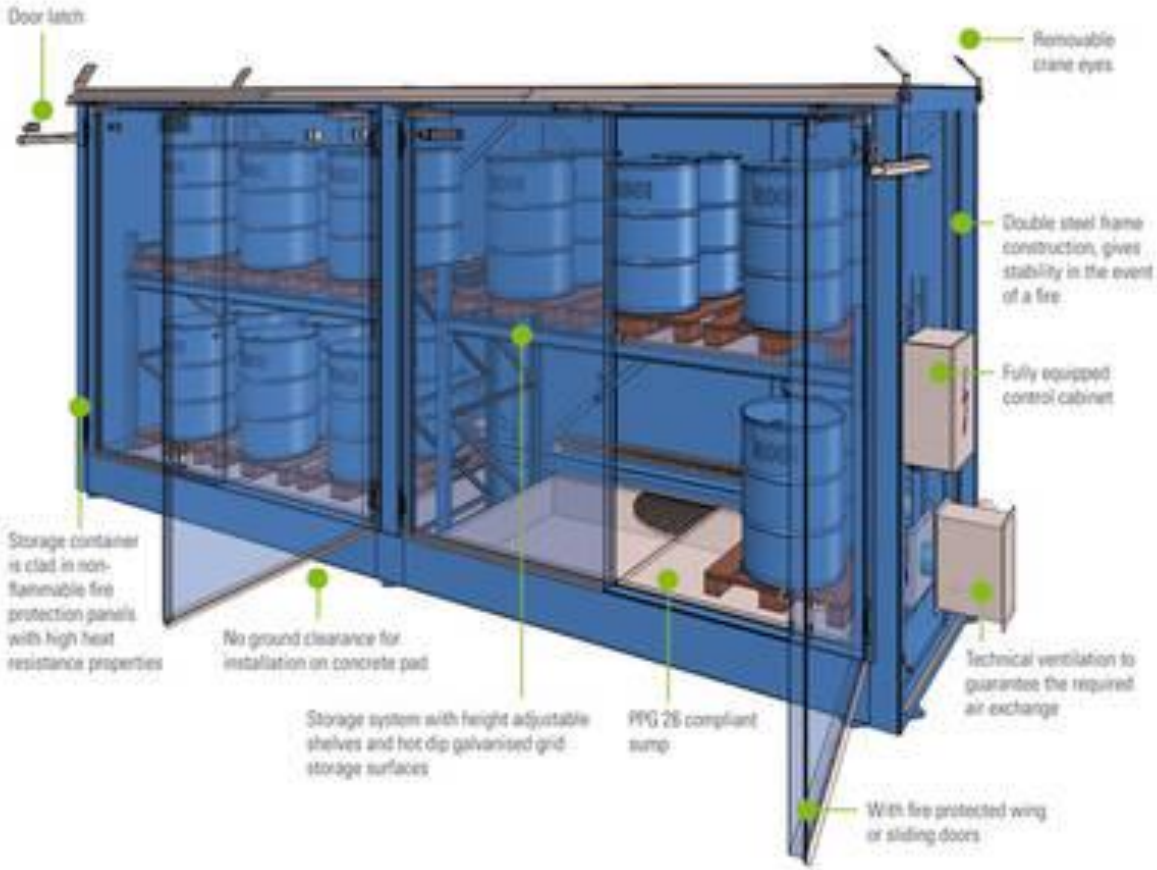
* *Method of Thomas - Reference: SFPE Handbook of Fire Protection Engineering, 2nd Edition, 1995, Page 3-204.*

** *Assuming 2,500,000 BTU/hr Boiler*

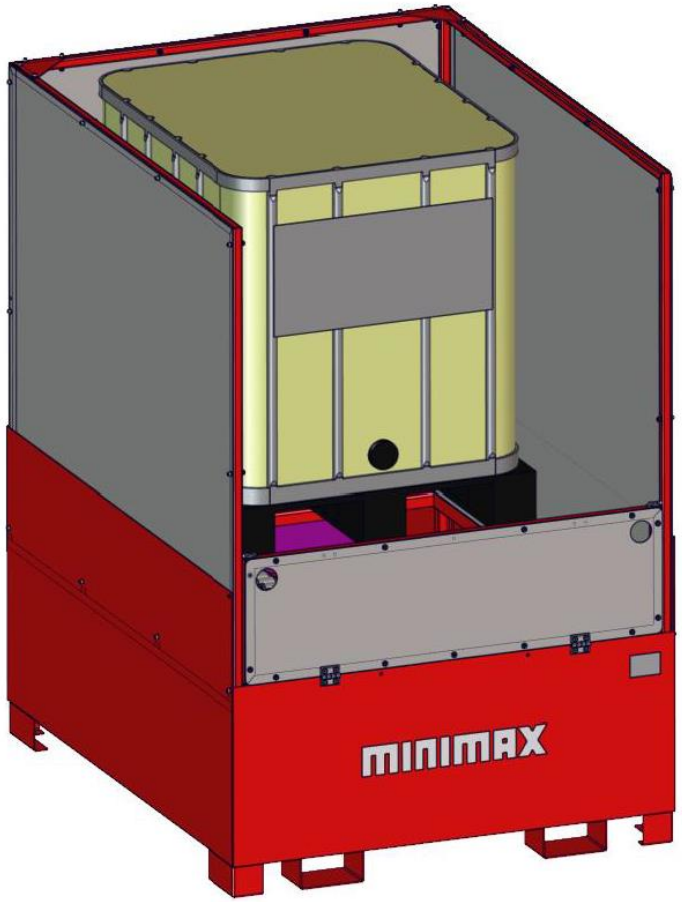
Doorway Spill Barriers

FM Global


DENIOS


Door latch
Removable crane eyes
Double steel frame construction, gives stability in the event of a fire
Fully equipped control cabinet
Storage container is clad in non-flammable fire protection panels with high heat resistance properties
No ground clearance for installation on concrete pad
Storage system with height adjustable shelves and hot dip galvanised grid storage surfaces
PPG 26 compliant sump
Technical ventilation to guarantee the required air exchange
With fire protected wing or sliding doors

FM Approved containment



FM Approved IBC

ECOBULK SX-D

Pool Fires – High FP Ignitable Liquids

- Fire spread across pool is slow
- AS can impact high FP liquids if containment provided
- Moderate damage to building but loss of structure is not expected
- Exception is excessive quantity of liquid, heated, or pumped feeding the pool fire

Liquid Flash Point °F	Drainage Required	Protection Goal	Maximum Roof Height ft	Ceiling Sprinkler		Density gpm/ft^2	Demand Area ft^2
				Response / Nominal Temperature Rating / Orientation	K-factor gpm/psi$^{1/2}$		
FP ≥ 200 and < 414 Or FP ≥ 414 and heated in equipment that will resist failure in a fire (e.g., steel)	Yes	Fire control only	40	SR / High / Any	≥ 8.0	0.3	4,000
				SR / Ordinary / Any	≥ 8.0		6,000
	No	Fire Extinguishment	15	SR / Ordinary / Any	≥ 11.2	0.3	2,000 for pool areas up to 200 ft^2 8,000 >200 ft^2 < 625 ft^2
			30	SR / Ordinary / Any	≥ 11.2	0.4	
			40	SR / Ordinary / Any	≥ 11.2	0.7	
			45	SR / Ordinary / Any	≥ 11.2	0.8	

Pool Fires – Low FP Ignitable Liquids

- Fire spread is fast across the pool
- AS cannot put fire out in non-miscible liquids
- AS can impact water miscible (alcohols, acetone) liquids but this takes time
- **Drainage is required**
- Protection is to control steel temperatures in building only

Liquid Flash Point °F	Drainage Required	Protection Goal	Maximum Roof Height ft	Ceiling Sprinkler		Density gpm/ft^2	Demand Area ft^2
				Response / Nominal Temperature Rating / Orientation	K-factor gpm/psi$^{1/2}$		
FP < 200	**Yes**	**Fire control only**	40	**SR / High / Any**	**≥ 8.0**	**0.3**	**4,000**
				SR / Ordinary / Any	**≥ 8.0**		**6,000**

Fire Protection Strategy

- Pool fires with flash points above 200°F ,
- Water-miscible liquids,
- Liquids that are heavier than water (specific gravity greater than
  - ***(These are fires that can be extinguished by automatic sprinklers)***

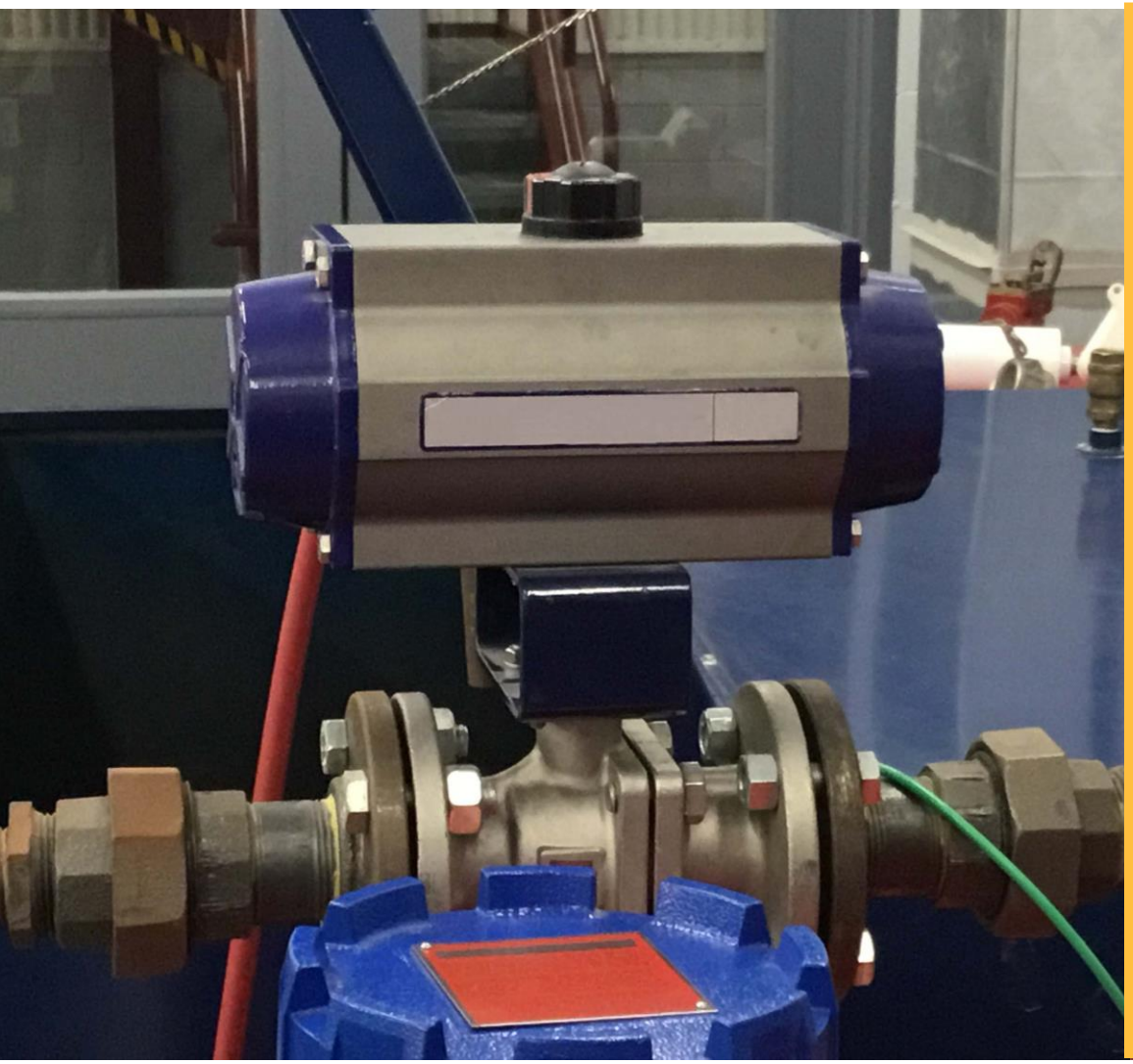
- Pool fires with flash points below 200°F
- Spray fires
- Three-dimensional pool fires
  - ***(These are fires that cannot be extinguished by automatic sprinklers)***

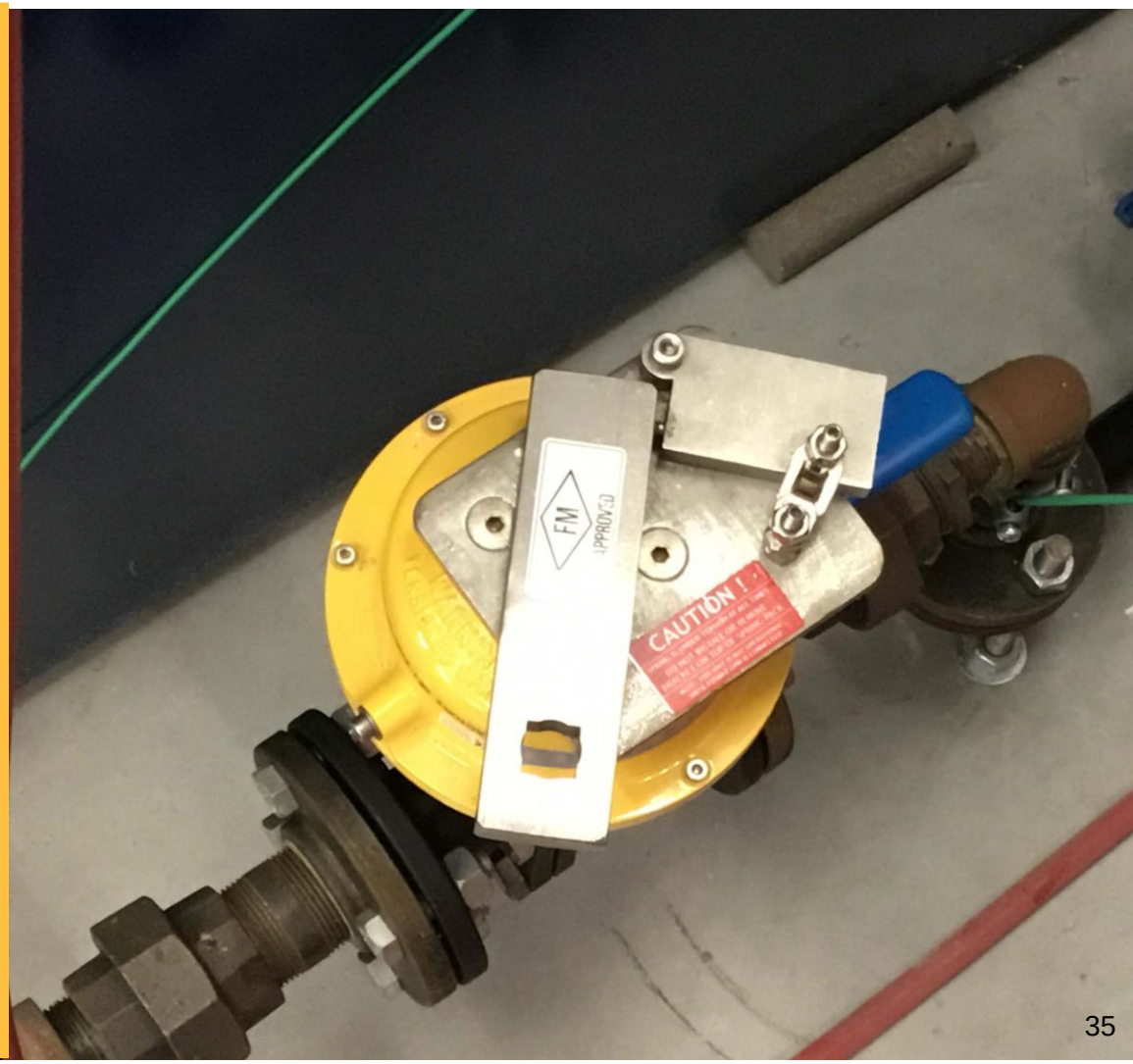
Spray Fire

Spray Fire

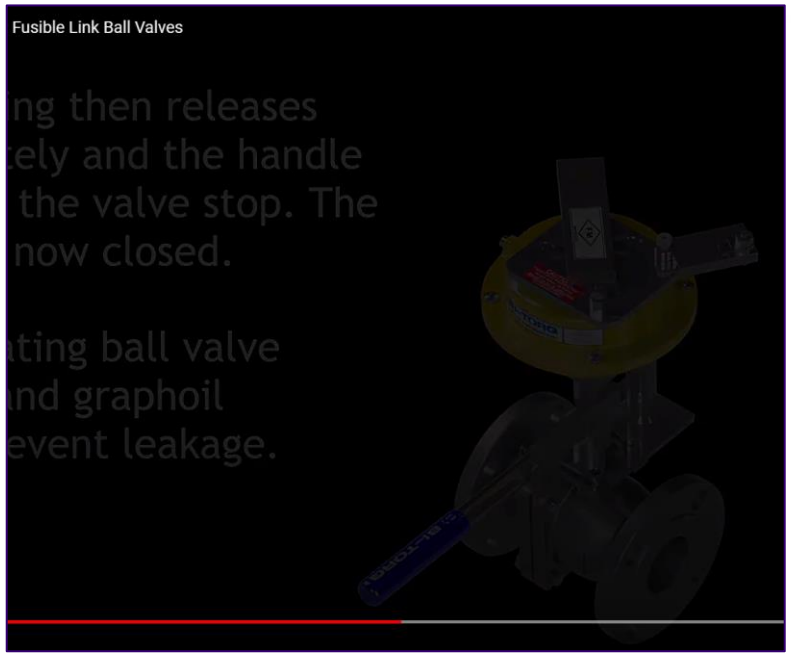
Location and isolation

Automatic shutoffs





FM Approved Ignitable Liquid shutoff valves



FM Approvals

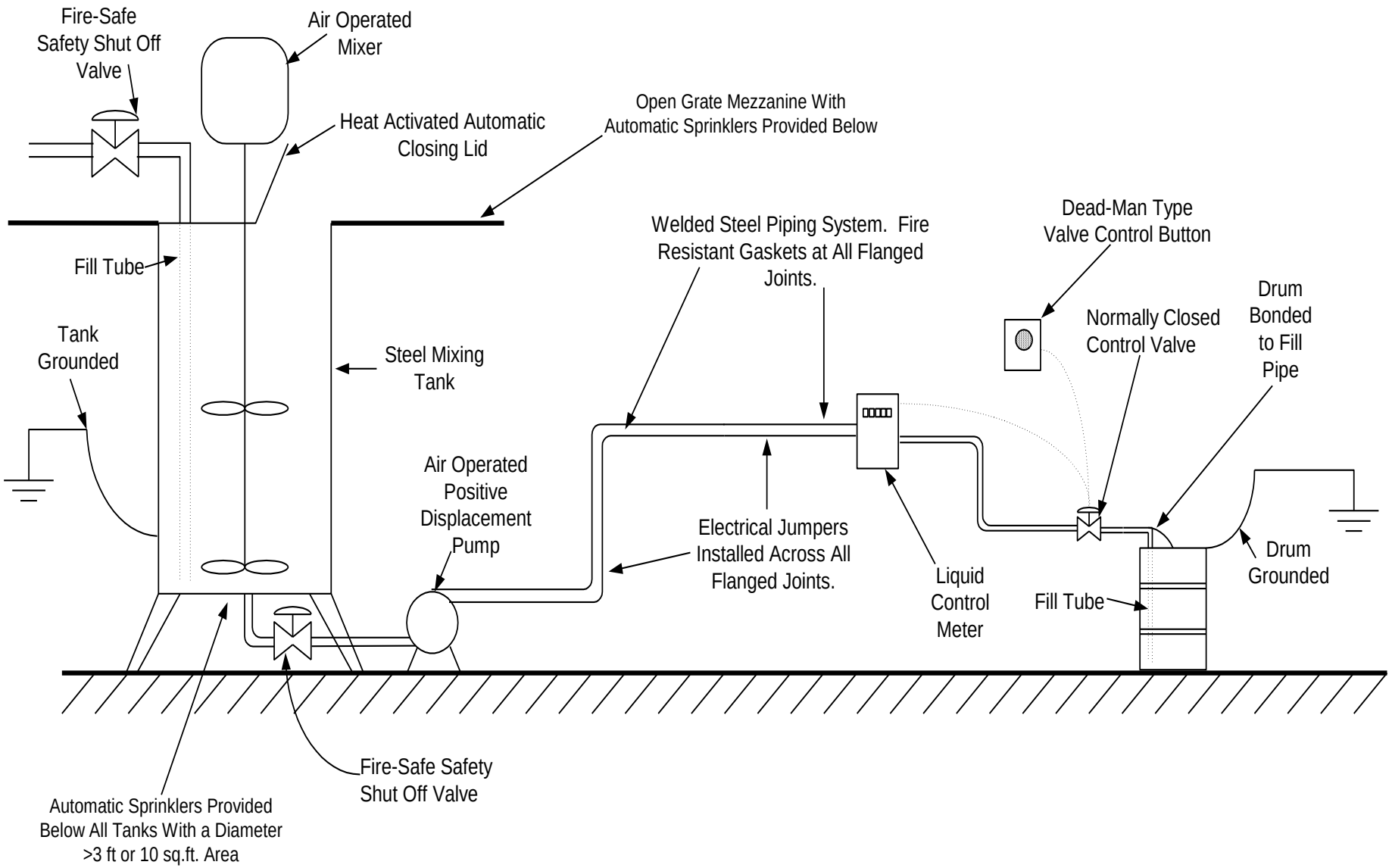
Member of the FM Global Group

Approval Standard for Liquid and Gas Safety Shutoff Valves

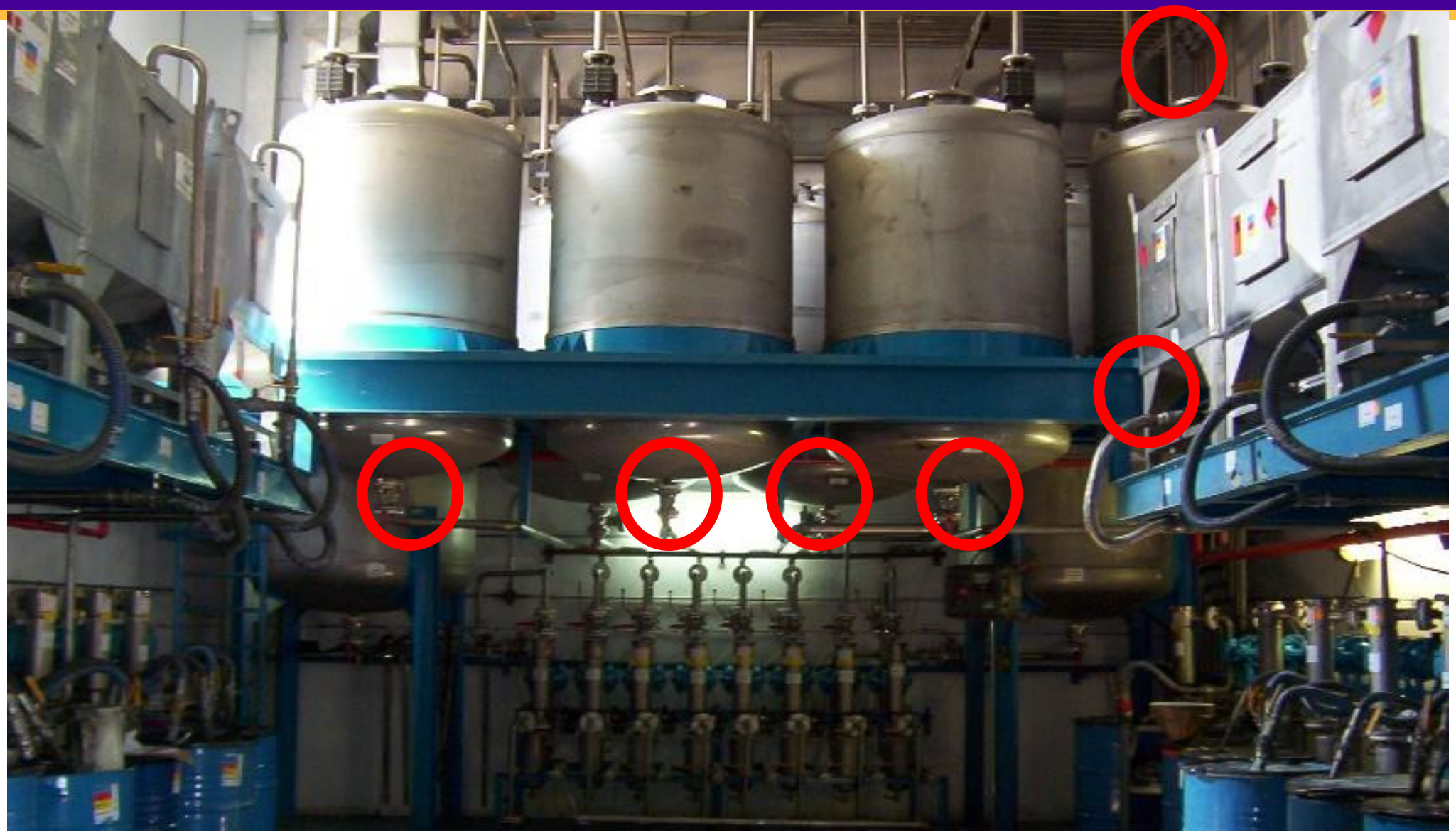
Class Number 7400

November 2016

Emergency / Safety Shutoff Valves (SSOV)

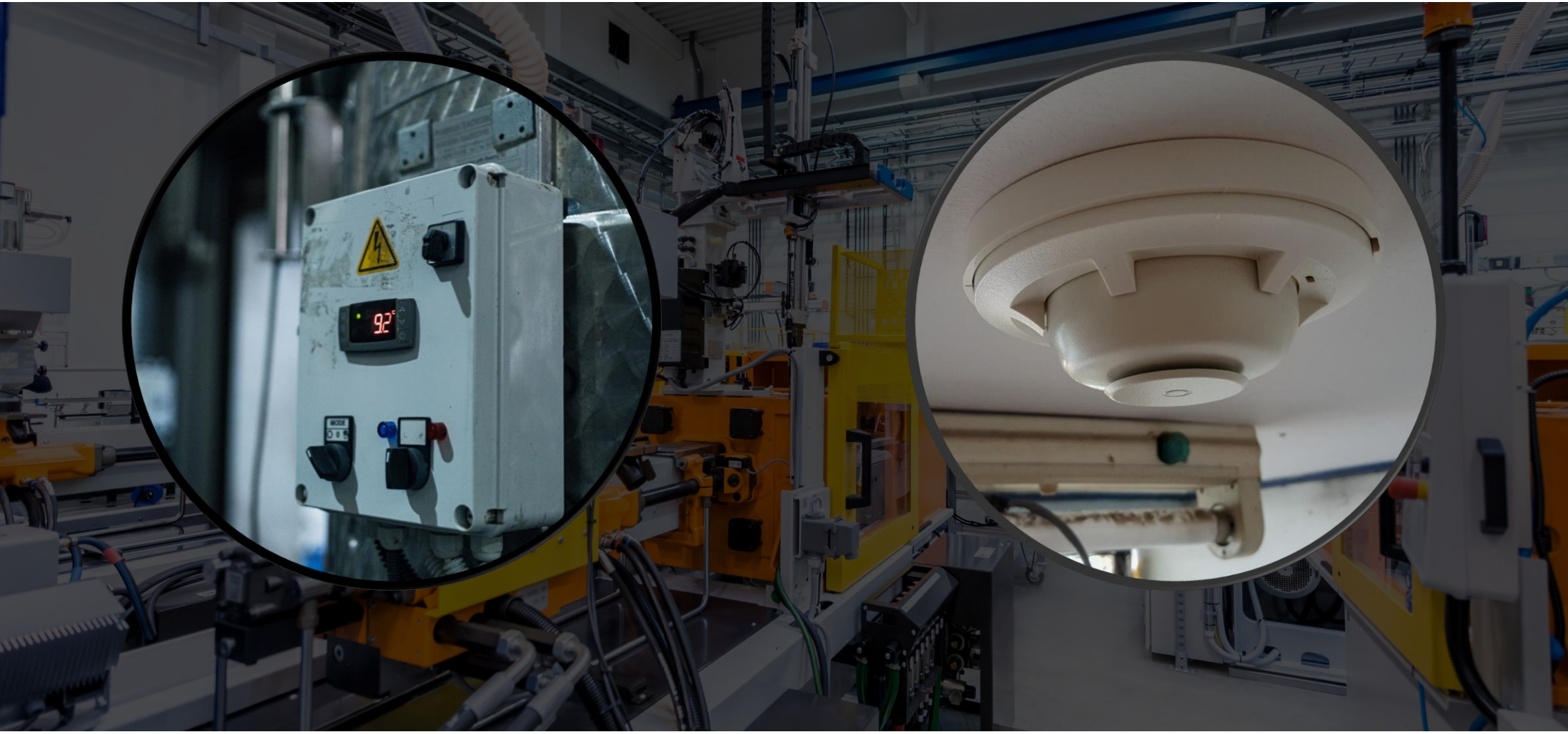


Emergency / Safety Shutoff Valves (SSOV)



Manual intervention?

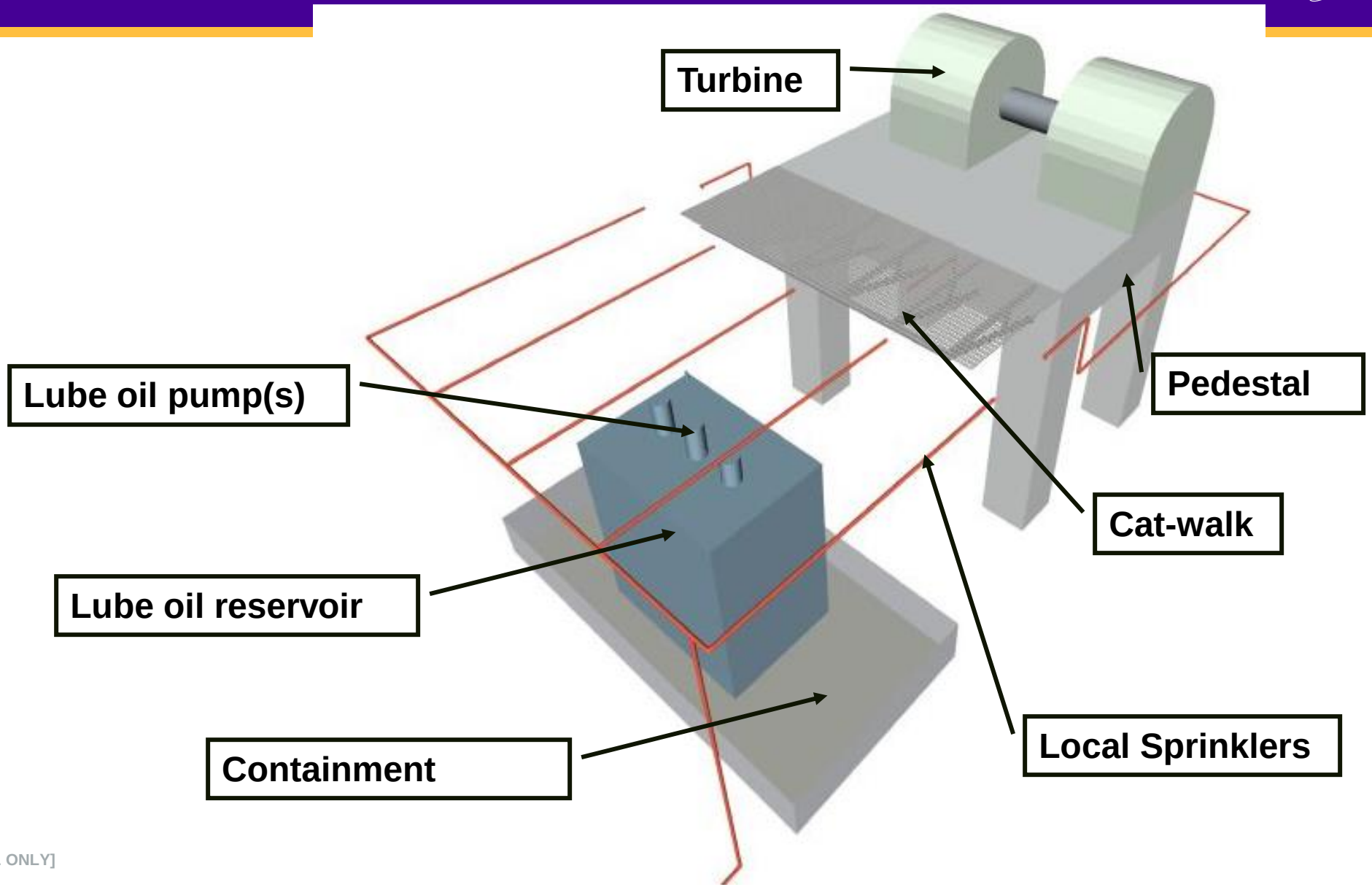
Automatic shutoffs



Automatic shutoffs

Three Dimensional Spill Fire

3-D Fire potential



‘Low’ flash point liquids

Drainage

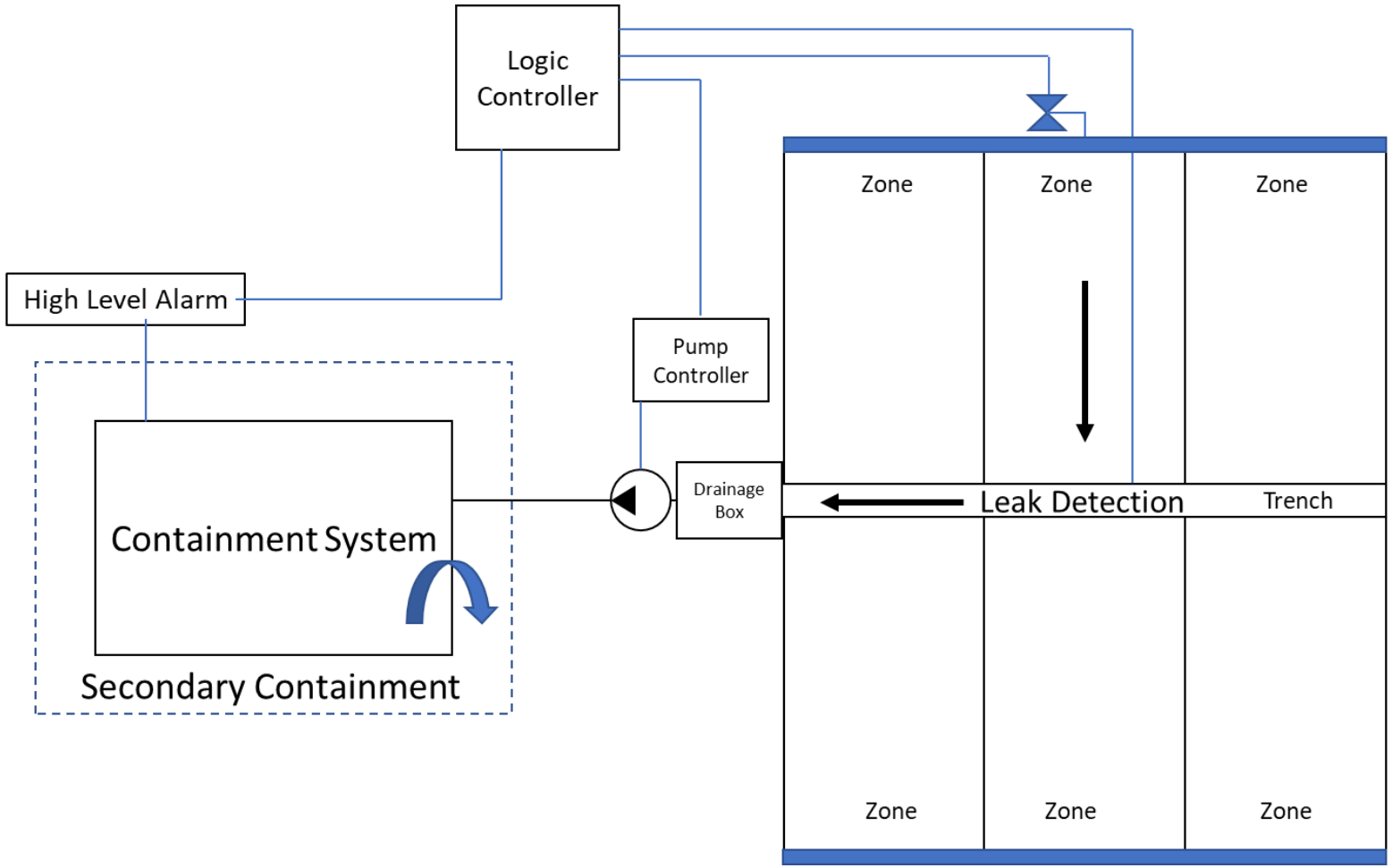
- Needed **if fire protection cannot extinguish the fire**

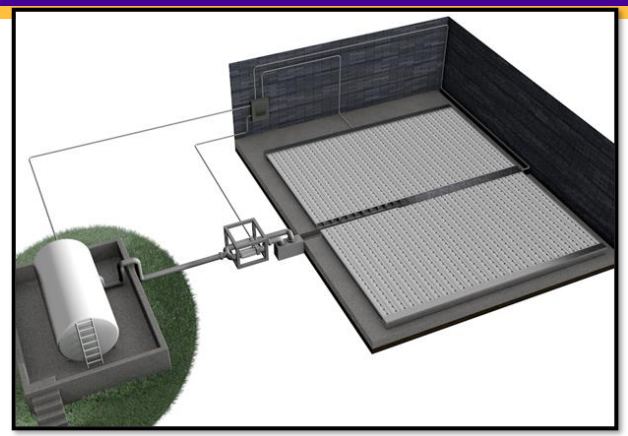
Ignitable Liquid drainage floor assembly

FM Approved Drainage Floor Assembly

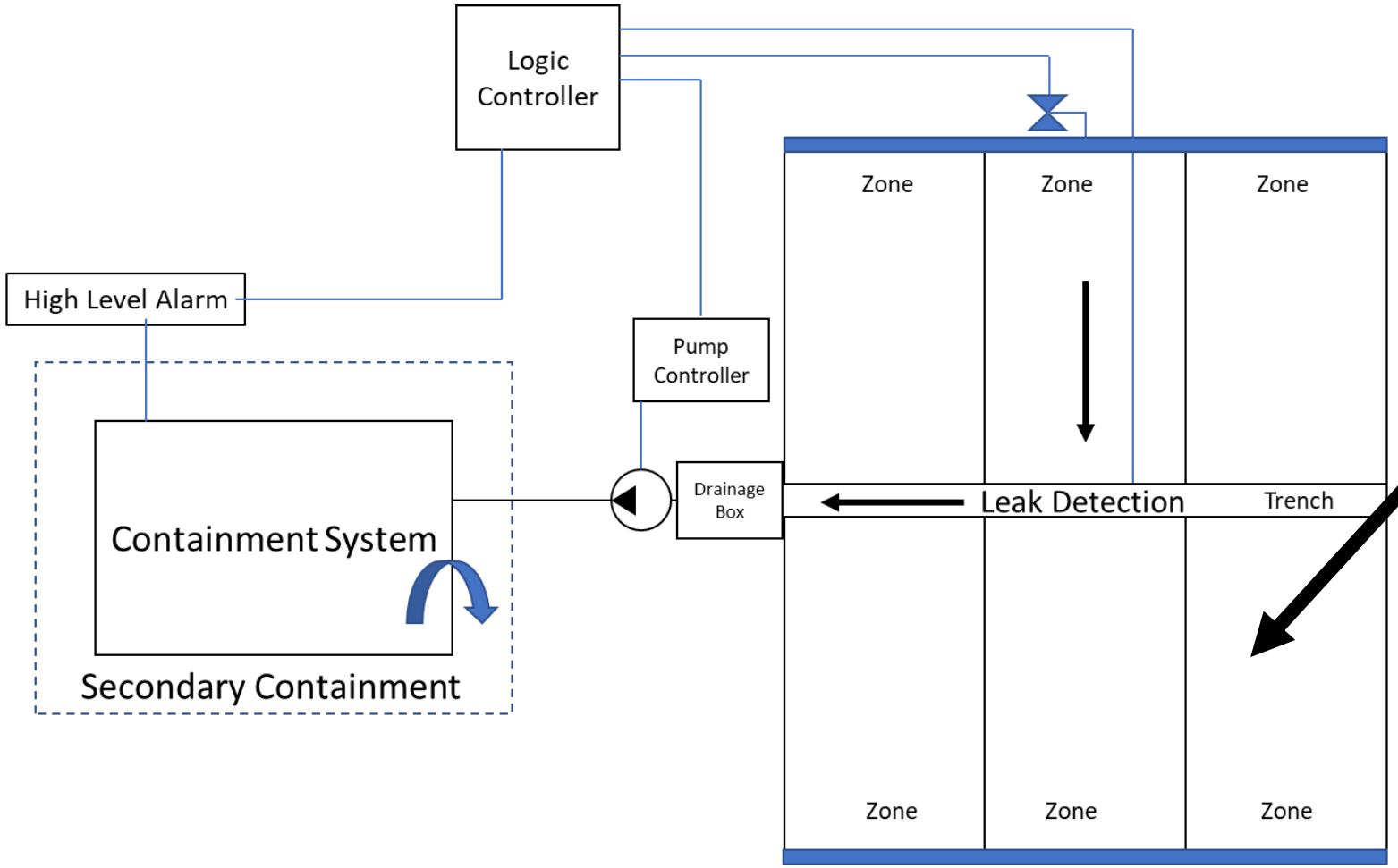
[IN

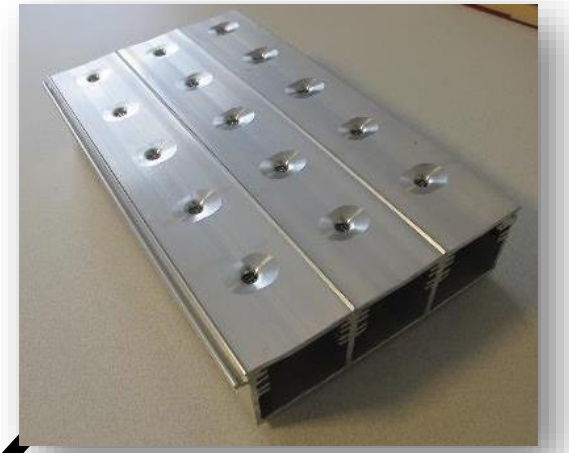
Ignitable Liquid Drainage Floor Assembly



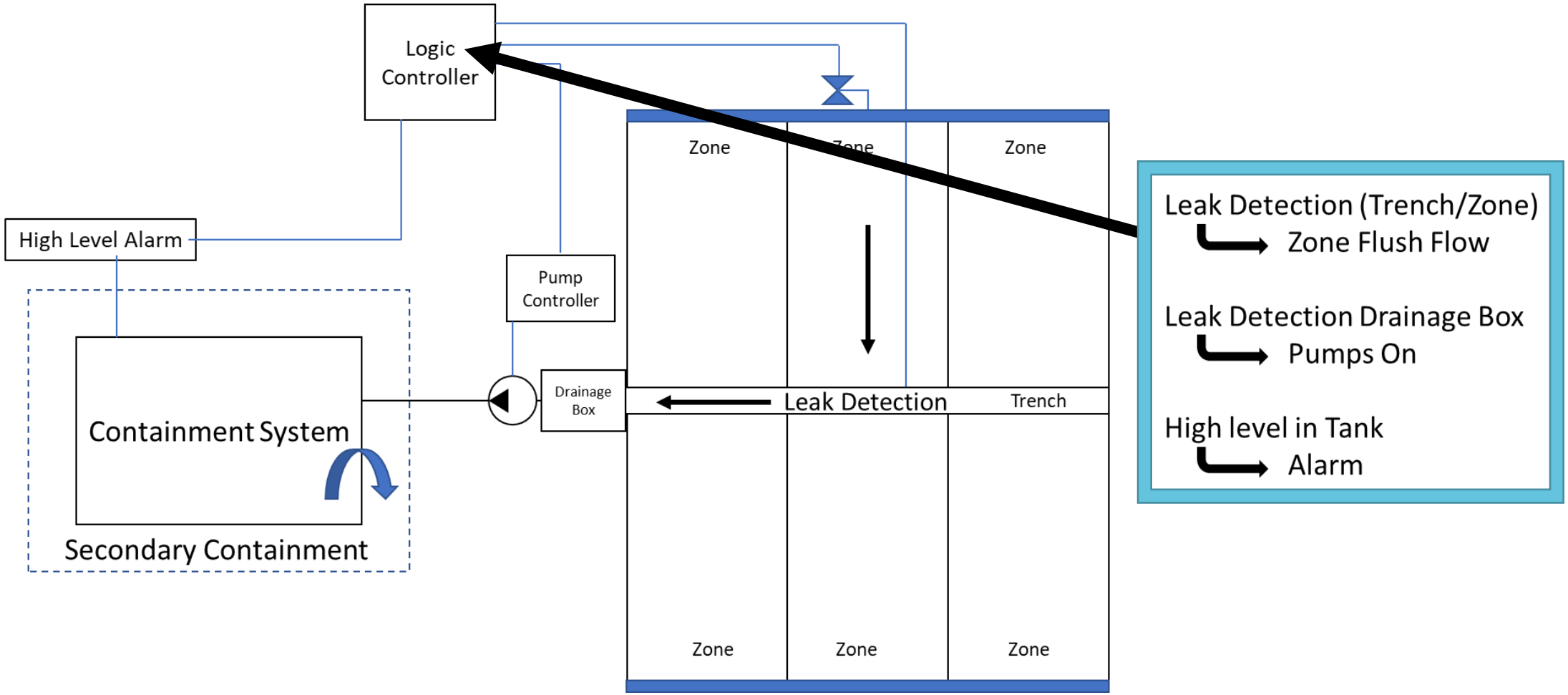


Ignitable Liquids Drainage Floor Assembly

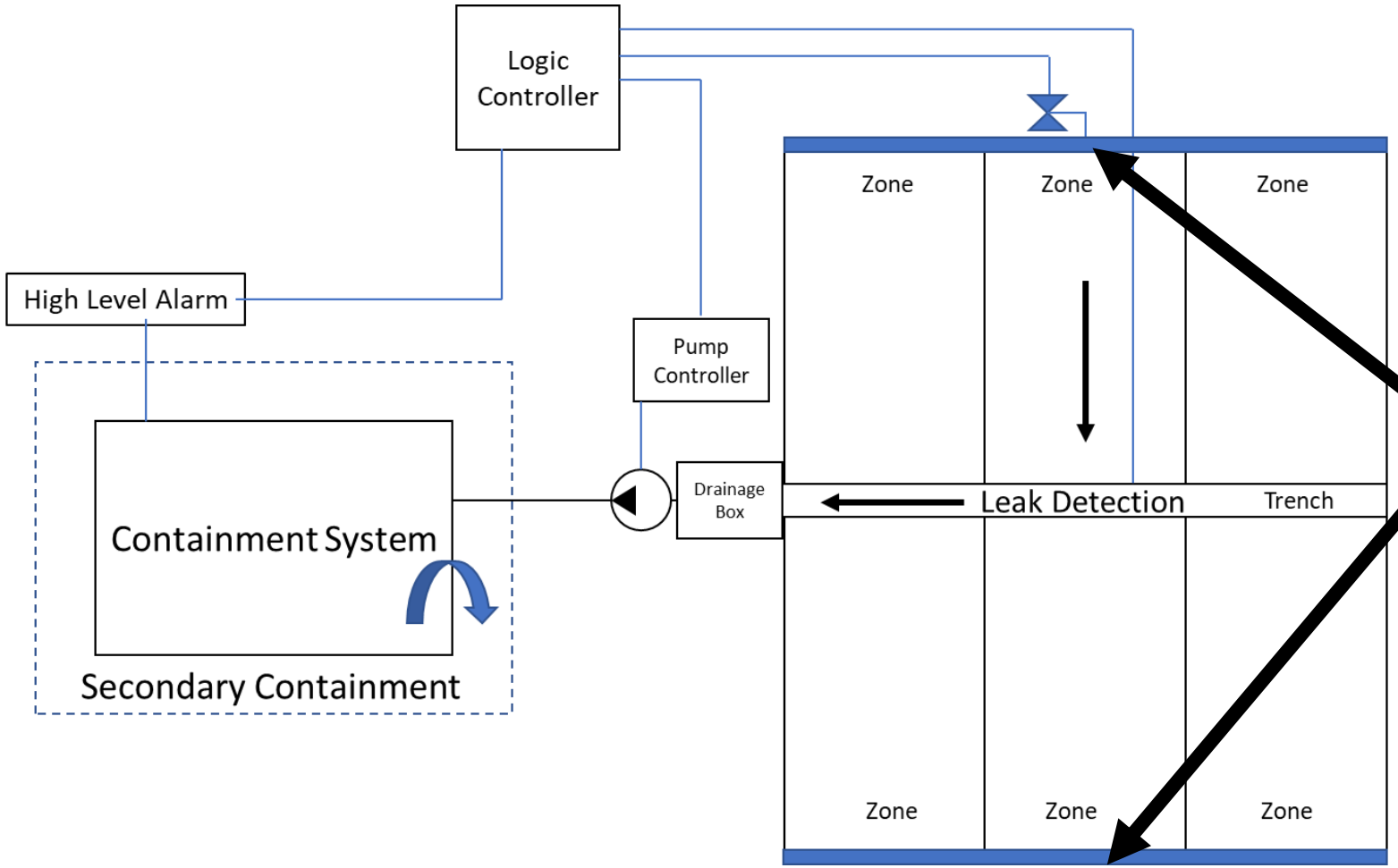


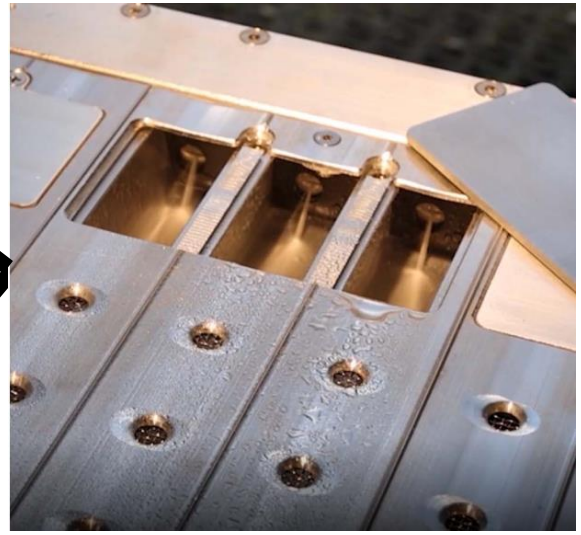


Six-Zone ILDFA System

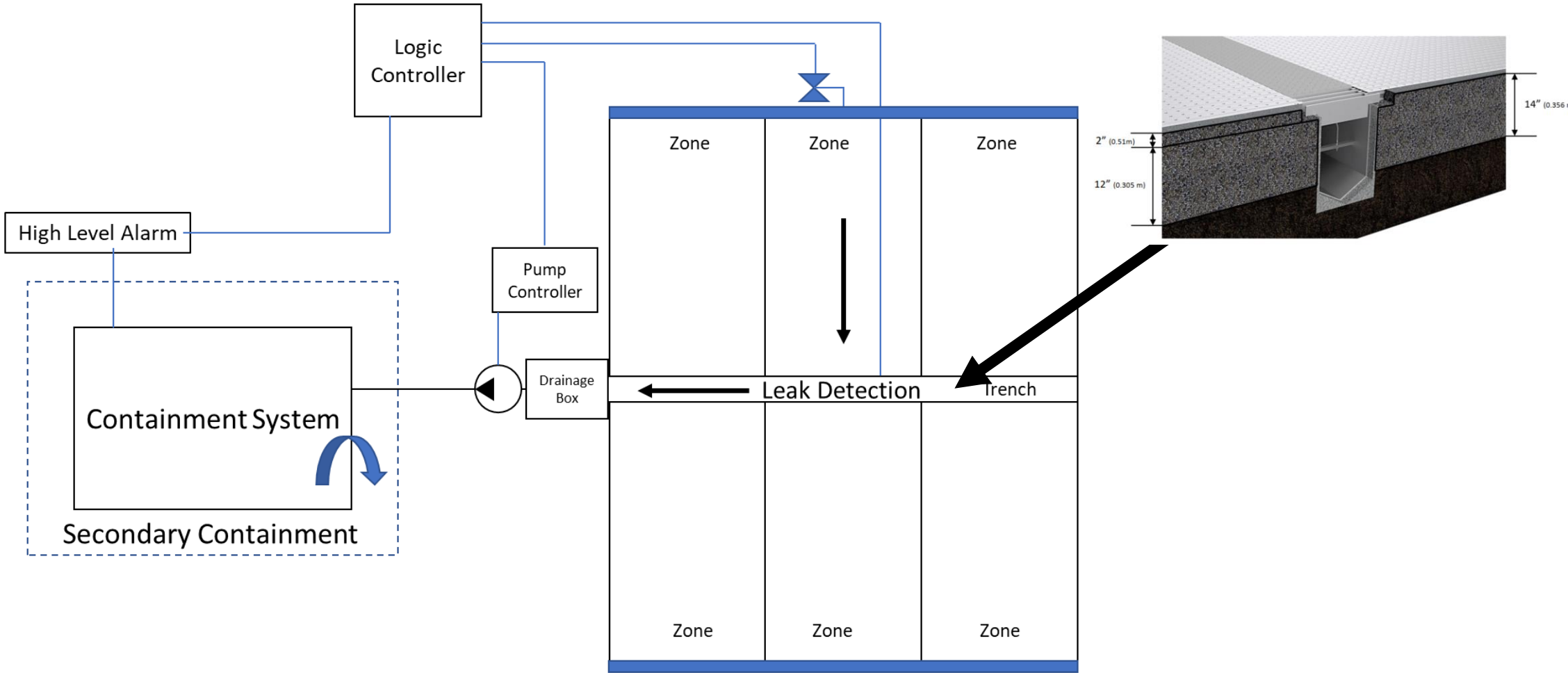


Flushing System

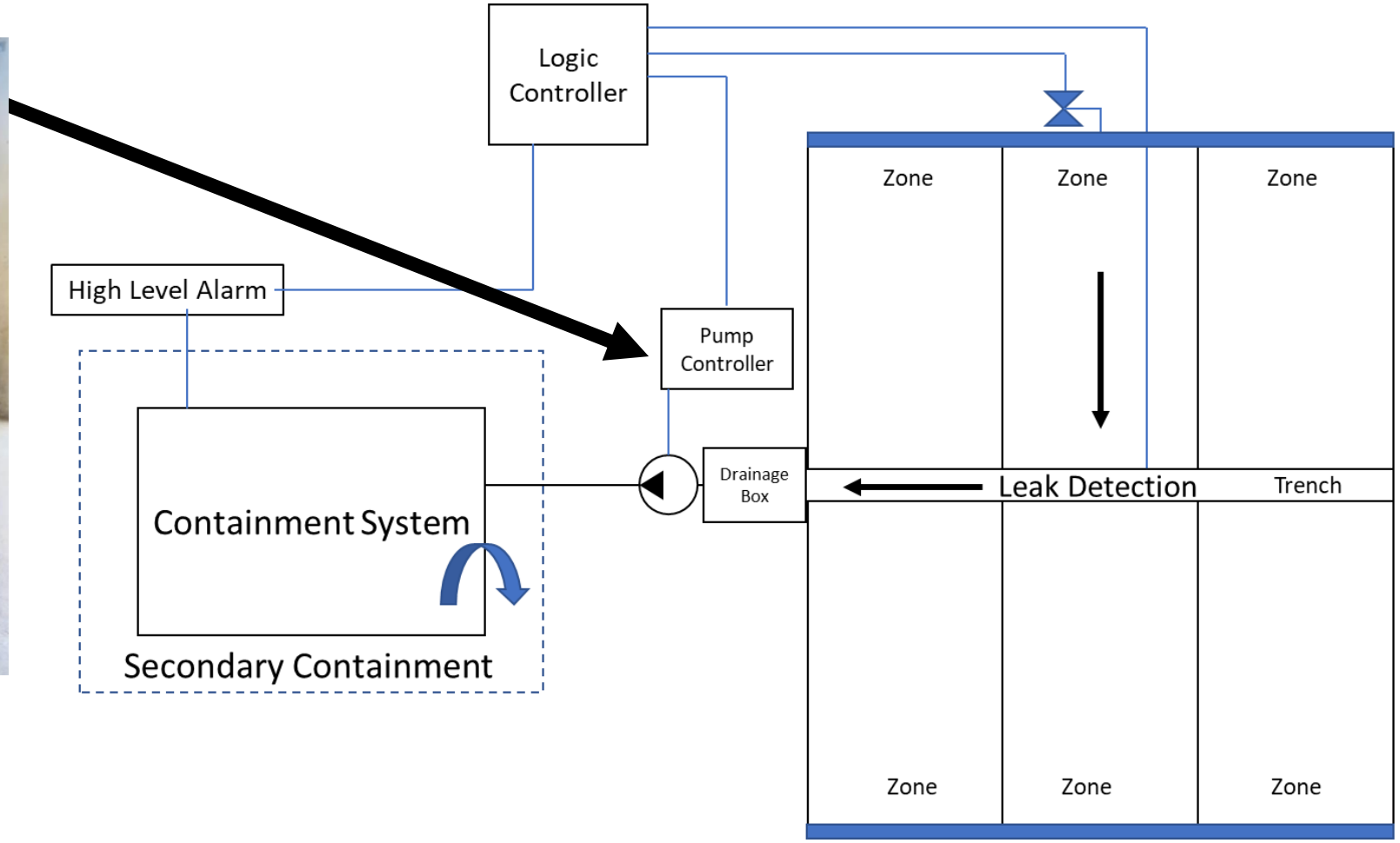




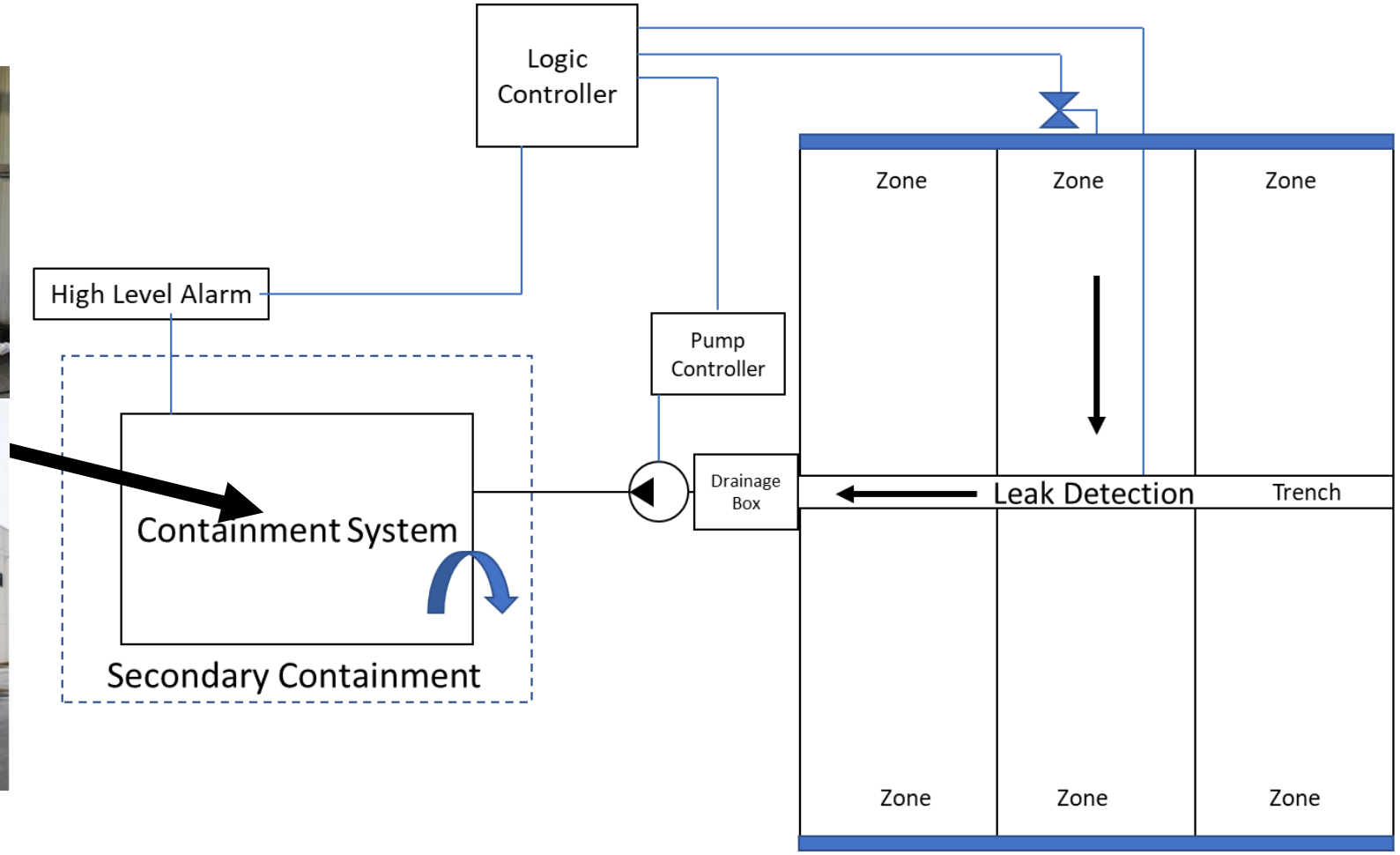
Collection Trench



Discharge Pump & Controller



Containment System



Drainage Flooring System

Second Revision No. 7-NFPA 409-2021 [Section No. 6.1.1]

6.1.1

The protection of aircraft storage and servicing areas for Group I aircraft hangars shall be in accordance with any one of the following:

(1) A foam-water deluge system, as specified in 6.2.2. In addition, supplementary protection systems as specified in 6.2.3 shall be provided in hangars housing single aircraft having wing areas greater than 279 m^2 (3000 ft^2).

(2) A combination of automatic sprinkler protection in accordance with 6.2.4 and an automatic low-level low-expansion foam system in accordance with 6.2.5.

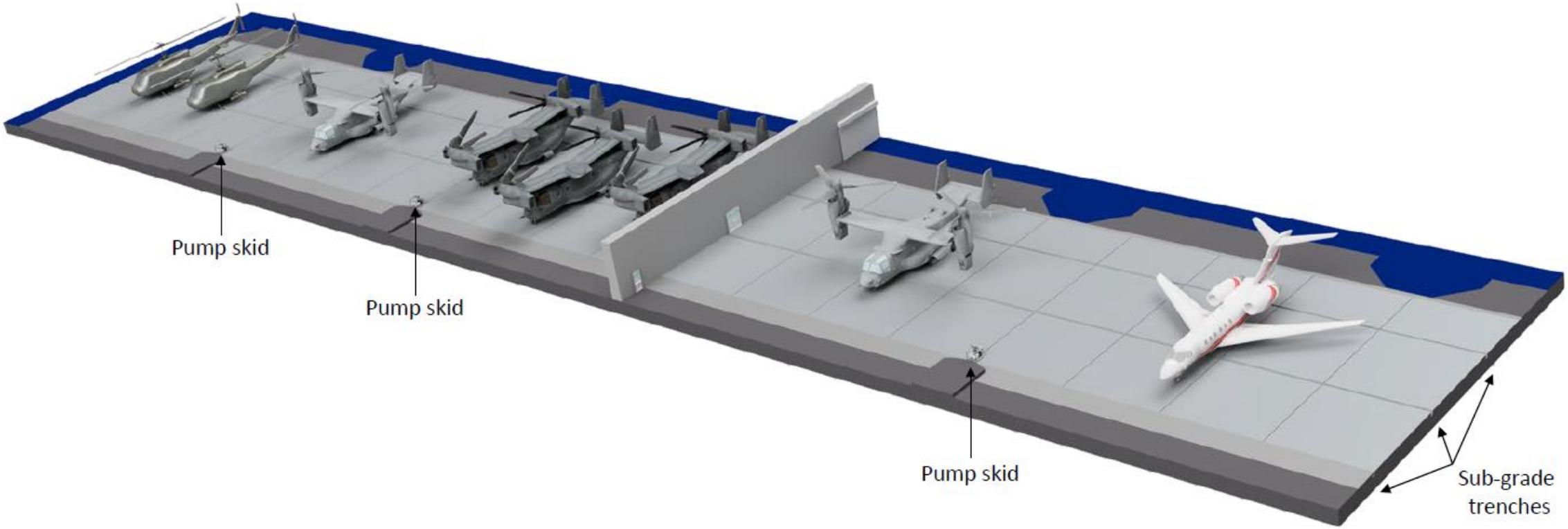
(3) A combination of automatic sprinkler protection in accordance with 6.2.4 and an automatic low-level high-expansion foam system in accordance with 6.2.5.

(4) A combination of automatic sprinkler protection in accordance with 6.2.4 and an ignitable liquid drainage floor assembly in accordance with 6.2.13.

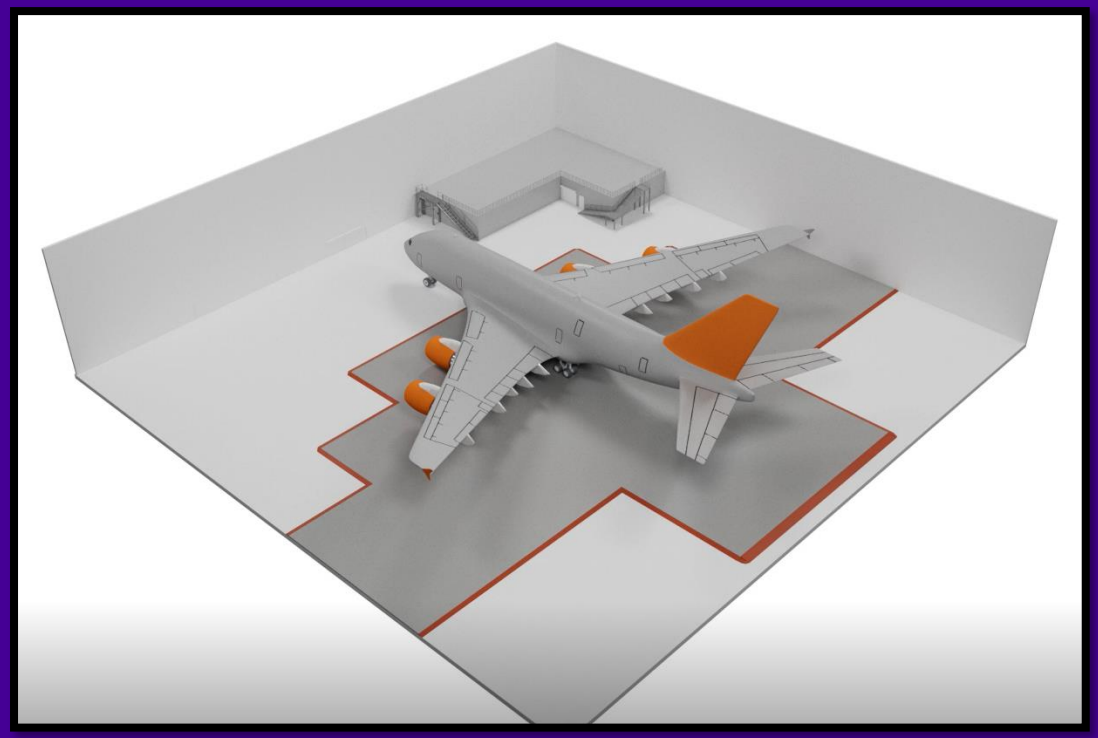
Drainage Flooring System

Floor Dimensions:

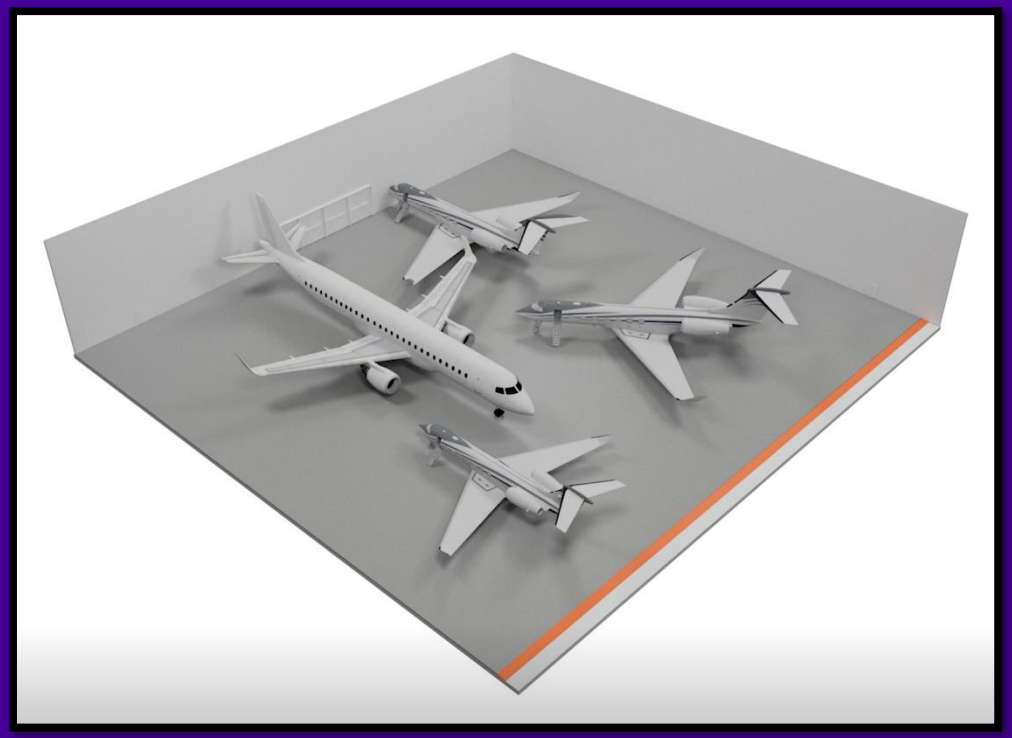
Two bay: 224 ft wide * 82 ft long
Three bay: 351 ft wide * 82 ft long
Total Sqft: 47,150 ft^2



Floor Footprint



Partial Layout



Wall-to-Wall Layout

Drainage Flooring System

Resources

FM Global
Property Loss Prevention Data Sheets 7-32

April 2020
Page 1 of 60

IGNITABLE LIQUID OPERATIONS

Table of Contents

Page

IGNITABLE LIQUID STORAGE IN PORTABLE CONTAINERS

Table of Contents

Page

General Performance Goal

- Limit release
- Contain release
- Remove fuel
- Provide cooling
- Extinguish – in some cases

Eight step evaluation process

- Recognize and understand the process
- Identify hazards of liquid
- Identify hazard isolation
- Design active protection systems
- Design passive protection systems
- Design equipment process and controls
- Design ignition source control
- Finalize hazard analysis

NFPA and Ignitible Liquids

Fire and Explosion Prevention and Risk Control

6.1* Scope.

This chapter shall apply to the hazards associated with storage, processing, handling, and use of ignitible (flammable or combustible) liquids. This chapter shall also apply when specifically referenced by another chapter.

6.4.1.2.2

An engineering evaluation shall include, but not be limited to, the following:

(1) Analysis of the fire and explosion hazards of the operation

(2) Analysis of emergency relief from process vessels, taking into consideration the properties of the materials used and the fire protection and control measures taken

(3) Analysis of applicable facility design requirements in Chapters **17**, **18**, **19**, **28**, and **29**

(4) Analysis of applicable requirements for liquid handling, transfer, and use, as covered in Chapters **17**, **18**, **19**, **28**, and **29**

(5) Analysis of local conditions, such as exposure to and from adjacent properties and exposure to floods, earthquakes, and windstorms

(6) Analysis of the emergency response capabilities of the local emergency services

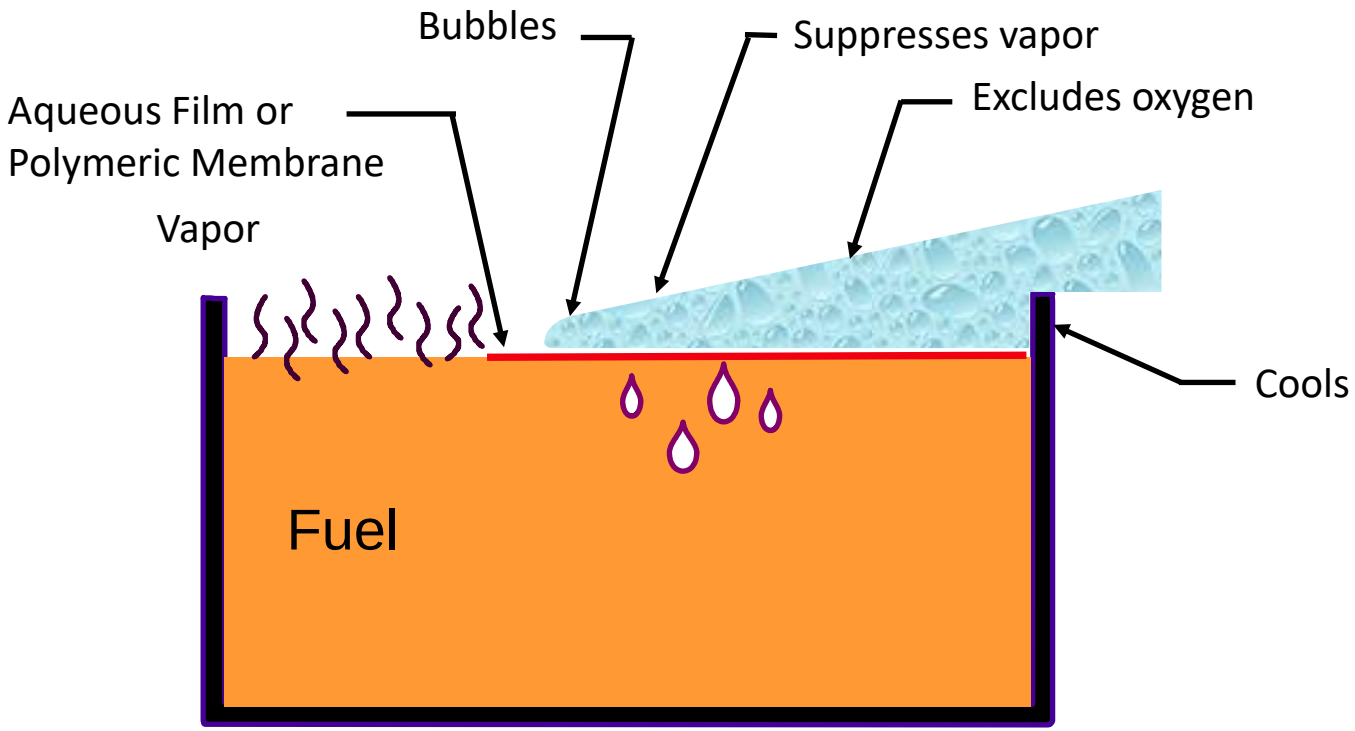
FOAM Protection

FIREFIGHTING FOAM ENVIRONMENTAL LEGISLATION IMPACT

The purpose of this publication is to help your company understand firefighting foam environmental legislation changes and the potential impact on foam-water sprinkler protection.

Foam Properties, Effectiveness, Limitations

Why is AFFF, AR-AFFF or SFFF effective?



SFFF Properties, Effectiveness, Limitations

- Performance on Ignitable Liquid Type

- Not a “Drop-In” replacement

- Specific Discharge Devices as FM Approved

SFFF Update – Fuel Analysis

- Hydrocarbons
  - Heptane is key
    (≥ flash point and ≤ vapor pressure)
- Polar solvents
  - What is polar?
    - Miscible / soluble
  - Pure
    - What was tested
    - Risk Service Test????
  - Mixture
    - Hydrocarbon + any amount polar solvent

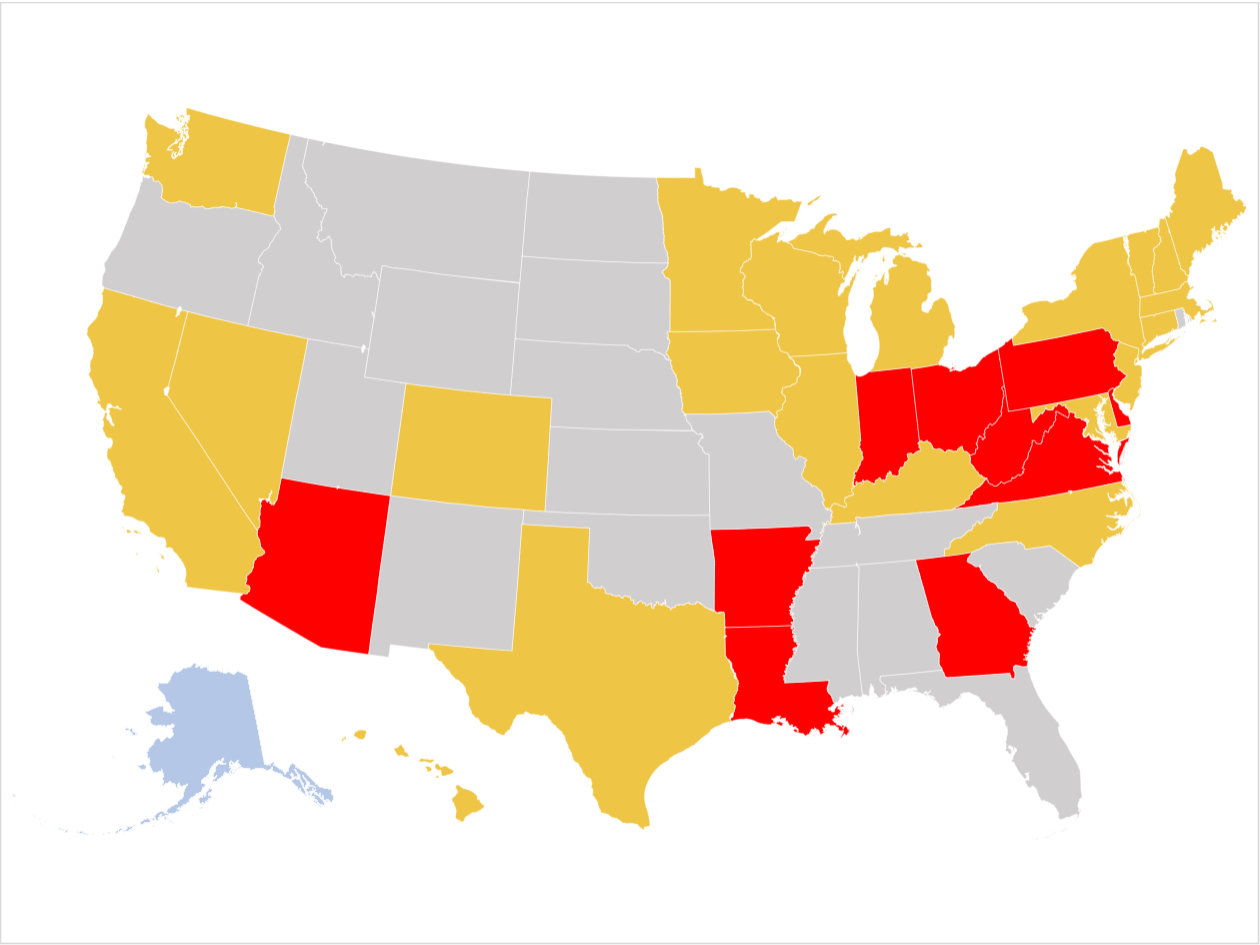
SFFF Update: <FM> Systems – Discharge Devices

- Sprinklers – Yes
- Foam chambers – ~~No~~ Yes
- Grate nozzles – No
- Monitor nozzles – No

Compressed Air Foam systems

- Deluge water, Foam-Water, Compressed Air Foam
  - Deluge – containment & drainage provided
  - Foam-Water – containment but no drainage; costly installation & on-going maintenance (AFFF, AFFF-AR, SFFF)
  - Compressed Air Foam – Containment but no drainage; less costly, more effective, less on-going maintenance

Firefighting Foam Regulations and Bills Update



- Use or Discharge Requirements, such as Training or Testing Requirements
- Discharge Notification or Reporting Processes
- Multiple Categories
- No Regulations

Firefighting Foam Regulations and Bills Update

Firefighting Foam Regulations and Bills Update

United States Environmental Protection Agency

Search EPA.gov

Environmental Topics | Laws & Regulations | Report a Violation | About EPA

Reducing HFCs

CONTACT US

- Reducing HFCs Home
- HFC Allowance Allocation and Reporting
- Technology Transitions
- Managing Use and Reuse
- **Background on HFCs and the AIM Act**
- Notices and Rulemakings
- Public Meetings

Background on HFCs and the AIM Act

Find information on upcoming and past public meetings here.

On this page:

- What is the AIM Act?
- AIM Act Enforcement
- Sector Fact Sheets
- Kigali Amendment to the Montreal Protocol
- Inflation Reduction Act Provisions for AIM Act Implementation

What is the AIM Act?

On December 27, 2020, the American Innovation and Manufacturing (AIM) Act of 2020 was enacted as section 103 in Division S, Innovation for the Environment, of the Consolidated Appropriations Act, 2021 (H.R. 133 (116th): Consolidated Appropriations Act, 2021 [Including Coronavirus Stimulus & Relief]). The AIM Act authorizes EPA to address hydrofluorocarbons (HFCs) by providing new authorities in three main areas: to phase down the production and consumption of listed HFCs, manage these HFCs and their substitutes, and facilitate the transition to next-generation technologies through sector-based restrictions.

- Read the AIM Act (42 U.S. Code section 7675)

Chemical Name	Common Name
CHF_2CHF_2	HFC–134
CH_2FCF_3	HFC–134a
CH_2FCHF_2	HFC–143
$CHF_2CH_2CF_3$	HFC–245fa
$CF_3CH_2CF_2CH_3$	HFC–365mfc
CF_3CHFCF_3	HFC–227ea
$CH_2FCF_2CF_3$	HFC–236cb
CHF_2CHFCF_3	HFC–236ea
$CF_3CH_2CF_3$	HFC–236fa
$CH_2FCF_2CHF_2$	HFC–245ca
$CF_3CHFCHFCF_2CF_3$	HFC–43–10mee
CH_2F_2	HFC–32
CHF_2CF_3	HFC–125
CH_3CF_3	HFC–143a
CH_3F	HFC–41
CH_2FCH_2F	HFC–152
CH_3CHF_2	HFC–152a
CHF_3	HFC–23
$CHFC1_2$	HCFC–21
CHF_2C1	HCFC–22
$C_2HF_3C1_2$	HCFC–123
C_2HF_4C1	HCFC–124
CH_3CFC1_2	HCFC–141b
CH_3CF_2C1	HCFC–142b
$CF_3CF_2CHC1_2$	HCFC–225ca
CF_2C1CF_2CHC1F	HCFC–225cb
$CFC1_3$	CFC–11
CF_2C1_2	CFC–12
$C_2F_3C1_3$	CFC–113
$C_2F_4C1_2$	CFC–114
C_2F_5C1	CFC–115

FIREFIGHTING FOAM ENVIRONMENTAL LEGISLATION IMPACT

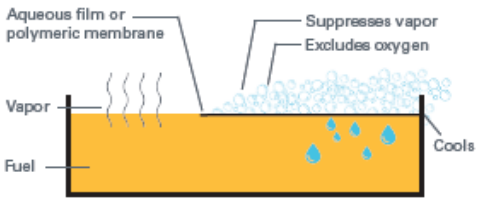
The purpose of this publication is to help your company understand firefighting foam environmental legislation changes and the potential impact on foam-water sprinkler protection.

History of Foam

Firefighting foam has been used for over 100 years to control ignitable liquid pool fires—evolving from early foams that mixed powders with water, to liquid protein-based foams, to foam concentrates containing fluorine, and most recently to synthetic fluorine-free concentrates (due to environmental concerns with fluorine foams).

HOW FOAM WORKS

Low-expansion aqueous film-forming foam (AFFF) forms a film over the surface of an ignitable liquids pool to suppress the generation of flammable vapors and prevent oxygen from mixing with vapors to form a flammable mixture. These fluorine-based foam concentrates have been used in various applications including protection of ignitable liquids storage and operations in manufacturing facilities, aircraft hangars, fuel unloading stations and many others.



Low-expansion synthetic fluorine-free foam (SFFF) also forms a barrier to isolate the fuel and vapors from air; however, the strength of this barrier is significantly less than that created by fluorinated foam. This reduction in strength necessitates the formation of a stable layer of bubbles for the foam blanket to protect the barrier until the fire can be extinguished. Failure to generate a stable layer of bubbles will not allow the fire to be extinguished.

Environmental Concerns

Government restrictions on fluorine-based foam concentrates are increasing. The focus of restrictions was originally on foam concentrates that contain or break down into perfluorooctane sulfonate (PFOS) and/or perfluorooctanoic acid (PFOA). Both substances are believed to have adverse health effects. For health and environmental reasons, electrochemical fluorinated and long-chain fluorosurfactant C8 foam concentrates associated with these substances are no longer produced and there are no C8 foam concentrates listed in the FM Approval Guide.

Once foam manufacturers recognized the environmental challenges of C8 foam concentrates, they began to develop new chemistries. Replacement C6 foam concentrates became available around 2016. These foams, manufactured with short-chain fluorosurfactants, do not contain or break down into PFOS or PFOA. However, both C6 and C8 foam concentrates have fluorochemicals and are per- and polyfluoroalkyl substances (PFAS). Much of the enacted and proposed legislation treats all PFAS chemicals the same, regardless of the length of the fluorosurfactant chain. This has prompted the development of SFFF concentrates, which do not contain fluorine. While formulations are improving, there are limitations on the fuels which can be adequately protected by SFFF. Another significant issue with SFFF replacement concentrates is that these are not "drop in" alternatives. There are often differences in viscosity and other physical properties which necessitate the redesign of the foam delivery system (storage container, proportioner) and discharge devices (foam-water sprinklers, foam chambers, etc.).

Impact of Recent Firefighting Foam Legislation

Legislative activity regarding PFAS is rapidly increasing, with many countries and states enacting or proposing restrictions on PFAS chemicals. As of 2022, nearly half of the U.S. states have enacted legislation banning, phasing out, or restricting the testing and discharge of PFAS firefighting foam. Many of the other U.S. states have proposed legislation which may be enacted in the coming years. Federal legislation has also been proposed in the U.S. which would ban all firefighting foam with PFAS. Similar legislation has been enacted in New Zealand and several Australian states. The Netherlands, Denmark, Germany, Norway and Sweden have published their intention to propose a ban on all PFAS in Europe (including firefighting foam).

FM Global clients are facing requirements to remove existing foam systems, difficulty in obtaining compatible foam concentrate to refill systems, bans on testing of foam-water sprinkler systems, and requirements to capture and incinerate released foam. Recognizing the challenges our clients face with maintaining their foam-water sprinkler systems, FM Global, with FM Approvals, continues to assess ways to test the systems, e.g., surrogate foam concentrates and water equivalency or flowmeters, that either eliminate the discharge of foam or at least minimize it.

Key Issues Related to Foam System Testing

1. Sales of PFAS foam concentrates have been banned in several countries/states. As of 2022, at least eight U.S. states, three Australian states, and New Zealand have enacted legislation to ban sales of some or all PFAS firefighting foam.
2. Some jurisdictions have established mandatory dates for decommissioning existing fire protection systems containing PFAS foam.
3. System discharge testing of PFAS foam concentrates has been prohibited or restricted in several states and countries.
4. Collection and disposal of the foam materials containing PFAS (typically with high-temperature incineration) is also mandated in many states and several countries. The disposal requirements for fluorine-free foams have not been defined.

Foam discharge collected for disposal during testing

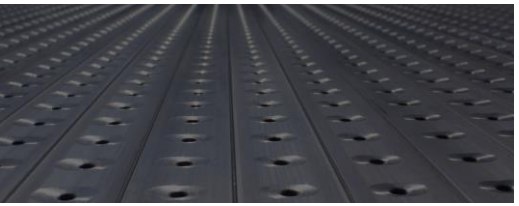
Firefighting Foam Recommendations

1. Significant action should not be taken for existing foam systems (i.e., remove or replace them) unless mandated, as proven replacement options continue to evolve. However, begin planning/budgeting for the future changes by documenting the specifications of current AFFF foam systems which are likely to be mandated for replacement in the coming years.
2. If removal/replacement of a foam system is mandated, or if any other changes to foam systems are planned, contact your FM Global representative to identify FM Approved systems for replacement to ensure acceptable fire protection performance. Never replace an existing AFFF concentrate with an SFFF concentrate without a full evaluation of the current equipment.
3. Verify the operability of foam systems using alternative discharge test methods as recommended in FM Global Property Loss Prevention Data Sheets as assessed by FM Approvals. If alternative methods are not available, conduct testing of foam systems prior to any legislative changes which would make proper testing more difficult. Dispose of any discharged foam-water solution effluent or foam in accordance with local regulations.
4. Confirm all foam concentrate tanks are full and verify continued availability of reserve supplies prior to any legislative changes which would make obtaining the foam concentrate more difficult.
5. Thoroughly consider the design implications and budget for long-term testing costs before installing new foam systems.
6. Consider designs that eliminate the need for a foam system—including solutions such as emergency drainage, limiting liquid quantities, and use of FM Approved containment systems or drainage systems.

If you have additional questions, please contact your FM Global engineer or client service team.

Alternatives to Foam

- Drainage
- Drainage + Shut-offs
  - Reduced duration



Alternatives to Drainage

- Leak Detection and Shutoffs

Questions