

# Fluid Collections at the Smithsonian

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Smithsonian Institution

# Who We Are

## OSHEM

- Authority Having Jurisdiction for Smithsonian Properties
- Hybrid of:
  - Engineer
  - Fire Marshal
  - Building Official
  - Consultant

## Fire Protection Division

- Duties:
  - Review plans
  - Perform inspections
  - Give training
  - Write policy
  - Interface with units to ensure safety of staff, visitors and collections



# Agenda

- Sao Paulo, Brazil Fire
- Properties of Flammable Liquids
- Characteristics of Flammable Liquids Fires
- Fire Protection Objectives & Strategy
- Design of a Small Collections Room
- Design of MSC Pod 5
- Working With Your AHJ
- Where Are the Codes Headed?
- Questions



# Sao Paulo, Brazil Fire

- Butantan Institute
- Herpetological Collection
  - 77,000 snakes
  - 450,000 spiders & scorpions
- Most important type collections of Brazilian snakes
- Fire on May 15, 2010
- 80% of collections destroyed
- No sprinklers or fire alarm



# Properties of Flammable Liquids

- Classes: IA, IB, IC, II, IIIA, IIIB
- Categorized by flash point
- Flash point: What temperature does vapor become ignitable?
- Heat of combustion: How much energy is released?
- Vapor pressure: How easily do molecules escape the liquid?
- Latent heat: How much energy does it take to turn the liquid into a vapor/gas?
- LEL/UEL: What concentration of vapor is flammable?
- Miscibility: Whether a substance mixes in a solution with other substances



# Properties of Flammable Liquids

Substance	Flash Point (°F)	Heat of Comb. (MJ/kg)	Vapor Pres. (mm Hg)	Latent Heat (kJ/kg)	LEL-UEL (%)	Miscible?
100% Ethanol	55	26.8	44.0	837	3.3-19.0	Yes
100% Isopropanol	53	30.5	33.0	663	2.0-12.7	Yes
70% Ethanol	72	26.8	24.0	1664	3.3-19.0	Yes
50% Isopropanol	~73	30.5	23.6	1889	2.0-12.7	Yes
37% Formalin*	147	18.7	40.0	--	7.0-70.0	Yes
Gasoline	-45	43.7	38-300	349	1.4-7.6	Insoluble
Acetone	0	28.6	180	501	2.5-12.8	Yes
Water	N/A	N/A	17.6	2257	N/A	N/A



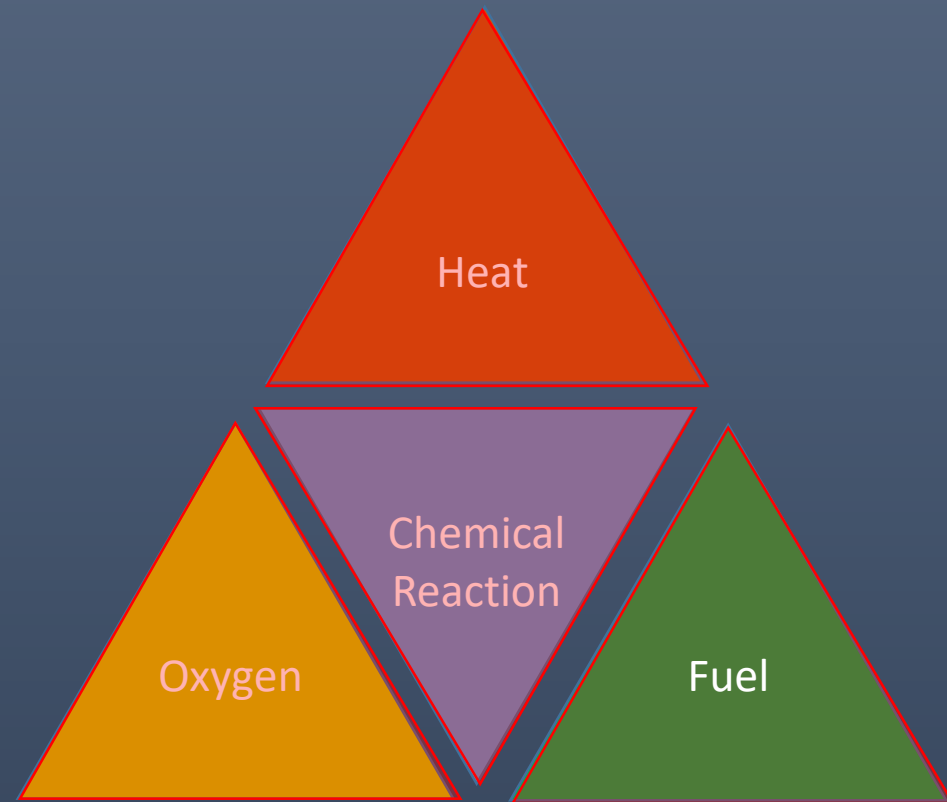
# Characteristics of a Flammable Liquids Fire

- Ethanol and Isopropanol are flammable until concentration is very low (~20%)
- Rapid fuel spread
- Can cause other containers to fail
- LOTS of water needed for control
- Sprinkler discharge can initially spread the fire



# How to Kill a Fire

- Fuel
  - Remove fuel source
- Heat
  - Cool the environment/fuel
- Oxygen
  - Remove or displace the oxygen
- Sustained Chemical Reaction
  - Inhibit the reaction





# Fire Protection Objectives & Strategy

- Prevention
  - Limiting operations (storage only, no study or processing)
  - Design controls (ignition sources, vapors)
- Detection & Suppression
  - Fire Suppression
  - Fire Detection
- Containment
  - Spills (trenching, curbs)
  - Fire-rated Barriers



# Design of Spaces

Manufacturer's Safety Data Sheets

International Building Code

NFPA 13: Standard for the Installation of Sprinkler Systems

FM Data Sheet 07-29

NFPA 30: Flammable and Combustible Liquids Code

NFPA 72: National Fire Alarm and Signaling Code

Engineering Judgment

Fire Modeling

International Fire Code

NFPA 68: Standard on Explosion Protection by Deflagration Venting

International Mechanical Code

DISCUS Fire Protection Guide

NFPA 70: National Electrical Code

NFPA 10: Standard for Portable Fire Extinguishers



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# NMNH Fluid Collections Storage

- Control Areas
- Avoids Group H High Hazard
- Avoids Liquid Warehouse Designation
- Maximum area: 500 ft<sup>2</sup>
- Shelves are 2 feet deep, 9 feet high
- Maximum glass container size is 5 liters



# Prevention – Operations

- No processing or research in the storage rooms
- Topping off containers
- Transport of specimens
- Self-righting carboys
- Catch basins



# Prevention – Spills

- Rails on each storage shelf
- Secured racks



# Prevention – Vapor Control

- 1 CFM/ft<sup>2</sup> minimum
- Inlets within 12” of floor
- HVAC balanced for negative pressure
- Discharged to safe location
- On emergency power



# Prevention – Ignition & Combustibles

- Minimize excess/accessory storage
- Control ignition sources
- Classified (C1D2) electrical service and devices



# Detection – Gas/Vapor

- Gas detection system





# Detection – UV/IR

- Detect ultraviolet & infrared light, specific to a fuel
- Ethanol fires are invisible to the naked eye



# Suppression – Fire Sprinklers

- Required for all liquid storage
- More robust design than standard sprinklers
- Dependent on layout & height of shelving
- Perforated shelving



# Containment – Fire Barriers

- Fire-rated structure, walls, ceilings, and floors
- Rating depends on room size and floor level



# Containment – Fire Doors

- Rated doors are required for fire barriers
- Rating is dependent on the barrier
- Door hold-opens



# Containment – Flooring

- Noncombustible
- Liquid-tight
- Sloped towards drains

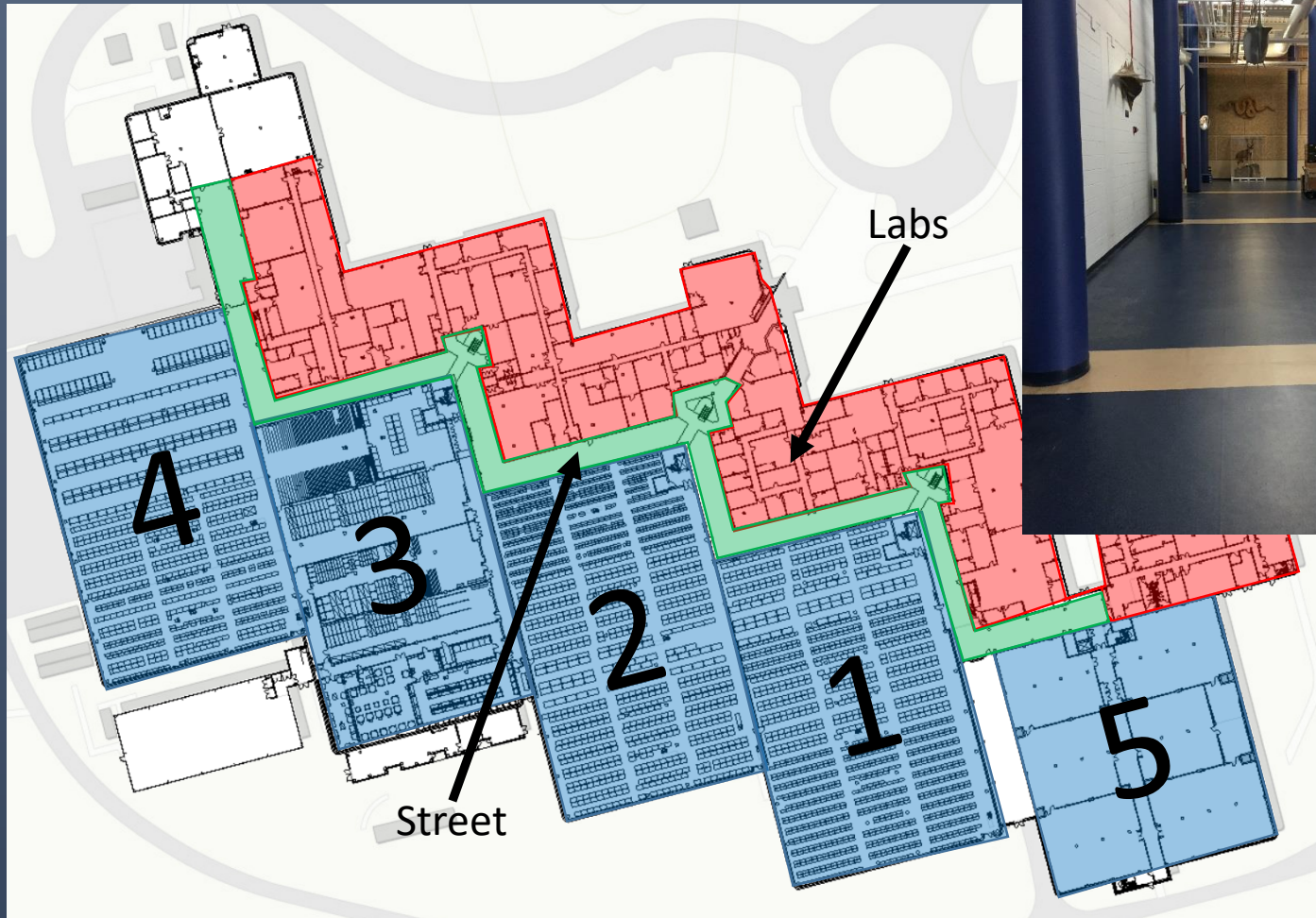


# Containment – Spill Control

- Designed to contain a spill from the largest container
- Installed at NMNH as an extra precaution



# Fluid Collections Storage at the Museum Support Center



# What is Pod 5?



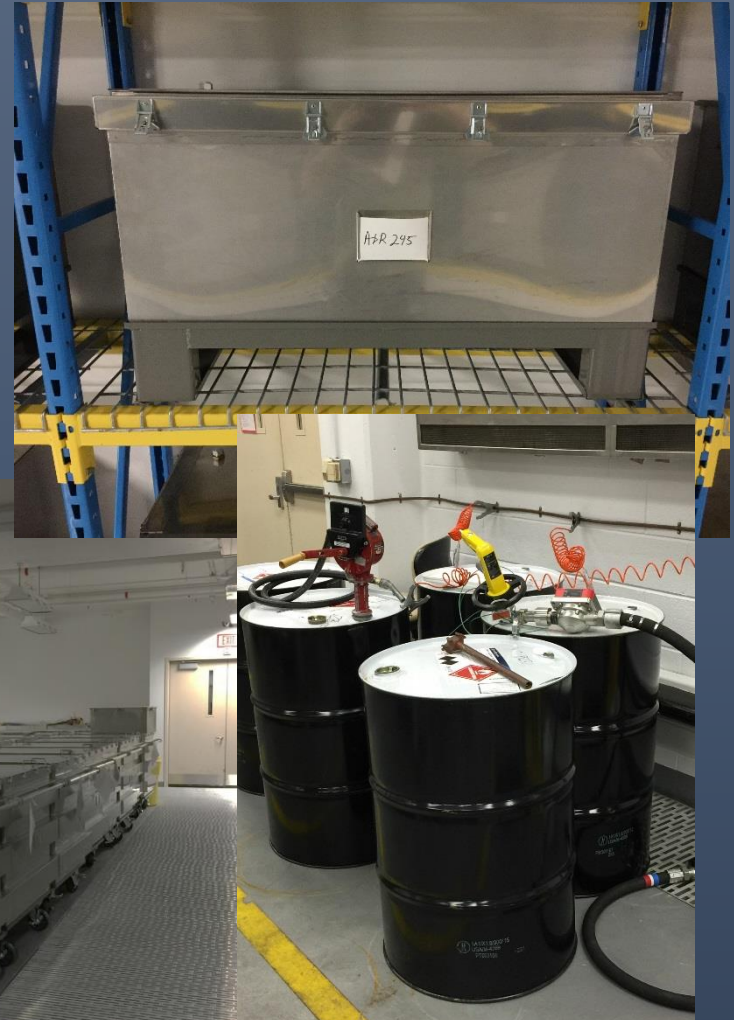
Bulk Storage





# What is Stored There?

- 500,000+ gallons of flammable liquids containing specimens



# What Pod 5 is Not



# Performance Based Engineering

- Fire Modeling used to gain understanding of the impact of a pool fire on:
  - Sprinkler activation times
  - Temperatures
  - Effects of geometry on fire growth

Likelihood	Description
Anticipated	Incident might occur several times over facility lifetime
Unlikely	Incident not anticipated to occur over facility lifetime
Extremely Unlikely	Event that would require more than a single failure of equipment
Beyond Extremely Unlikely	Events so remote as to not warrant serious consideration



# Likelihood of a Spill

Failure Mode	Potential Alcohol Spill Volume (gal)	Likelihood
Drop or breakage of 5-gallon or smaller jar	5	Anticipated
Drop or spill of 10-gallon topping-off jar	10	Anticipated
Drop or breach of 3 foot cubic tanks	152	Unlikely
Collapse of (1) 3-foot shelf component	9.3	Unlikely
Collapse of (7) 3-foot wide shelf components – successive collapse	65	Extremely Unlikely
Collapse of (1) 21-foot wide shelf	185	Extremely Unlikely
Collapse of (1) compactor shelf unit	2735	Beyond Extremely Unlikely



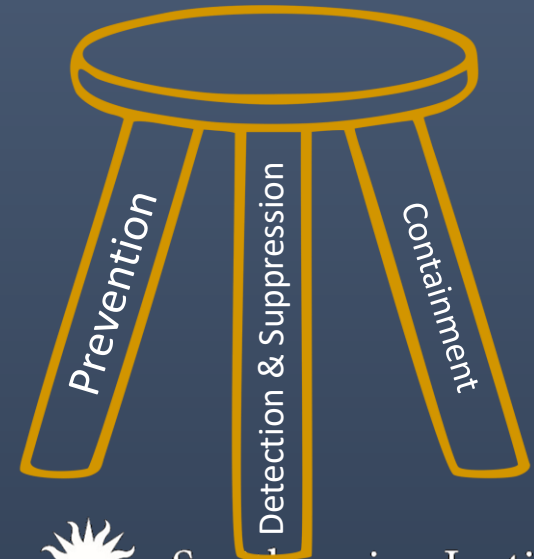
# Model Results

- Higher temperature sprinkler heads
- Draft curtains



# MSC Liquid Collections Storage

- Group H-3 High Hazard
- Liquid Warehouse Designation
- Remember:
  - Prevention
  - Detection & Suppression
  - Containment



# Prevention – Operations

- All procedures are the same
  - Topping off
  - Cart transport
  - No processing/research



# Prevention – Vapor Control

- Same as NMNH, but more robust
- If HVAC malfunctions, lighting is turned off
- Local alarm for malfunctions
- Negatively pressurized





# Prevention – Ignition Sources

- Class 1, Division 2 equipment is provided throughout each area.
- Class 1, Division 1 equipment is provided within the trench drain system.



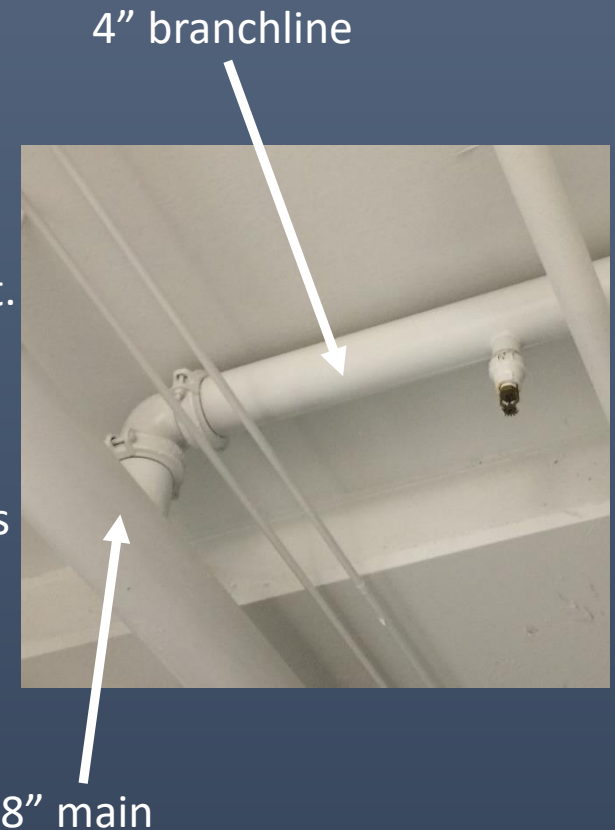
# Detection – Gas/Vapors

- Gas detection provided in all storage spaces as required
- Supervisory alarm sounds at 25% LEL
- System will then increase ventilation and use 100% outside air
- UV/IR detectors not provided; they would be infeasible & expensive



# Suppression – Performance Based

- Sprinkler density is usually in a code book
- Not this time!
- Surveyed codes for closest match
  - NFPA 13: Defers to NFPA 30
  - NFPA 30: Doesn't address containers >1 gal over 6 ft. Doesn't address compact shelving
  - DISCUS: Class III commodity per NFPA 13; Assumes finished product in packaging
  - FM 07-29: Many test scenarios that the above codes didn't have.
  - SI: Hybrid









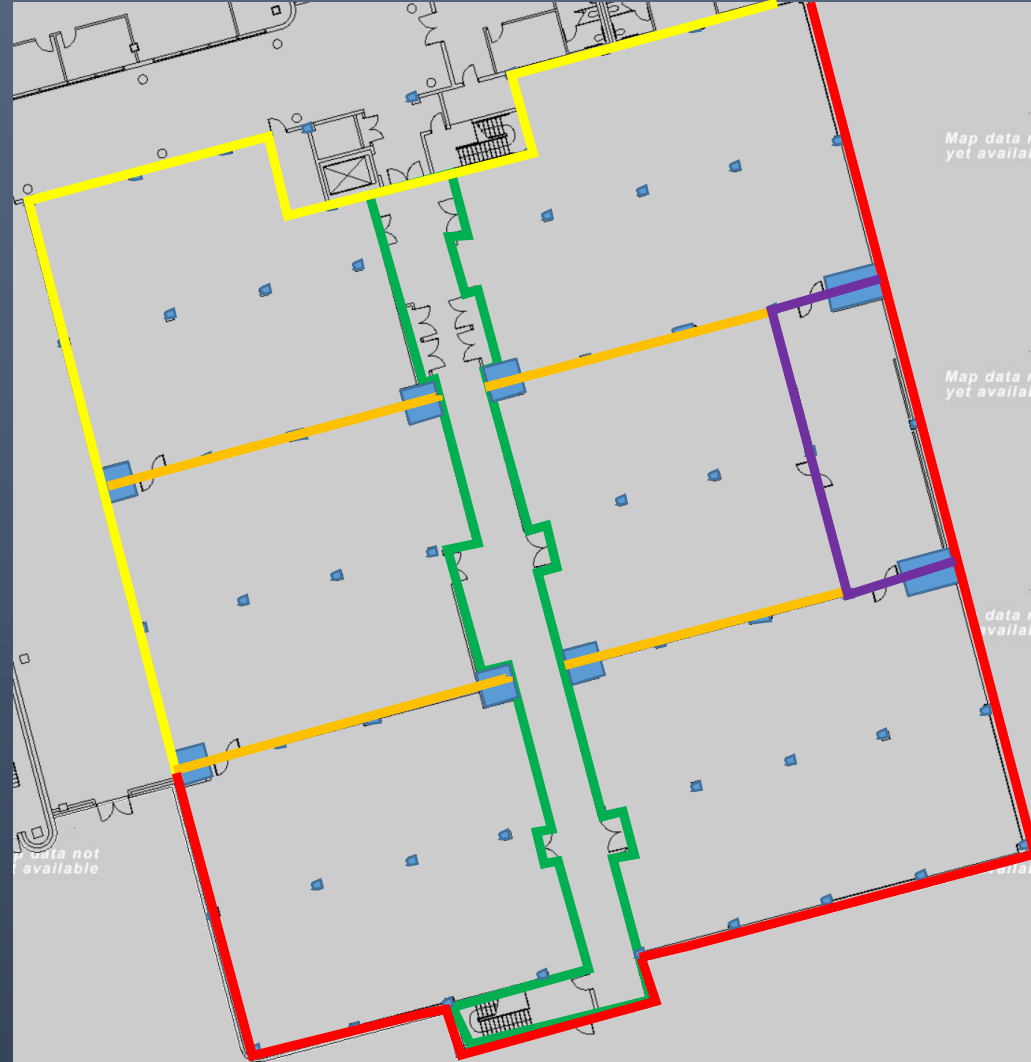
# Suppression – Unused Options

- Deluge
- Foam-water
- High-expansion foam
- Carbon dioxide
- Water mist



# Containment – Fire Barriers

- Type I-A Structure (4-hours) 
- 4-hour floors
- 4-hour exterior walls 
- 4-hours between pods (structurally independent) 
- 2-hours between compartments 
- 3-hours at bulk storage 
- 2-hour horizontal exit egress corridor 



# Containment – Flooring

- Watertight compartment
- Flooring resistant to ethanol



# Containment – Draft Curtains

- Splits compartments in two



# Containment – Spill Control

- Combination of trenches and drainage
- Same layout as draft curtains





# Containment – Spill Control

- Drain discharges to sanitary sewer



# Working with Your Local AHJ

- Get them involved
  - Tell your mission
  - Show them an existing space if you have one
- Hire a fire protection engineer!
  - You may have to ask a design firm to do so
  - Know their way around the codes
  - Can perform performance based analysis and engineering
  - Can explain project nuances to the AHJ



# Where Are the Codes Going From Here?

- Challenges with applying existing codes for owners and AHJ's
- Common issues raised by multiple organizations
- NFPA Cultural Resources Committee examining these challenges



# References

- International Building Code, 2015 Edition
- International Fire Code, 2015 Edition
- International Mechanical Code, 2015 Edition
- NFPA 13, 2016 Edition
- NFPA 30, 2012 Edition
- NFPA 72, 2013 Edition
- DISCUS Fire Protection Guide, 1981 Edition
- Factory Mutual Data Sheet 07-29
- Fuel Data:
  - American Institute of Chemical Engineers (AIChE)
  - National Institute for Occupational Safety & Health (NIOSH)
  - Society of Fire Protection Engineers (SFPE) Handbook, 3<sup>rd</sup> Edition
  - Chemical Safety Data Sheets (SDS), various



Questions?



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Thank you!



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