



Chemical Safety and Security Training
Balitvet – Indonesian Institute for Veterinary
Science
July 25-27, 2011



International Year of
CHEMISTRY
2011



SAND No. 2010-7455 P, SAND No. 2009-8395P
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin
Company,
for the United States Department of Energy's National Nuclear Security Administration
under contract DE-AC04-94AL85000.





Laboratory Inspection Checklist (See Handout)



Laboratory Inspection Guidance

Access to building
Access to labs
Stockrooms



Access-security

Proper arrangement and storage of chemicals

Emergency equipment- Location and condition

Spill kits, showers, eyewash

Fire extinguishers, sensors, alarms, sprinklers

Warning signs and labels

External-internal to room, cabinets, fume hoods

Emergency contact numbers, evacuation map





Laboratory Inspection Guidance

Other Hazards

- Compressed gas bottles
- Tripping hazards
- Electrical hazards
- Flame generating equipment

Housekeeping

- Waste- secondary containment
- Chemical reagents and samples labeled
- Uncluttered fume hoods

Personal protective equipment

- Gloves, goggles, aprons

SOPs, MSDSs

Unblocked exits





Group Discussion /Scenario Analysis



Break

REHAT



Group Discussion /Scenario Analysis



Lunch

MAKAN SIANG



Fire Protection and Prevention in Chemical Laboratories



Fires

- **Preventable**
- **Caused by unsafe practices**
 - Electrical safety violations
 - Uncontrolled use of flammable and combustible materials
- **Control**
 - Inspect, inspect, inspect
Educate, educate, educate!





Home Fires

1 million fires and 8,000 deaths annually in the US



Leading causes:
Cigarettes
Heating/cooling equipment
Electrical
Matches, lighters, candles





Industrial Fires

- **Fifth leading cause of accidental death**
 - Vehicles, falls, poison, drowning, fire
- **Most dangerous industries from fire hazard:**
 - Mines
 - Grain elevators and mills
 - Refineries
 - Chemical plants
- **Leading causes:**
 - Electrical
 - Smoking
 - Friction
 - Overheating
 - Hot surfaces





Key Elements of Fire Safety



Get occupants out
Minimize property loss and interruption
Fire Containment/Suppression



Common Myths

- **Fire will light the way out**
 - Smoke cloud & soot
- **Plenty of time to escape**
 - 1 min from small to inescapable fire
- **People are killed by the flames**
 - #1 killer in fires is CO, not flames
- **Wait to be rescued**
 - No! Act to save self
 - Ladders can reach to about 6th floor
- **Can not prepare for a fire**
 - Preparation can save your life





It's the Smoke...





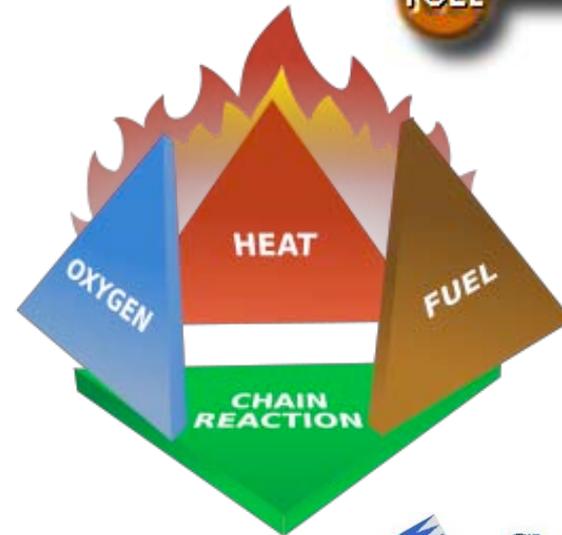
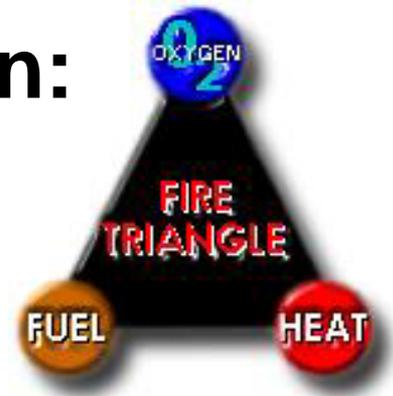
Facial Burns





Fire

- A fire must have four things to ignite and maintain combustion:
 - Fuel
 - Heat
 - Oxygen
 - Chain reaction





Flash Point

- **Flash point:**

- The minimum temperature at which a liquid gives off enough vapor to form an ignitable mixture.
- In general, **the lower the flash point, the greater the hazard.**

- **Flammable liquids:**

- have flash points below 38°C
- are more dangerous than combustible liquids
- may be ignited at room temperature

- **Combustible liquids:**

- have flash points at or above 38°C
- Can pose serious fire and/or explosion hazards when heated

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Flammability/Explosive Limits

Above UFL/UEL, mixture is too rich to burn

Upper Flammability/Explosive Limit (UFL/UEL)



Flammability/Explosive Range

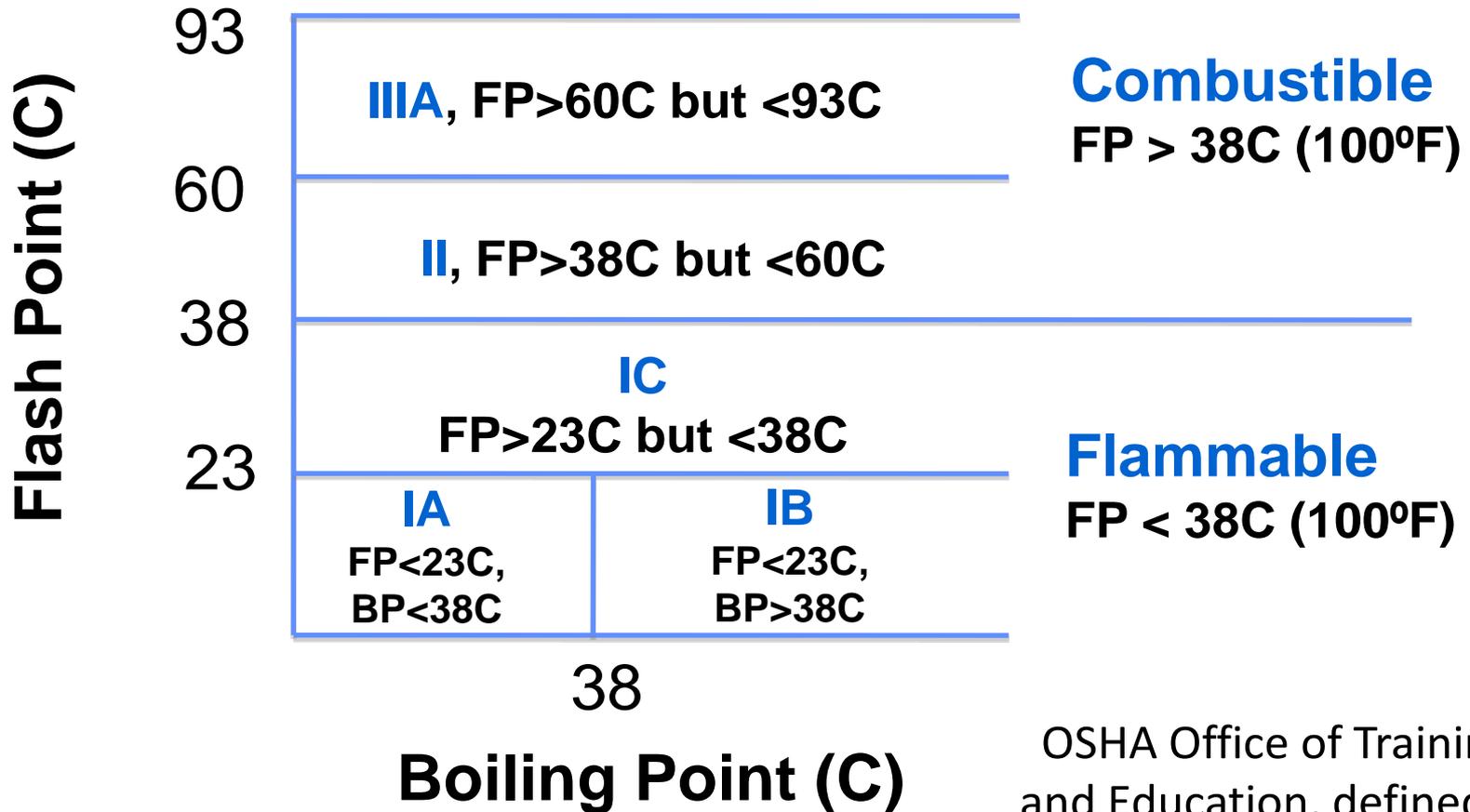
Lower Flammability/ Explosive Limit (LFL/LEL)

Below LFL/LEL, mixture is too lean to burn

Defined in terms of the amount of fuel in air.



Classes of Flammable and Combustible Liquids



OSHA Office of Training and Education, defined in Fahrenheit





Classes of Some Flammable Liquids

	<u>Common Name</u>	<u>Flash Point (C)</u>
CLASS IA	Ethyl Ether	- 45
CLASS IB	Gasoline	- 43
	Methyl Ethyl Ketone	- 6
	Toluene	4
CLASS IC	Xylene	27 - 46
	Turpentine	35

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Fire Safety Program Components

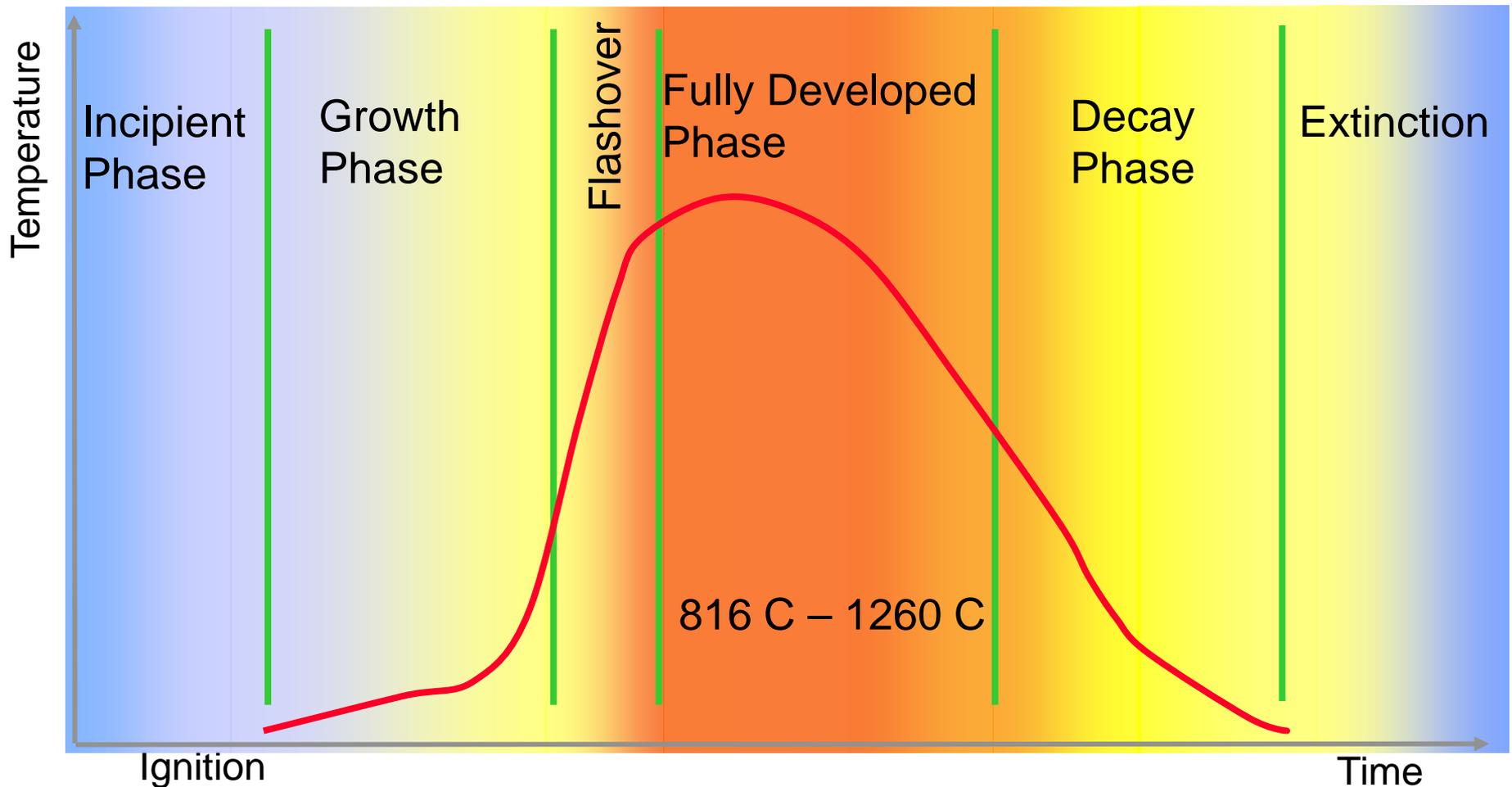
A good plan for safe use of flammable and combustible liquids contains at least these components:

- **Control of ignition sources**
- **Proper storage**
- **Fire control**
- **Safe handling**

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Fire Behavior

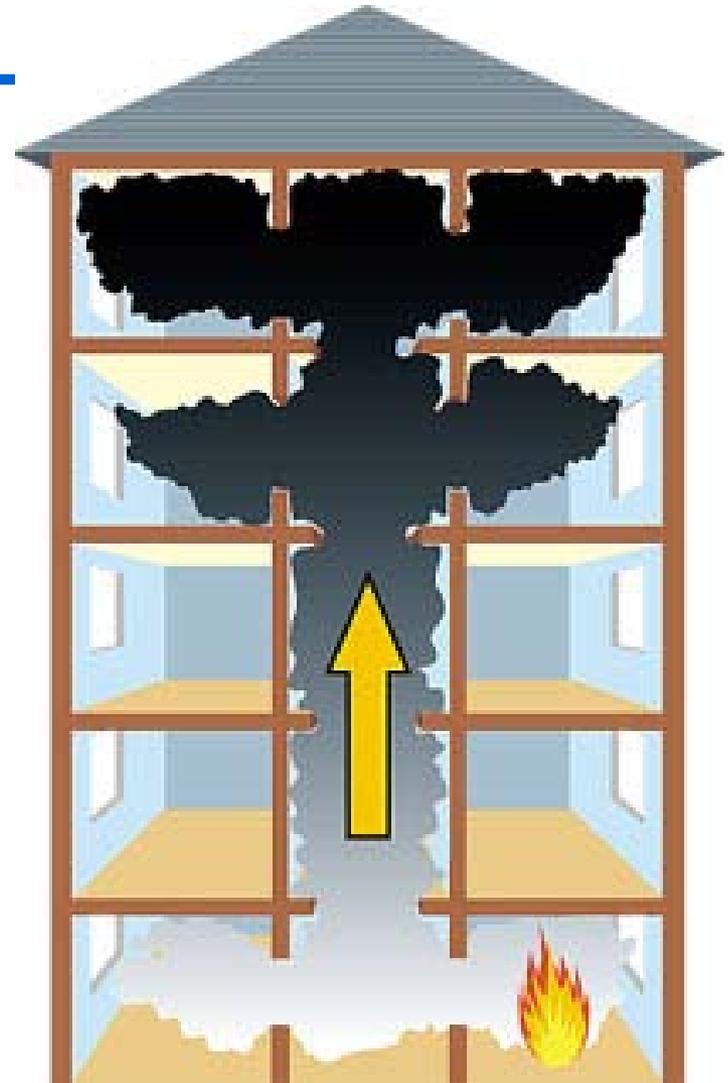




Fire Behavior

- **Hot expanding gases move vertically**
 - Tightness of construction
 - External winds
 - Internal/external temperature
 - Vertical openings
 - Stairways
 - Elevator shafts
 - Ventilation shafts

Stack Effect





Vapor Volume

Volume of gas formed when a liquid substance evaporates

Computed from specific gravity and vapor density

$$\text{Vapor Volume (m}^3\text{/liter)} = \frac{0.829 (\text{SpG})}{\text{Vapor density}}$$

Example: What is the vapor volume of a liter of acetone?

[SpG = 0.9, relative to water; Vapor density = 2, relative to air]

$$\text{Vapor Volume (m}^3\text{/l)} = \frac{0.829 (0.9)}{2} = 0.373 \text{ m}^3\text{/l}$$



Vapor Volume

What is the probability of forming a combustible mixture if a 4 liter container of acetone is used in a room 3 x 4 x 2.5 m?

[LEL = 2.5%; assume incomplete mixing factor 5]

Volume of the space = 30 m³

Vapor volume = 0.373 m³/L

**Vapor volume necessary to form a
Combustible mixture:**

$$30 \text{ m}^3 \times 0.025 = 0.75 \text{ m}^3$$

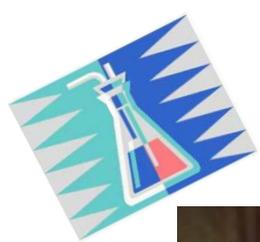
$$\frac{0.75 \text{ m}^3}{0.373 \text{ m}^3/\text{L}} = 2.01 \text{ L}$$

Applying the mixing factor of 5:

$$2.01 \text{ L} / 5 = 0.40 \text{ L}$$

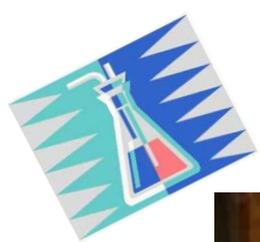
[About = 1 coffee mug]

Since it doesn't take much more than "1 coffee mug" of acetone to form a combustible mixture, the probability appears to be high!



Housekeeping...



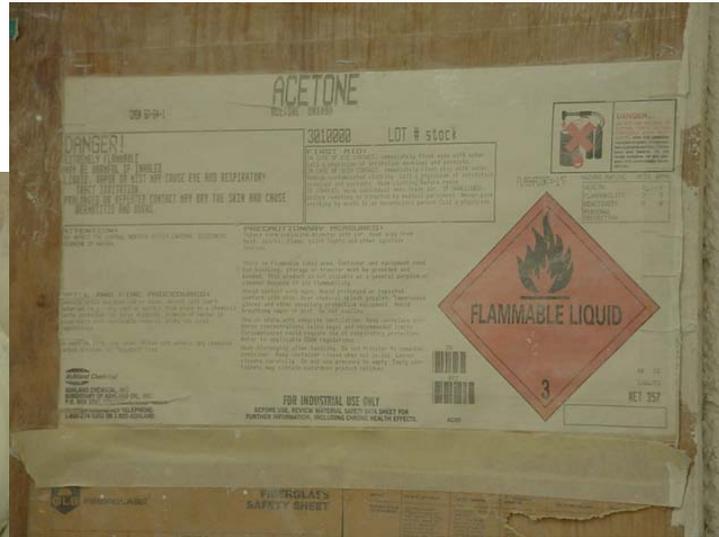


Flammable Liquid Containers





Tool Cleaning (Acetone)





Fire Hazards

- **Sources of fuel**

- Flammable liquids
- Flammable gases
- Wood, paper, cardboard
- Oil soaked rags

- **Sources of heat (ignition)**

- Electrical circuits:
 - Shorts, sparks
 - Arcs (switches)
 - Heat build-up
- Hot surfaces
- Space heaters
- Hotplates, coffee pots, coffee makers
- Welding
- Smoking
- Open flames
- Static electricity

Train employees to notice & report fire hazards

Periodic inspections

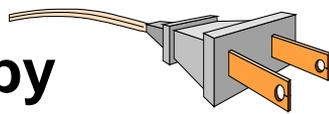
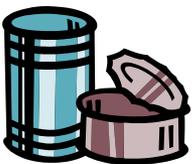
Drills





Classification of Fires

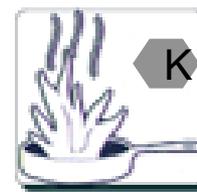
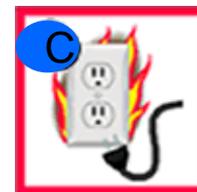
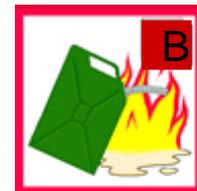
With recommended extinguisher distances

- **A** Ordinary combustibles – cloth, paper, wood, coal ~23 m 
- **B** Flammable/combustible liquids, gases, greases and oils - gasoline, diesel fuel ~15 m 
- **C** Energized Electrical equipment cables, motors nearby 
- **D** Combustible metals - sodium, magnesium, titanium ~23 m 
- **K** Restaurant grease fires associated with cooking nearby 



Classification of Fires

- **A** Extinguish by cooling or smothering.
(water)
- **B** Extinguish by inhibiting release of combustible vapors or interfering with the chemical reaction-release of OH radicals.
(CO₂ or dry powder: monoammonium phosphate)
- **C** Extinguishing agent must ***not*** be conductive.
(CO₂ or dry powder)
- **D** Extinguishing agents must absorb heat and not react with the metal.
(special dry powder, sand)
- **K** (Special liquid chemicals)



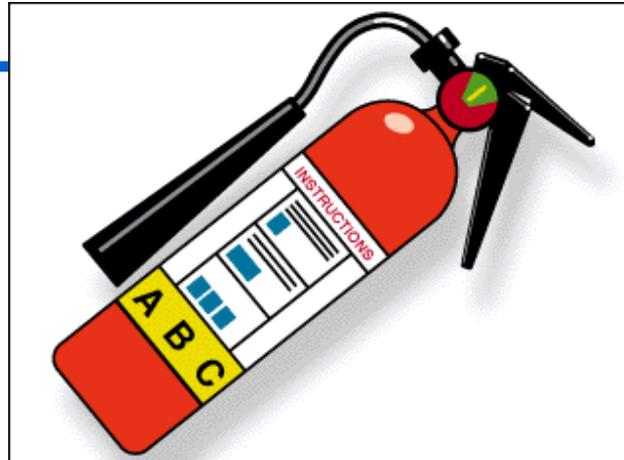
Chemical





Fire Extinguishers

Dry Chemical



CO₂



Water



Placed within ~15-25 m



Annual & Monthly inspections



Large Fire Extinguisher





Fire Extinguishers





Fire Alarm Systems

- **Will it be recognized and followed?**
 - Audible, visual, public address systems...
- **What about deaf or blind employees?**
 - Are there “dead spaces”...
- **System reliability**
 - System failure may not be obvious
 - Supervised systems (built-in monitoring)
 - Testing, maintenance and backup systems





Fire Detection & Alarms

- **Thermal**

- **Heat**

- Fixed temp
- Rate of rise
 - ~6 to 8 C/min (12 to 15°F/min)



- **Smoke**

- Photoelectric
 - IR from smoke
 - Ionization
 - Ionize smoke
- **Flame Detectors**
 - Flames – IR or UV
 - **Gas Sensors**

Issues:

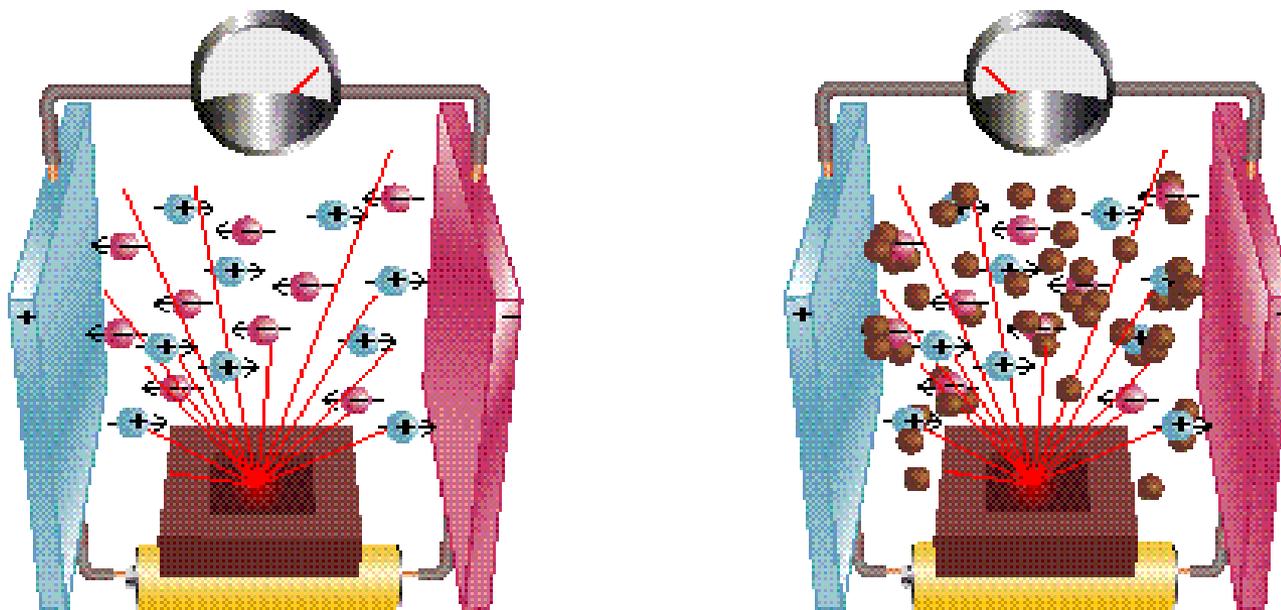
Testing

Dust, corrosion, hot processes, weather, mechanical damage





Smoke Detectors



- Alpha particles from Americium-241 (red lines) ionize the air molecules (pink and blue spheres).
- The ions carry a small current between two electrodes.
- Smoke particles (brown spheres) attach to ions reducing current and initiate alarm.





False Alarms



False alarms
may be
triggered by
construction
dust created
during
renovations



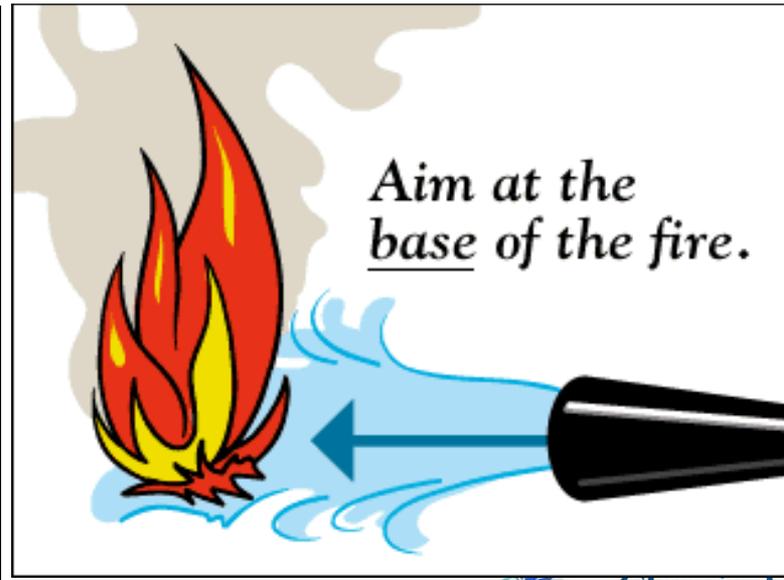
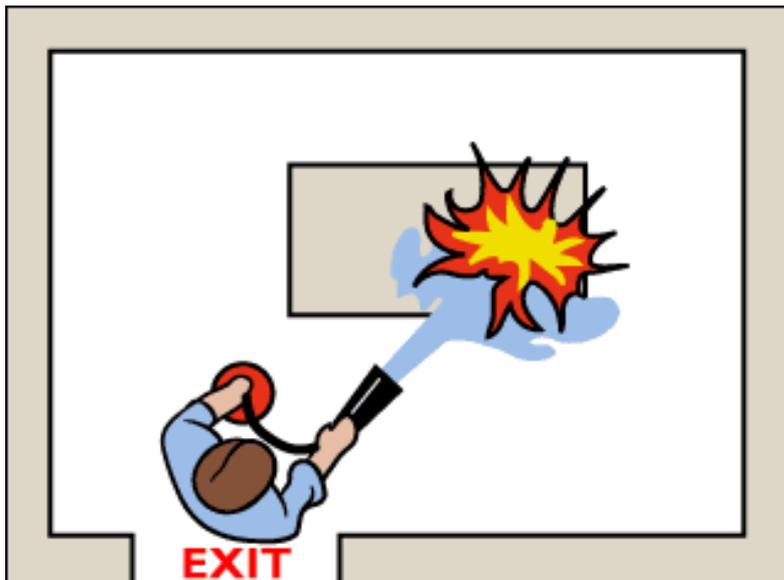
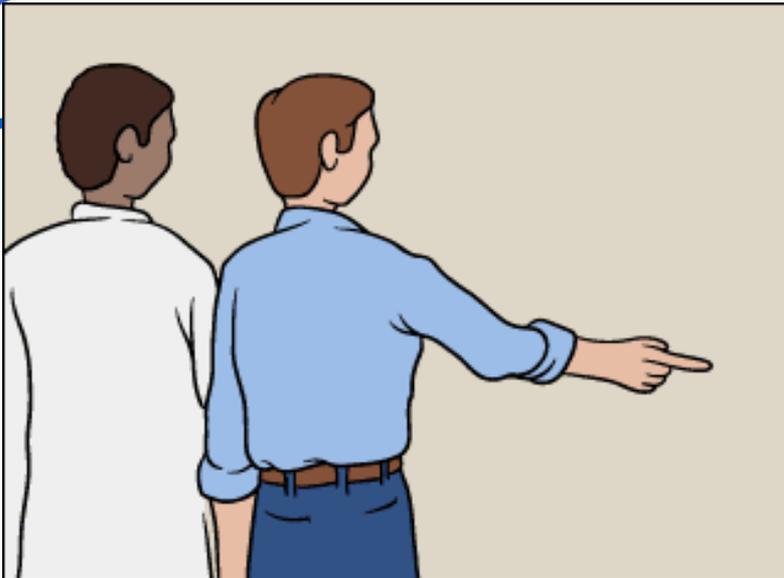
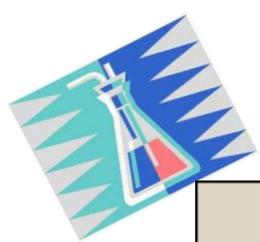
Manual Pull Stations

- Manual Pull Stations are devices located on the wall (usually near an exit)
 - Sends a signal to the building's fire alarm system when activated
 - Places the building into alarm



People are reluctant to sound fire alarms!

Responding To A Fire





Employee Training



Few employees know how to *effectively* use extinguishers!

Need for training:

- Initial training
- Annual refresher

Emergency Response (phone numbers)



Using a Fire Extinguisher



- P** Pull
- A** Aim
- S** Squeeze
- S** Sweep



Video Courtesy of Washington State Emergency Management Division, Public Education Program



Water



- **Water is highly effective on Class A fires, by cooling down the fire and surrounding atmosphere.**
- **Water is usually available.**
- **It can be used to cool down the firefighting team to prevent heat exposure.**



Disadvantages

- Water should **NOT** be used to control a B or C fire.
- Inadequate pressure or too high pressure can cause problems.
- The volume of water can be restricted by the length of water lines and hoses (frictional loss ~ 3500 Pa for every 3 meters of 4 cm diameter hose).
- The fire nozzle can clog due to non-filtered materials in the lines.
- Hydrogen can be produced if water is applied to very-hot fires.



Electrical Fires



Pull the plug out or switch off the power at the fuse box. This may stop the fire immediately.



Smother the fire with a fire blanket, or use a dry powder.



Never use water on it.





WHAT TO DO IF SOMEONE CATCHES ON FIRE

If *you* should catch on fire:

STOP - where you are

DROP - to the floor

ROLL - around on the floor

This smothers the flames, possibly saving your life.

Remember ***STOP, DROP and ROLL***

If a *co-worker* catches on fire:

Smother flames by grabbing a blanket or rug
Wrap them in it.

Could save them from serious burns or death.





WHEN NOT TO FIGHT A FIRE

Don't fight a fire, when:

- It is bigger than a waste paper bin
- One extinguisher is not enough
- The fire is spreading beyond the spot where it started
- Smoke is affecting your breathing
- You can't fight the fire with your back to an escape exit
- The fire can block your only escape
- You don't have adequate fire-fighting equipment



DON'T FIGHT THE FIRE YOURSELF

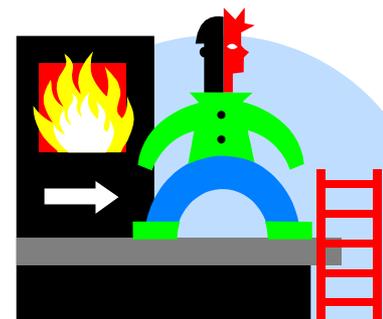
CALL FOR HELP



Remember

When...

- The extinguisher runs out of agent
- Your path of escape is threatened
- The extinguisher proves to be ineffective
- You are no longer be able to safely fight the fire



...LEAVE THE AREA IMMEDIATELY!



Storage Guidelines

- ❖ All storage must be at least 1 m from electrical panels. In some emergency situations it will be necessary to access these panels quickly.



Improper Storage in front of Electrical Panel

- Maintain at least 1 m clearance from heating surfaces, air ducts, heaters, and lighting fixtures.
- Storage of combustible materials in mechanical rooms is prohibited.

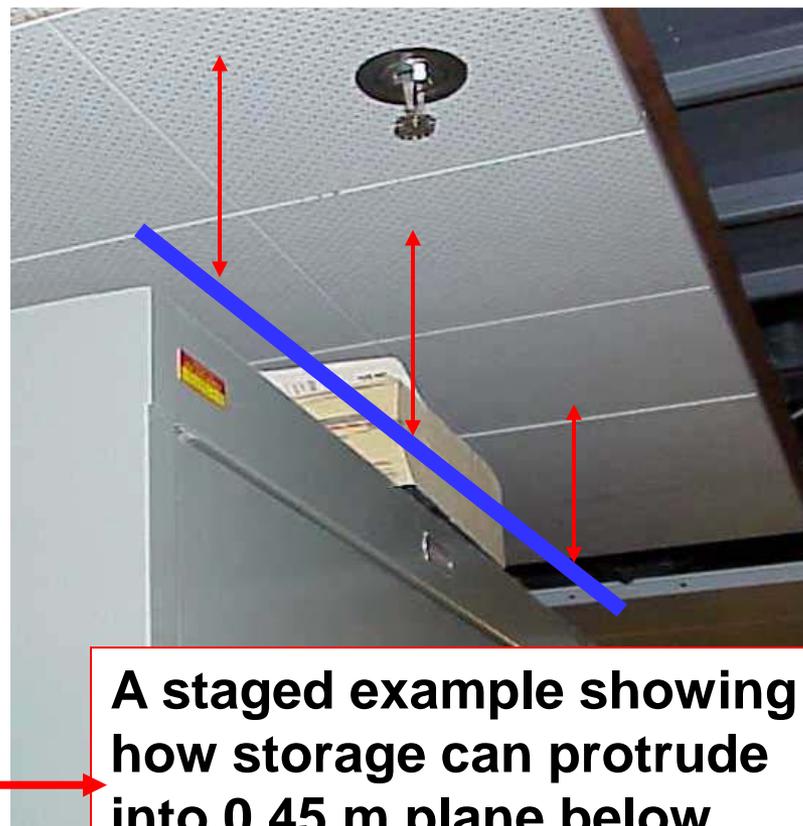


Improper Mechanical Room Storage



Storage Guidelines

- ❖ No storage is allowed in corridors and stairwells. A cluttered hallway could slow down emergency evacuation.
- ❖ Storage must not exceed a plane of 0.45 m below sprinkler heads or smoke detectors. Storage that breaks this plane may prevent sprinkler heads from fully covering room during a fire.



A staged example showing how storage can protrude into 0.45 m plane below sprinkler heads.







Myths about Sprinkler Systems

- **A sprinkler system will cause excessive water damage**
 - Sprinklers use a fraction of water compared with a fire hose.
 - Sprinklers release ~30 – 100 liters per minute compared to a fire hose at ~200 – 500 liters per minute.
 - Sprinklers operate very early in the fire development, and consequently require a smaller quantity of water.
- **When a fire occurs, every sprinkler head goes off**
 - Sprinkler heads are individually activated by fire.
 - > 50% of the fires are controlled by ≤ 4 sprinkler heads, and in many instances fires are controlled with one sprinkler.
- **The pipes burst due to freezing**
 - Sprinklers can be protected with various forms of frost protection, such as installing a dry system or providing heating elements to protect the sprinkler systems.



More Myths about Sprinkler Systems

- **Sprinkler systems might accidentally go off**
 - Sprinklers are very reliable; the chances of going off without mechanical assistance are 1 in 16 million; Fork lift truck drivers soon learn to avoid them.
- **Smoke detectors provide enough protection**
 - Smoke detectors provide early warning and save lives, but do nothing to extinguish a fire or protect those physically unable to escape on their own.
 - Too often, battery operated smoke detectors fail to function because the batteries are dead or have been removed.
- **Sprinklers are designed to protect property, but are not effective for life safety**
 - Sprinklers can reduce property losses up to 85%.
 - Combining sprinklers and early warning systems can reduce overall injuries, loss of life and property damage by 50%.



Fire Safety Planning

- **Construction**
 - Building materials
 - Fire-resistive ratings (minutes to hours)
 - Interior finishes (3 classes: A, B, & C)
- **Containing the fire**
 - Stair enclosures and fire walls
 - Separate building units or zones (control spread)
 - Fire doors
 - Smoke, heat and noxious gases control
 - Exits
- **Egress**
 - Two ways out, exit to safe area

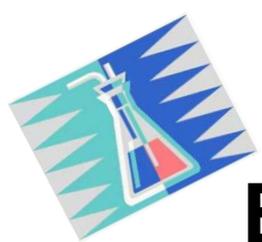




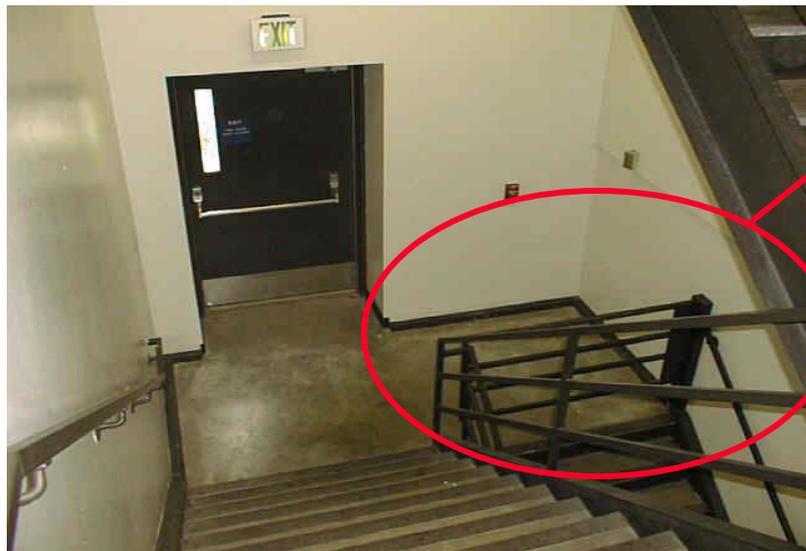
Egress – Exit Route

- Exit routes must be permanent
 - Exits must be separated by fire-resistant materials
 - Openings into an exit must be protected by an approved self-closing fire door that **remains closed or automatically closes in an emergency**
 - Unobstructed
- Well marked





Best Practices: Safety During a Fire...



- Stairs have a bar blocking the steps going down to indicate ground level fire egress
- Keep fire exits and stairwells free from any obstruction to allow for an easy exit during a fire emergency





Emergency Lighting





Proper storage of Flammables is an important part of Fire Safety



Limit quantities stored

Safety cans

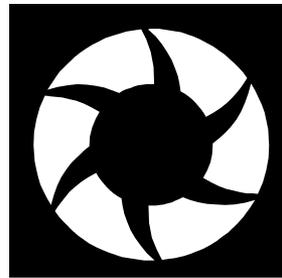
Secondary Containment

Flammable storage cabinets, rooms or buildings



Ventilation

Always provide adequate ventilation to reduce the potential for ignition of flammable vapors.

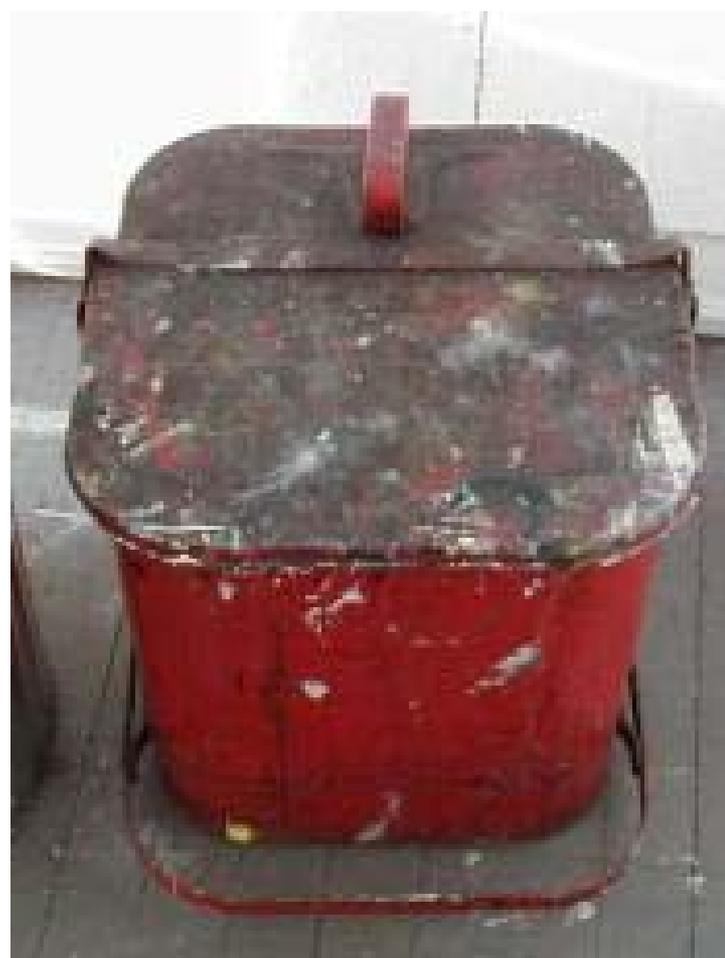


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Storage Containers

- Oily Rags
- Drying process exothermic
- Container (reduces fire risk)
 - Limits oxygen.
 - Encourage air circulation to remove heat.
 - Limits access to ignition source.





Storage Containers

- **Containers should be tightly sealed when not in use.**
- **Approved safety cans are recommended for smaller quantities.**
 - The spring-loaded safety cap prevents spillage.
 - Prevents vapors from escaping
 - Acts as a pressure vent if engulfed in fire
 - Prevents explosions and rocketing of the can





Flame Arrester Screen

- Prevents fire flashback into can contents.
- Double wire - mesh construction
- Large surface area provides rapid dissipation of heat from fire so that vapor temperature inside can remains below ignition point.



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64





Storage Areas

Flammables should be stored in an approved cabinet in a cool, well ventilated area to avoid pressure buildup and vaporization





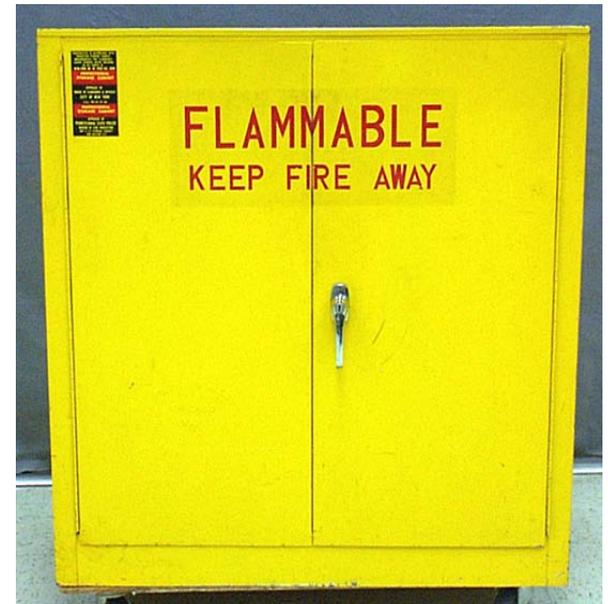
Flammable Storage Cabinets





Storage Cabinets

- Not more than 225 L of Class I and/or Class II liquids, or not more than 450 L of Class III liquids permitted in a cabinet.
- Must be conspicuously labeled, **“Flammable - Keep Fire Away”**
- Doors on metal cabinets must have a three-point lock (top, side, and bottom), and the door sill must be raised at least 5 cm above the bottom of the cabinet.



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Static Electricity

- **Some flammable liquids accumulate a static electric charge, which can release a spark that ignites the liquid**
- **Static electricity is generated by contact and separation of dissimilar materials:**
 - **Fluid flow through a pipe or into a tank**
 - **Agitation or mixing**
 - **Splash filling of containers**

benzene

toluene

gasoline

xylene



Transfer Techniques

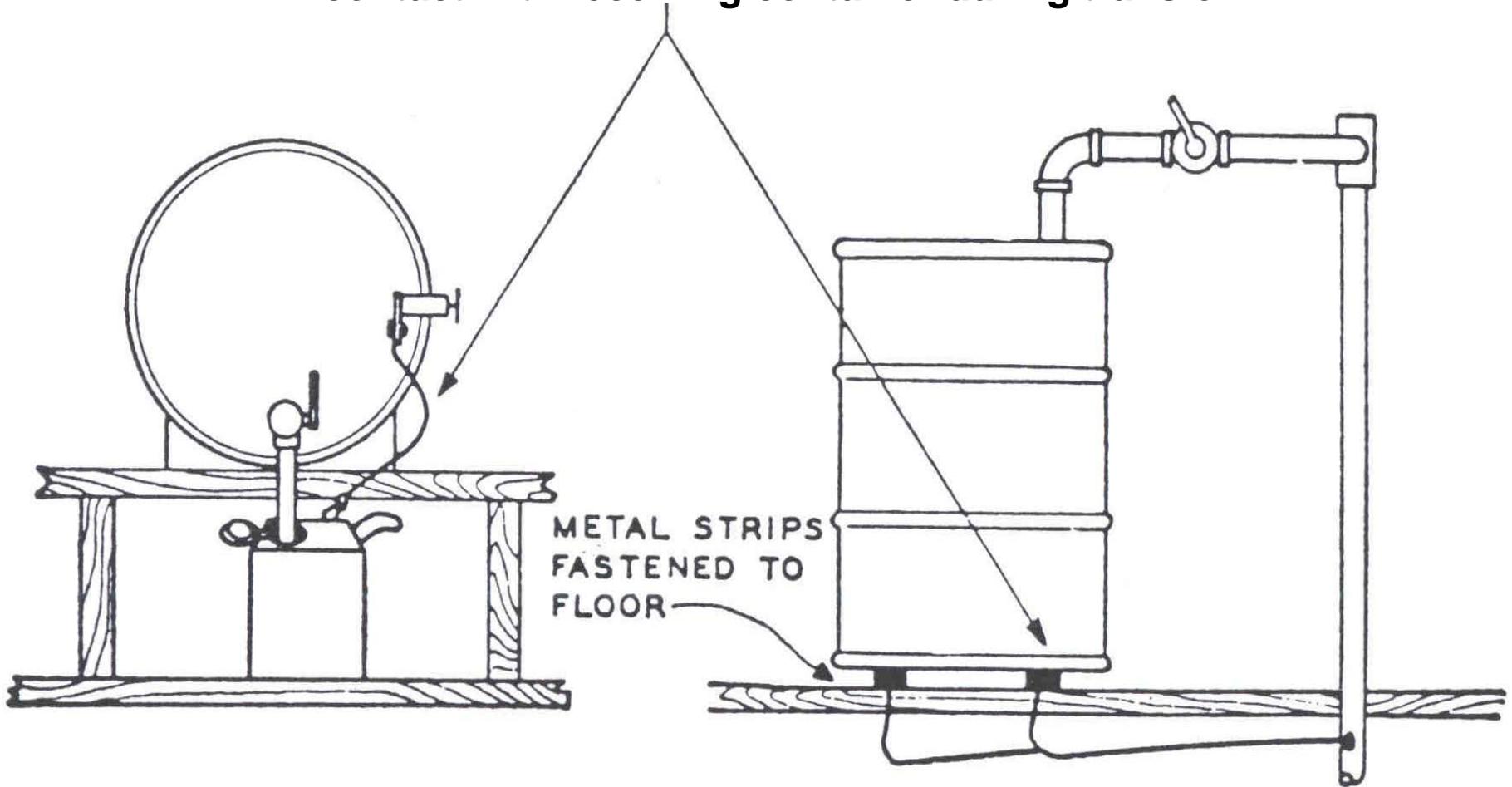
- **Bond containers**
 - Containers are wired together before pouring
 - One container is connected to a good ground point to allow any charge to drain away safely
- **Limit use of plastic containers to small volumes (< 4L)**
 - No easy way to bond plastic containers





Control of Static

Bond wire necessary except where containers are inherently bonded together, or arrangement is such that fill stem is always in metallic contact with receiving container during transfer



Star Mart

\$8.99





Fire Prevention Inspections

- **Minimize size of fires**
 - Control storage of combustible and flammable materials
- **Reduce possibility of a fire**
 - Control ignition sources
- **Ensure fire protection equipment is operational**
 - Fire extinguishers not blocked
- **Ensure exits are maintained**
 - Don't block egress pathways
 - Don't prop open fire doors





Violations





Violations

6-Way Multi-plug



Multi-plug



Any Questions?

