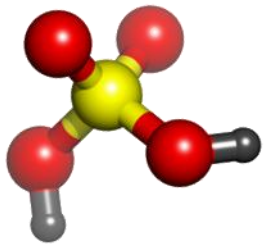

Implementing Inherently Safer Chemistry

SAND No. 2012-7064C

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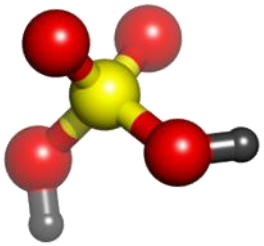
CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Sandia National Laboratories



Part of formal IST definition

- IST is an iterative process that considers such options, including eliminating a hazard, reducing a hazard, substituting a less hazardous material, using less hazardous process conditions, and designing a process to reduce the potential for, or consequences of, human error, equipment failure, or intentional harm.

Pillar One

Minimize

Substitute

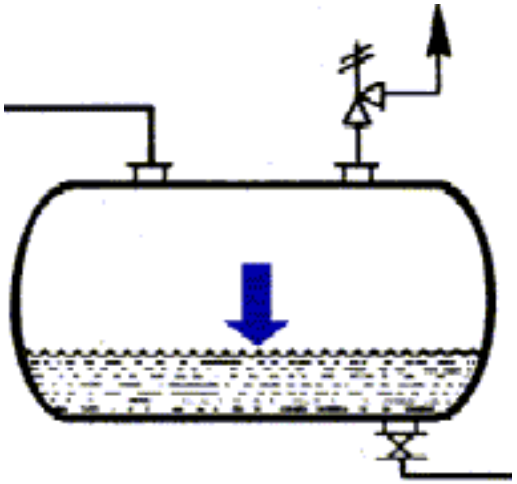
Moderate

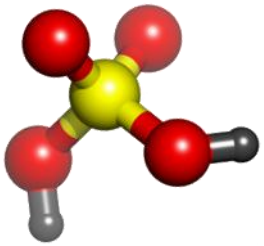
Simplify

Minimize

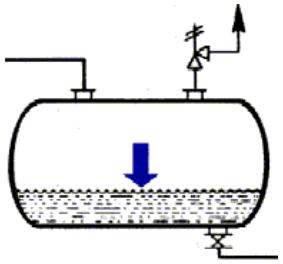
To *minimize* is to reduce the amount of potential energy present (get the system closer to a zero energy state),

this reduces the potential impacts if containment or control of the hazard is lost.



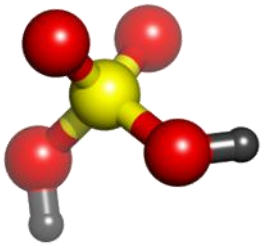


Minimize

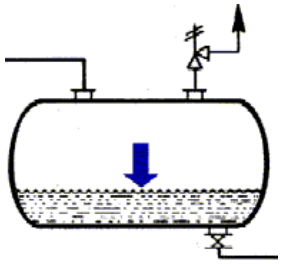


Some strategies for making a process inherently safer by ***minimization***:

- Inventory reduction:
  - less material stored ⇦ *requires administrative control*
  - fewer tanks; just-in-time delivery
  - less vapor volume
  - generate on demand (chlorine, MIC, ammonia, hydrogen...)
  - receive by pipeline instead of by truck or rail
- Process intensification
- Process operation closer to ambient conditions



Minimize



Ultimate case:

- Elimination of the hazard:
  - Eliminating use of a particular hazardous material
  - Operating the system at a zero energy state with respect to a particular hazard
  - Shutting down the process
  - Using a toll manufacturer (risk *transfer*)

Pillar Two

Minimize

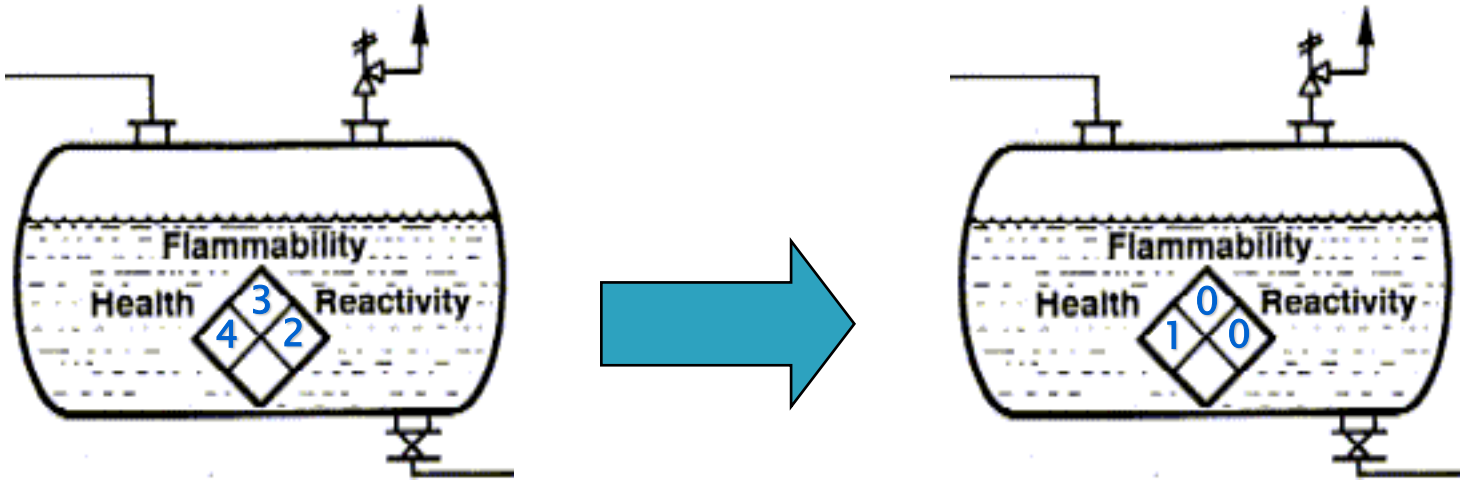
Substitute

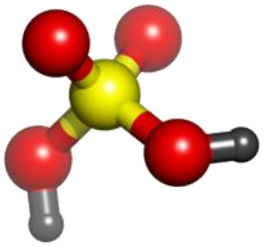
Moderate

Simplify

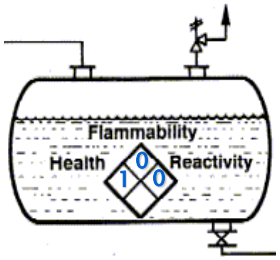
Substitute

To *substitute* is to replace with a less hazardous material or condition.



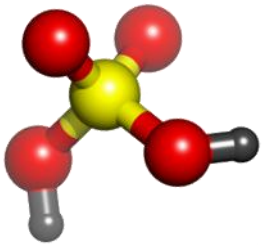


Substitute

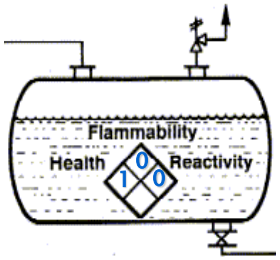


Some strategies for making a process inherently safer by *substitution*:

- Commercially available alternatives
- Alternative raw material or intermediate that can be transported and stored more safely
- Alternative chemistry- Biosynthesis routes
- Oleum alternative: Sulfur burning to generate SO_3 on demand



Substitute

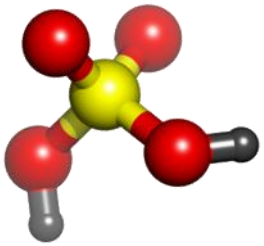


Solvent substitutes:

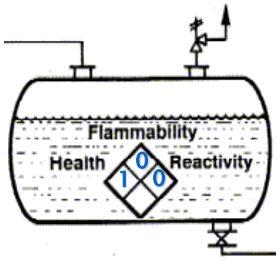
- Water-based paints, adhesives
- Aqueous cleaning systems
- Less volatile solvents; higher flash point
- Dibasic esters for paint stripping

Web resources are available

- "Substitutes in Non-Aerosol Solvent Cleaning," **www.epa.gov/ozone/snap/solvents/solvents.pdf**



Substitute



Some chlorine alternatives: Cl_2

- Sodium hypochlorite
- Calcium hypochlorite
- Hydrogen peroxide
- Chlorine dioxide
- Bromine
- Mixed oxidants
- Other technologies (UV radiation)

Pillar Three

Minimize

Substitute

Moderate

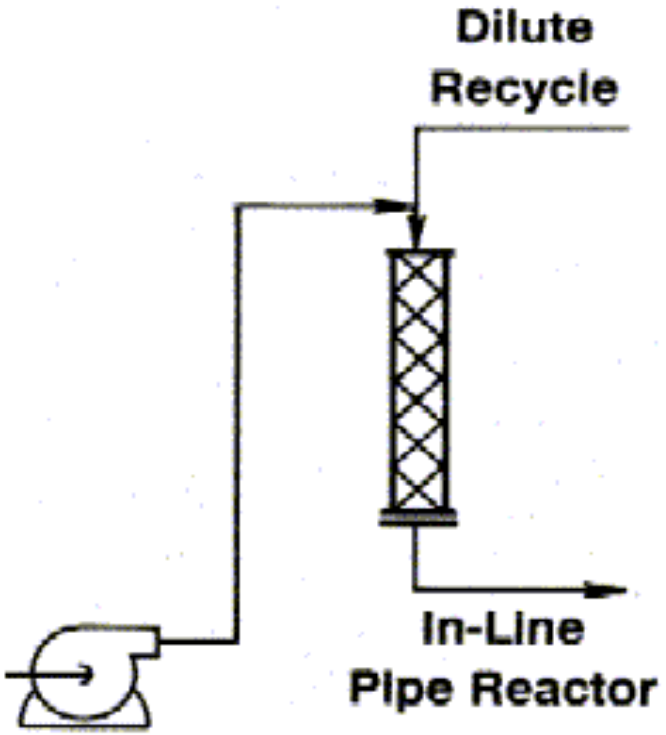
Simplify

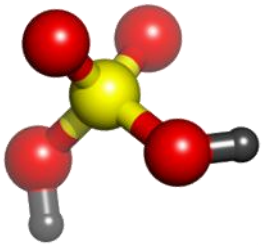
Moderate

To *moderate* (or *attenuate)* is to handle a material under less hazardous process conditions.

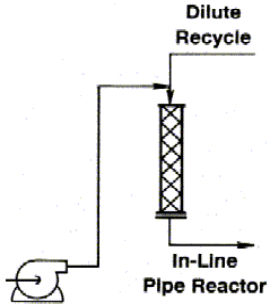
Dilution
Refrigeration
Less severe processing conditions

Note: Available energy may be the same, but potential loss event impacts can be reduced



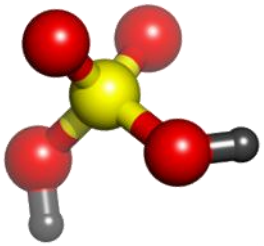


Moderate



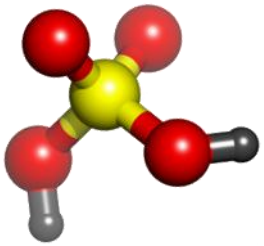
Some strategies for making a process inherently safer by *moderation* :

- **Dilution:**
  - using in aqueous instead of anhydrous form
  - Using in solution such that the solute would boil off before a runaway reaction temperature was achieved
  - Lower concentration of benzoyl peroxide in paste
  - Mixing coal dust with rock dust
- **Refrigeration:**
  - storing anhydrous ammonia as a refrigerated liquid instead of as a liquefied gas



Moderate

- Aqueous ammonia instead of anhydrous
- Aqueous HCl in place of anhydrous HCl
- Sulfuric acid in place of oleum
- Wet benzoyl peroxide in place of dry
- Dynamite instead of nitroglycerine



Less severe processing conditions

- Ammonia manufacture
  - 1930s - pressures up to 600 bar
  - 1950s - typically 300-350 bar
  - 1980s - plants operating at pressures of 100-150 bar were being built
- Result of understanding and improving the process
- Lower pressure plants are cheaper, more efficient, as well as safer

Pillar Four

Minimize

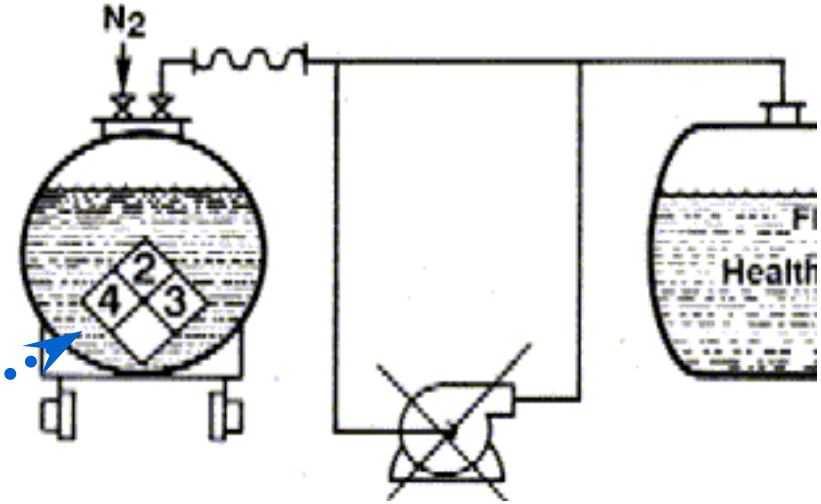
Substitute

Moderate

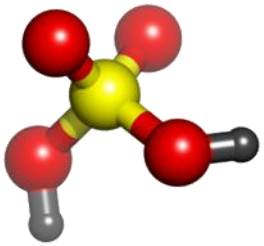
Simplify

Simplify

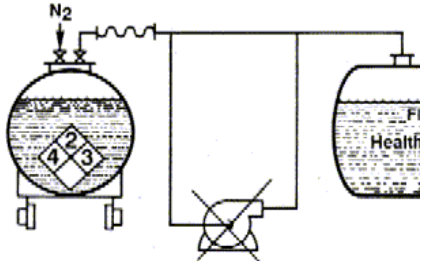
To ***simplify*** is to eliminate unnecessary complexity.



(Not "first-order" inherent safety, since the underlying hazard is still there.)



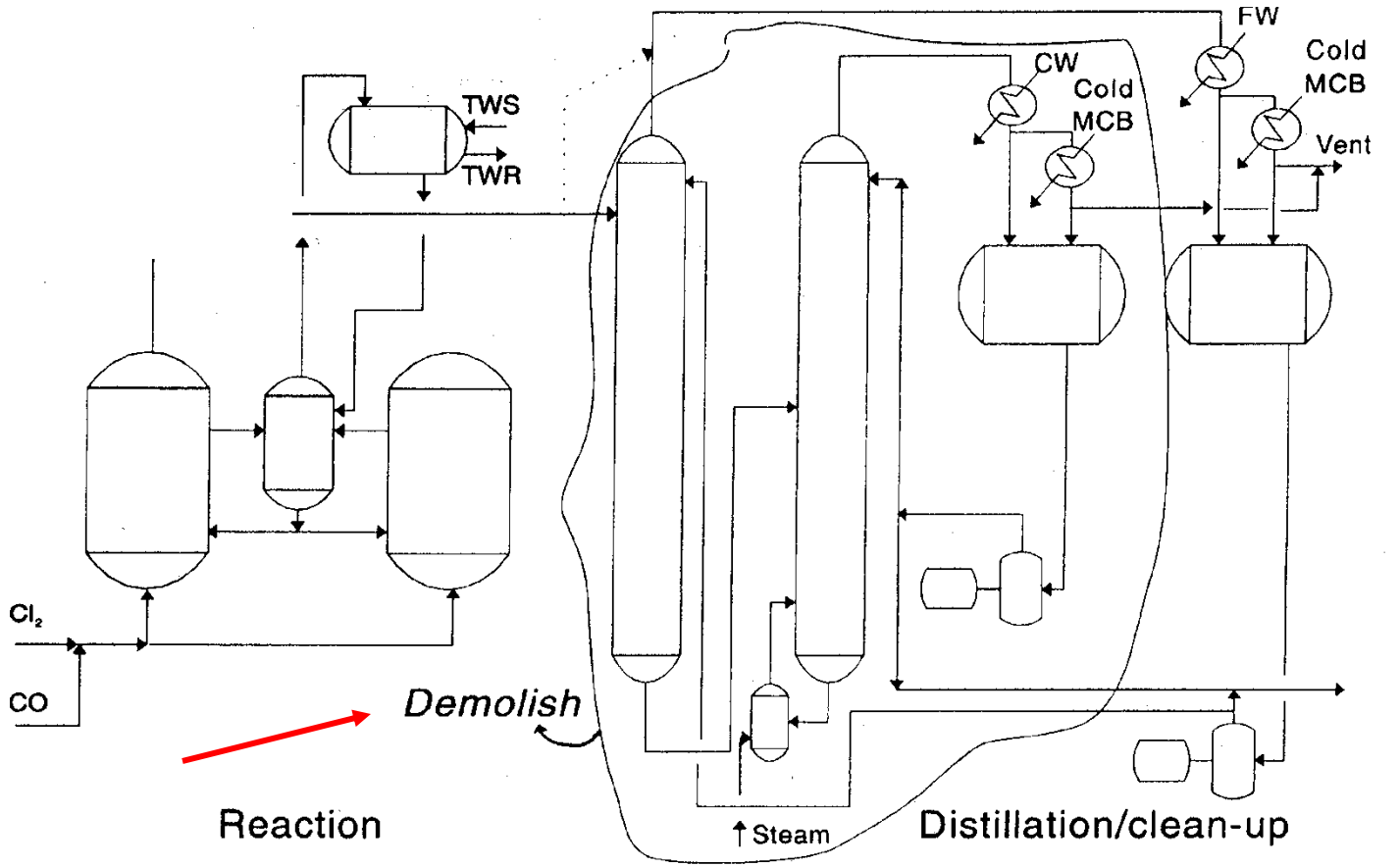
Simplify



Some ***simplification*** strategies:

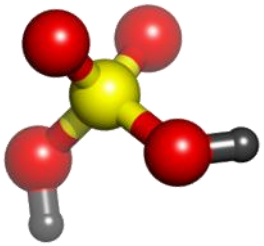
- **Use simpler equipment arrangement:**
  - Gravity flow
  - Natural convection
  - Collocation of shutoff valves
- **Eliminate interconnections** to reduce the likelihood of inadvertent mixing
- **Minimize number of flanges, connections, and other potential leak locations**

Simplify…



Simplification of Dow Phosgene Unit for MDI Production

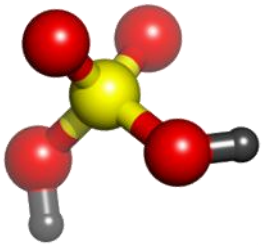
R. Gowland, "Applying Inherently Safer Concepts to a Phosgene Plant Acquisition," *Process Safety Progress 15*(1), 57



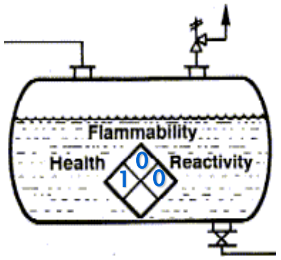
DISCUSSION

- An inherent safety review recommends eliminating intermediate storage of a hazardous raw material:

- What are the inherent safety benefits?
  -
  -
- What are the possible drawbacks?
  -
  -

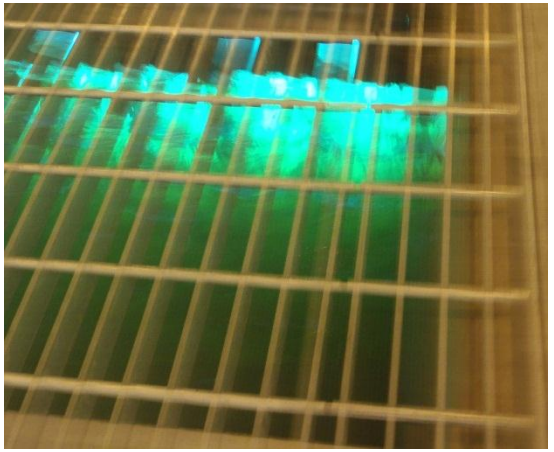


Case Study - Substitute Wastewater Plant



Chlorine alternative : Cl_2

- **Alternative Disinfection (UV radiation)**



Wastewater plant chlorination process- Substitute

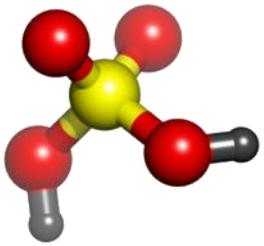
2-25 ton Cl_2

Cl_2 Evaporators

Chlorinator

Shower/Eyewash

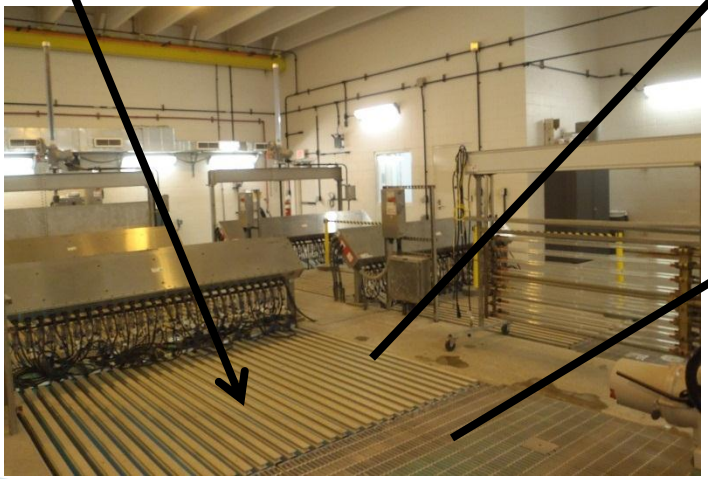
Chlorine contactor

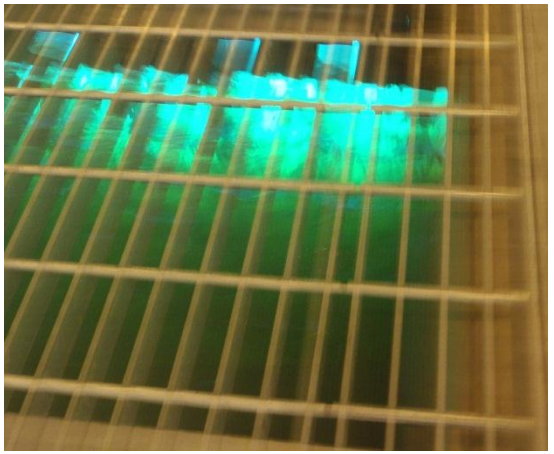


SO_2 used to remove excess chlorine before discharge - Substitute

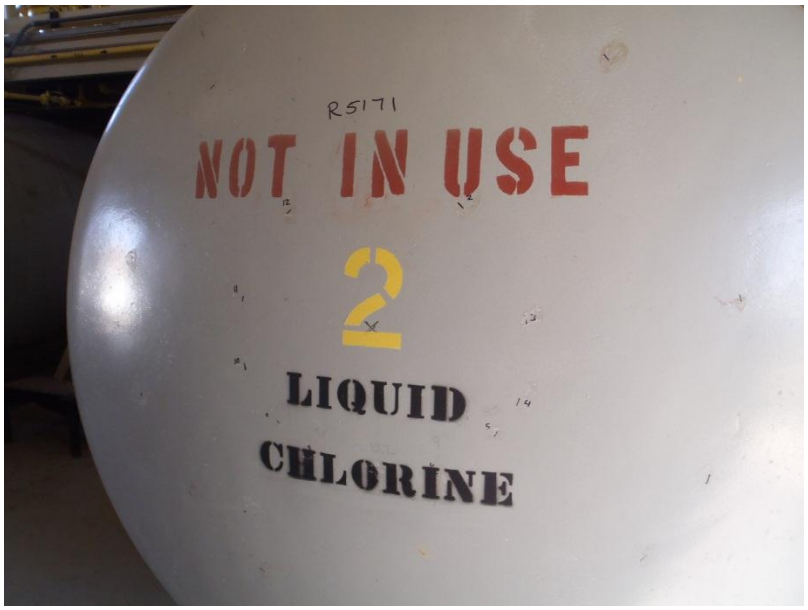
Two 15 ton SO_2

Ultraviolet disinfection replaces both Cl_2 and SO_2- Substitute



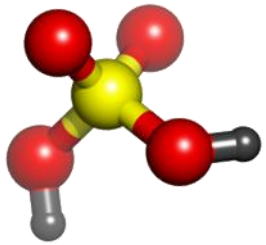


Bulk chemical removed from process - Substitute



2-25 ton Cl_2

2-15 ton SO_2



Inherently Safer Chemistry Risks and Regulations

SAND No. 2012-7064C

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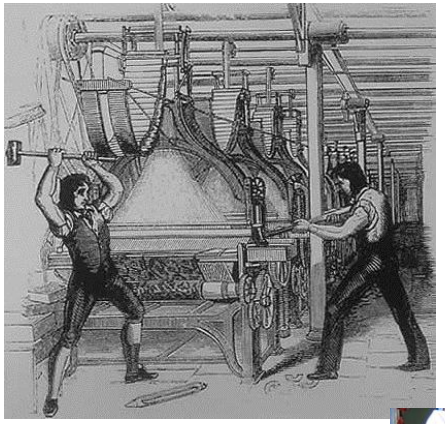
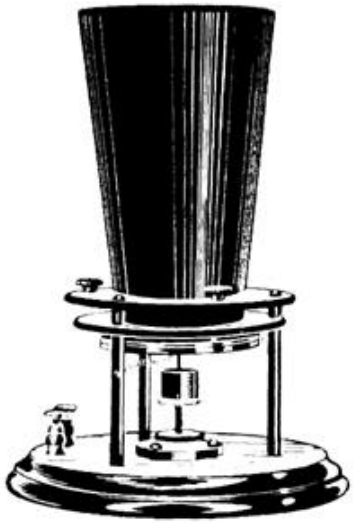
The world and its inventions are always changing



Luddite loom smashing

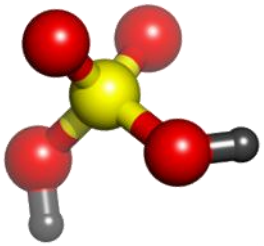
Rapier weaving machine



1876 - Bell's original telephone

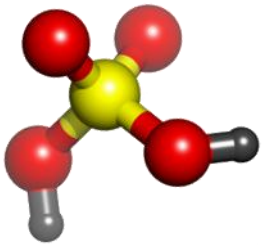
Smart phone

Photo Credits: Wikipedia – public domain



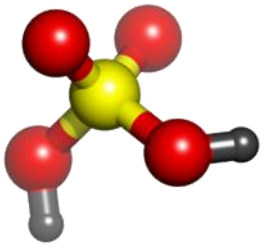
Chemical management is necessary to society

- New chemicals and chemical industries are part of modern life.
- Chemicals can provide an increased quality of life and an increased length of life
- Chemical hazards can also cause health and environmental damage.
- Informed chemical regulation can enhance the safety and security of chemical usage



Regulations are informed by natural science and public opinion

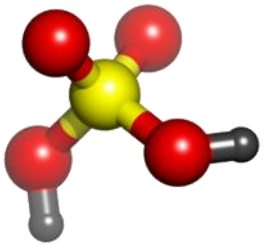
- Change must be managed
- Tradeoffs must be measured



Economic trade and regulations are important factors

Discussion

- Can you give an example of unintended consequences due to trade practices?
- Can you give an example of unintended consequences due to regulations?
- What is risk transfer?



Examples of environmental risk transfer and unintended consequences

Transboundary shipment of waste

Cement production in Europe vs North Africa

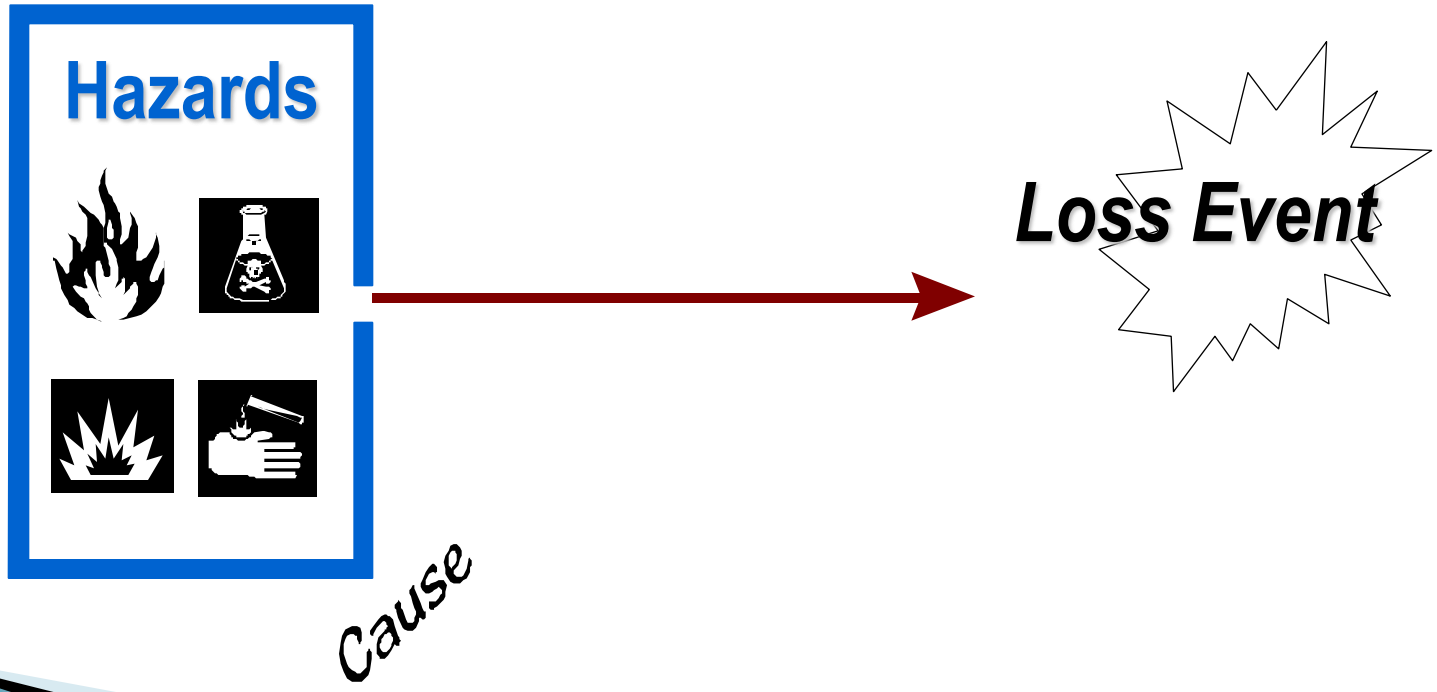
Palm oil production for transboundary biofuel

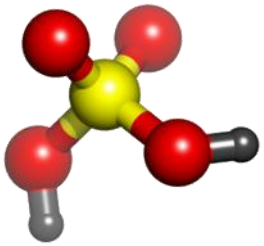
Ethanol fuel production from corn

E-waste export and recycling

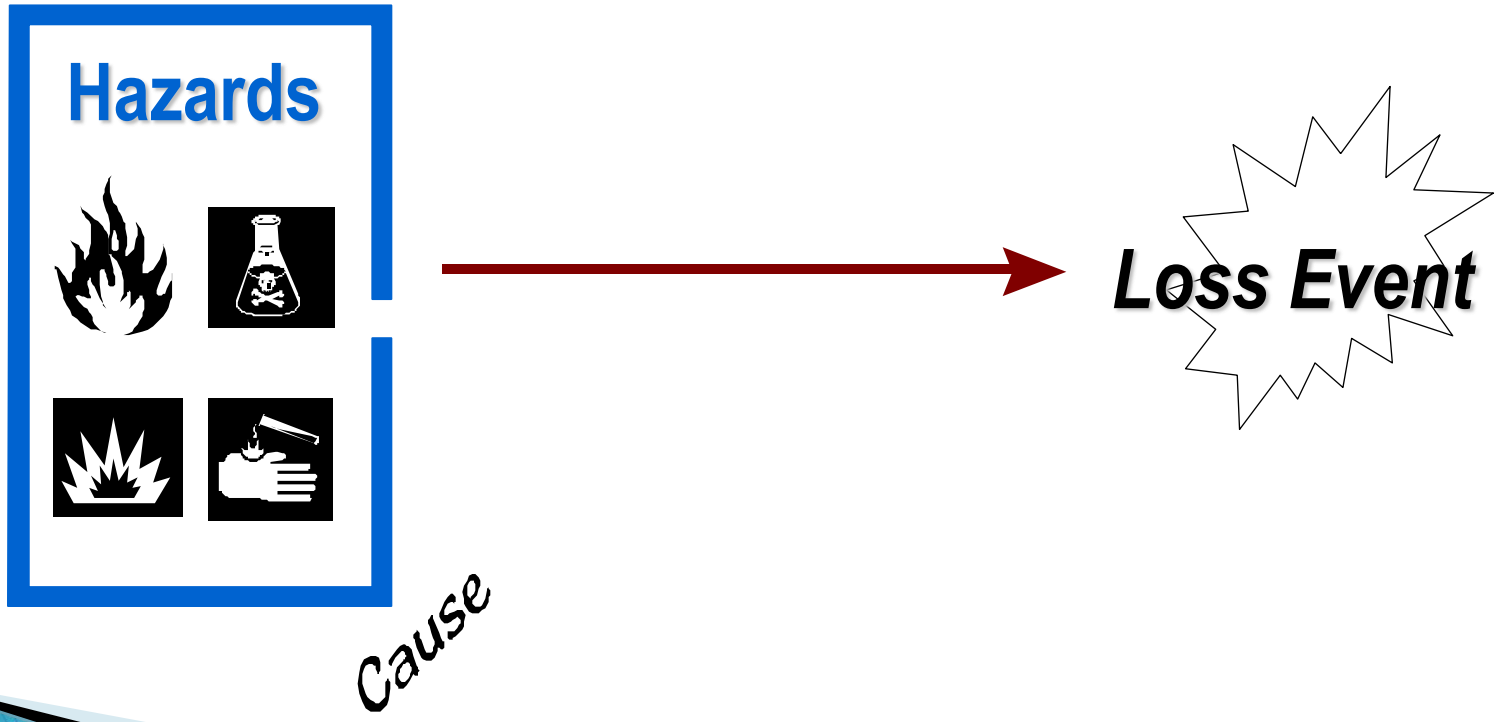
Risk can be transferred to a place where the ultimate risk increases or even decreases

Risk increases with increasing hazard

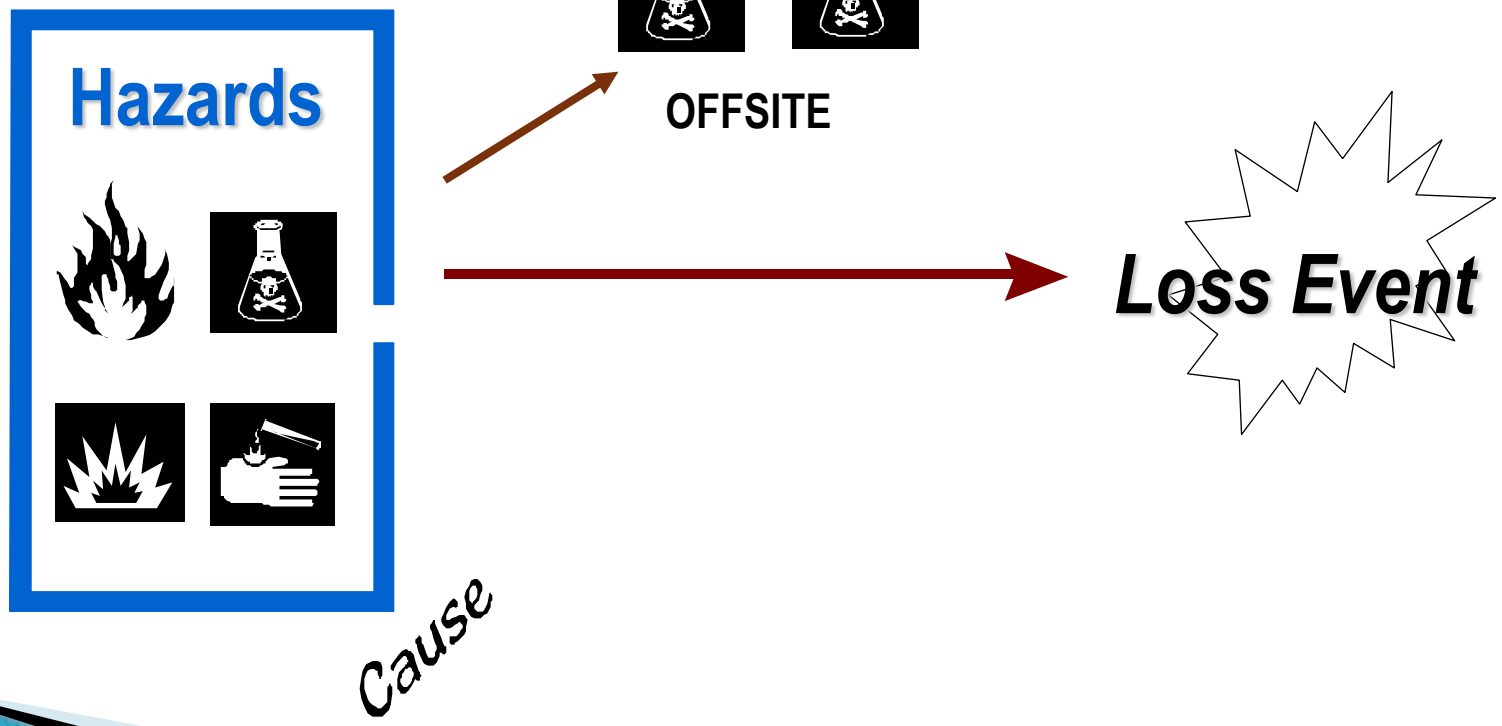




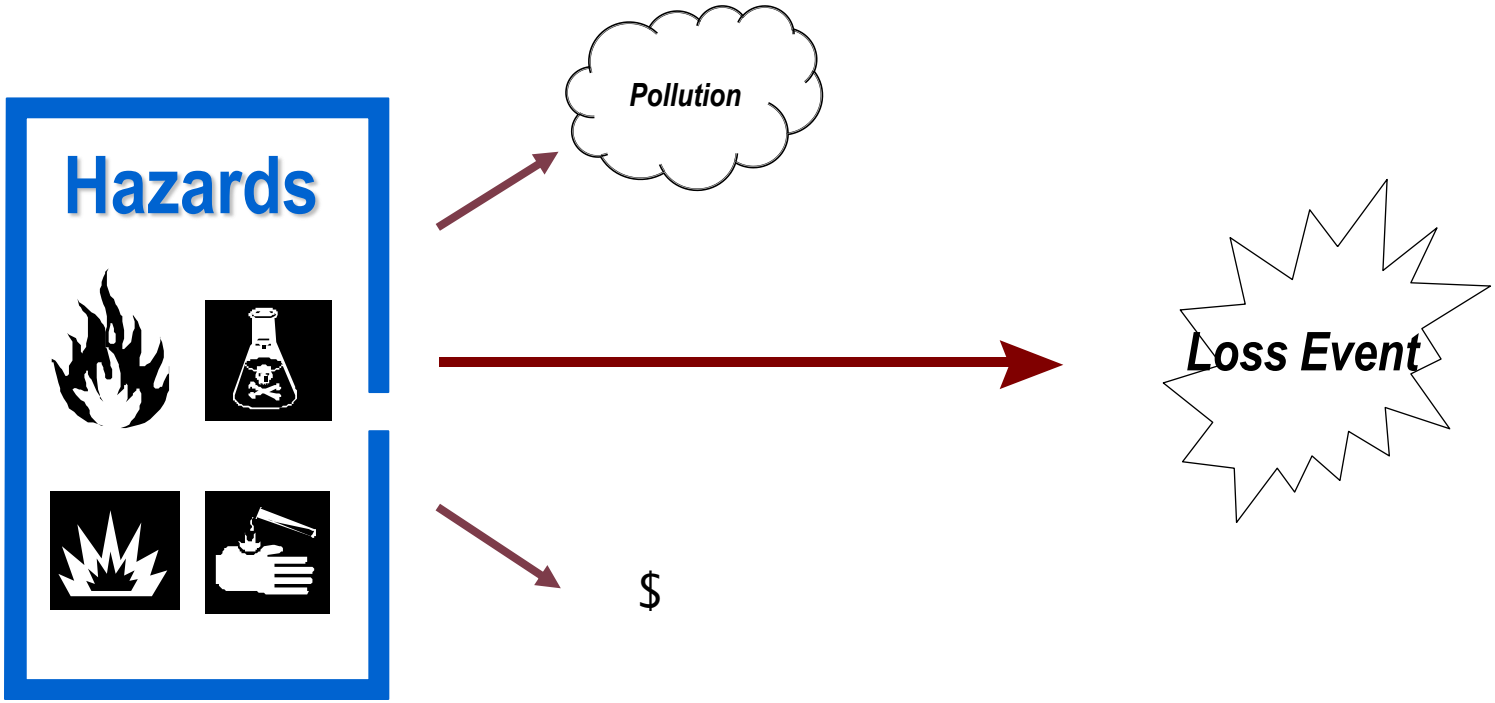
Risk decreases with decreasing hazard

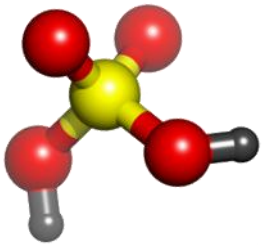


Risk can be transferred from one place to another



Risk can be transferred from one type to another





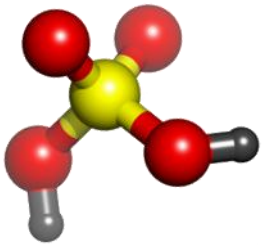
The natural history of a technology

Discovery of benefit–widespread adoption

Re-adoption of technology with appropriate control (or alternative found)

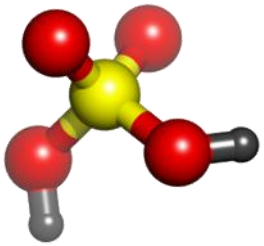
Problem discovered – legislation to limit or eliminate

Elimination may result in risk transfer or lost opportunity

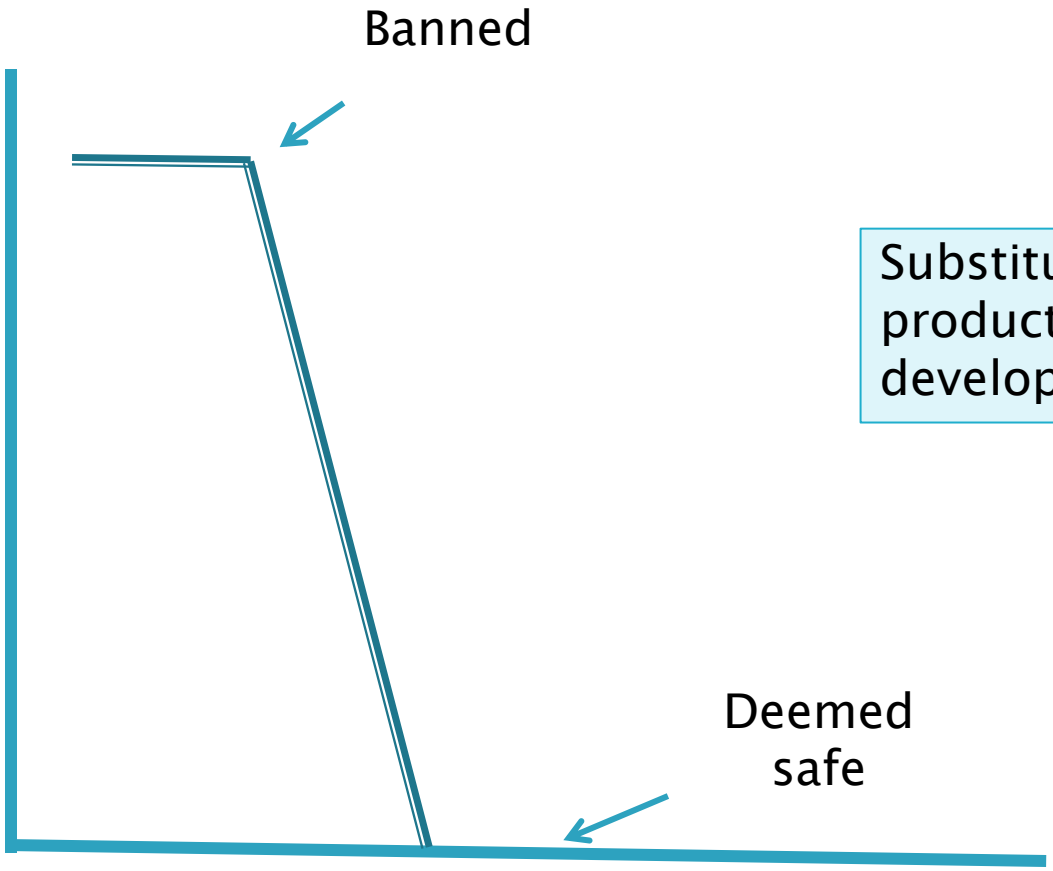


Discussion question

- Can you identify a particular chemical that was accepted by society and then determined to be hazardous ?
  -
  -
  -
- What was eventually done?

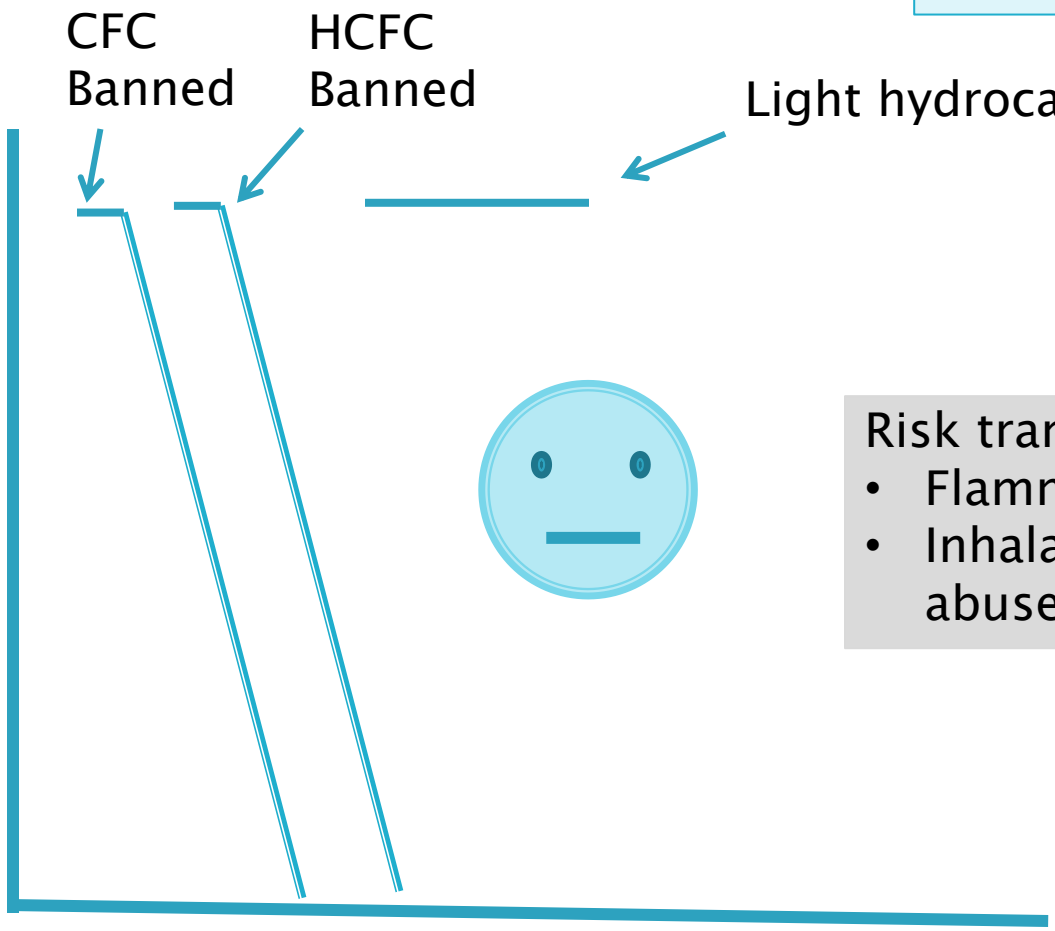


Cyclamates (artificial sweetener)



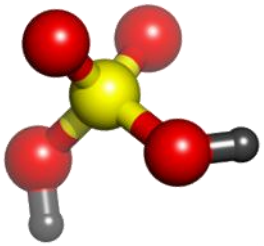
Propellants (spray can)

Substitution

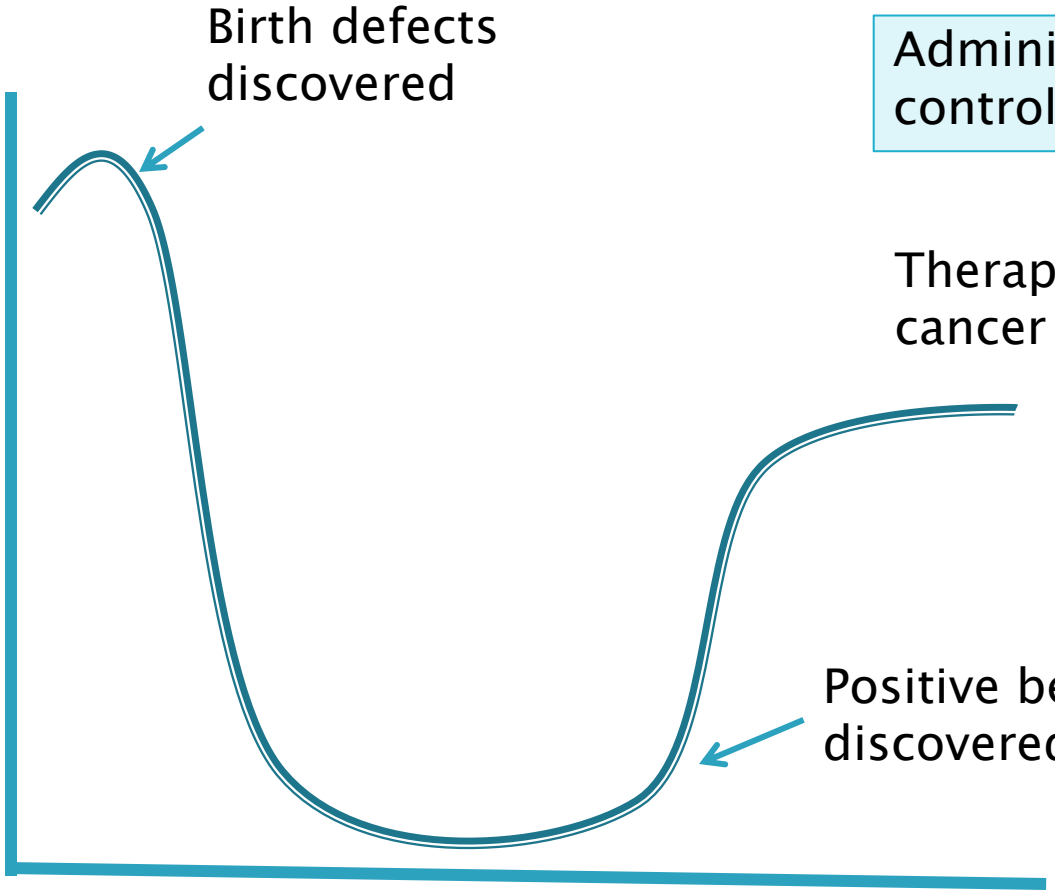


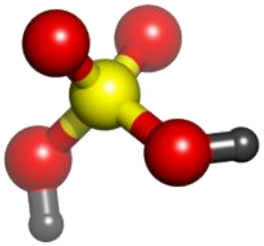
Montreal Protocol

Risk transfer–
- Flammable
- Inhalant abuse

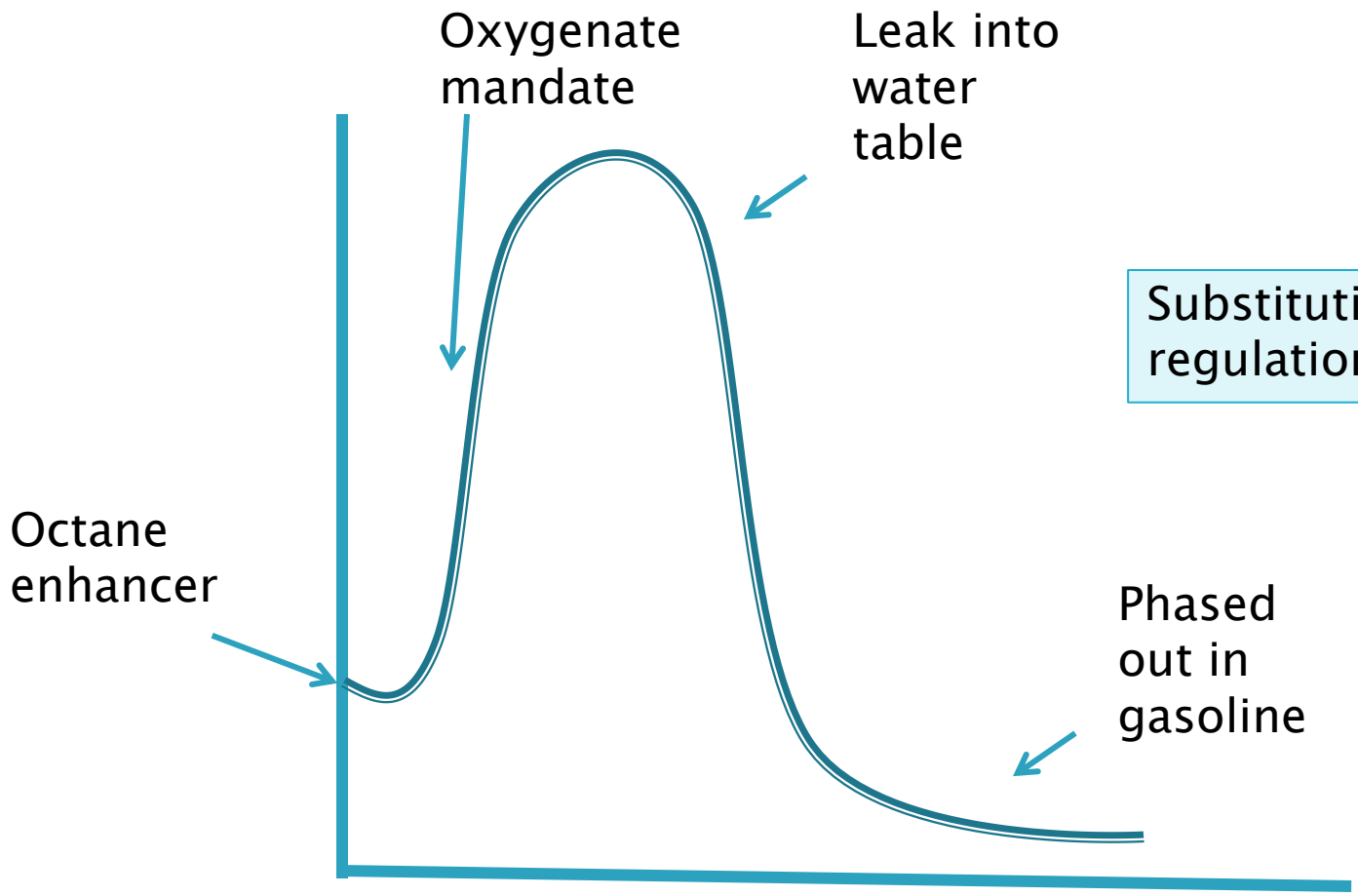


Thalidomide (therapy drug)

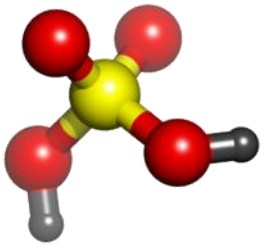




MTBE (gasoline additive)

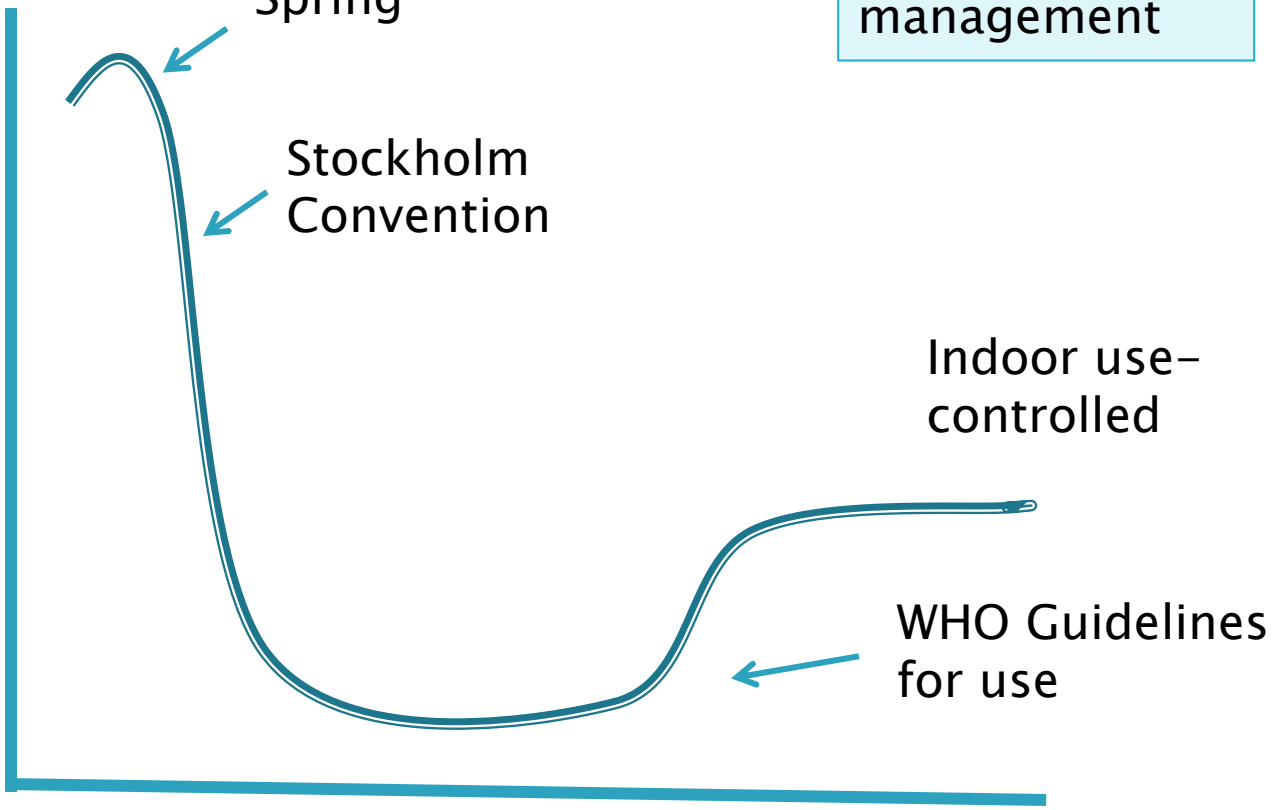


Substitution–regulation change

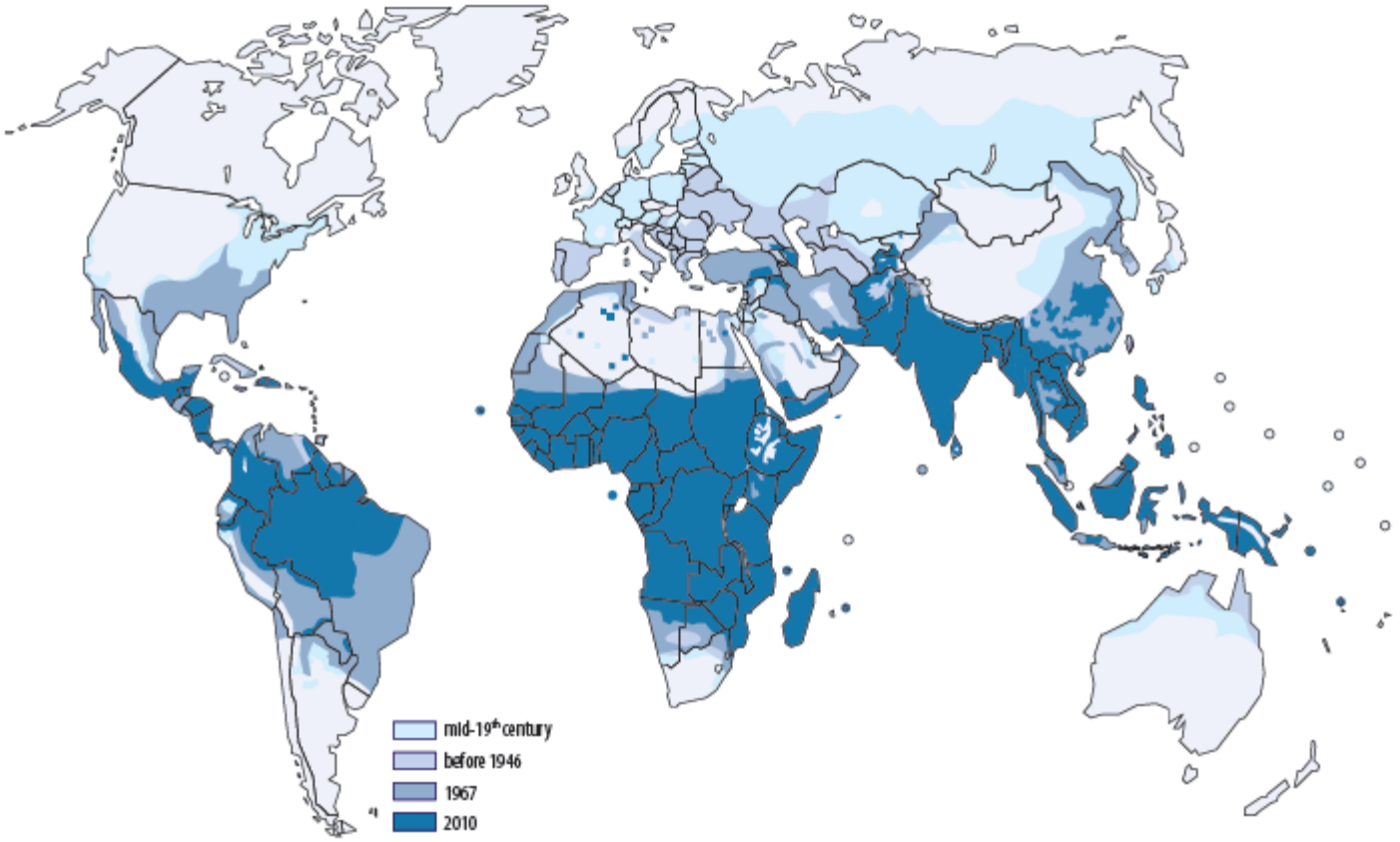


DDT (pesticide)

Minimization–
Integrated pest
management



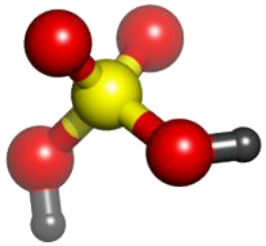
Malaria has retreated in the world

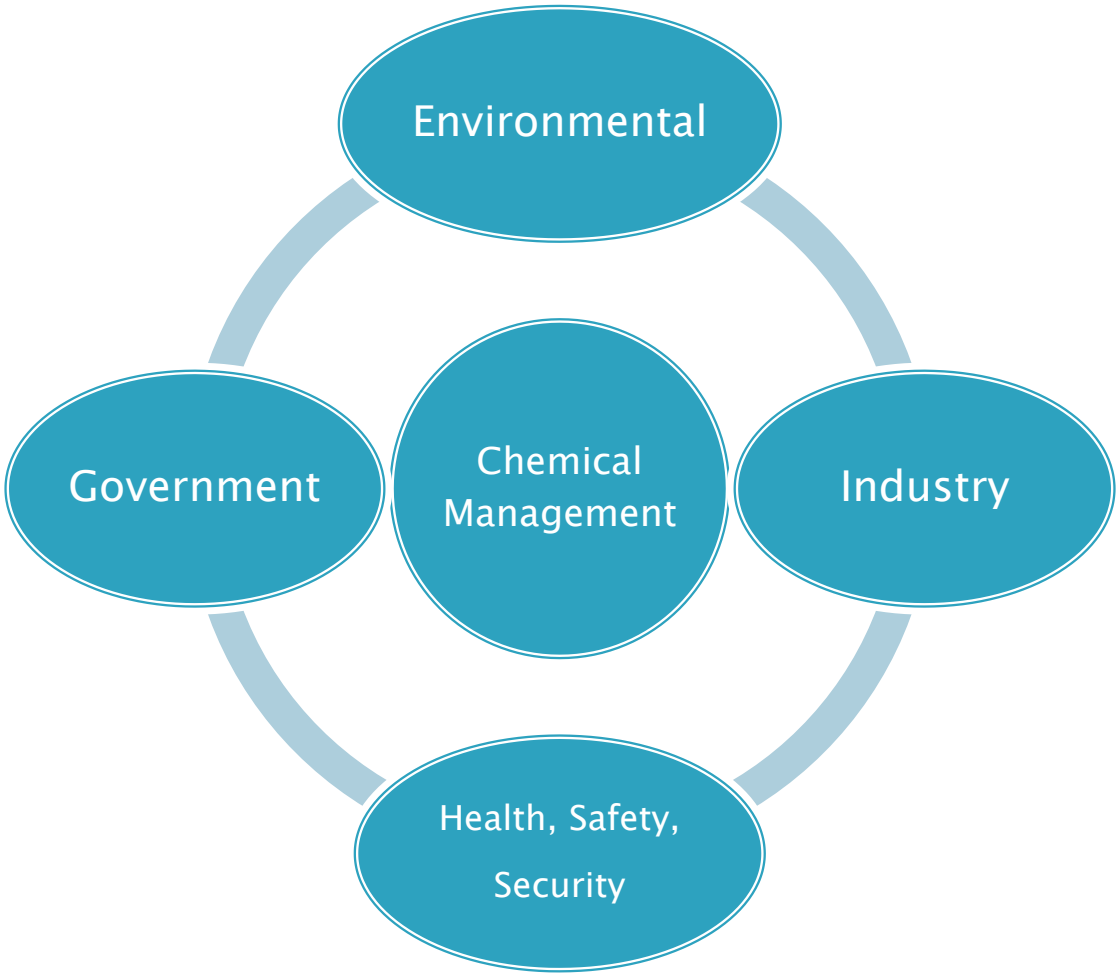


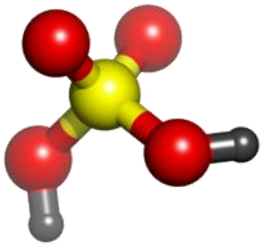
Note: This compositive map does not claim to be complete. It is intended to illustrate where malaria transmission existed over the years.

Source: Mendis K, et al and WHO.

Regulation results in mandatory and voluntary improvement



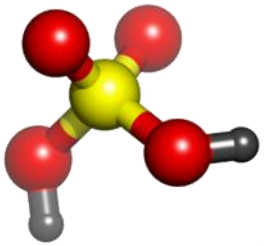




Various stakeholders in the chemical enterprise

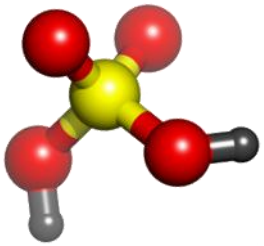
Government	Trade Associations	Professional Societies	NGO – Environmental
EPA, DHS, OSHA	ICCA, ACC, SOCMA	AIChE, ACS, RSC	Various
Legislation, implementation	Advocacy, implementation	Science, engineering	Advocacy
Compulsory – TSCA, SARA	Voluntary– Responsible Care	Voluntary	Voluntary

International Bodies –WHO, UNEP, FAO, OECD, ECHA



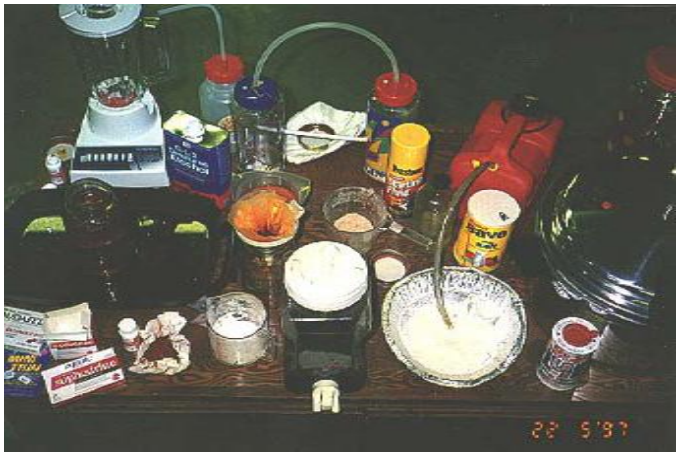
Regulation must also consider security (dual-use chemicals)

Chemical	Legitimate use	Illegitimate use
Ammonium Nitrate	Fertilizer, Explosive	Improvised Explosive
Sodium Cyanide	Mining, Jewelry	Poisoning, Coral reef fishing
Pseudoephedrine	Medicine	Drug making
Chlorine	Chemicals, disinfection	Poisoning



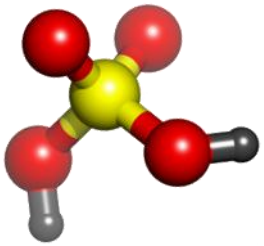
Dual-use chemical example: Pseudoephedrine

- Common ingredient in cold medicines
- Precursor to crystal methamphetamine
- Recipes on web



- Clandestine meth labs in US, 2002
  - -Caused 194 fires, 117 explosions, and 22 deaths
  - -Cost $23.8 million for cleanup

US DEA, http://www.deadiversion.usdoj.gov/pubs/brochures/pseudo/pseudo_trifold.htm, viewed Dec 2007

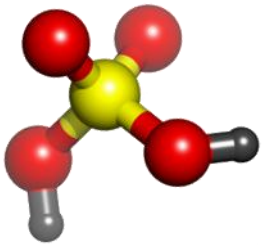


Pseudoephedrine – Regulation / Voluntary

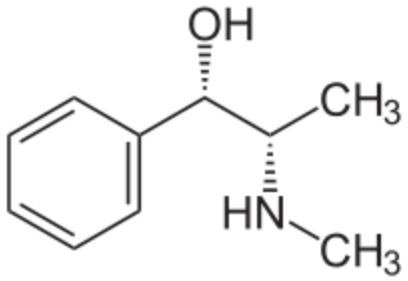
The two key precursor chemicals used in methamphetamine production, ephedrine and pseudoephedrine are not under international controls. However, they are included in a special monitoring list of chemicals not included in the 1988 UN Convention, but for which substantial evidence exists of their use in illicit drug manufacture. – 2012 International Narcotics Control Strategy Report

FDA continues to consider NDA-approved and over the counter monograph products containing pseudoephedrine as safe and effective for their intended uses. Measures restricting the sale of pseudoephedrine to achieve important public safety goals that would result from reduced product misuse should be balanced with the need to maintain access for legitimate use. –U.S. Senate Testimony– Dr. Charles Ganley – 2010

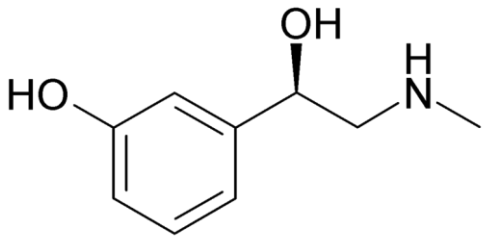
http://www.state.gov/j/inl/rls/nrcrpt/2012/



Pseudoephedrine – IST-Substitution



Pseudoephedrine



Phenylephedrine

The substitute is less effective because it is broken down in the stomach

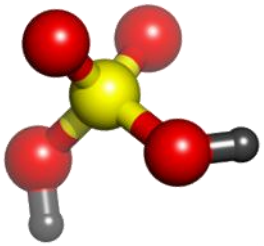
Dual-use chemical example: Cyanide

Therence Koh/AFP/Getty Images

Wikipedia

- Widely used in mining and metal plating industries, but is also a well known poison.
- Product tampering–Tylenol capsules
- Used for illegal reef fishing
- Popular with criminals and terrorists because it is relatively easy to obtain
- HCN is CW agent AC

Cyanide fishing: squeeze bottle – ian.umces.edu/imagelibrary/



Cyanide Code - Voluntary

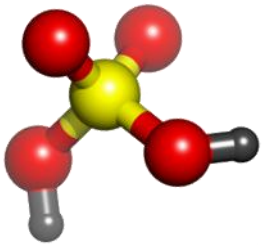
The "**International Cyanide Management Code For The Manufacture, Transport and Use of Cyanide In The Production of Gold**" is a voluntary industry program for the gold mining industry to promote:

- Responsible management of cyanide used in gold mining
- Enhance the protection of human health, and
- Reduce the potential for environmental impacts.

Signatories to the Cyanide Code must be audited by an independent third party to demonstrate their compliance with the Cyanide Code.

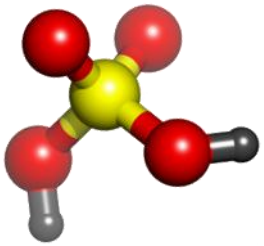
Audit results are made public.

http://www.cyanidecode.org/



Cyanide Mining- Regulation

European Directive 2006/21/EC on the management of waste from extractive industries. Article 13(6) requires "the concentration of weak acid dissociable cyanide in the pond is reduced to the lowest possible level using best available techniques", and at most all mines started after 1 May 2008 may not discharge waste containing over 10ppm weak acid dissociable (WAD) cyanide, mines built or permitted before that date are allowed no more than 50ppm initially, dropping to 25ppm in 2013 and 10ppm by 2018.



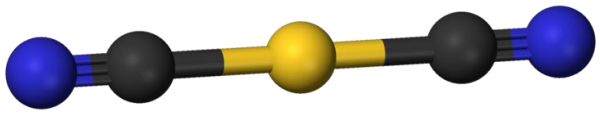
Cyanide IST Substitution-Minimization

Gold Mining

- Thiosulfate
- Proprietary Extraction

Metal Plating

- Reduce concentration
- ZnCN with ZnCl
- CuCN with $CuSO_4$



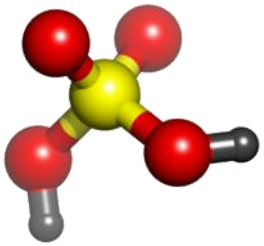
$[Au(CN)_2]^-$

There are no easy substitutes for cyanide in mining gold or in some metal finishing applications.

Dual-use chemical example: Fertilizer bomb

Photo: US DOD

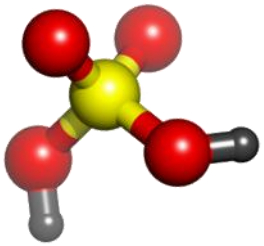
- Ammonium nitrate fertilizer and fuel oil (diesel, kerosene)
- Used to bomb building in Oklahoma City, OK, USA–April 1995
  - with nitromethane and commercial explosives
  - 168 dead, including children
- Favored by IRA, FARC, ETA, etc.



Ammonium nitrate : regulation

Proposed Rule: Ammonium Nitrate Security Program Published August 3, 2011. Under the proposed rule, the Department of Homeland Security would regulate the sale and transfer of ammonium nitrate pursuant to section 563 of the Fiscal Year 2008 Department of Homeland Security Appropriations Act with the purpose of preventing the use of ammonium nitrate in an act of terrorism.

https://www.dhs.gov/files/laws/ammonium-nitrate-regulations.shtm



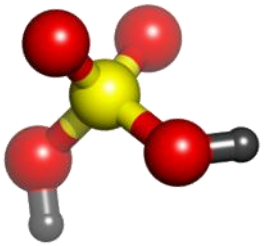
Ammonium nitrate : ISD Substitution

Fertilizer substitute

- Polymer coated urea
- Sulf-N® 26 -Ammonium nitrate/sulfate

Substitutes for ammonium nitrate are not possible for explosives applications

Slow release polymer coated urea



Some resources

- E-Chemportal – Global Information on Chemical Substances

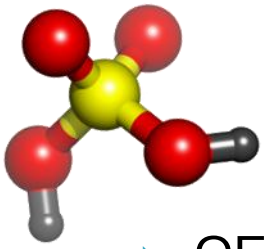
http://www.echemportal.org/echemportal/index?pageID=0&request_locale=en

- National Environmental Methods Index

https://www.nemi.gov/apex/f?p=237:1:12144787178799 85

- Organisation for the Prohibition of Chemical Weapons

http://www.opcw.org/



Some resources

- OECD- Environment, Health and Safety Publications

http://www.oecd.org/env/chemicalsafetyandbiosafety/environmenthealthandsafetypublications.htm

- UNEP Flexible Framework for Addressing Chemical Accident Prevention and Preparedness – A Guidance Document

http://www.unep.fr/scp/sp/saferprod/pdf/UN_Flexible_Framework_WEB_FINAL.pdf

- U.S. Chemical Safety Board

http://www.csb.gov/

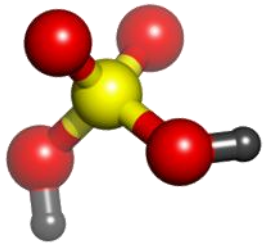
- Center for Chemical Process Safety

http://www.aiche.org/ccps/

Discussion topic

How can we measure tradeoffs when designing chemical legislation?

What practical legislative steps can be taken for chemical security?

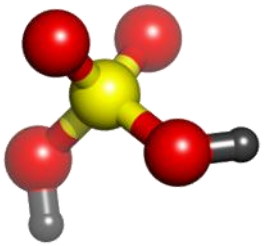


Safe Work Practices

SAND No. 2011-0785C

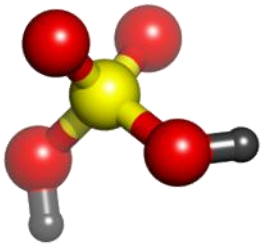
CSP
CHEMICAL SECURITY
ENGAGEMENT PROGRAM

Sandia
National
Laboratories



Overview

- Process Safety Management Standard (US)
- Safe Work Practices
- Job Hazard Analysis
- Lockout-tagout (LOTO)
- Confined Space
- Line Breaking
- Hot Work



Process Safety Management Standard (US)

Requires Safe Work Practices

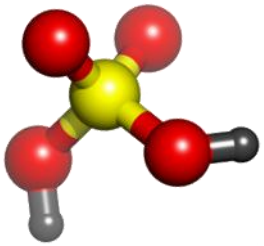
Hazards

- Material hazards
- Energy hazards
- Chemical interaction hazards

Controls

- Job hazard analysis
- Operating procedures (OPs)
  - Safe Work Practices
    - Lockout-Tagout
    - Confined space
    - Line breaking
- Hot work permit

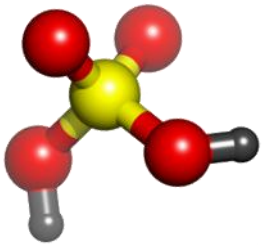
CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM



Job Hazard Analysis

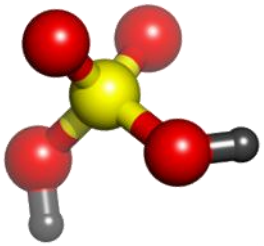
Job Hazard Analysis focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment.

*Not the same as process hazard analysis.



Essential Steps in Job Hazard Analysis

- Involve your employees!
- List, rank, and set priorities for hazardous jobs
- Review your accident history/lessons learned
- Conduct a preliminary job review
- Outline the steps or tasks

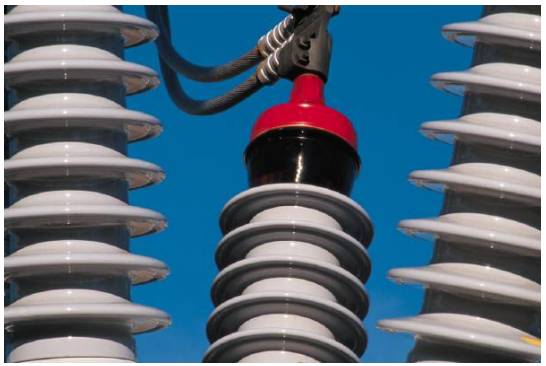


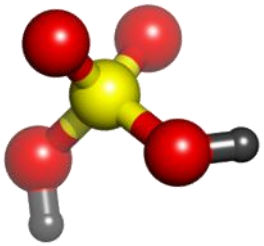
What Jobs Need a Hazard Analysis?

- Jobs with the highest injury or illness rates
- Jobs with the potential to cause severe or disabling injuries or illness
- Jobs in which one simple human error could lead to a severe accident or injury;
- Jobs that are new to your operation or have undergone changes in processes and procedures; and
- Jobs complex enough to require written instructions

The Job Hazard Analysis Asks Several Questions

- What can go wrong?
- What are the consequences?
- How could it happen?
- What are other contributing factors?
- What is the likelihood of an incident?





Job Hazard Analysis Form

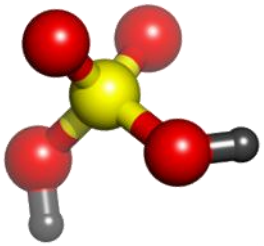
Job Hazard Analysis		
Date: _____	JHA Number: _____	Steps: 1 through 5
Location of Task:	_____	
Task Description:	_____	
Step 1 Description	Hazards	Preventive Measure(s)
Step 2 Description	Hazards	Preventive Measure(s)
Step 3 Description	Hazards	Preventive Measure(s)
Step 4 Description	Hazards	Preventive Measure(s)
Step 5 Description	Hazards	Preventive Measure(s)
Safe Job Procedures		

Exercise

Task Description: Worker reaches into metal box to the right of a grinding wheel machine, grasps a 15-pound casting and carries it to grinding wheel. Worker grinds 20 to 30 castings per hour.

- What are the hazards? Consider the equipment hazards, the material hazards, and ergonomic stressors.
- What controls can mitigate the hazards?

Credit: US Occupational Safety and Health Administration



Safe Work Practices

Safe Work Practices provide for the control of hazards during work activities

Safe Work Practices required by the US Process Safety Management Standard:

- Lockout –Tagout
- Confined space entry
- Line breaking
- Control over entry by maintenance contractors

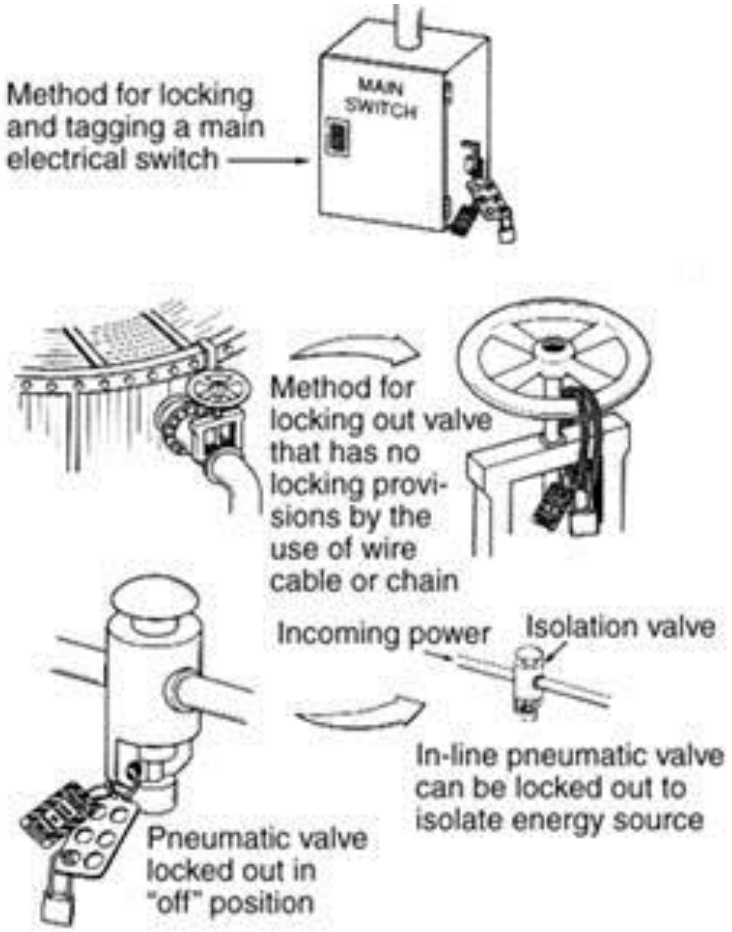
They are generally written methods outlining how to perform a task with minimum risk to people, equipment, materials, environment, and processes.

They are issued

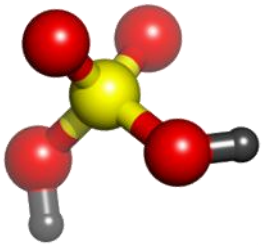
- to specific persons
- for a specific time period
- for a specific job

LOTO Addresses *All* Forms of Hazardous Energy

- Electrical energy *from generated elec*trical power, static sources, or electrical storage devices (batteries or capacitors)
- Kinetic (mechanical) energy – *in the* moving parts of mechanical systems
- Potential energy –*stored in pressure* vessels, gas tanks, hydraulic or pneumatic systems, and springs
- Thermal energy *(high or low temperature)* resulting from mechanical work, radiation, chemical reactivity, or electrical resistance



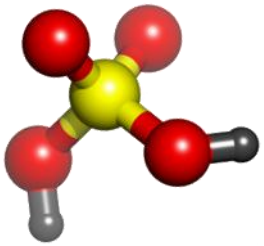
Credit: Lawrence Berkeley Laboratory



LOTO Definition

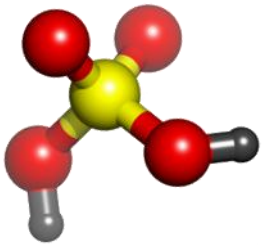
Lockout-Tagout (LOTO) or lock and tag is a safety procedure which is used in industry and research settings to ensure that dangerous machines are properly shut off and not started up again prior to the completion of maintenance or servicing work.

OSHA
1910.147



LOTO U.S. Department of Labor Statistics

- Approximately 3 million workers are at risk of injury if LOTO is not properly implemented.
- LOTO prevents an estimated 120 fatalities and 50,000 injuries each year.
- Workers injured on the job from exposure to hazardous energy lose an average of 24 workdays for recuperation.
- United Auto Workers (UAW) reported that 20% of their fatalities between 1973 and 1995 were attributed to inadequate hazardous energy control procedures.

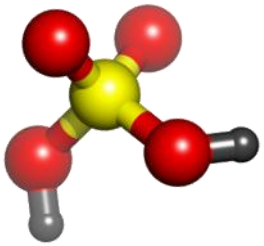


LOTO Incidents

- A worker attempted to prevent an elevator from moving by jamming the doors open with a wooden plank while the elevator was on the second floor and then turning off the outside panel switch on the main floor. Worker was killed when the elevator returned to the main floor.

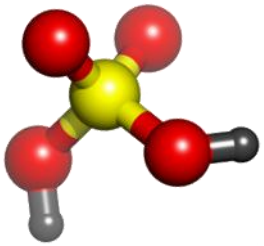
- Worker turned off the power to a packaging machine and attempted to remove the jam. Residual hydraulic pressure activated the holding device and the worker's arm was caught in the packaging machine.

- A mechanic was repairing an electrically operated caustic pump and had turned off the pump toggle switch. A co-worker dragged a cable across the toggle switch and caustic liquid was sprayed on the mechanic.



Steps to Safe LOTO

- Prepare for shutdown
- Shutdown machine or piece of equipment
- Isolate or block all hazardous energy sources for the equipment
- Apply lockout or tagout devices
- Release all stored energy
- Verify energy isolation
- Perform work



Steps to Release from LOTO

- Make the work area safe
- Check the work area to ensure individuals are clear of the hazard area
- Remove locks, tags, and devices
- Notify affected workers
- Re-energize

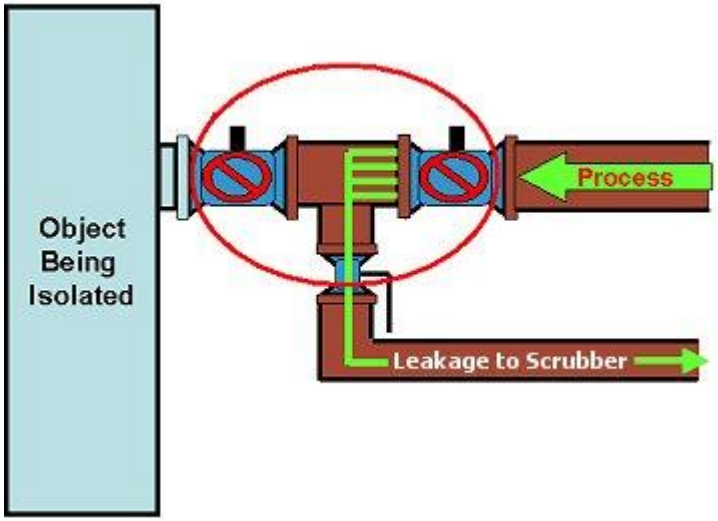
Isolation of Energy

LOTO Practices-

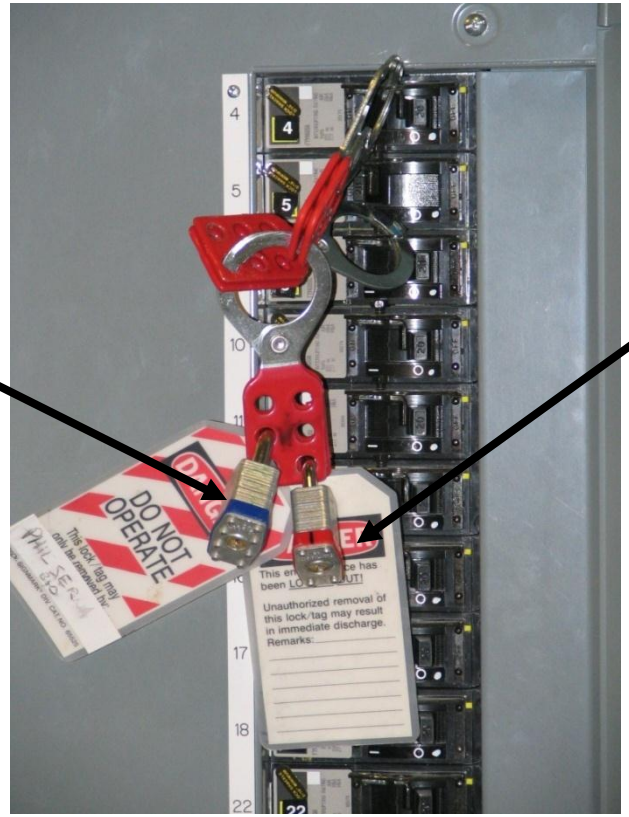
•Only <u>one</u> key for each lock the worker controls
•<u>Only</u> the worker who installs lock can remove it
•Shift changes- New lock added <u>before</u> old one removed
•*Authorized employee* for group lockout device
•LOTO program
    •Energy control procedures
    •Training
    •Periodic inspections
•Alternatives (US regulation)
    •Cord & plug
    •Hot tap procedures

Dissipation or Control of Energy

•Blind or blank piping
    •Lock and tag inline valves
•Remove stored energy-springs, hydraulics



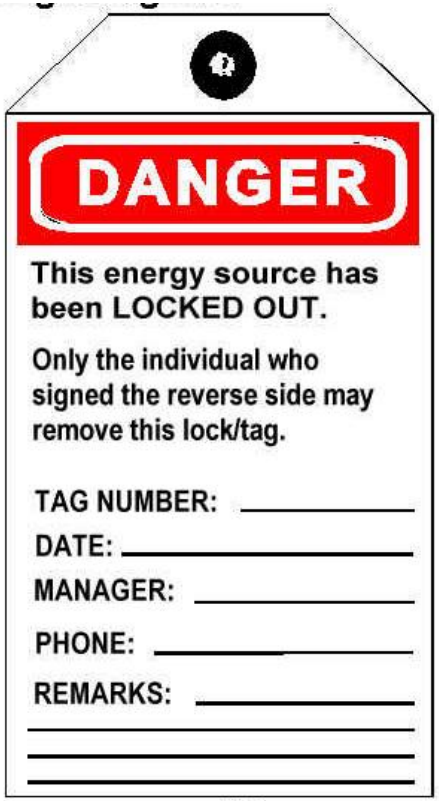
Each Company Assigns Unique Locks and Tags



LOTO Locks and Tags

Lock Self Adhesive Band , IDEAL Part Number 34-003

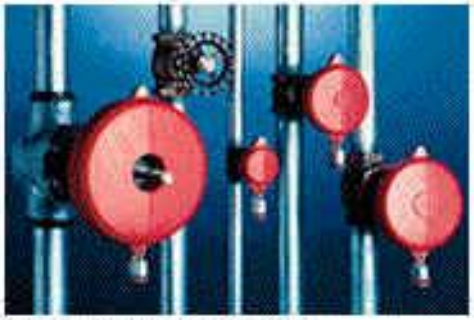
Front



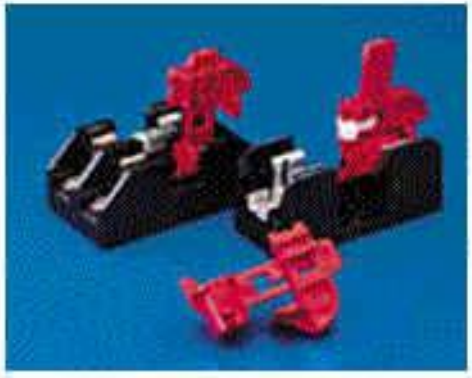
Back

Other LOTO Devices

BALL VALVE LOCKOUTS -
Brady Catalog #65666 & #65669
Panduit Catalog #PSL-BV1 &
#PSL-BV2 (Similar)

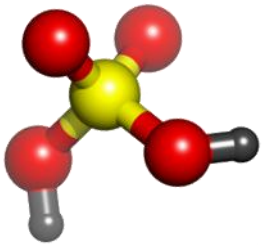


GATE VALVE LOCKOUT -
Brady Catalog #65560 to 65564



Circuit Breaker LOCKOUT...OPEN

Circuit Breaker LOCKOUT...LOCKED

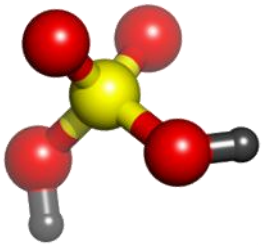


Case Study

Replacement of Nitrogen Pressure Vessel Seals

A group of employees are assigned to replace the head seals on twelve large nitrogen pressure vessels (accumulator bottles) at a manufacturing facility. Each pressure vessel has an operating pressure of about 5,000 psig. Replacement of the seals on each vessel requires that its head be opened, releasing any vessel contents to the atmosphere. The vessels lack individual gauges to indicate internal pressure levels.

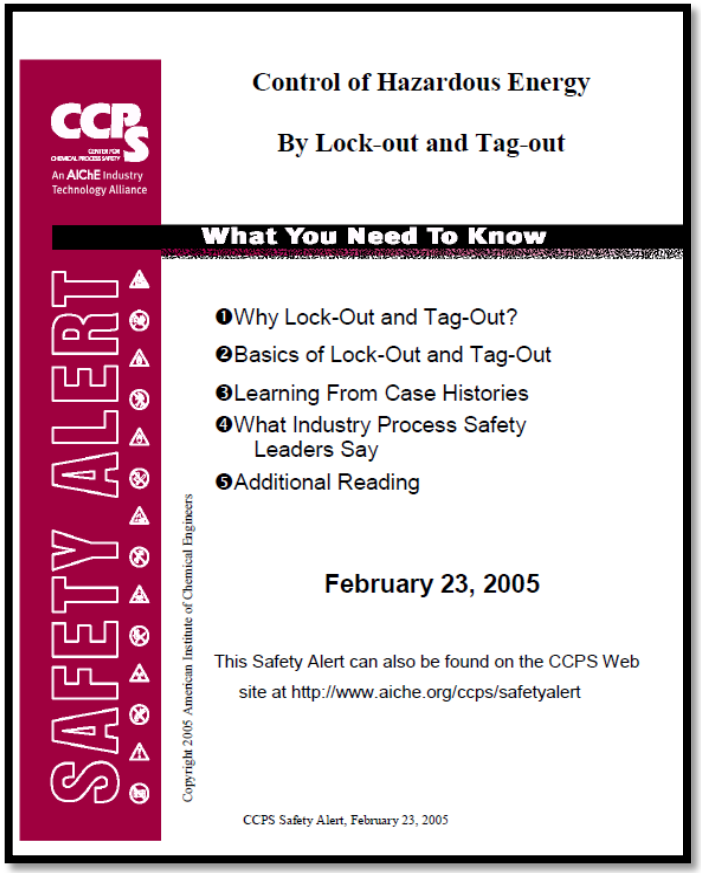
Credit: US Occupational Safety and Health Administration



Case Study

- Did the pressure within the nitrogen vessels constitute hazardous energy?
- Were the employees performing a servicing and/or maintenance operation that was subject to unexpected energization, start up, or release of hazardous energy?
- Would the group lockout or tagout provisions apply to this operation?

Resources: LOTO



CCPS
An AIChE Industry Technology Alliance

SAFETY ALERT

Control of Hazardous Energy

By Lock-out and Tag-out

What You Need To Know

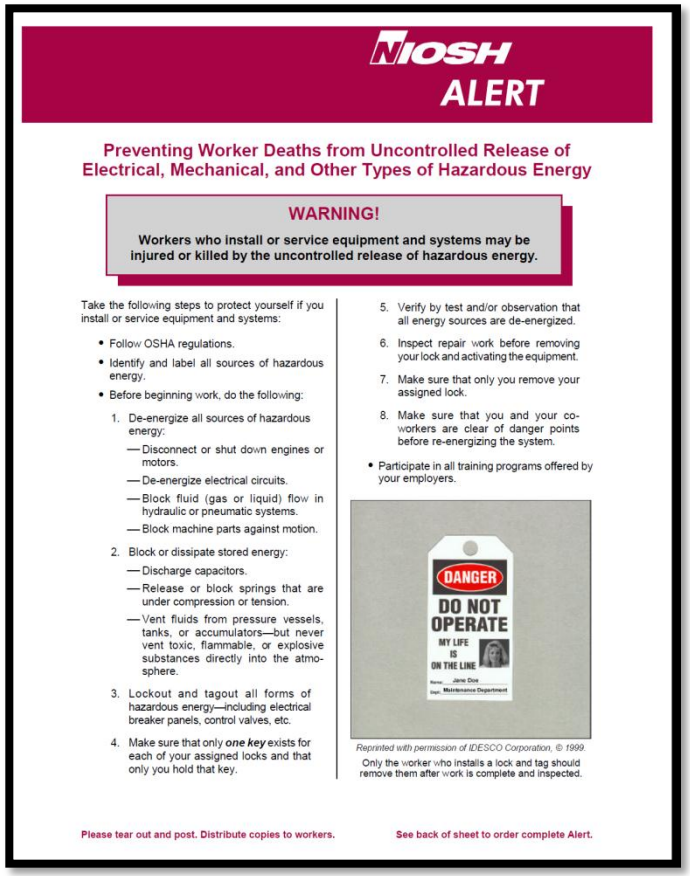
❶Why Lock-Out and Tag-Out?
❷Basics of Lock-Out and Tag-Out
❸Learning From Case Histories
❹What Industry Process Safety Leaders Say
❺Additional Reading

February 23, 2005

This Safety Alert can also be found on the CCPS Web site at http://www.aiche.org/ccps/safetyalert

CCPS Safety Alert, February 23, 2005

http://www.osha.gov/SLTC/controlhazardousenergy/index.html



NIOSH ALERT

Preventing Worker Deaths from Uncontrolled Release of Electrical, Mechanical, and Other Types of Hazardous Energy

WARNING!

Workers who install or service equipment and systems may be injured or killed by the uncontrolled release of hazardous energy.

Take the following steps to protect yourself if you install or service equipment and systems:

- Follow OSHA regulations.
- Identify and label all sources of hazardous energy.
- Before beginning work, do the following:

1. De-energize all sources of hazardous energy:
   - —Disconnect or shut down engines or motors.
   - —De-energize electrical circuits.
   - —Block fluid (gas or liquid) flow in hydraulic or pneumatic systems.
   - —Block machine parts against motion.
2. Block or dissipate stored energy:
   - —Discharge capacitors.
   - —Release or block springs that are under compression or tension.
   - —Vent fluids from pressure vessels, tanks, or accumulators—but never vent toxic, flammable, or explosive substances directly into the atmosphere.
3. Lockout and tagout all forms of hazardous energy—including electrical breaker panels, control valves, etc.
4. Make sure that only ***one key*** exists for each of your assigned locks and that only you hold that key.
5. Verify by test and/or observation that all energy sources are de-energized.
6. Inspect repair work before removing your lock and activating the equipment.
7. Make sure that only you remove your assigned lock.
8. Make sure that you and your co-workers are clear of danger points before re-energizing the system.

- Participate in all training programs offered by your employers.

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Only the worker who installs a lock and tag should remove them after work is complete and inspected.

Please tear out and post. Distribute copies to workers.

See back of sheet to order complete Alert.

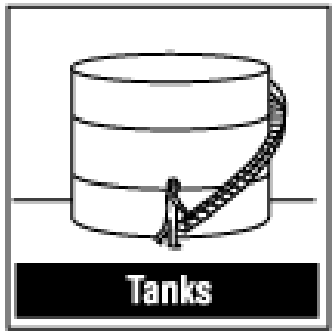
http://www.cdc.gov/niosh/docs/99-110/pdfs/99-110sum.pdf

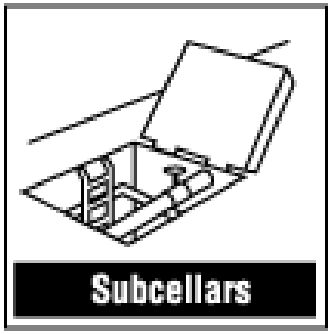
Confined Space

Confined space is any space that has:

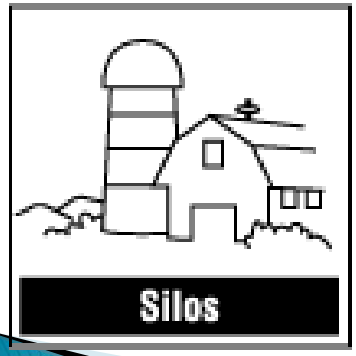
- Limited or restricted means of entry or exit;
- Is large enough for a person to enter to perform tasks and is not designed or configured for continuous occupancy

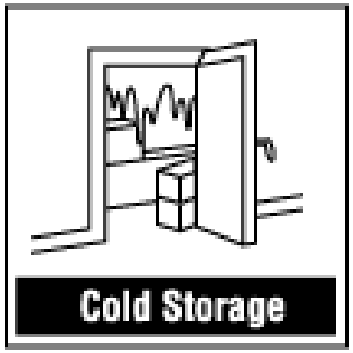
Confined Space

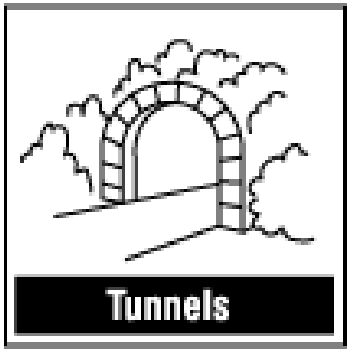


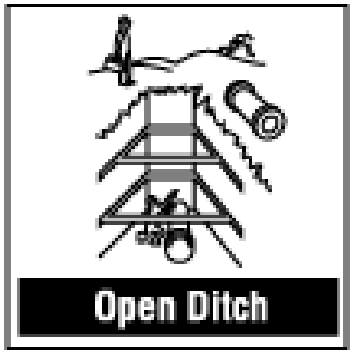


*<u>All</u> of these spaces constitute a c*onfined space…

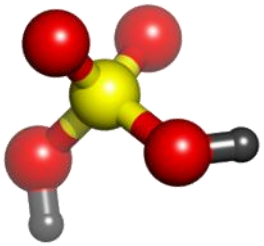








Credit: Canadian Centre for Occupational Health and Safety



Permit-Required Confined Space

- Contains or has the potential to contain a hazardous atmosphere
- Contains a material that has the potential for engulfing the entrant
- Has an internal configuration that might cause an entrant to be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section
- Contains any other recognized serious safety or health hazards
- Work activities may introduce serious health & safety hazards
  - Welding
  - Spray paintings or coatings

Confined Space Incidents

60% of fatalities are of would-be rescuers!

- 2003-City engineer killed in landfill manhole when retrieving flow meter
- 2004-Mechanic dies from lack of oxygen in transport tank
- 2005-A utility cleanup worker for a brick manufacturer suffocated in a storage silo
- 2006-Welder dies during welding repair inside of cargo tank compartment

Confined Space Permit

- Essential Elements of a CS Permit:
  - List potential hazards
  - List hazard controls
    - PPE, ventilation, barricades,
    - line blanking. LOTO
  - Communication equipment
  - Emergency & retrieval equipment
  - Pre-entry & continuous monitoring values
    - Oxygen, flammability, toxicity concentrations
  - Calibration/bump test information

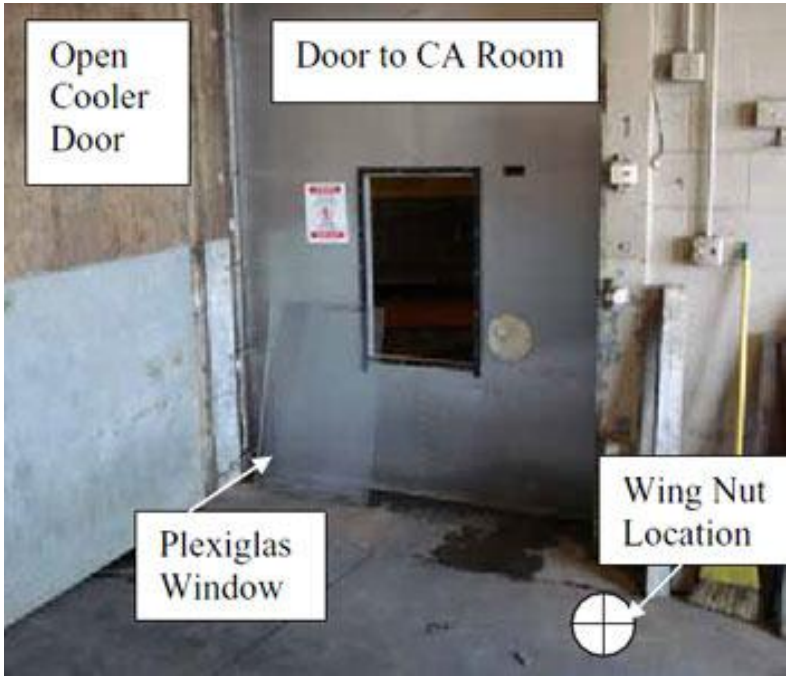
Confined Space Alternate Procedures

1. The *only* hazard posed by the space is an actual or potential atmospheric hazard controlled by mechanical ventilation.
   - Example: Underground communication vaults
2. No actual or potential atmospheric hazards, and all hazards are eliminated without entering the space.
   - Energy isolation–LOTO
   - Pipe or line isolation
   - Shielding of entrapment , mechanical hazards
   - Fall protection

Credit: Utah Safety Council

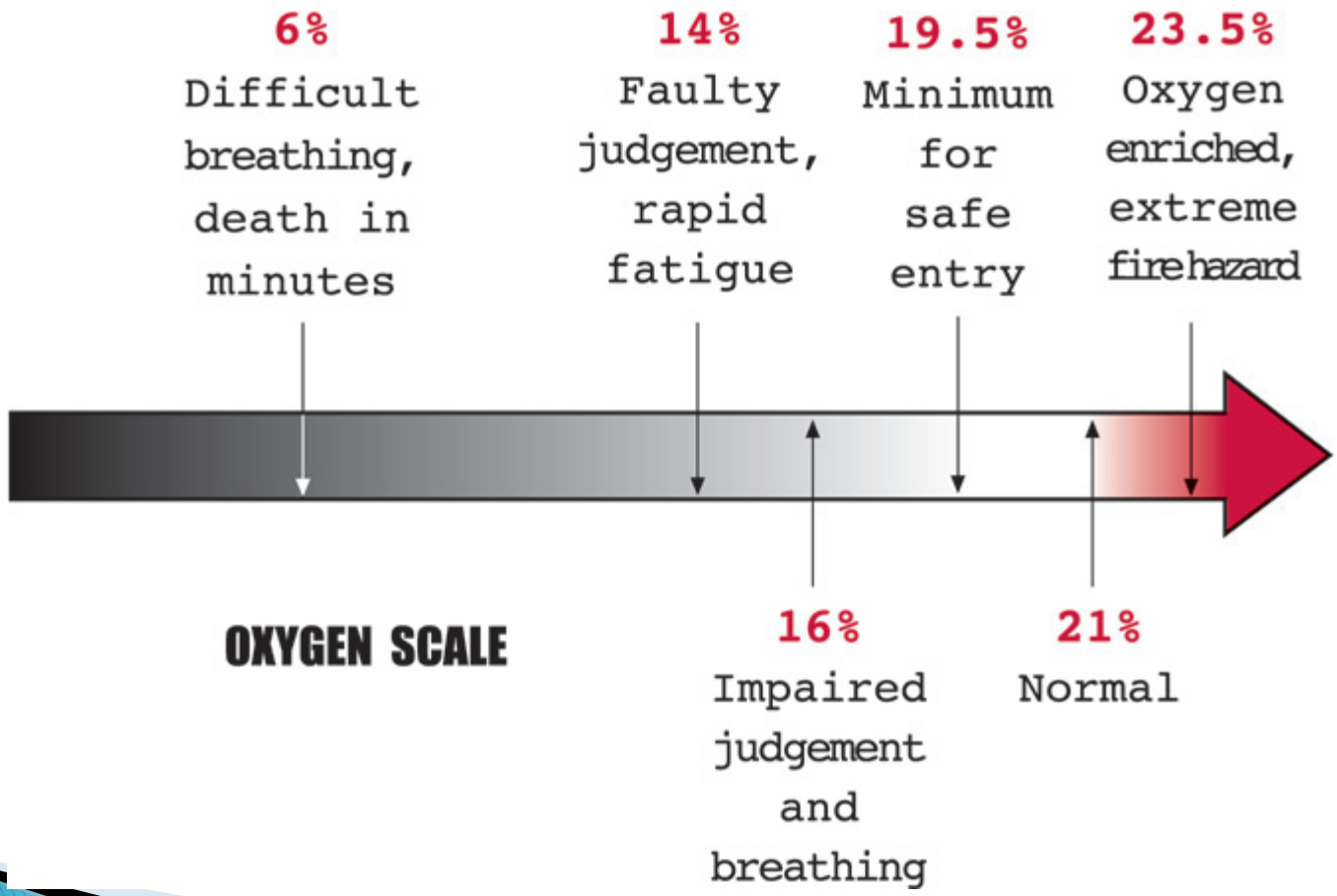
Atmospheric Hazards in Confined Spaces

- Oxygen Deficiency
- Oxygen Enrichment
- Flammable Vapors
- Flammable Gases
- Combustible Dust
- Toxic Vapors or Gases



Controlled Atmosphere Storage Room
Credit: US NIOSH

Oxygen Concentration



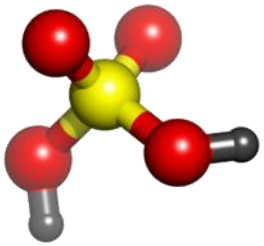
Atmospheric Testing of the Confined Space

1. Oxygen is tested first
   Combustible gas meters are oxygen-dependent and will not provide reliable readings when used in oxygen-deficient atmospheres.

2. Combustible gases and vapors are tested second
   The threat of fire and explosion is a more immediate acute hazard

3. Toxic atmospheres are tested last
   In most instances, the exposure limit for a toxic gas or vapor is less likely to be exceeded than the flammability limit over a short period of time.

Many modern direct-reading instruments provide simultaneous readings of multiple gases.



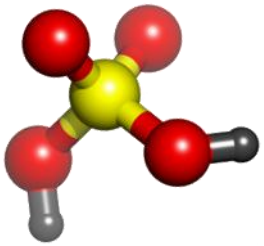
Example of Need to Air Sample for Toxics

- American Conference of Governmental Industrial Hygienists (ACGIH) short term exposure limit (STEL) to styrene exceeded
  - 186 parts per million (ppm) measured as STEL
  - ACGIH STEL is 40 ppm
  - Standard set to minimize the potential of irritation to the eyes and respiratory tract
- Task involved positioning and securing of uncured liner material in a sewer manhole.
- Lining expanded and off gassed styrene
- Manhole was under continuous ventilation
- Oxygen and flammable limits in acceptable range

Confined Space Air Monitoring Poor Practices

- No monitoring checklist
- Using your senses to detect atmospheric hazards
- No training in gas detection monitoring
- No factory instrument calibration
- No daily “bump” test
- No pre-entry monitoring
- No continuous monitoring
- No attendant trained in monitoring

Credit: OC Environmental Services



Emergency During Entry

- Entrants evacuated–entry aborts.
(Call rescuers if needed).
- Permit is *void*.
- Reevaluate program to correct/prevent prohibited condition.
- Occurrence of emergency (usually) is proof of deficient program.
- No re-entry until program (and permit) is amended.
(May require new program.)

Opening Lines and Vessels
”Line Breaking” Definition

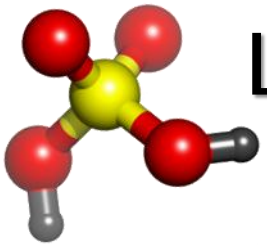
Line breaking means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

US OSHA “Ammonia High Pressure Receiver Standard Operating Procedure” http://www.osha.gov/SLTC/etools/ammonia_refrigeration/receiving/receiver_sop.html

Hazards of Opening Lines and Vessels

- Hot or cold fluids
- Toxic release and exposure
  - Ammonia
  - Hydrogen Sulfide
- Fire and explosion
  - Hydrocarbons
  - Pyrophoric materials
  - Moisture sensitive materials
- Pressure release
  - Pipeline pigging
  - Steam

Credit: Reagan Safety



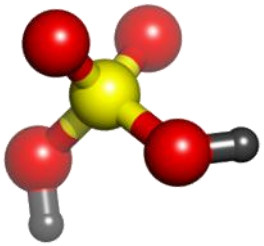
Line Breaking Procedures & Permitting

- Operating procedures
- Scope includes both employees *and* contractors
- Permit
  - Identify the hazard
    - SDS, process information
    - Consider cleaning agents which may be reactive
  - Establish required controls
    - Barricades-warning signs, cones, flags
    - Safety equipment-pipe supports, fall protection, fire extinguisher, monitoring equipment
    - Isolate or control system hazards
      - Cool system
      - Depressurize system
      - Flush system
      - LOTO energy sources
    - Appropriate personal protective equipment (PPE)

Line Breaking/Line Opening Procedures

- Additional considerations:
  - Replace broken, corroded and stripped bolts first
  - If transferring flammable chemical residue, bond the container to the pipe
  - Control access to area to authorized personnel
  - Log all isolation valves
  - Ensure personnel are trained and training documented
  - Prepare emergency plan

Credit: Reagan Safety



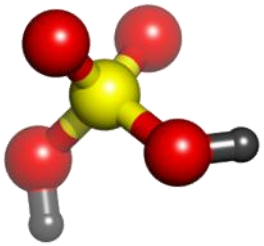
Hot Work Definition

Hot work is work involving electric or gas welding, torch cutting, grinding, brazing, or similar flame or spark-producing operations.

OSHA 1910.252

Hot Work Permit

- Fire prevention and protection requirements
- Implemented prior to beginning the hot work operations
- Date(s) authorized for hot work
- Identify the object on which hot work is to be performed
- Permit shall be kept on file until completion of the hot work operations.



WARNING!
HOT WORK IN PROGRESS
WATCH FOR FIRE!

PART 2

INSTRUCTIONS

1. **Person doing Hot Work: Indicate time started and post permit at Hot Work location. After Hot Work, indicate time completed and leave permit posted for Fire Watch.**
2. **Fire watch: Prior to leaving area, do final inspection, sign, leave permit posted and notify Firesafety Officer.**
3. **Monitor: After 4 hours, do final inspection, sign and return to Firesafety Officer.**

HOT WORK BEING DONE BY:

☐ EMPLOYEE _____ LIFE NO. _____

☐ CONTRACTOR _____ CO. _____

DATE | JOB NO.

LOCATION/BUILDING & FLOOR

NATURE OF JOB

NAME OF PERSON DOING FIRE WATCH

I verify the above location has been examined, and permission is authorized for this work.

SIGNED: (FIRE/SAFETY OFFICER)

DATE:

PERMIT EXPIRES	DATE	TIME AM PM

I verify that the List of Precautions is Understood and work will proceed only if precautions are followed:

Signed: (Supervisor)

FIRE WATCH SIGNOFF

Work area and all adjacent areas to which sparks and heat might have spread were inspected during the fire watch period and were found fire safe.

Signed:

FINAL CHECKUP

Work area was monitored following Hot Work and found fire safe.

Signed:

Required Precautions Checklist

MAY BE RETAINED AS RECORD OF HOT WORK ACTIVITY

☐ Available sprinklers, hose streams and extinguishers are in service/operable.

☐ Hot Work equipment in good repair.

Requirements within 35 ft (10m) of work

☐ Flammable liquids, dust, lint and oil deposits removed.

☐ Explosive atmosphere in area eliminated.

☐ Floors swept clean.

☐ Combustible floors wet down, covered with damp sand or fire-resistive sheets.

☐ Remove other combustibles where possible. Otherwise protect with fire-resistive tarpaulins or metal shields.

☐ All wall and floor openings covered.

☐ Fire-resistive tarpaulins suspended beneath work.

Work on walls or ceilings

☐ Construction is noncombustible and without combustible covering or insulation.

☐ Combustibles on other side of walls moved away.

Work on enclosed equipment

☐ Enclosed equipment cleaned of all combustibles.

☐ Containers purged of flammable liquids/vapors and monitored for vapor buildup.

Fire watch/Hot Work area monitoring

☐ Fire watch conractor/department will supply during and for 60 minutes after work, including any coffee or lunch breaks.

☐ Fire watch is supplied with suitable extinguishers, charged small hose.

☐ Fire watch is trained in use of this equipment and in sounding alarm (telephone, alarm box, radio).

☐ Fire watch may be required for adjoining areas, above, and below (see other precautions).

☐ Monitor Hot Work area for 4 hours after job is completed.

Other Precautions Taken

☐ False alarm with detection systems considered.

☐ _____

_____

3195

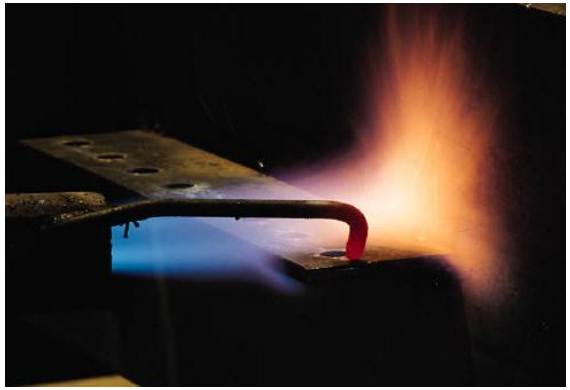
Responsibility for Hot Work is Clearly Outlined

Permit Authorizing Individual – Inspects hot work site before starting

Hot Work Operators – Perform hot work operations

Fire Watch – is posted to monitor safe operations

Designated Area – Location approved for hot work operations.



Fire Protection during Hot Work

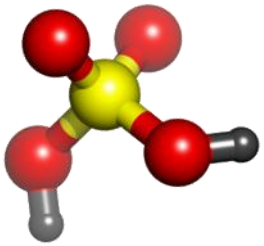
- All entrances and exits clear
- Correct poor housekeeping practices
- Use appropriate shielding of flammable surfaces
- Keep work area free of unnecessary combustible materials
- Do not use flammable degreasing agents
- Monitor the atmosphere-<10 % of Lower Explosive Limit (LEL)

Fire Fighting Equipment and Procedures

- All workers should know the location of the fire fighting equipment in their area.
- Fire extinguishers are checked monthly
- Mark empty fire extinguisher with “empty” and never return empty extinguisher to its fire station.
- All fire extinguishers should be inspected on an annual basis by a certified company.
- All workers should receive training before using fire extinguishing equipment.
- If Fire Watch determines fire may grow beyond control- emergency services must be contacted

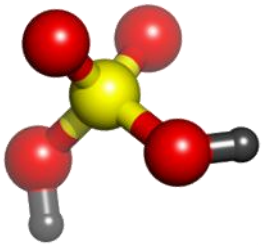
Hot Work Area is Controlled by Zoning

- Hot zone- inside permit space
- Warm zone – outside occupied by attendant personnel
- Cold or support zone – equipment and supplies
- Barricades and barriers
- Shields and railings



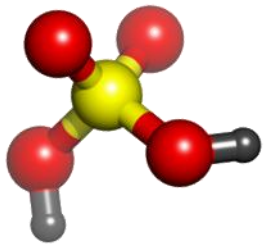
Summary of Presentation

- Stated safe work practices are required by US Process Safety Management Standard (PSM)
- Described steps in a Job Hazard Analysis process
- Reviewed Lockout-tagout (LOTO) incidents and requirements
- Defined non-permit and permit-required confined space and described confined space procedures
- Discussed hazards and controls for Line Breaking
- Described requirements for Hot Work permitting



TEA BREAK!

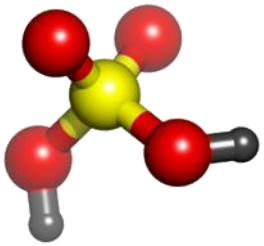
Controlling Chemical Hazards
Personal Protective Equipment



SAND No. 2012-1421C

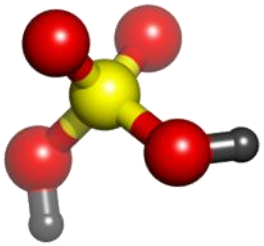
CSP
CHEMICAL SECURITY
ENGAGEMENT PROGRAM

Sandia
National
Laboratories



Personal Protective Equipment (PPE)

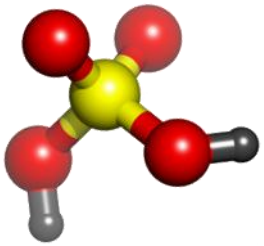
- Hierarchy of controls
- Limitations of PPE
- Hazard assessment
- Training
- Characteristics of PPE
- Protective clothing
- Gloves
- Eyewear
- Respirators
- Exercise



Hierarchy of Controls

- Limiting exposure to chemical hazards should follow the *Hierarchy of Controls*

1. Eliminate
2. Substitute
3. Engineering control
4. Administrative control
5. Personal Protective Equipment

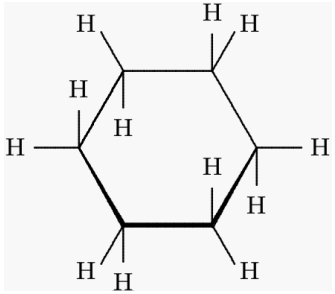


Hierarchy of Controls

Change the process

eliminate the hazard

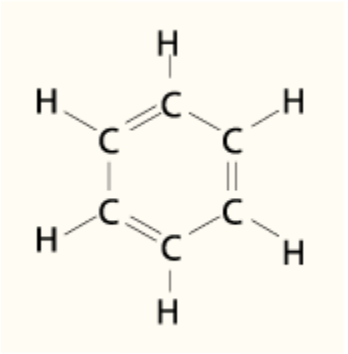
(e.g. Lower process temperature)



Substitution

less-hazardous substance

(e.g. – cyclohexane for benzene)



Engineering Controls

Enclose the hazard,

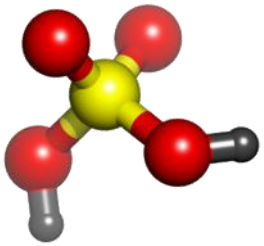
- **Use a barrier or**
- **Ventilate**
  - **Dilution ventilation**
  - **Local exhaust ventilation** (LEV)

Administrative Controls

Organizational safety policies,
Standard operating procedures,
Task-specific procedures

Personal Protective Equipment (PPE)

- PPE is the *least* desired control
- Does not eliminate the hazard
- Depends on worker compliance
- May create heat stress



PPE

- However, PPE may be necessary when:
  - Engineering controls are being installed
  - During emergency response
  - Non-routine equipment maintenance
  - When engineering controls are not feasible
  - To supplement other control methods

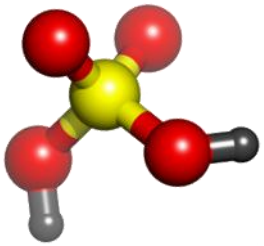
Can exposure be controlled by other means?

PPE Hazard Assessment (Required by US regulations)

- Identify the hazard(s)
  - Chemical
  - Mechanical
  - Electrical
  - Light energy (lasers, welding)
  - Fire response
  - Hot processes
- Identify the potential exposure route
  - Inhalation
  - Skin contact
  - Eye contact
- Select the PPE

PPE Hazard Assessment

- Identify the type of skin contact
  - Immersion
  - Spray
  - Splash
  - Mist
  - Vapor (gaseous)
- Consider the exposure time
  - Incidental contact
  - Continuous immersion
  - Unknown/emergency response



Exercise

- List one work activity in your laboratory or facility that uses PPE
- What is the hazard?
- What is the route of exposure? Inhalation, skin, eyes, or ?
- Are there ways to control exposure to this hazard other than PPE?
- What other ways?

Training

Employees should be trained to know:

- When PPE is necessary
- What PPE is necessary
- How to properly don, doff, adjust and wear PPE
- Limitations of PPE
- Proper care, maintenance, useful life and disposal
- Involve workers in selection

http://www.free-training.com/OSHA/ppe/Ppemenu.htm

Training

Retraining is necessary when there is:

- A change in the hazards
- A change in the PPE required
- Inadequate worker knowledge or use of PPE

http://www.free-training.com/OSHA/ppe/Ppemenu.htm

General Characteristics of PPE

Protective clothing and gloves:

- Act as a barrier to prevent contact with the skin
- Protect against
  - Toxics
  - Corrosives
  - Irritants
  - Sensitizers (allergens)
  - Thermal injury (burns)
  - Physical Trauma

General Characteristics of PPE

Protective clothing and gloves

- When selecting consider:
  - Permeation
    - Breakthrough time
    - ASTM F739 Standard
  - Penetration
  - Degradation
  - Comfort
  - Heat stress
  - Ergonomics
  - Cost

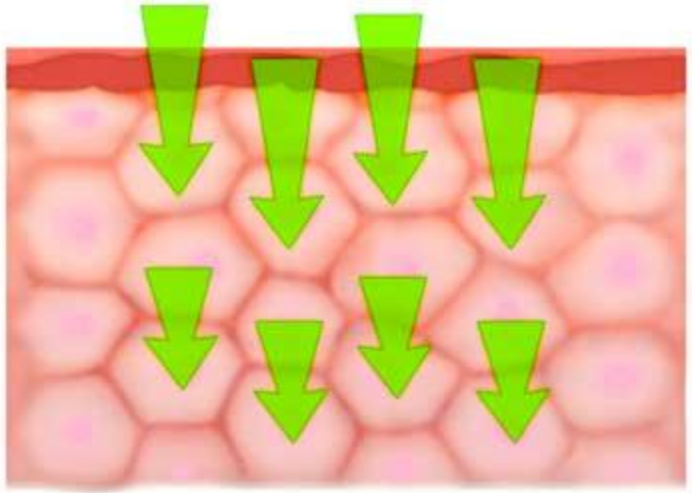
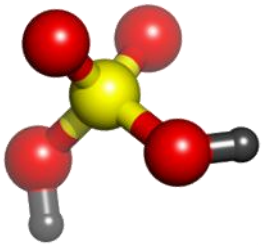


Photo credit: Permeation, http://www.cdc.gov/niosh/topics/skin/

Permeation Rate (PR)	Permeation Breakthrough (PB)	Permeation Degradation rate (DR)
E- Excellent; permeation rate of less than 0.9 mg/cm^2/min	>Greater than (time - minutes)	E - Excellent; fluid has very little degrading effect.
VG - Very Good; permeation rate of less than 9 mg/cm^2/min	< Less than (time - minutes)	G - Good; fluid has minor degrading effect.
G - Good; permeation rate of less than 90 mg/cm^2/min		F - Fair; fluid has moderate degrading effect.
F - Fair; permeation rate of less than 900 mg/cm^2/min		P - Poor; fluid has pronounced degrading effect.
P - Poor; permeation rate of less than 9000 mg/cm^2/min		NR - Fluid is not recommended with this material.
NR - Not recommended; permeation rate greater than 9000 mg/cm^2/min		† Not tested, but breakthrough time > 480 min DR expected to be Good to Excellent
		†† Not tested, but expected to be Good to Excellent based on similar tested materials

Protective Clothing

- Special Applications
  - Hot processes
  - High voltage/arc flash
    - NFPA 70E
  - Foundries/molten metal
  - Refineries
- Select flame resistant clothing
- Chemical resistant coating may be added to flame resistant clothing



Gloves

- **Evaluate the work task**
  - **Chemical immersion or incidental contact?**
  - **Consider ergonomics/dexterity required**
- **Use glove charts**
  - **Charts recommend gloves for specific chemicals**
    - **Evaluate permeation rates and breakthrough time of selected glove for the specific task**
  - **Consider several glove manufactures data before final selection.**
    - http://www.mapaglove.com
    - http://www.ansellpro.com
    - http://www.bestglove.com/site/chemrest/

The first square in each column for each glove type is color coded. This is an easy-to-read indication of how we rate this type of glove in relation to its applicability for each chemical listed. The color represents an overall rating for both degradation and permeation. The letter in each square is for Degradation alone…

- GREEN: The glove is very well suited for application with that chemical.
- YELLOW: The glove is suitable for that application under careful control of its use.
- RED: Avoid use of the glove with this chemical.







CHEMICAL	LAMINATE FILM BARRIER			NITRILE SOL-VEX			UNSUPPORTED NEOPRENE 29-865			SUPPORTED POLYVINYL ALCOHOL PVA			POLYVINYL CHLORIDE (Vinyl) SNORKEL			NATURAL RUBBER CANNERS AND HANDLERS*			NEOPRENE/ NATURAL RUBBER BLEND CHEMI-PRO*		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
1. Acetaldehyde	■	380	E	P	—	—	E	10	F	NR	—	—	NR	—	—	E	7	F	E	10	F
2. Acetic Acid	■	150	—	G	270	—	E	60	—	NR	—	—	F	180	—	E	110	—	E	260	—
3. Acetone	▲	>480	E	NR	—	—	E	10	F	P	—	—	NR	—	—	E	10	F	G	10	G
4. Acetonitrile	▲	>480	E	F	30	F	E	20	G	■	150	G	NR	—	—	E	4	VG	E	10	VG
5. Acrylic Acid	—	—	—	G	120	—	E	390	—	NR	—	—	NR	—	—	E	80	—	E	65	—
6. Acrylonitrile	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. Allyl Alcohol	▲	>480	E	F	140	F	E	140	VG	P	—	—	P	60	G	E	>10	VG	E	20	VG
8. Ammonia Gas	■	19	E	▲	>480	—	▲	>480	—	—	—	—	■	6	VG	—	—	—	■	27	VG
9. Ammonium Fluoride, 40%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—
10. Ammonium Hydroxide	E	30	—	E	>360	—	E	250	—	NR	—	—	E	240	—	E	90	—	E	240	—
11. Amyl Acetate	▲	>480	E	E	60	G	NR	—	—	G	>360	E	P	—	—	NR	—	—	P	—	—
12. Amyl Alcohol	—	—	—	E	30	E	E	290	VG	G	180	G	G	12	E	E	25	VG	E	45	VG
13. Aniline	▲	>480	E	NR	—	—	E	100	P	F	>360	E	F	180	VG	E	25	VG	E	50	G
14. Aqua Regia	—	—	—	F	>360	—	G	>480	—	NR	—	—	G	120	—	NR	—	—	G	180	—
15. Benzaldehyde	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	G	10	VG	G	25	F
16. Benzene, Benzol	▲	>480	E	P	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—
17. Benzotrichloride	—	—	—	E	>480	E	NR	—	—	—	—	—	—	—	—	NR	—	—	NR	—	—
18. Benzotrifluoride	—	—	—	E	170	G	F	—	—	E	—	—	G	<10	F	P	50	G	—	—	—
19. Bromine Water	—	—	—	E	>480	E	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—
20. 1-Bromopropane	▲	>480	E	■	23	F	■	<10	P	▲	>480	E	■	<10	F	■	<10	P	■	<10	P

General Types of Glove Material

Laminated Gloves: 4H®, Silver Shield®

- Useful for a wide range of chemicals.

  NOT HYDROGEN FLUORIDE!

- Can use with a nitrile over glove to improve dexterity.

Butyl Rubber

- Highest permeation resistance to gas or water vapors.
- Uses: acids, formaldehyde, phenol, alcohols.

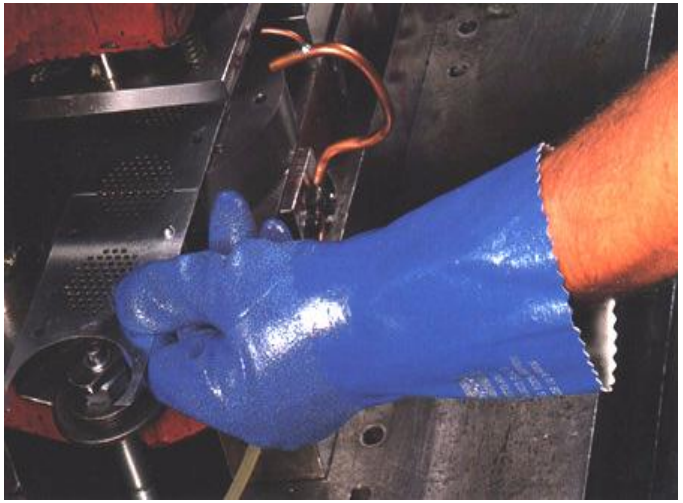
General Types of Glove Material

Neoprene

- Protects against acids, caustics.
- Resists alcohols, glycols.

Nitrile

- Good replacement for latex
- Protects against acids, bases, oils, aliphatic hydrocarbon solvents and esters, grease, fats
- NOT ketones
- Resists cuts, snags, punctures and abrasions



Latex Allergy

Proper Steps for Removing Gloves

1

2

3

4

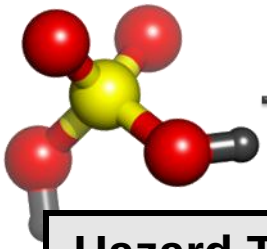
5

6

Eye and Face Protection

- Each day, 2000 U.S. workers have a job-related eye injury that requires medical treatment.
- Nearly *three out of five* U.S. workers are injured while failing to wear eye and face protection.

NIOSH. (2010). http://www.cdc.gov/niosh/topics/eye/



Types of Eye Hazards

Hazard Type	Common related tasks	Protective Eyewear
Impact	Chipping, grinding, machining, abrasive blasting, sawing, drilling, riveting, sanding,…	Safety glasses with sideshields Goggles
Heat	Furnace operations, smelting, pouring, casting, hot dipping, welding, …	Face shield with infrared protection
Chemicals	Pouring, spraying, transferring, dipping acids, solvents or other injurious chemicals	Goggles Faceshield
Particles/ Dust	Woodworking, metal working, and general dusty conditions	Safety glasses with sideshields
Optical Radiation	Welding, torch-cutting, brazing, and laser work	Welding helmet Laser glasses -Must protect for specific wavelength of ultraviolet or infrared radiation.

Examples of Eye & Face Protection

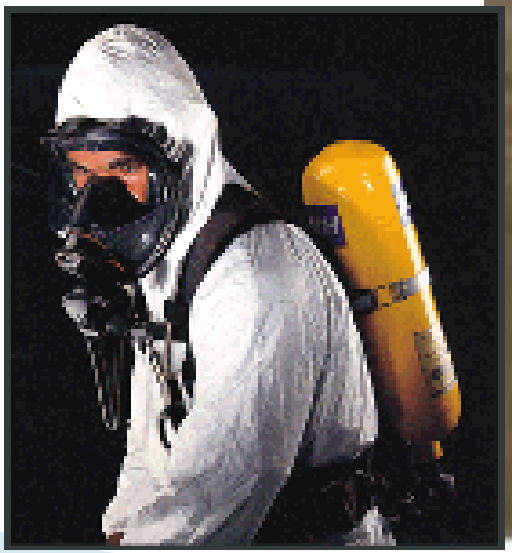
- Goggles
- Face shield
- Safety glasses
- Welding helmet
- Hooded faceshield

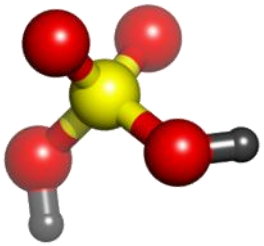
Respiratory Protection

- U.S. Respirator Requirements
- Written program
- Hazard assessment
  - Air monitoring
- Medical clearance
- Fit testing
- Respirator selection
- Procedures
  - Cleaning, maintenance, repairing
- Training (annual refresher)

Basic Types of Respirators

- Air purifying (APR)
  - Half Face
  - Full Face
  - Powered APR (PAPR)
- Air supply
  - Air line
  - SCBA





Air Purifying Respirators (APR)

- Work area must have at least 19.5% oxygen
- The contaminant must have adequate warning properties. Ex. ammonia
  - Never use APR in oxygen deficient atmospheres
- APRs work by filtering, absorbing, adsorbing the contaminant or chemical reaction.
  - Filters, cartridges, canisters
- The contaminant concentration must NOT exceed the maximum use concentration.
- Some cartridges have “end of service life” indicators or can use change schedules

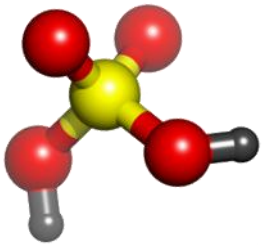
Types of APR Cartridges

Cartridge	Description
	**Organic Vapor**
	**Organic Vapor and acid gases**
	**Ammonia, methylamine and P100 particulates filter**

End of Service Life Indicators (ESLI)

There are very few NIOSH-approved ESLI's:

- ammonia
- carbon monoxide
- ethylene oxide
- hydrogen chloride
- hydrogen fluoride
- hydrogen sulfide
- mercury
- sulfur dioxide
- toluene-2,4-diisocyanate
- vinyl chloride

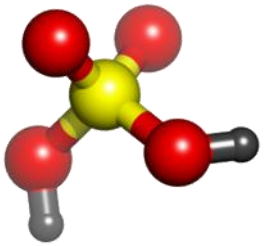


APR Filter Efficiency

National Institute of Occupational Safety and Health

Filter Efficiencies

Filter Class	
N95	Filters at least 95% of airborne particles. Not resistant to oil.
N99	Filters at least 99% of airborne particles. Not resistant to oil.
N100	Filters at least 99.97% of airborne particles. Not resistant to oil.
R95	Filters at least 95% of airborne particles. Somewhat resistant to oil.
P95	Filters at least 95% of airborne particles. Strongly resistant to oil.
P99	Filters at least 99% of airborne particles. Strongly resistant to oil.
P100	Filters at least 99.97% of airborne particles. Strongly resistant to oil

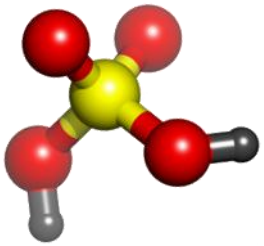


Assigned Protection Factors (APF)

- Level of workplace respiratory protection that a respirator or class of respirators is expected to provide.
- Each specific *type* of respirator has an Assigned Protection Factor (APF).
- Select respirator based on the exposure limit of a contaminant and the level in the workplace.

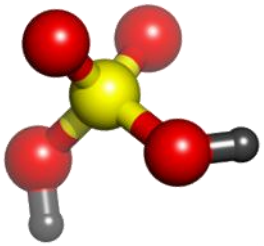
Maximum Use Concentration (MUC)

= APF x Occupational Exposure Limit (e.g. PEL, TLV)



Assigned Protection Factors

Type of Respirator	Half Face Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
Air-Purifying	10	50	-	-
PAPR	50	1,000	25/1,000	25
Supplied-Air or Airline				
– Demand	10	50	-	-
– Continuous flow	50	1,000	25/1000	25
– Pressure demand	50	1,000	-	-
SCBA				
– Demand	10	50	50	-
– Pressure Demand	-	10,000	10,000	-



Assigned Protection Factors

Workplace air sampling indicates the exposure to benzene is 15 parts per million (ppm). The exposure limit is 0.5 ppm (ACGIH TLV).

What respirator should you choose?

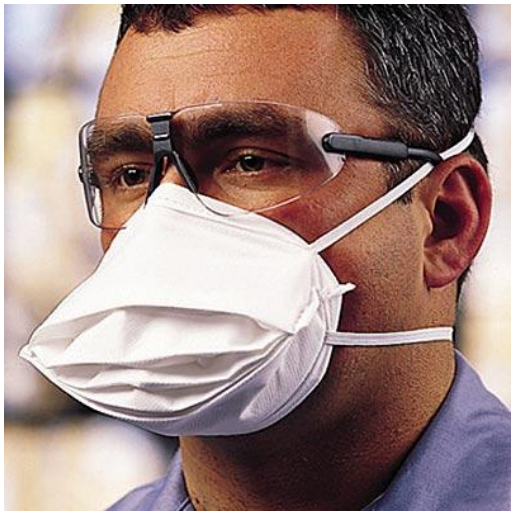
Maximum Use Concentration (MUC) = APF x OEL

Half Face Mask: MUC = 10 x 0.5 ppm = 5 ppm

PAPR (LFF): MUC = 25 x 0.5 ppm = 12.5 ppm

Full Face Respirator: MUC = 50 x 0.5 ppm = 25 ppm

Filtering Facepieces



Filtering Facepiece- Inappropriate Use

Respirator Fit Testing

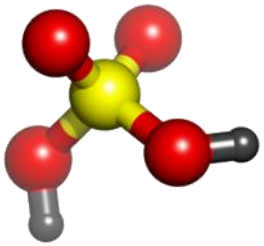
- Qualitative
  - Irritant smoke
    - stannic chloride
  - Isoamyl acetate
    - banana oil
  - Saccharin
  - Bitrex
- Quantitative
  - Portacount

Respirator Fit Test

Positive / Negative pressure fit test

Supplied Air

- Supplies breathing air to worker
  - SCBA
  - Airline
- Must use Grade D Air
- Many limitations

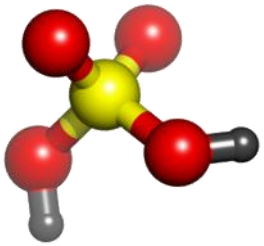


Breathing Air Quality and Use

- Compressed breathing air must be at least Type 1 – Grade D [ANSI/CGA G-7.1-1989]:
  - Oxygen content = 19.5 – 23.5%
  - Hydrocarbon (condensed) = 5 milligrams/cubic meter or less
  - CO ≤ 10 parts per million (ppm) or less
  - CO_2 of 1,000 parts per million (ppm) or less
  - Lack of noticeable odor
- Compressors may be equipped with in-line air-purifying sorbent beds and filters.

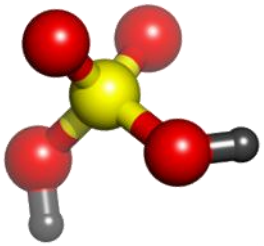
Maintenance & Storage Procedures

- Disposable filtering face-piece:
  - Dispose after use
- Air purifying respirators:
  - Discard cartridges based on expiration date, end-of-service life indicator or calculated service life
  - Clean
  - Dry
  - Place in sealable bag (write your name on bag)
  - Contact Safety Office for repairs
- SCBA:
  - Inspected monthly
  - Accessible and clearly marked



Discussion

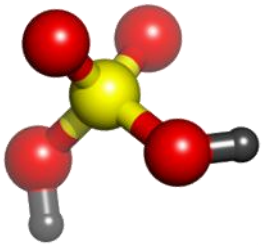
- A contractor has been hired to sweep out a work area that contains lead dust. The plant safety officer has recommended that the worker don a full-face air purifying respirator with a HEPA filter (P100) during this activity.
- Later that week the plant safety officer observes the worker sweeping without wearing the respirator. When asked why he is not wearing the respirator, the worker states “it is too uncomfortable to wear.”
- What approach should the safety officer take to ensure the worker wears a respirator?



PPE Exercise

- Worker A needs to transfer 10 liters of acetone into a hazardous waste drum.
- The safety officer has determined that due to the use of ventilation, the air concentration of acetone is below the exposure limit.
- The worker may have incidental skin contact with the acetone during pouring.
- Prolonged skin exposure to acetone causes dry and cracked skin, but acetone is not normally absorbed through the skin.
- There is also a possibility that the acetone may splash in the worker's face during pouring.

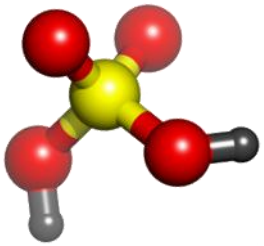
What PPE should Worker A wear?



PPE Exercise

- Worker B is walking back from the break room when he notices a yellow cloud of chlorine coming towards him from the chlorine storage area. He also notices that some of the chlorine has come into contact with water under one of the tanks and formed chlorine hydrate.
- He alerts the emergency response team who arrive at the emergency staging area.
  - Chlorine is a corrosive and toxic gas by inhalation.
  - Chlorine hydrate is corrosive to the skin and eyes.
  - The airborne concentration of chlorine is unknown in this situation.

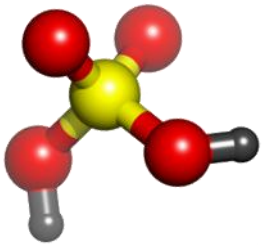
What PPE should the emergency response team use?



PPE Exercise

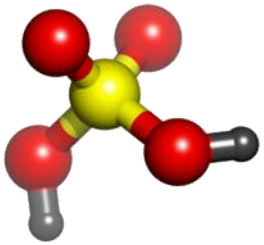
- Worker C is tasked with adding zinc oxide pigment into a mixing bath by hand.
- This task will take 15 minutes.
- Worker C performs this task once every day.
- The safety officer has determined that the airborne concentration during this task is 20 milligrams/cubic meter.
- The short term exposure limit (15 minutes) for zinc oxide is 10 milligrams/cubic meter .
- Zinc oxide powder is mildly irritating to the skin and eyes, but not toxic or corrosive.

What PPE should Worker C wear?



LUNCH

Controlling Chemical Hazards Laboratory and Industrial Ventilation



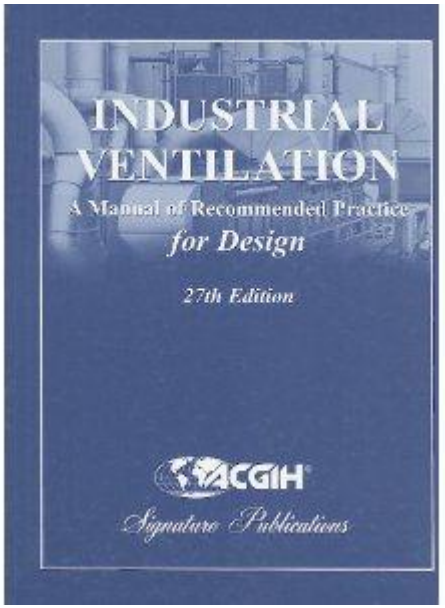
SAND No. 2012-1603C
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

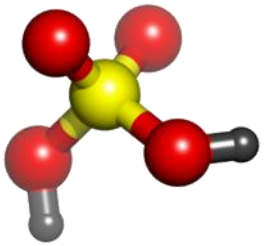
Sandia National Laboratories

Ventilation

- Definitions
- Common Terminology
- Purpose
- Hazard Assessment
- General Ventilation
- Local Exhaust Ventilation
- Ventilation Evaluation
- Troubleshooting
- Exercises

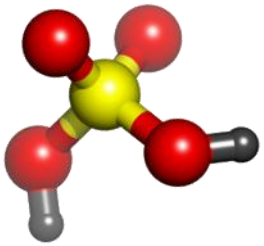


American Conference of Governmental Industrial Hygienists (ACGIH) Ventilation Manual 27th Edition
http://www.acgih.org/store/ProductDetail.cfm?id=1905



Definitions

- **Heating, ventilating and air conditioning** (HVAC):refers to the distribution system for heating, ventilating, cooling, dehumidifying and cleansing air.
- **Replacement/Supply air**: refers to replacement air for HVAC and local exhaust ventilation.
- **General ventilation**: refers to ventilation that controls the air environment by removing and replacing contaminated air before chemical concentrations reach unacceptable levels.
- **Local exhaust ventilation (LEV):** refers to systems designed to enclose, or capture and remove contaminated air at the source.



Common Terminology

Q = volume of air in cubic meters

V = velocity of air in meters per second

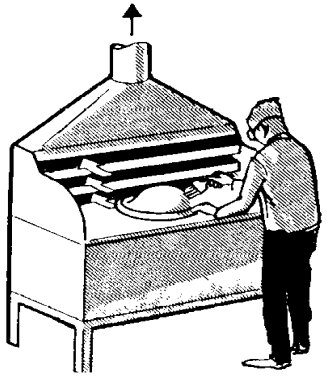
- Duct velocity-velocity required to transport the contaminant
- Face velocity-velocity on the front of an enclosing hood
- Capture velocity-velocity required to capture contaminant at point of generation

A = cross sectional area of hood opening in square meters

X = distance of ventilation from the source in meters

Purposes of Ventilation

- Protect workers from health hazards
  - *Dilute, capture, or contain* contaminants
- Protect workers from hot processes
  - *Ovens, foundries*
- Protect the product
  - *Semiconductor*
  - *Electronics*
  - *Pharmaceuticals*



Slot Hood

Canopy Hood

Purposes of Ventilation

- Emergency ventilation
  - Standalone fans
  - Detectors connected to ventilation or scrubber systems
  - Safe room
    - Positive pressure
- Enclosed vented rooms or cabinets
  - Gas cabinets
- Comply with health and safety regulations

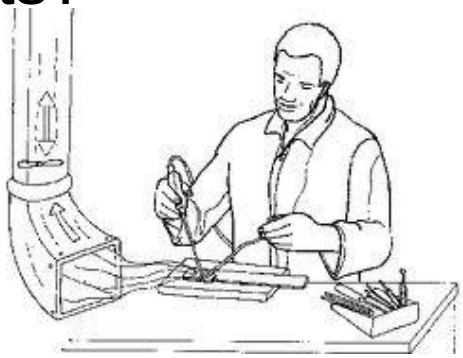
Photo credit: Emergency Responder Products

Photo credit: Advanced Specialty Gas Equipment

Hazard Assessment

- What are the airborne contaminants?
  - Particles
  - Solvent vapors
  - Acid mists
  - Metal fumes
- How do to the workers interact wi source contaminant?
- Are workers exposed to air contaminants in concentrations over an exposure limit?

  *Requires air monitoring of the task
- Dilution or local exhaust ventilation?



Picture Credit : International Labor Organization

General Ventilation

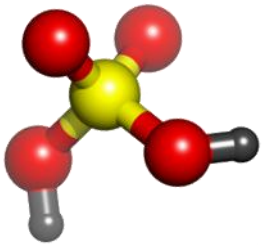
- Natural Ventilation:
  - Useful for hot processes
  - Chimney effect
  - Windows and doors kept open
- Example: a warehouse opens the w
  create natural ventilation

Q = 0.2 AV

A = square meters (area of open doors)

V = wind speed in kilometers/hour

Q = estimates the volumetric flow rate through the building (m^3/s)



General Ventilation

Dilution Ventilation

-Heat control

-Dilution of odors, flammables

-Not for control of toxics

Principles

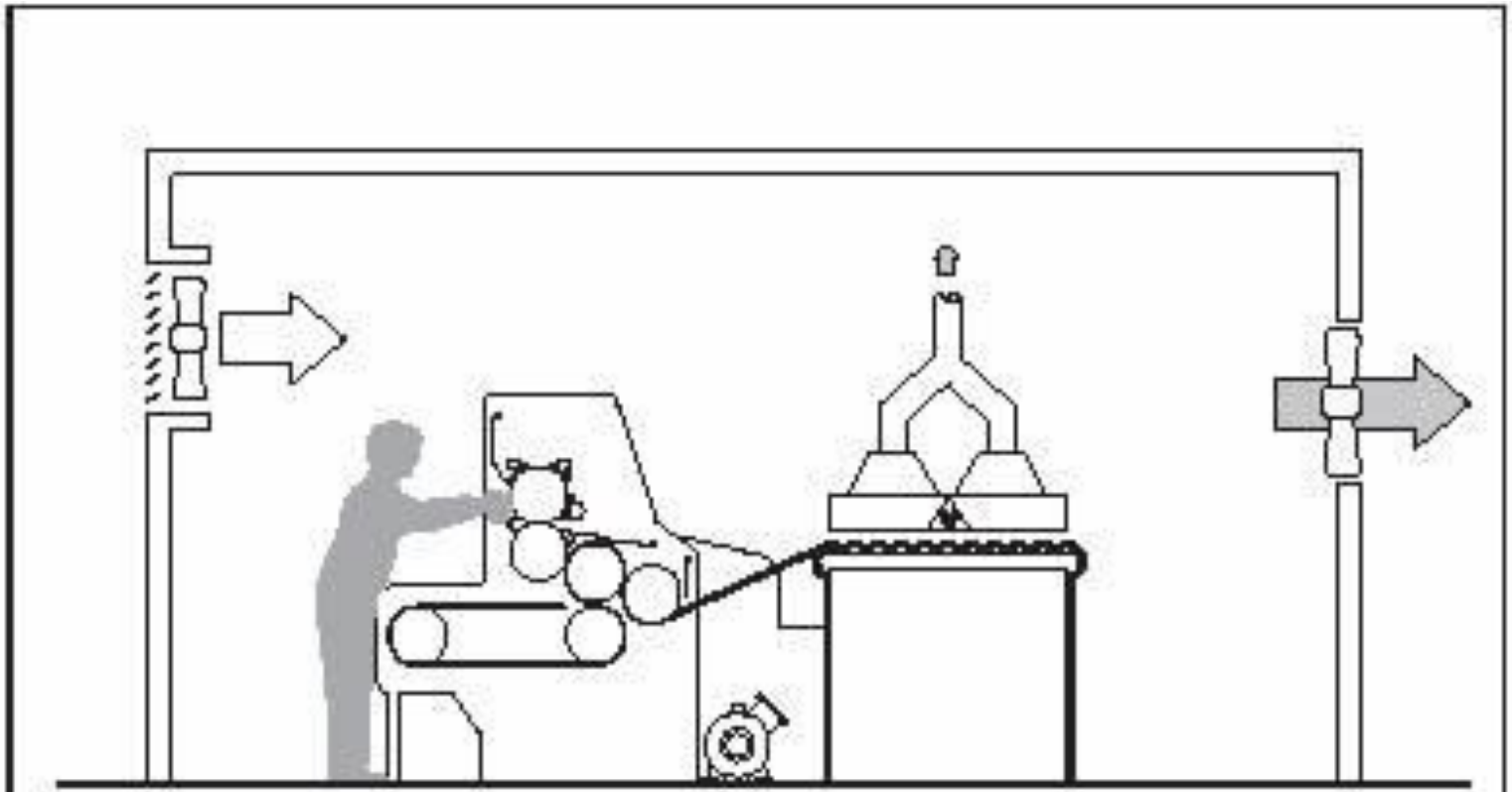
-Contaminant emissions must be widely dispersed

-Exhaust openings must be near contaminant source

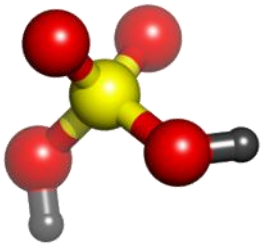
-The worker must not be downstream of contaminant

-Air flow over worker should not exceed 3.5 meters/sec

General Ventilation



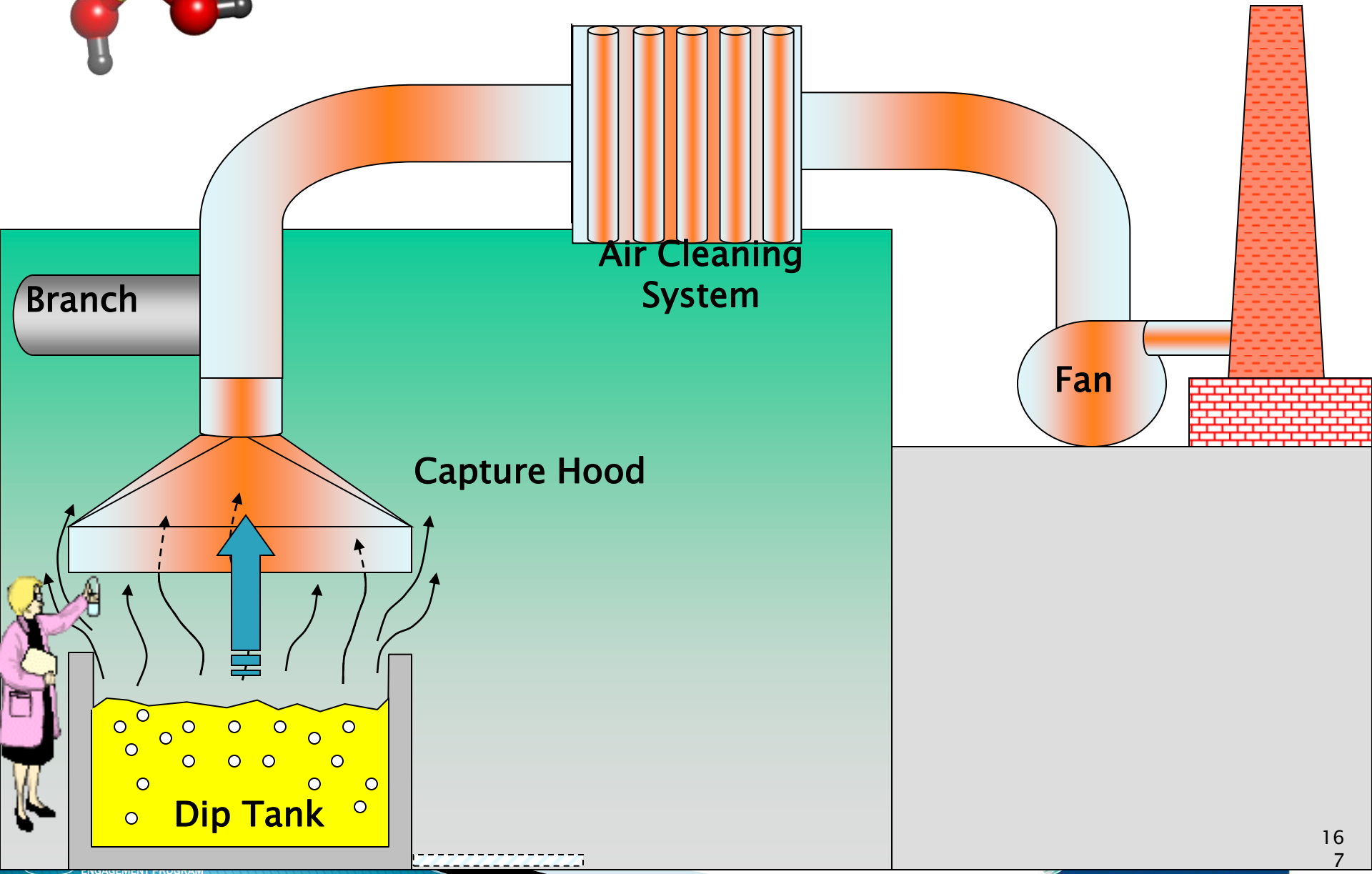
General ventilation for cleaning a printing press



Local Exhaust Ventilation (LEV)

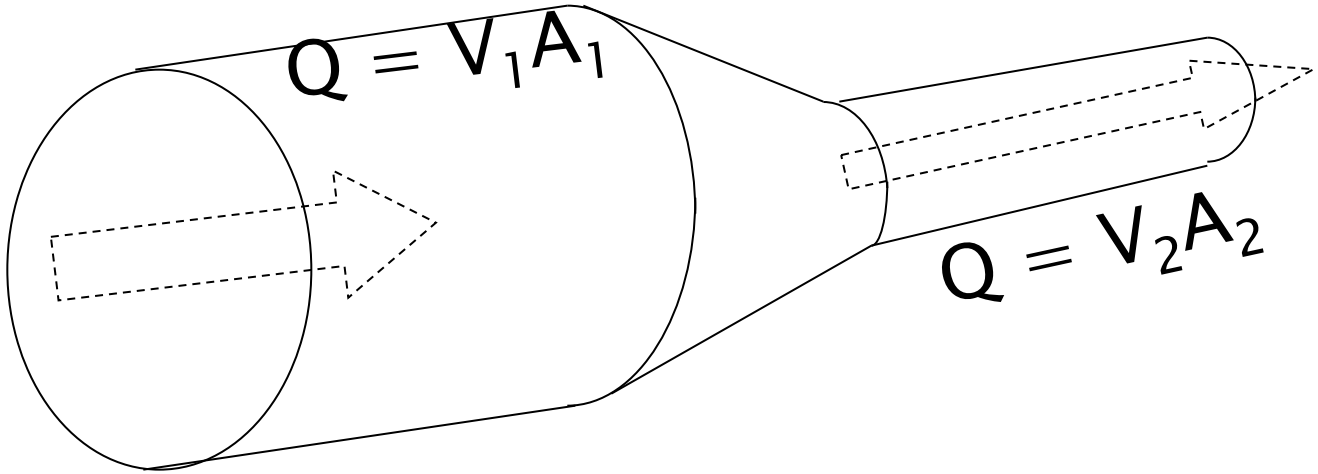
- Use when contaminant concentration cannot be controlled by dilution ventilation or other controls
- Select the type of LEV from hazard assessment
  - Which type is best to capture the contaminant?
    - Enclosed or capture hood?
    - Consider worker's needs
  - What duct transport velocity is required to carry the contaminant? Heavy particles?
  - What face or capture velocity is required?
- Select duct material for the contaminant
- Ensure enough replacement air/adequate fan size

Local Exhaust Ventilation



Local Exhaust Ventilation

Volumetric Flow Rate, Q = VA [**Circular Opening**]

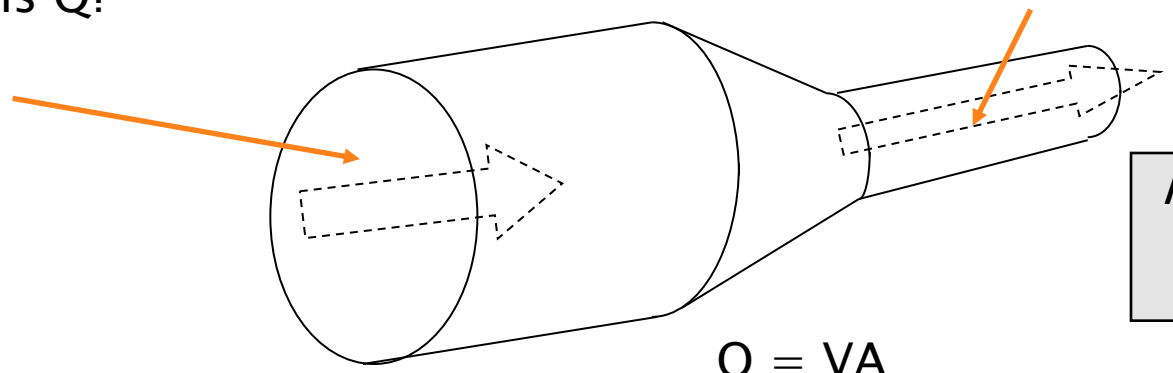


Q = Volumetric flow rate, in cubic meters/second
V = Average velocity, in meters/second
A = Cross-sectional area in square meters

Local Exhaust Ventilation

Duct diameter = 1 meter
V = 600 meters/second
What is Q?

Duct diameter = 0.5 meter
What is the duct velocity (V)?



For circular ducts

$A = \pi d^2/4$

$Q = VA$

$Q = (600\ m/s)(\pi[1m]^2/4)$

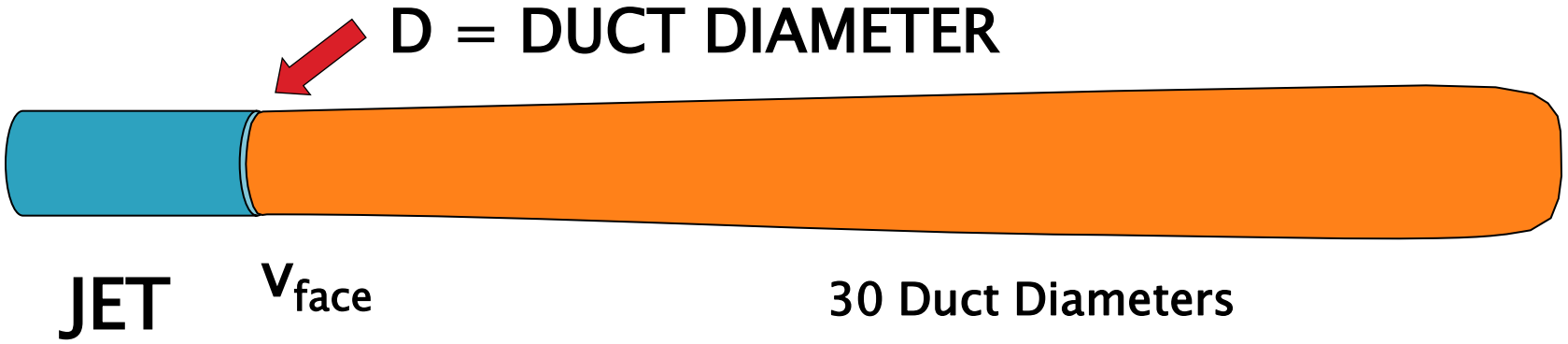
$Q = 471\ meters^3/second$

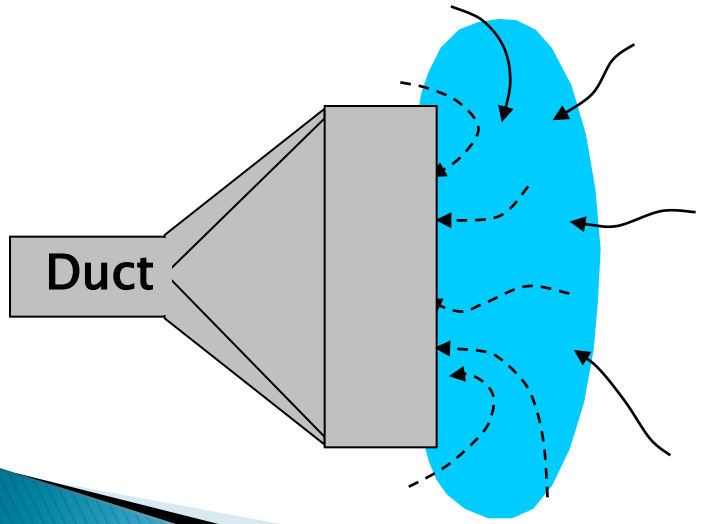
$Q = VA$

$471\ meters^3/s = V\ (\pi[0.5m]^2/4)$

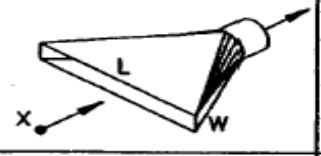
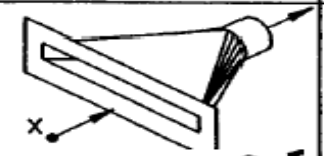
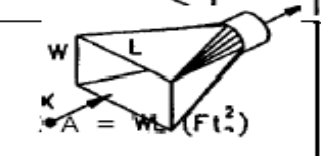
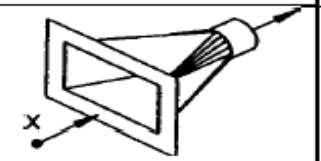
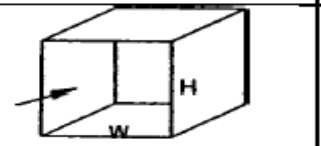
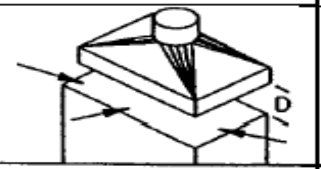
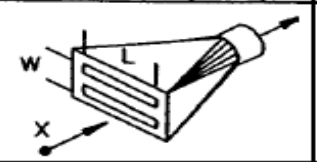
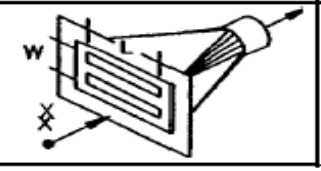
$V = 2400\ meters/second$

Local Exhaust Ventilation



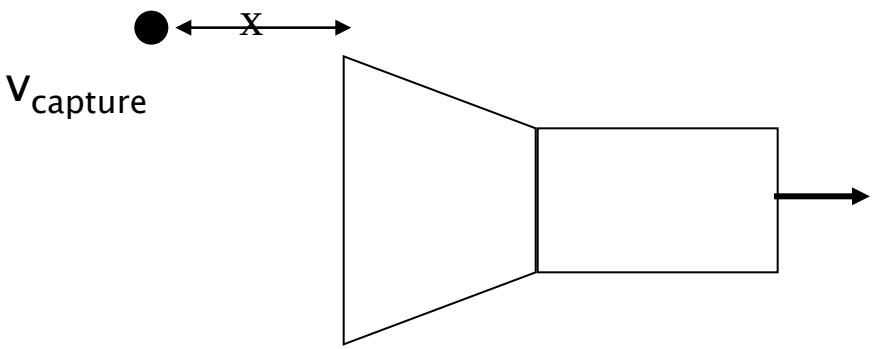


Capture of contaminant is only effective within <u>one (1) duct diameter</u>

HOOD TYPE	DESCRIPTION	ASPECT RATIO, W/L	AIR FLOW
	SLOT	0.2 OR LESS	$Q = 3.7\ LVX$
	FLANGED SLOT	0.2 OR LESS	$Q = 2.6\ LVX$
	PLAIN OPENING	0.2 OR GREATER AND ROUND	$Q = V(10X^2 + A)$
	FLANGED OPENING	0.2 OR GREATER AND ROUND	$Q = 0.75V(10X^2 + A)$
	BOOTH	TO SUIT WORK	$Q = VA = VWH$
	CANOPY	TO SUIT WORK	$Q = 1.4\ PVD$ SEE FIG. VS-99-03 P = PERIMETER D = HEIGHT ABOVE WORK
	PLAIN MULTIPLE SLOT OPENING 2 OR MORE SLOTS	0.2 OR GREATER	$Q = V(10X^2 + A)$
	FLANGED MULTIPLE SLOT OPENING 2 OR MORE SLOTS	0.2 OR GREATER	$Q = 0.75V(10X^2 + A)$

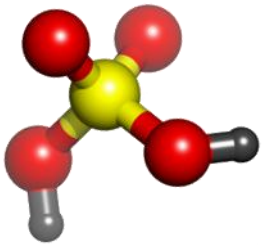
Local Exhaust Ventilation

Capture Velocity (V) : [Plain Opening]



$Q = V (10x^2 + A)$

X = distance of source from hood face



Recommended Capture Velocities

CONDITION	EXAMPLES	CAPTURE VELOCITY Range in meters/second
No velocity, Quiet air	Evaporation from tanks, degreasers	0.25 – 0.5
Low velocity, moderately still air	Spray booths, container filling, welding, plating	0.5 – 1.0
Active generation into rapid air motion	Spray painting (shallow booths), crushers	1.0 – 2.5
High initial velocity into very rapid air motion	Grinding, abrasive blasting, tumbling	2.5 – 10.1

Recommended Duct Velocities

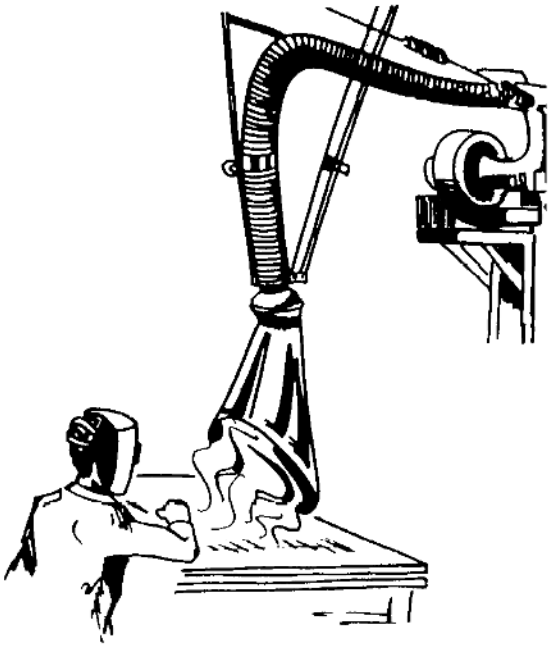
CONTAMINANT	EXAMPLES	DUCT VELOCITY Meters/second
Vapors, gases, smoke	Vapors, gases, smoke	5.0 – 10.1
Fumes	Welding	10.1 – 12.7
Very fine dust	Cotton lint	12.7 – 15.2
Dry dusts & powders	Cotton dust	15.2 – 20.3
Industrial dust	Grinding dust, limestone dust	17.8 – 20.3
Heavy dust	Sawdust, metal turnings	20.3 – 22.9
Heavy/moist dusts	Lead dusts, cement dust	> 22.9

Local Exhaust Ventilation

- Canopy hood:
  - Best for controlling hot processes
  - Not good for capturing dusts, or vapors
  - Not good where cross-drafts exist
  - Worker must not put head under canopy

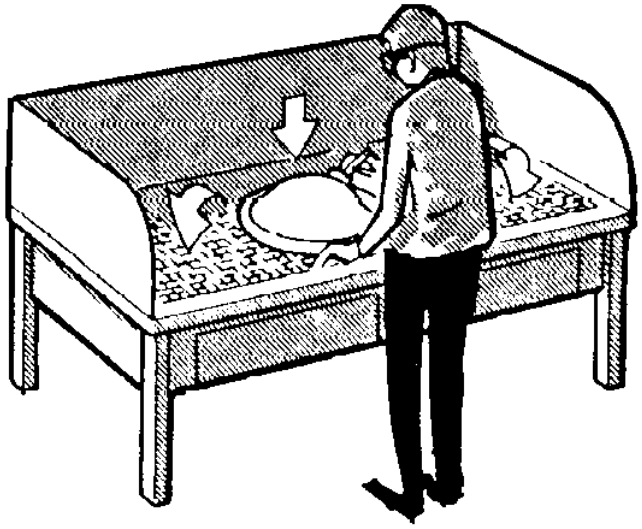
Local Exhaust Ventilation

- "Elephant trunk":
  - Good for welding fumes, small process tasks, machining, disconnecting process lines
  - Place close to contaminant
  - Ensure adequate capture velocity at distance from contaminant
  - *Flanged* opening captures contaminant better



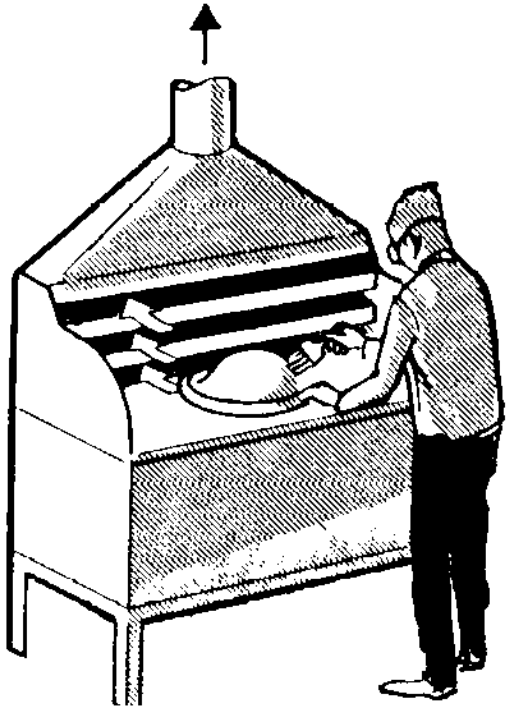
Local Exhaust Ventilation

- Downdraft hood:
  - Vapors pulled down through grill
  - Capture velocity depends on source distance from grill
  - Not for hot operations



Local Exhaust Ventilation

- Slot ventilation:
  - Best for liquid open surface tanks
    - Acid baths
    - Plating tanks
  - Pulls air across the tank away from worker
  - Side enclosures prevent cross drafts
  - Push-Pull design is optional (push jet)



Local Exhaust Ventilation

- Fume hood:
  - Laboratory use
  - Best for small amounts of chemicals
  - Sash must be kept at set level
  - NO storage of equipment in the hood!

Local Exhaust Ventilation

- Enclosures:
  - Example:
    - Paint booths
  - Control of exposure to liquid aerosols and vapors
  - Flammability hazard
  - Must have scheduled filter changeout
  - Operator must be upstream

Local Exhaust Ventilation

- Other vented enclosures
  - Glove boxes
  - Furnaces/ovens
  - Abrasive blasting

Photo credit: Borel Furnaces and Ovens

Photo credit: U. S. Department of Labor. OSHA

Local Exhaust Ventilation

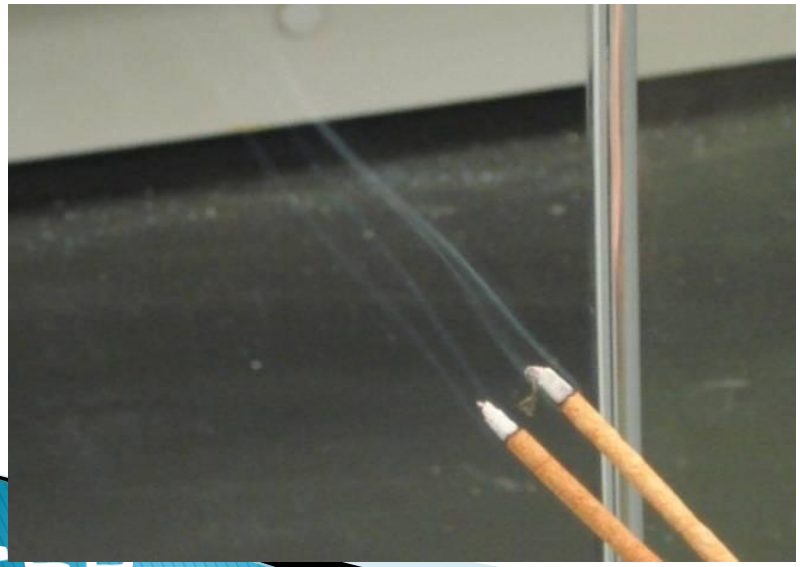
Exhaust Systems:

- Do not place exhaust stack near air intakes
  - Re-entrains contaminants into the building
- Do not use rain caps
- Stack height depends on:
  - Contaminant temperature
  - Building height
  - Atmospheric conditions
  - Discharge velocity
  - Ideal discharge velocity is 15 meters per second

Ventilation System Evaluation

- Evaluate capture velocity
  - Quantitatively-anemometers, velometers
  - Qualitatively-smoke tubes,
    - Visualizes air movement
    - Use water vapor for clean rooms

Photo Credit: All Products Inc.

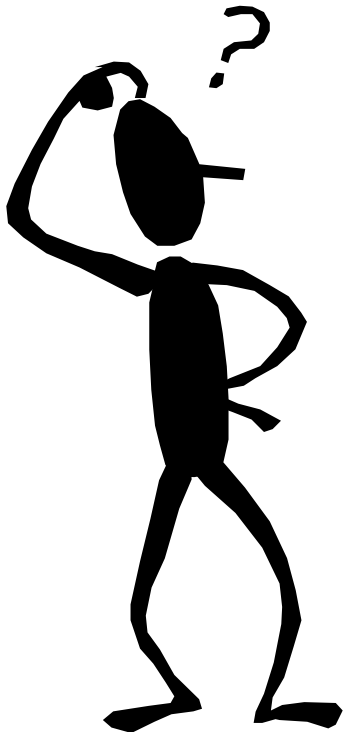


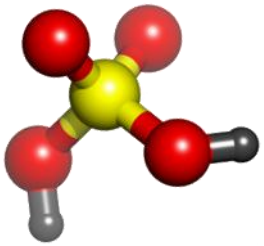
Ventilation System Evaluation

- Air velocity measurements
  - Measure air velocities (meter/sec) at a number of points
  - Average the results and determine volumetric flow rate: Q = VA
  - All instruments must be calibrated periodically
  - Types:
    - Swinging vane velometer
    - Hot-wire anemometer

Troubleshooting

- Wrong hood for process
  - Example: canopy hood for toxics
- Insufficient capture velocity
- Insufficient duct velocity
  - ~14 meters/second for vapors
  - ~18 meters/second for dust
- Too much air flow = turbulence
- Traffic or competing air currents
- Insufficient make up air
  - Negative pressure
  - Can't open doors

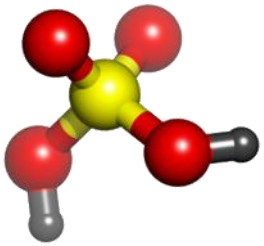




Exercise

- What is the preferred ventilation system for the following situation?
  - Dilute non-toxic odors in the warehouse

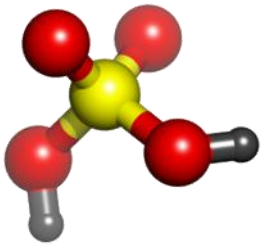
A) General ventilation
B) Local exhaust ventilation



Exercise

- What is the preferred ventilation system for the following situation?
  - Acid processing bath with open surface area

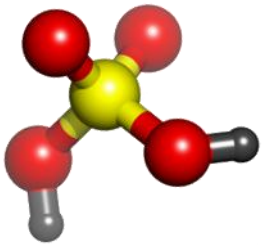
A) Lab fume hood
B) Slot ventilation
C) Elephant trunk
D) Canopy hood
E) Paint booth



Exercise

- What is the preferred ventilation system for the following situation?
  - Welding table

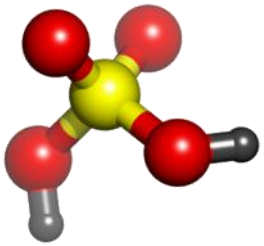
A) Lab fume hood
B) Slot ventilation
C) Elephant trunk
D) Canopy hood
E) Paint booth



Exercise

- What is the preferred ventilation system for the following situation?
  - Chemical analysis of small samples for quality control

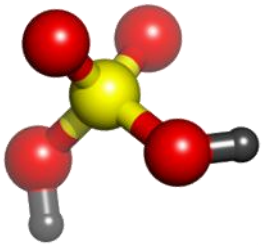
A) Lab fume hood
B) Slot ventilation
C) Elephant trunk
D) Canopy hood
E) Paint booth



Exercise

- What is the preferred ventilation system for the following situation?
  - Spray painting a large piece of equipment

A) Lab fume hood
B) Slot ventilation
C) Elephant trunk
D) Canopy hood
E) Paint booth



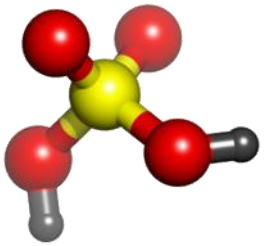
US Standards & Guidelines

ACGIH
American Conference of Governmental Industrial Hygienists
Industrial Ventilation, A Manual of Recommended Practice

AIHA
American Industrial Hygiene Association
Standard Z9.2, Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems

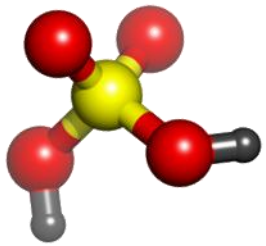
ASHRAE
American Society of Heating, Refrigeration and Air Conditioning Engineers
Standard 62.1-2010*, *Ventilation for Acceptable Indoor Air Quality

OSHA
Occupational Safety and Health Administration
Ventilation, 29 Code of Federal Regulations 1910.94
http://osha.gov/



Summary of Presentation

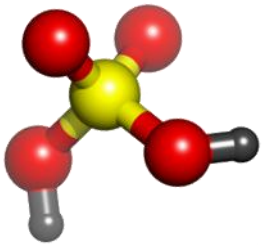
- Provided ventilation definitions and terminology
- Summarized the purpose of ventilation
- Described general exhaust ventilation
- Described local exhaust ventilation
- Demonstrated volumetric flow rate and capture velocity calculations
- Described how to evaluate a ventilation system
- Provided examples of ventilation problems (troubleshooting)
- Listed ventilation standards and guidelines



Chemical Inventory System Demonstration

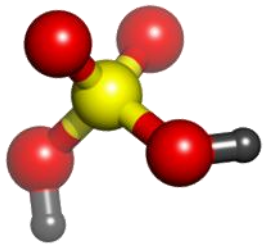
CSP
CHEMICAL SECURITY
ENGAGEMENT PROGRAM

Sandia
National
Laboratories



Breakout Sessions

- Group 1: Laboratory Assessment Exercise
- Group 2: Process Hazard Analysis Exercise

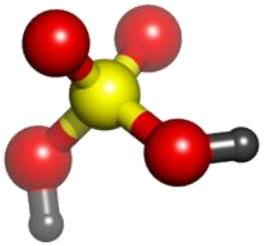


Laboratory Assessment Exercise, Part 1

SAND No. 2012-5234C
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.

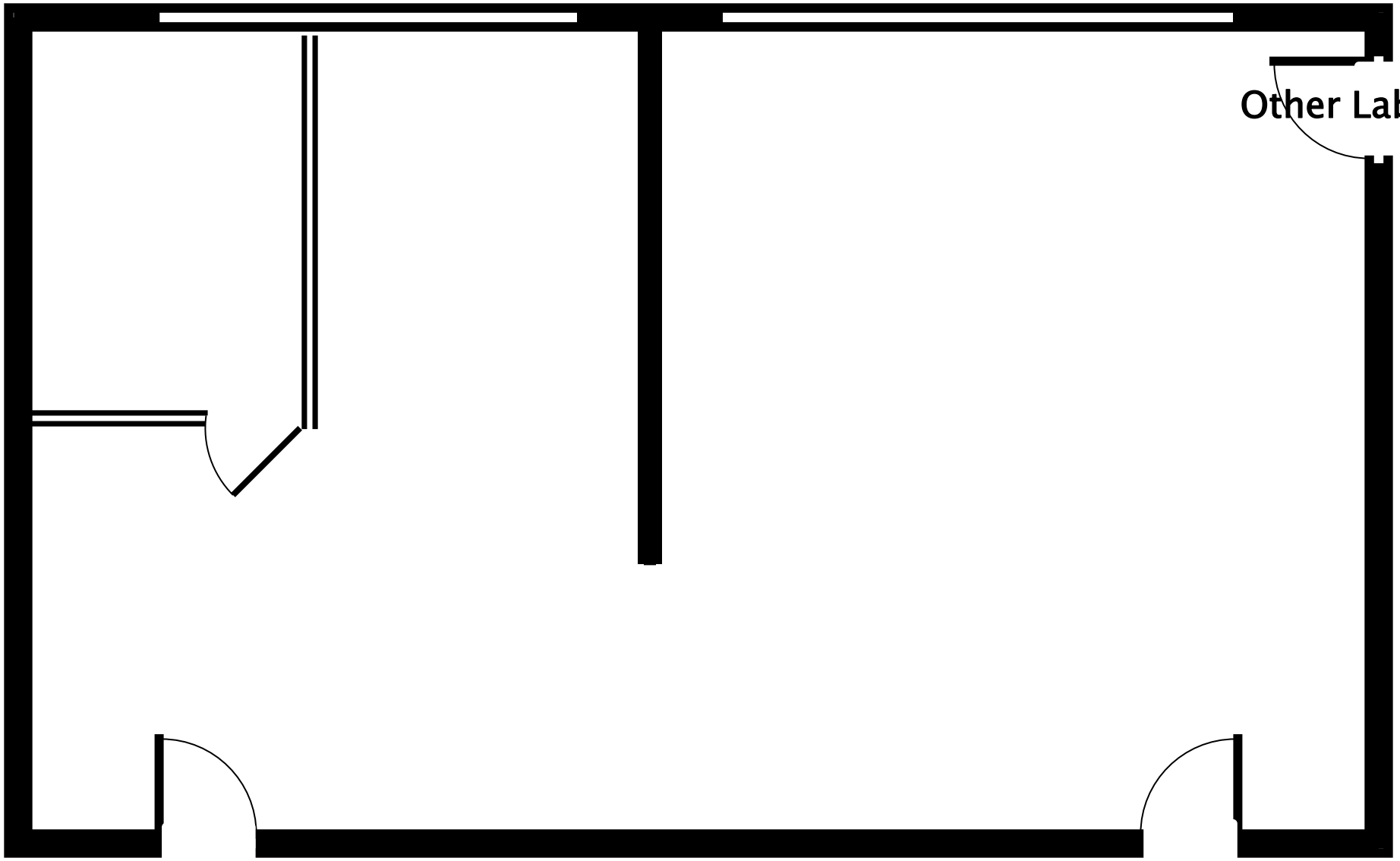
CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Sandia National Laboratories

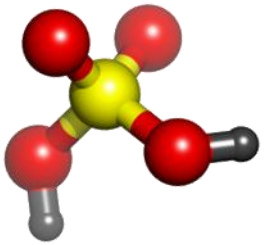


Activity: Laboratory Assessment Exercise

- Form groups of 3-4 people
- Draw the floor plan of a chemical laboratory on a large sheet of paper
  - Use an actual floor plan of a laboratory that someone in the group works in, if possible
  - Identify the main laboratory features such as doors, windows, lab benches, refrigerators, chemical hoods, instruments and other equipment, etc.



Chemical Lab Floor Plan



Laboratory Assessment, Part 2

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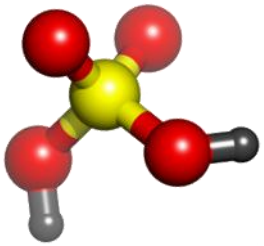
CSP
CHEMICAL SECURITY
ENGAGEMENT PROGRAM

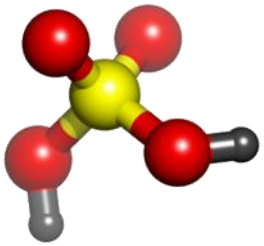
Sandia
National
Laboratories



Part 2: Laboratory Assessment Exercise

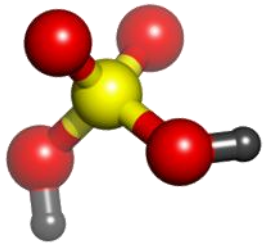
- Once the floor plan is done, get hazard stickers from the instructor and apply them to the appropriate places in your laboratory floor plan

- Write down a list of the hazards present



Part 2: Laboratory Assessment Exercise

- Identify the safety controls present in your laboratory
- Apply stickers describing the safety controls to your laboratory floor plan



Laboratory Assessment: Part 3

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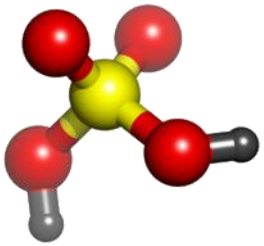
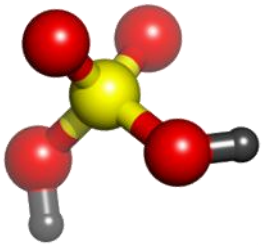
CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Sandia National Laboratories



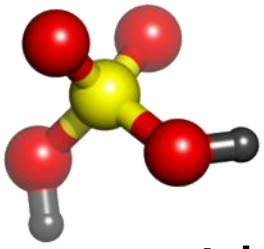
Part 3a: Laboratory Assessment Exercise

- Circle on your layout with a blue pen, the controls that your laboratory does well.



Part 3b: Laboratory Assessment Exercise

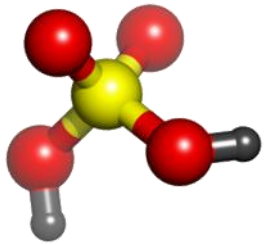
- What could your laboratory do better? For example, what hazards are <u>not</u> controlled well?
  - Circle on your layout in **red** pen the hazards that are not controlled well.



Part 4: Laboratory Assessment Exercise

List and Prioritize Tasks for an Action Plan

- **Easiest** → **Medium** → **Difficult**
  - Inventory all chemicals
  - Remove expired chemicals
  - Separate incompatible chemicals
  - -Buy flammable cabinet
  - -Develop training program
  - -Set up inventory system
  - -New hood
- List who will be on the Chemical Safety Team:
  - Who will be responsible for completing action items?
- Set timeline for completion:



Process Hazard Analysis Exercise

SAND No. 2011-0991 C

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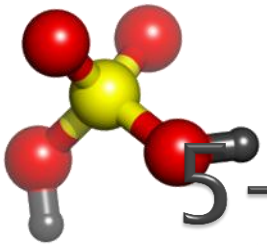
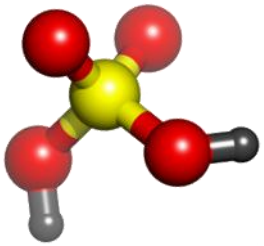
Sandia National Laboratories



5-Why and What-If Analysis

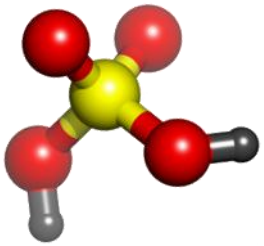
Break-Out Exercises for Hazard Evaluations



5 Why Analysis

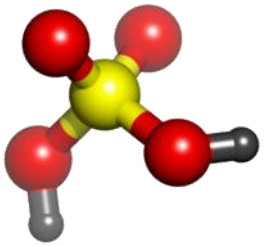
Concept: The 5 Why analysis method is used to move past symptoms and understand the true root cause of a problem

- **First developed by Toyota Motor Company**
- **Five iterations of asking "why" is generally sufficient to determine root cause**
- **Can do additional iterations as necessary**
- **"People do not fail, processes do"**



5 Why Analysis

- **Benefits**
- Quickly identify the root cause of a problem
- Determine the relationship between different root causes of a problem
- Can be learned quickly and does not require statistical analysis
- **Most useful…**
- When problems include human factors or interactions

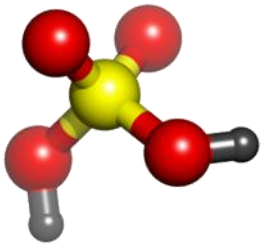


5 Why Analysis

- **Benjamin Franklin's 5-Why Analysis:**

- For want of a nail a shoe was lost,
  for want of a shoe a horse was lost,
  for want of a horse a rider was lost,
  for want of a rider an army was lost,
  for want of an army a battle was lost,
  for want of a battle the war was lost,
  for want of the war the kingdom was lost,
  and all for the want of a little horseshoe nail.
- *The text above is a common extension of the original theme from Poor Richard's Almanac*

5 Why Analysis



Problem Solution - 5 Why's Analysis Worksheet

Part Number:	Date:	Area:	Product/Process:
Problem Description:			

Use this route to specify the nonconformity that is being investigated.

Root Causes

Use this route to investigate why the problem wasn't detected

Use this route to investigate the root cause of the system.

Therefore / Why? (repeated)

A

B

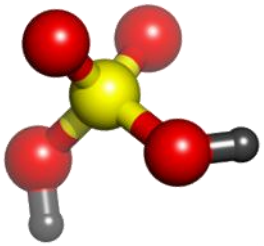
C

Corrective Action & Responsibility	Date
A	
B	
C	

Problem Solution Completed:	Solution Date:	Break point of the change in the process:	Implementation Date:

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

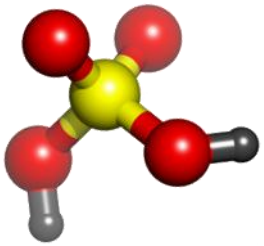
SAFETY AND SECURITY TRAINING



What-If Analysis

Concept: Conduct thorough, systematic examination by asking questions that begin with ***"What if..."***

- **Often conducted by a relatively small team (3-5)**
- **Process divided up into "segments" (e.g., unit operations)**
- **Review from input to output of process**
- **Question formulation left up to the team members**



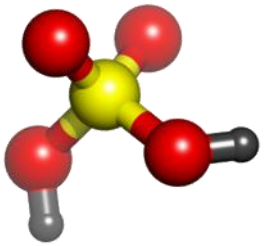
What-If Analysis

- Question usually suggests an **initiating cause**.

  "What if the raw material is in the wrong concentration?"

- If so, the postulated response develops a **scenario**.

  "If the concentration of oxidant was doubled, the reaction could not be controlled and a rapid exotherm would result..."

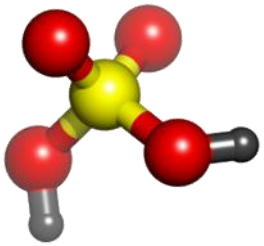


What-If Analysis

Answering each “What if …” question:

1. **Describe potential consequences and impacts.**
2. **If a consequence of concern, assess cause likelihood.**
3. **Identify and evaluate intervening safeguards.**
4. **Determine adequacy of safeguards.**
5. **Develop findings and recommendations (as required).**
6. **Raise new questions.**

Move to next segment when no more questions are raised.



Adequacy of safeguards

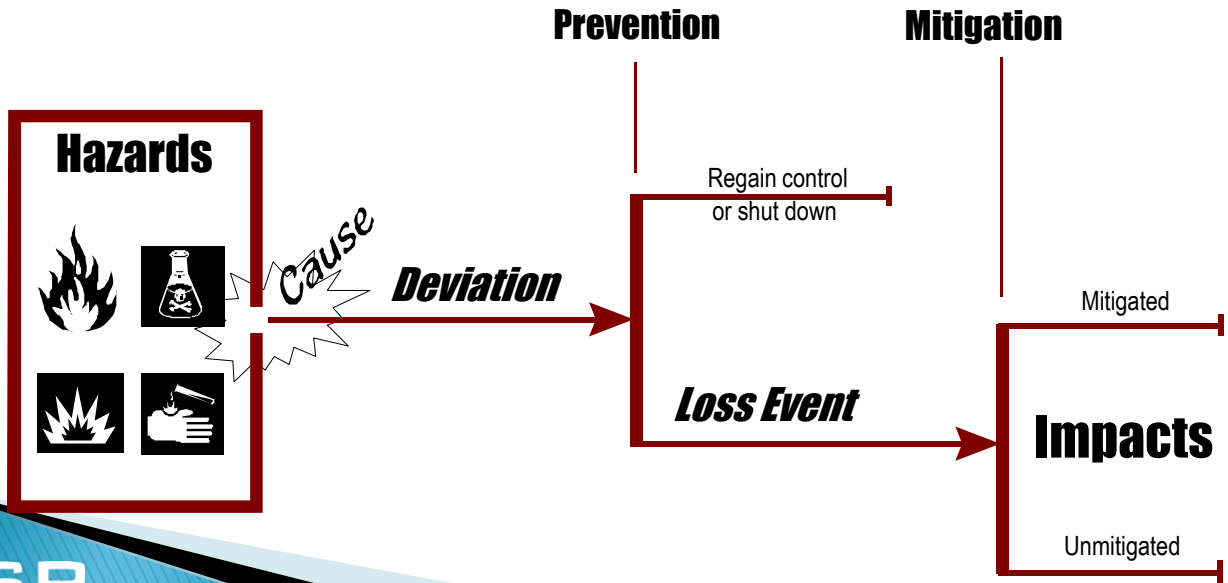
Determining the adequacy of safeguards is done on a scenario-by-scenario basis.

- ***Scenario risk*** is a combination of:
  - **Initiating cause frequency**
  - **Loss event impact**
  - **Probability of inadequate safeguards**
- If the ***scenario risk*** is found to be too high, safeguards are considered inadequate.

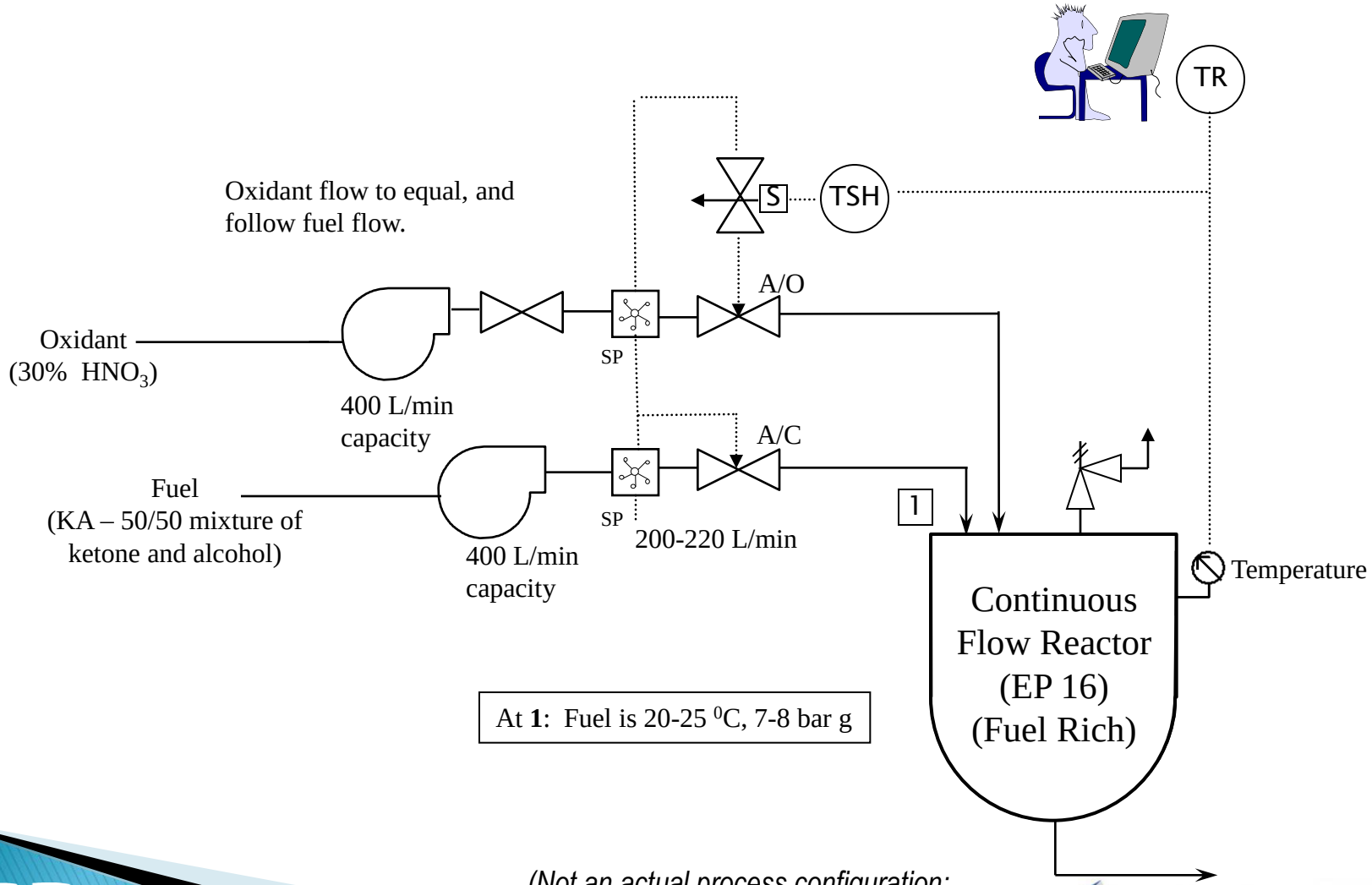
Safeguards

When your PHA team evaluates the effectiveness of a safeguard, consider whether the safeguard is:

- ***Fast*** enough?
- ***Independent*** ?
- ***Effective*** for this scenario?
- ***Reliable*** enough?



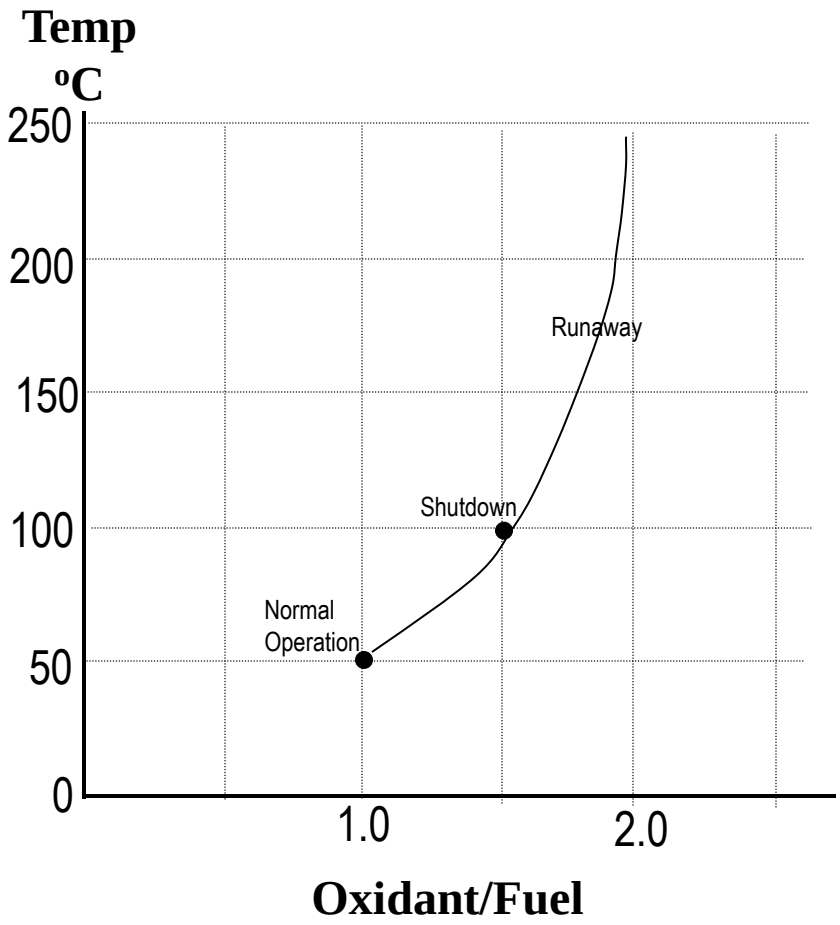
Example: Continuous process

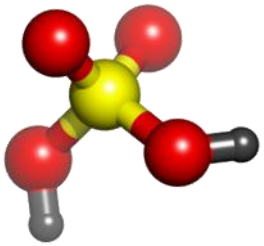


(Not an actual process configuration; for course exercise only)

Example: Continuous process

EP 16 produces adipic acid by an exothermic (heat-releasing) reaction of an oxidant (30% nitric acid) and a fuel (mixture of ketone and alcohol). An oxidant-to-fuel ratio greater that 2.0 in the reactor causes the reaction to run away (rapid temperature and pressure build-up). The high temperature shutdown system is intended to protect the reactor by stopping the oxidant flow if the reactor temperature reaches 100 °C. NOTE: RELIEF VALVE CANNOT CONTROL RUNAWAY REACTION.





EXERCISE

1. Suggest how this process might be divided into **study segments** for a What-If Analysis.
2. Choose **one** study segment and generate **four "What-If" questions** for that segment.
3. Answer two of your "What-If" questions ***as if no safeguards were present.***
4. List any existing **preventive safeguards** that apply to the cause-consequence pairs you developed with your questions and answers.
5. Do you think the safeguards are adequate?

PROCESS SEGMENT:	SCOPE:	What-If Analysis
REVIEW DATE:	INTENT:	

What If …	Consequences	Safeguards	Finding/Recommendation Comments