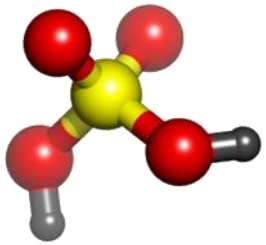

Emergency Management

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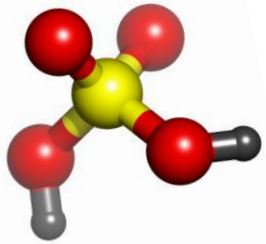

Overview of Presentation

- *Emergency* Defined
- Types of Emergencies
- Emergency Management
  - Emergency Planning
  - Incident Command System
  - Emergency Response
- Emergency Management Exercise

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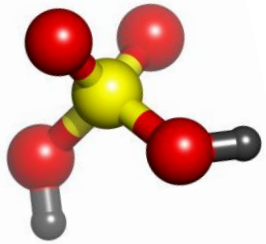
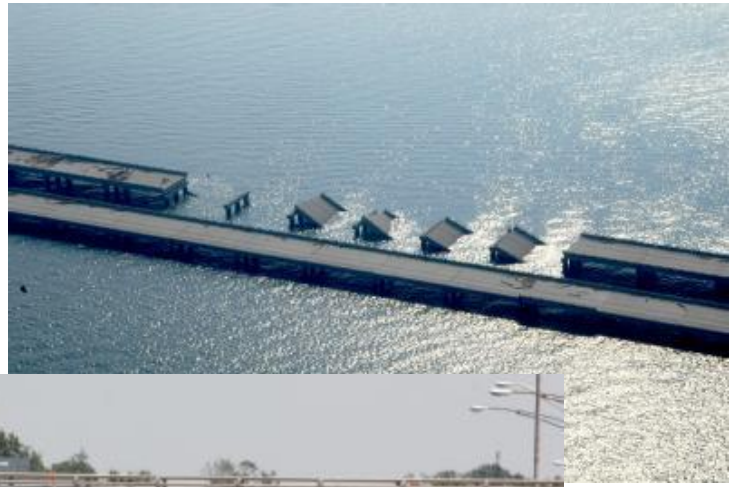


Emergency Defined

"An unforeseen combination of circumstances or the resulting state that calls for immediate action"

"An urgent need for assistance or relief"

"May occur without advance warning"



Merriam Webster definition
Photo Credit:http://www.fema.gov/

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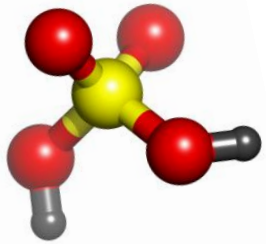

Emergencies

- Hazardous materials releases
  - Accidental
  - Intentional
- Fires
- Explosions
- Medical

- Natural Occurrences
  - Earthquakes, typhoons, fires, floods, etc.
- Other incidents
  - Bomb threat
  - Terrorism

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Emergency Management

- Planning
  - A continuous process
  - Purpose:
    - Avoid the emergency
    - Reduce the impact
- Response/Mitigation
  - Requires highly-trained personnel
- Recovery/Stabilization
  - Community or government support

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Emergency Planning

General Plant Emergency Plan

- Involve engineering, safety, & security
- Distribute to and train all employees
- Include in the plan:
  - Roles and responsibilities
  - Procedures for reporting emergencies
  - Emergency phone numbers
  - Procedures for specific emergencies
  - Maps
    - Evacuation routes
    - Assembly areas

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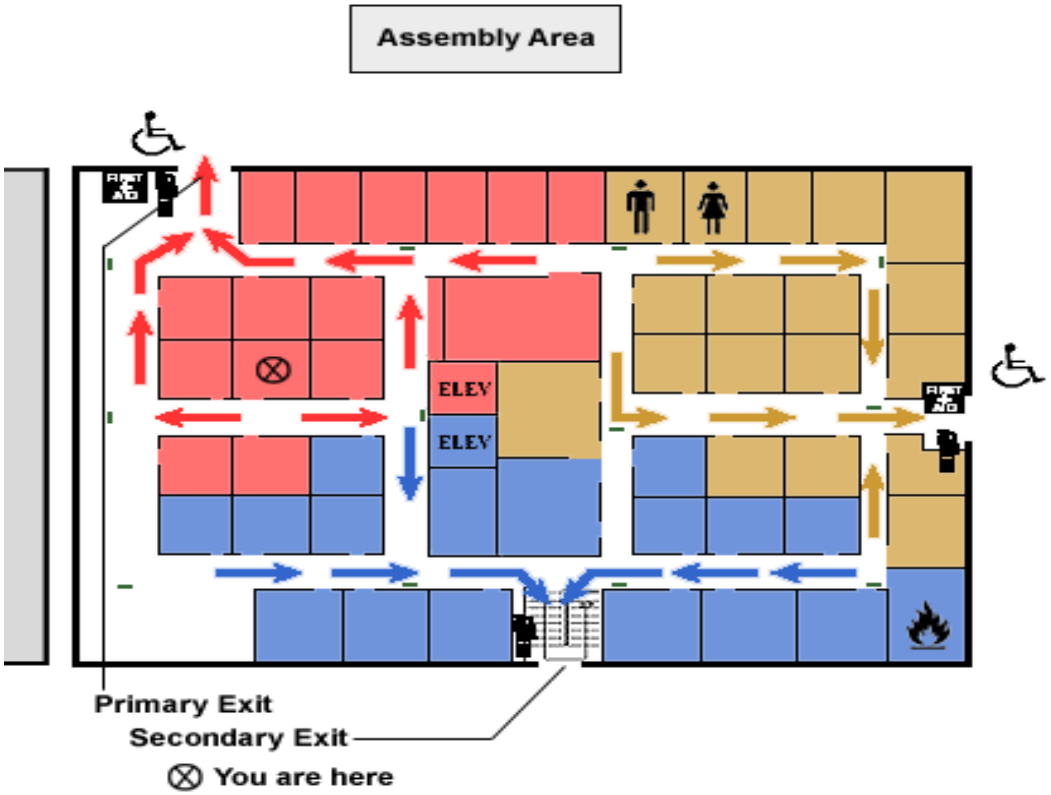
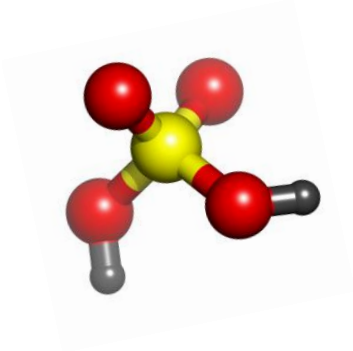
Emergency Planning

Have an evacuation map for all buildings and areas and

POST IT





Emergency Planning

Post each area with:

- Emergency phone numbers
- After hours phone numbers
- Person(s) to be contacted
- Alternate person(s)
- Unique hazards & procedures

Location	
Hazards Within:	
Primary Contact:	
Second Contact:	
Building Monitor/Safety:	
Department Head:	
Fire/Police/Ambulance:	911
Envir. Health & Safety (or RSO, if needed):	646-3327

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8

Emergency Planning

Plant Emergency Response Procedures

- Evacuate or shelter in place?
- Respond?
- Who will respond?
  - On-site HAZMAT team?
    - Require training
  - Community fire department?
    - Establish memorandum of understanding
- Medical support
  - In-house?
  - When to call for outside assistance
- Emergency shutdown procedures
- Decontamination procedure

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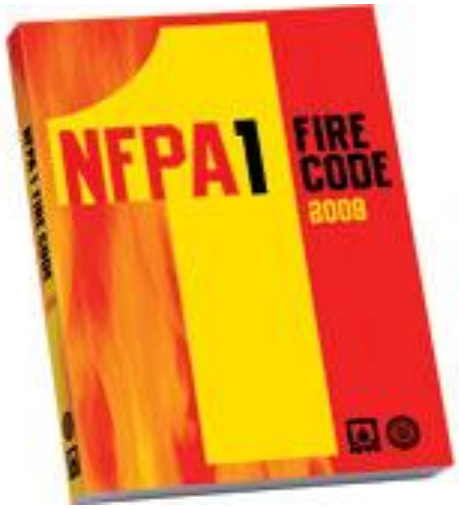
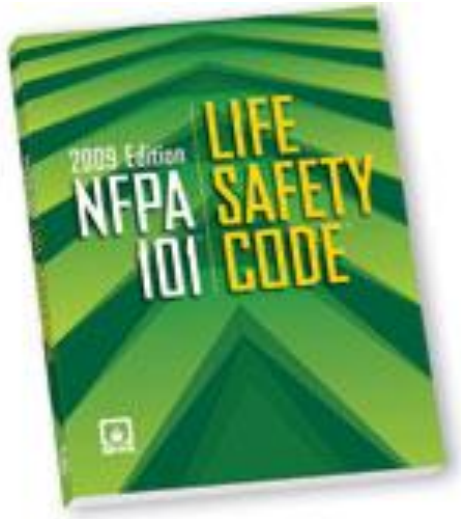
Emergency Planning

General Fire Protection

- Identify your fire and life safety codes
- Inventory your flammable materials
  - Quantity
  - Location
- Secure appropriate flammable liquid storage
- Identify & control ignition sources
- Housekeeping
  - Control combustible materials





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Emergency Planning

Post exit signs

Keep exits unlocked or equipped with panic bars.

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Emergency Planning

Detection & Mitigation Equipment

Alarms, smoke & heat detectors, sprinklers, emergency lighting and fire extinguishers need to be properly located, maintained, and serviced regularly.

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Emergency Planning

Response Equipment

- Initial hazard assessment
- Place in accessible locations
  - Fire extinguishers
  - Spill control kits
  - PPE
  - Respirators
  - DECON showers
- Schedule routine maintenance and inspection of all response equipment

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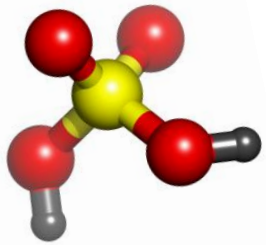

Emergency Planning

American Industrial Hygiene Association Emergency Response Planning Guidelines

- *ERPG-1*

  The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.

- *ERPG-2*

  The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

- *ERPG-3*

  The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

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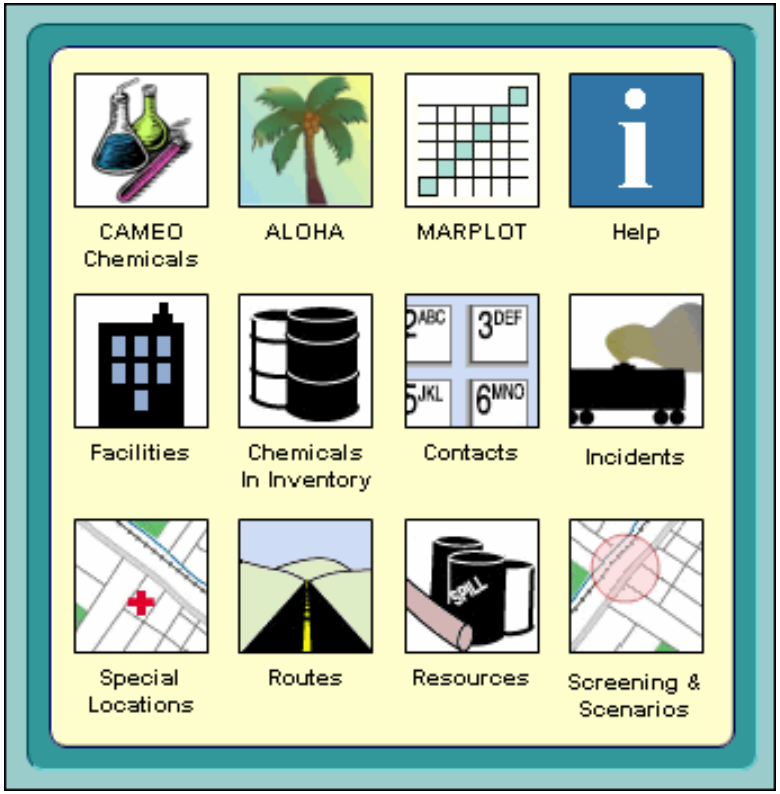
Emergency Planning

Software Applications

- Assist first responders with accessible and accurate response information
  - Interactive *Cameo* software modules
  - *Cameo Data Management*
    - Location of chemicals
    - Chemical quantities
    - Storage conditions



http://www.epa.gov/emergencies/content/cameo/request.htm

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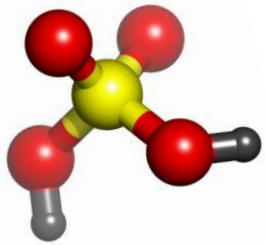
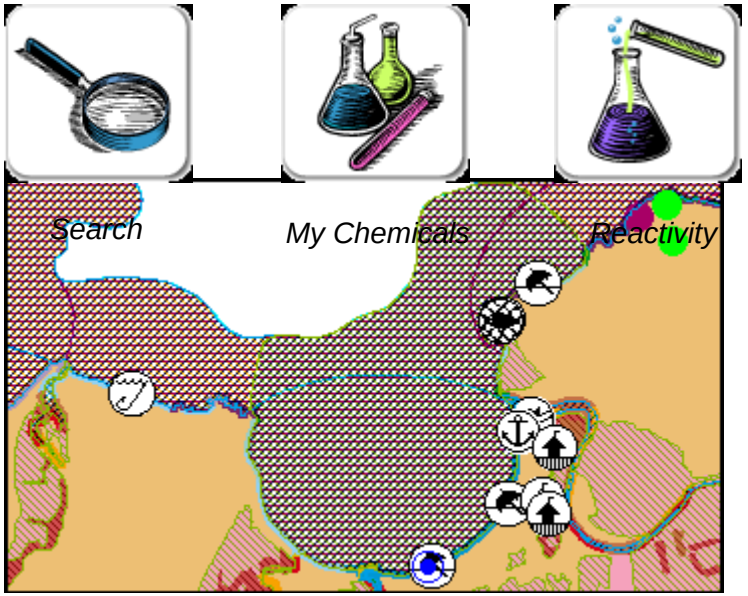


Emergency Planning

- Cameo Chemicals
  - Supplies information on the substance released and safe response actions
  - Outputs *chemical response datasheets*
  - http://cameochemicals.noaa.gov
- Mapping applications
  - *MARPLOT*
  - Can overlay a contaminated area over a map
  - Displays threat zones



http://www.epa.gov/emergencies/content/cameo/request.htm

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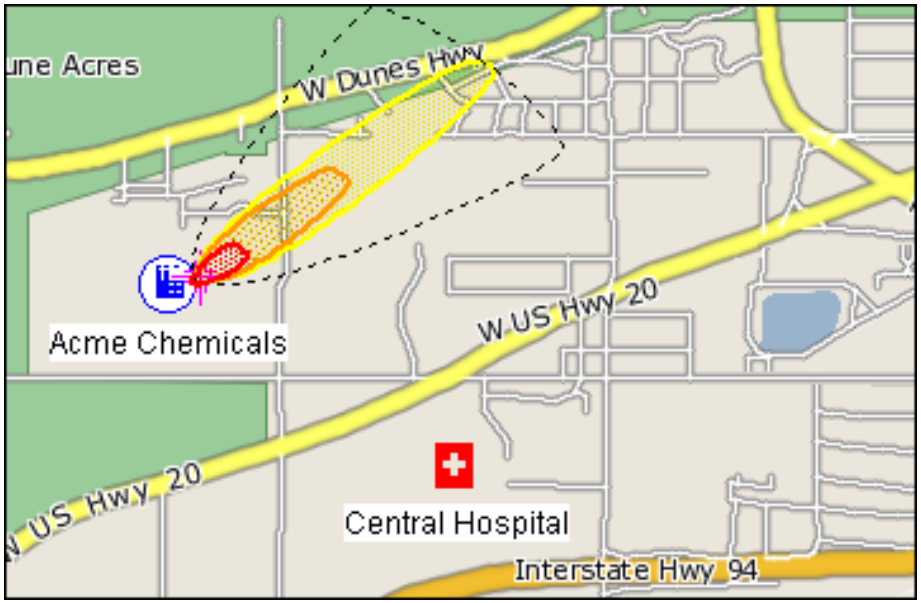
Emergency Planning

- Atmospheric dispersion models
- *Aloha* software
- Estimates threat zones associated with chemical releases, including toxic gas clouds, fires, and explosions



http://www.epa.gov/emergencies/content/cameo/request.htm

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Emergency Planning

Aloha Software:

- Example of Inputs
  - Enter date, time, location
  - Choose a chemical (Aloha library)
  - Enter atmospheric information
  - Choose a source:
    - direct, puddle, pipeline, or tank
  - Enter source information
    - Release amount, chemical fire
  - Specify the Levels of Concern (LOCs)
  - Choose the type of hazard
    - Toxic vapor cloud or a vapor cloud explosion

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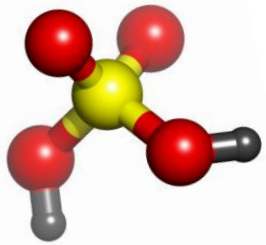

Emergency Planning

Unity of Effort:

- Success in managing an emergency depends on clear roles and responsibilities and a clear chain of command.
- Use of an Incident Command System (ICS) allows coordination among different jurisdictions and functional responsibilities to interact effectively on the scene.

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Emergency Planning

Incident Command System:

- Developed to resolve:
  - Ineffective communication
  - Lack of common command structure
  - Lack of accountability
  - Inability to coordinate resources
- Based on basic business management
  - Plan
  - Direct
  - Organize
  - Communicate
  - Delegate
  - Evaluate

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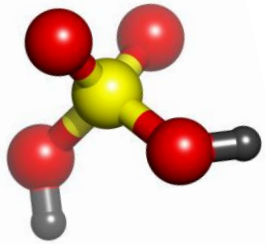
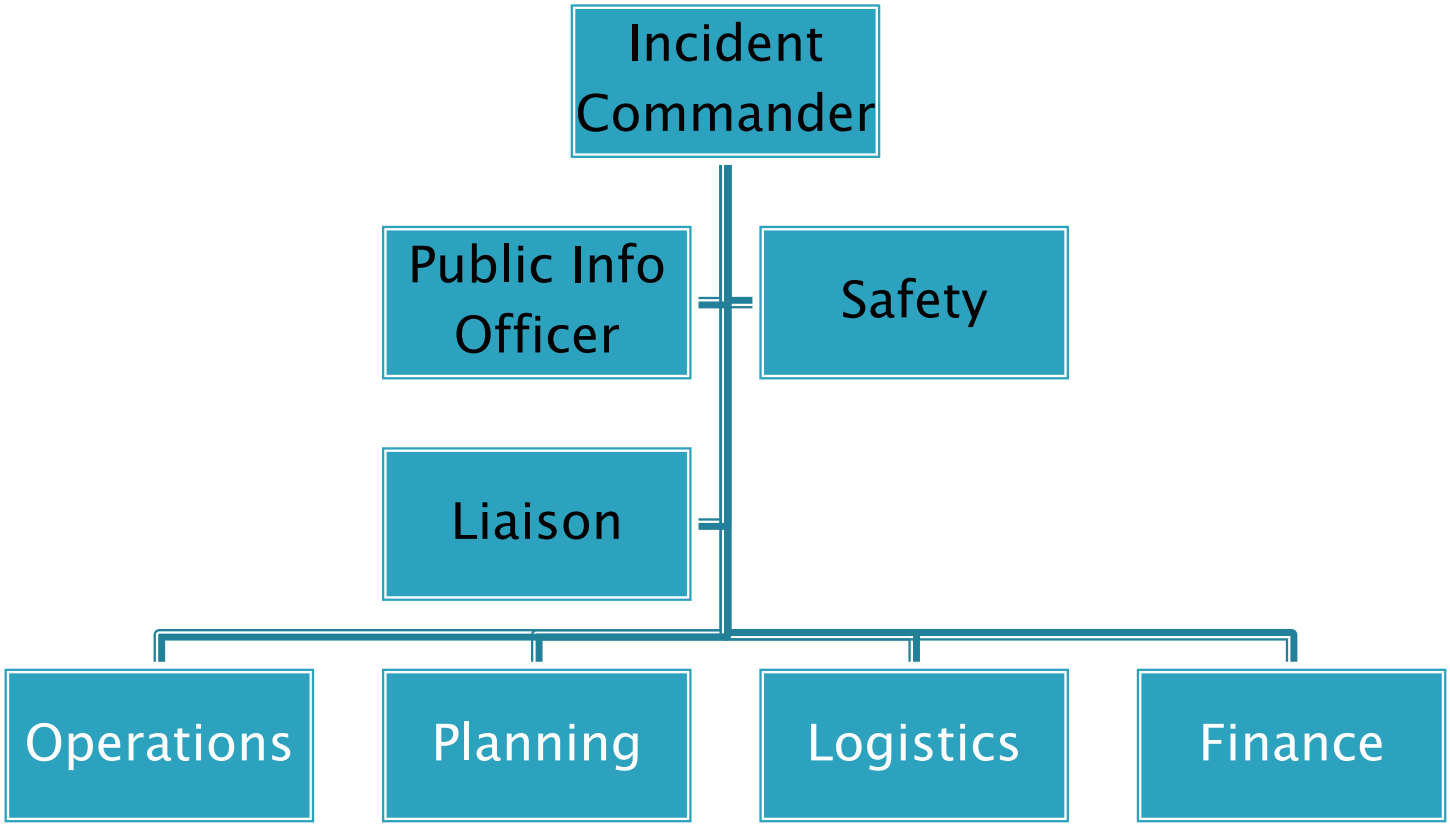


Incident Management System



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Emergency Planning

Community Involvement

- Prepare for emergencies involving local communities
  - Communicate!
  - Develop an emergency planning committee
  - Select notification method to community
  - Inform community of hazardous materials at your plant
    - Safety data sheets
    - TOXNET

http://toxnet.nlm.nih.gov/index.html

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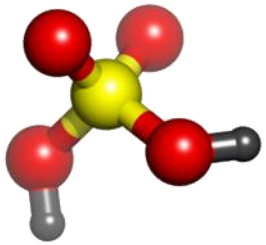

Emergency Response

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Response to Hazardous Materials Incidents

What makes hazardous materials incidents so dangerous?

- Material characteristics may be unknown
- Chemical, physical hazards, biological (?) hazards
  - Toxic
  - Corrosive
  - Flammable
  - Reactive

- Conditions may be confusing
- Limited time to respond to the incident

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Who Will Respond?

- Employees?
- Local police and fire department?
- Local ambulance, hospital?
- Military?
- Local HAZMAT team?
- Plant HAZMAT team?

<u>OR, ALL OF THE ABOVE</u>

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Emergency Response Decision Making

DECIDE Process

- Detect hazmat presence
- Estimate likely harm
  - Material properties
  - Containment
  - Weather
  - Modeling data
- Decide on objectives
- Identify action options
- Do best option
- Evaluate progress

Benner, L. (1978) ***DECIDE for Hazardous Materials Emergencies, Presented Papers.***

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Emergency Response Decision Making

Detect Hazardous Material Presence

- Worker reports incident/spill/injury
- Odors, smoke, flames, reactions
- Response team detection
  - Instrumentation must be calibrated!
  - Direct reading instruments
    - LEL, oxygen monitors
    - Photoionization detectors
    - Gas detectors-methane, $NH_{3,,}CO$, Cl_2, H_2S
  - Personal sampling and analysis

Industrial Scientific. http://www.indsci.com/products/#multi
RAE Instruments. http://www.raesystems.com/products
Sensidyne Air pumps. http://www.sensidyne.com

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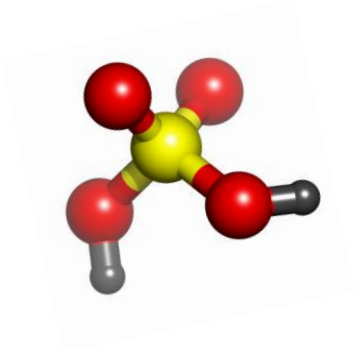
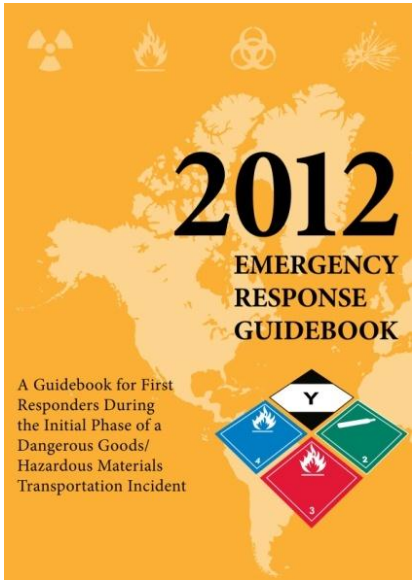


Emergency Response Estimate Likely Harm

- Determine material properties
  - Safety data sheets
  - Emergency Response Guidebook
  - ERPGs
- Access site conditions
  - Size of spill / release
  - Weather
  - Models
    - Cameo software



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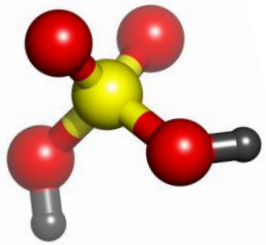

Emergency Response Estimate Likely Harm

Evaluate chemical(s) released:

- **By quantity**
  - Greater than 500 grams ? (40 CFR 302 & 355)
- **Toxicity**
  - $LC_{50} \leq 200$ ppm or 20mg/liter
- **Dispensability**
  - Boiling point $\leq 100^{o}$ C, $\leq$ 10 microns particle size
- **Flammability/Reactivity**
  - Flashpoint < 60^{o} C
- **Dispersion Modeling**
  - Example: AIHA ERPG 1 at 30 meters

(ERPG–1: 2 ppm; ERPG–2: 50 ppm; ERPG–3: 170 ppm)

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Emergency Response Decide on Objectives

Priorities

1. Persons
   - Responders
   - Workers
   - Community
2. Property
   - At the site
   - Protecting community
3. Environment
   - Air, ground and surface water, soil, wildlife

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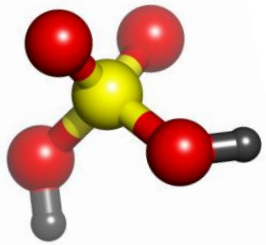

Emergency Response

Initiate the Incident Command System:

- Incident Commander
  - Establishes the strategy and tactics
  - Has ultimate responsibility for incident outcome
  - The position is established for every incident
  - May establish a command post
- Command Staff positions
  - Safety officer
  - Liaison officer
  - Information officer

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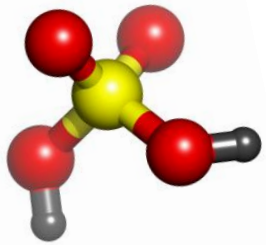
Identify Action Options- Size of spill may determine response



Emergency Response Identify Action Options

Large Catastrophic Incidents

- Perform a risk analysis of response options
  - Risk analysis should be a continuous process during an event
- Response options are dependent on plant capabilities and approach
  - Mode of response-defensive or offensive?
  - Training levels of responders (HAZMAT trained?)
  - Technical resources
  - External support available?
    - Local fire department or HAZMAT
    - Military

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Defensive or Offensive Approach?

Identify Action Options
Defensive Options Large Event

- Persons
  - Evacuate if possible
  - Shut off air intakes
  - Shelter-in-place/safe rooms
- Property/Equipment
  - Emergency shut offs
  - Emergency ventilation
  - Purging hazardous gas systems
- Environment
  - Diking water sources

http://earthbagbuilding.wordpress.com/
http://www.sb.fsu.edu/~xray/emergency.html
http://www.lpgventures.com/compliance/page2.html

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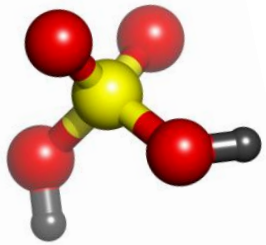

Identify Action Options Offensive Options Large Event

- Written Standard Operating Procedures
  - For each hazardous material or process on-site
- Select action from alternative strategies
- Select PPE/equipment for responders
  - http://osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9767
  - Ensure compatibility of PPE with hazards
- Safe approach is to select the highest PPE level
- Then, reduce the level when sufficient information on the hazard

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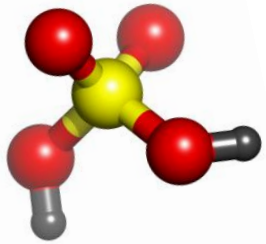

Identify Action Options Laboratory Incidents

- Perform an emergency response risk assessment
  - Identify potential hazards associated with laboratory tasks
  - Identify equipment and personal protective equipment required in the event of an incident
  - Document response and evacuation procedures (SOPs)
  - Train laboratory personnel to procedures
  - Report incidents and revise procedures as needed

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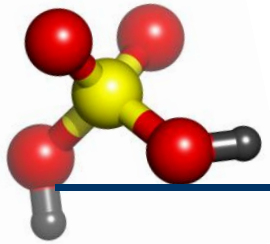
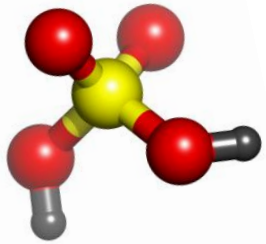


Identify Action Options Laboratory Incidents

- What is the worst thing that could happen?
  - inconvenience
  - skin burns
  - fire
  - explosion
  - chemical exposure (fatality; injury, disability)
- How you would respond to an emergency situation?
- Evacuate?
- What are the appropriate clean-up and decontamination procedures?



Identify Action Options Laboratory Incidents Spills

- Ensure you have considered
  - Internal and external communication
    - Telephone (Label all phones with emergency numbers)
    - Alarms
- Emergency equipment
  - Eyewash
  - Safety Shower
  - Spill Kits
  - Fire Extinguisher/fire blankets
  - First Aid Kits

Always know their location!

Are there are maintenance or inspection requirements?

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Identify Action Options Laboratory Incidents-"Small" Spills

- Small spills are less than 4 liters of chemical substance
- Must have appropriate PPE, spill equipment and training
- Do not clean up small spills of :
  - Acutely toxic (Low LD_{50}) chemicals
  - Carcinogens
  - Flammable liquids
  - Flammable metals
  - Chemicals of unknown toxicity or hazard

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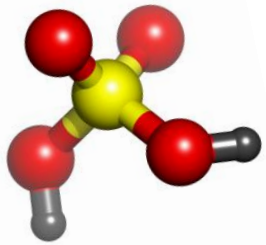

Post-Incident Follow-up

- Have a debriefing meeting
- Perform post-incident investigation
  - Prepare a report of the incident
  - Revise response plans
  - Share lessons learned
  - Keep all records
  - Correct response deficiencies
  - Mitigate identified hazards

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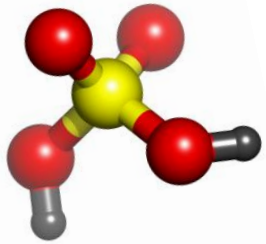

Summary of Presentation

- Defined “Emergency”
- Described the types of emergencies
- Discussed the elements of “Emergency Management”
  - Emergency Planning
  - Incident Command System
  - Emergency Response
  - Post incident follow-up

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Video – A North Carolina town is evacuated due to fire at waste site

Video file = EmergencyinApe_pdl.wmv 17 min

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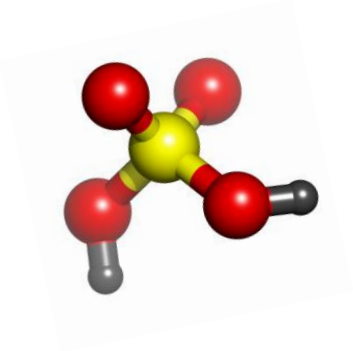

TEA BREAK

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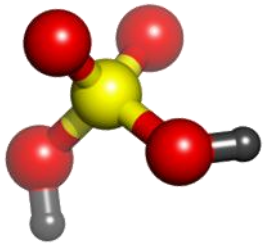
Laboratory Incident Emergency Response Exercise



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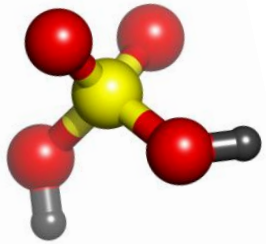

Emergency Management Exercise Laboratory Incident

- This exercise was taken from an actual incident that occurred at a University in the United States in December 2008.
- The incident resulted in the death of a 23 year old chemistry research assistant.
- The University was fined for numerous safety violations.
- The research assistant's advisor faces criminal charges.

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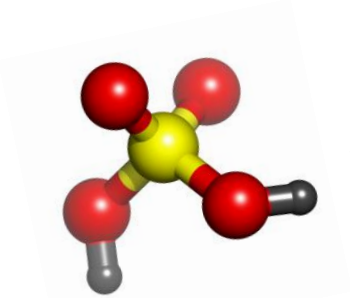

Summary of Incident

A research assistant in the University Chemistry Department was instructed to scale up a chemical reaction. She had only performed the chemical reaction once before on a small scale. The chemical reaction required the use of the pyrophoric (flammable in air) chemical tert-butyl lithium (tBuLi). The reaction was conducted in a nitrogen manifold (inert atmosphere) in a laboratory fume hood.

Personal Protective Equipment: The research assistant was wearing nitrile gloves and street clothing on the day of the incident. She was not wearing safety glasses or goggles.

On the day of the incident, the research assistant was using a syringe to remove tBuLi from a container when the syringe plunger came out of the barrel and the tBuLi was exposed to the air. The tBuLi caught fire. An open container of hexane fell over in the laboratory fume hood and caught fire. The research assistant's clothing caught fire.

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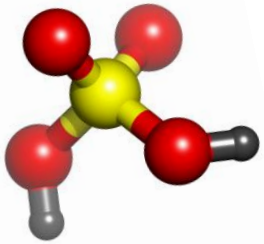
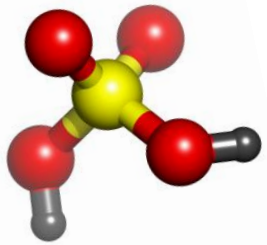


Summary of Incident, continued

Two research assistants who were in the lab responded to the research assistant's cries for help by wrapping her in a lab coat. The lab coat caught on fire. They then poured water on her from a laboratory sink.

A safety shower was present in the lab but was not used by the two research assistants to put out the fire on her clothing.

One of the lab assistants called emergency response (911). When the emergency response personnel arrived they first confirmed that the fire was contained before entering the lab. They then entered and placed the research assistant under the safety shower for decontamination . She was transported to the hospital where she later died.



Background of Laboratory Incident

- The University's Health and Safety Office provided general laboratory safety training for research assistants at the beginning of each academic quarter.
- The University required that the Advisor for each research lab provide laboratory specific safety training.
- The research assistant who died did NOT receive the general training as she started employment in the middle of the quarter. She DID receive laboratory specific training, but not in how to handle pyrophoric materials.
- An inspection of the laboratory by the Health and Safety Office before the incident reported that more than 40 liters of flammable solvents were stored outside of flammable cabinets and that lab research assistants were not wearing personal protective equipment appropriate for working with hazardous chemicals.

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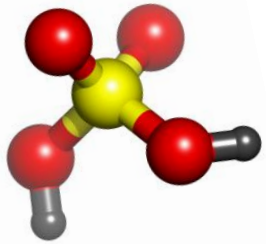

Laboratory Emergency Management Exercise

1. What University chemical risk management <u>policies</u> and <u>procedures</u> might have prevented this incident?

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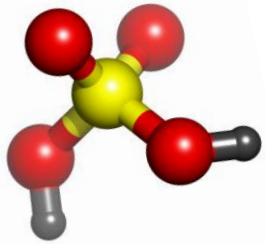

Laboratory Emergency Management Exercise

2. What additional information and requirements for personal protective equipment should be included in laboratory safety training?

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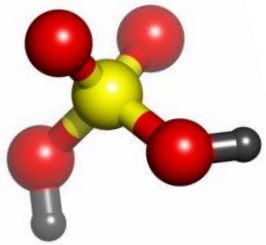

Laboratory Emergency Management Exercise

3. How could research assistants working in the laboratory be better prepared for emergencies?

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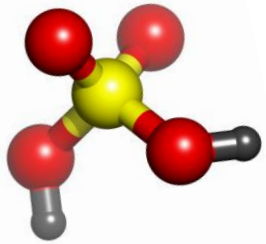

Laboratory Emergency Management Exercise

4. What emergency equipment should be present in the laboratory?

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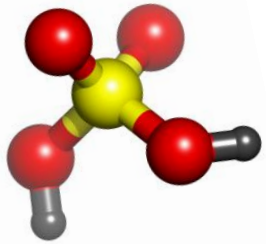

Laboratory Emergency Management Exercise

5. What did the research assistants and emergency response personnel do ***right*** in responding to this type of emergency?

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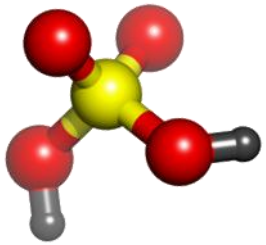

Emergency Management Exercise Industrial Incident

SAND No. 2011-0722C
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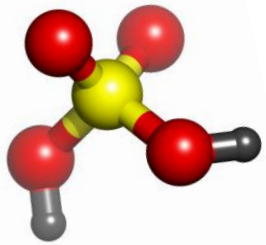

Emergency Management Exercise

- This scenario was taken from an incident investigated by the U.S. Chemical Safety Board that took place on August 14, 2002.
- Approximately 20,000 kilograms of chlorine gas were released from a railroad tank car unloading operation.
- 66 persons in a nearby community sought medical evaluation following the release.

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Photo of Chlorine Release

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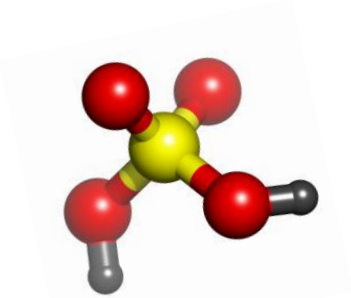

Summary of Incident

Around 9:20 am on March 3, 2011, a 2.5 centimeter chlorine transfer hose used in a railroad tank car unloading operation at the XXX Company facility ruptured, releasing 20,000 kilograms of chlorine. Unloading activities involve transferring liquefied pressurized chlorine gas from the tank car to individual gas cylinders.

Prior to the event, the two employees who were transferring the chlorine put the system on standby, and took their morning break in the break room next to the unloading area.

NOTE THAT WHEN THE SYSTEM IS IN STANDBY MODE, THE HOSE REMAINS CONNNECTED TO THE TANK CAR.

Upon hearing a large pop, the employees ran outside and observed that chlorine gas was being released from the tank car. They manually activated the emergency shut-down (ESD) system. The ESD system was designed to close the valves on the tank car and prevent release of chlorine. Three of the five valves failed to close and chlorine continued to be released from the tank car.

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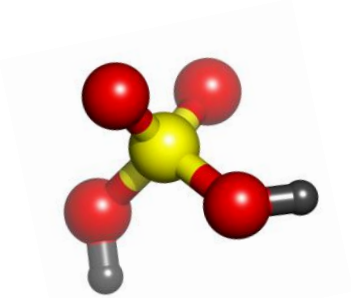


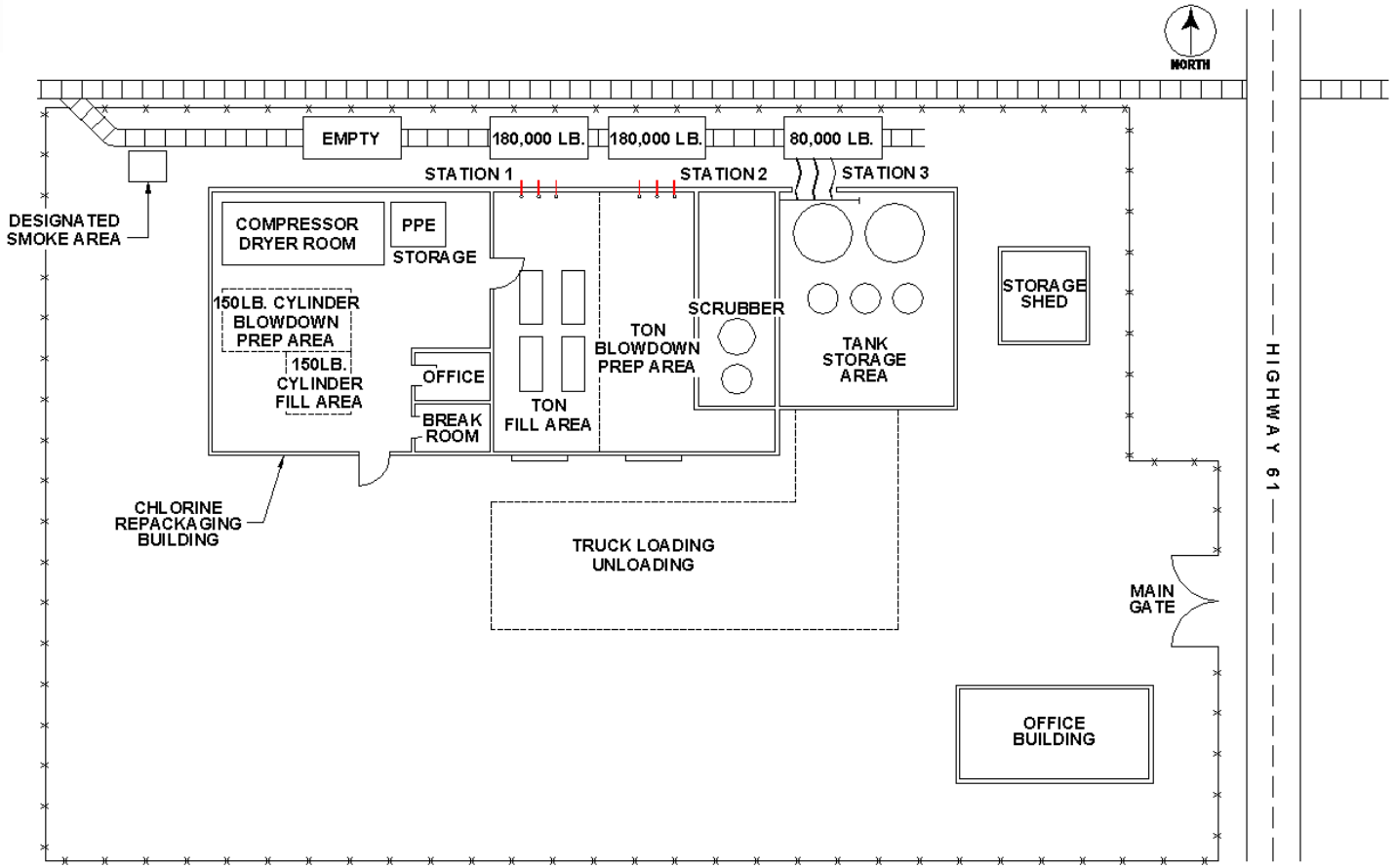
Summary of Incident, continued

A chlorine detection sensor in the facility activated an evacuation alarm. The XXX Company employees, who were also the emergency response team, attempted to respond to the release, but were unable to access the emergency protective equipment (PPE). The equipment consisted of self-contained breathing apparatus (SCBA), a chemical *resistant* suit, gloves, and boots.

The employees evacuated to the designated assembly point. One of the employees called 911 from the assembly point at approximately 7 minutes after the release.

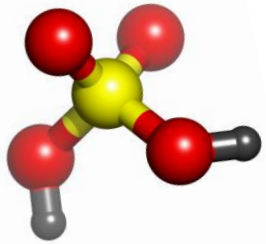
Upon receiving the 911 call, the Local HAZMAT team arrived at XXX Company, but did not have the appropriate PPE to respond to the release and could not shut down the chlorine leak. The HAZMAT team then evacuated the neighboring community. However, sixty-six people still required medical evaluation for respiratory distress. The release continued for 3 hours before the valve on the tank could be closed by the company's HAZMAT team who were finally able to access their emergency equipment (PPE). Two of the Company HAZMAT team received skin burns because they were not wearing fully-encapsulated PPE.

Facility Map



Tanker Hose Rupture

Photo credit: US Chemical Safety Board



Emergency Management Exercise

1. What emergency plans might XXX Company have had in place before the incident?

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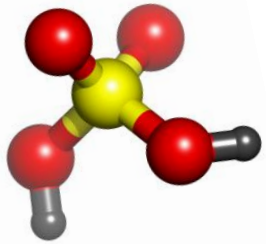

Emergency Management Exercise

2. What procedures/practices might XXX Company have for potential equipment malfunctions?

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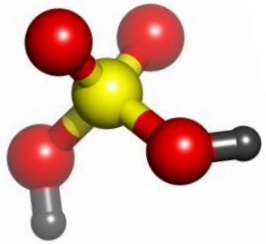

Emergency Management Exercise

3. How could the XXX Company emergency response team be better prepared?

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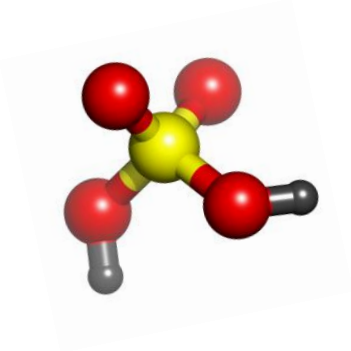

Emergency Management Exercise

4. How could the Local HAZMAT team be better prepared?

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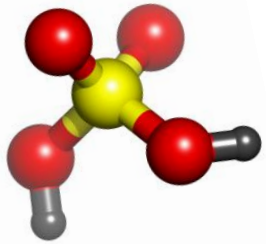

Emergency Management Exercise

5. What improvements might be made in regards to communication between XXX Company and the community HAZMAT team?

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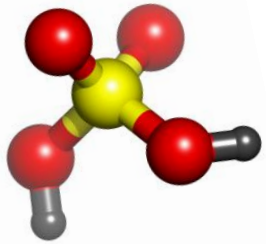

Emergency Management Exercise

6. What improvements might be made in regards to communication with the local community?

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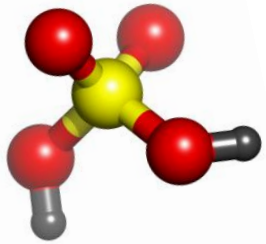

Emergency Management Exercise

7. What did XXX Company and the community HAZMAT team do *right* in planning and responding to this emergency?

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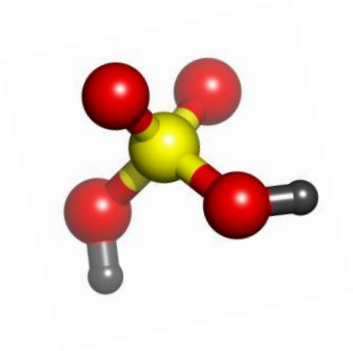

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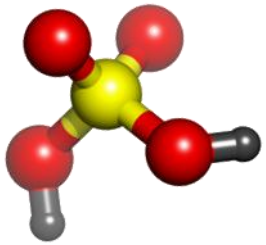

Chemical Waste Management

SAND No. 2011-0486P

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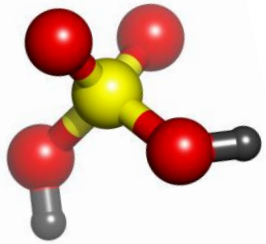

Overview of Presentation

- Definitions of hazardous waste
- Why government regulation is necessary
- Key elements of chemical waste management
- Laboratory waste management
- Industrial waste management
- Disposal considerations
- References

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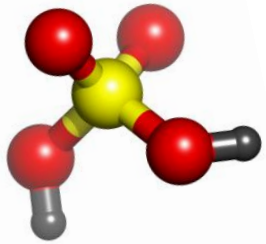

Definition of Waste

- **Definition of Waste- Basel Convention 1992**

  "Substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law"

- **Definition of Hazardous Waste- EPA**

" Liquid, solid, contained gas, or sludge wastes that contain properties that are dangerous or potentially harmful to human health or the environment."

Characteristic – Ignitable-Corrosive-Reactive-Toxic

Listed – by industrial source

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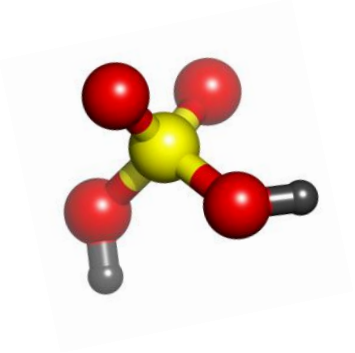

Why Government Intervention is Necessary

- Hazardous waste will be disposed of in the least expensive manner
- There is no profitable market for hazardous waste products
- Government regulations and fines provide an incentive for proper management
- Without regulation dumping will prevail

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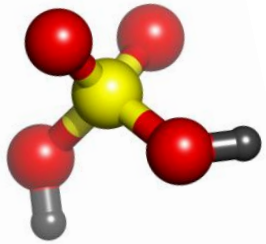
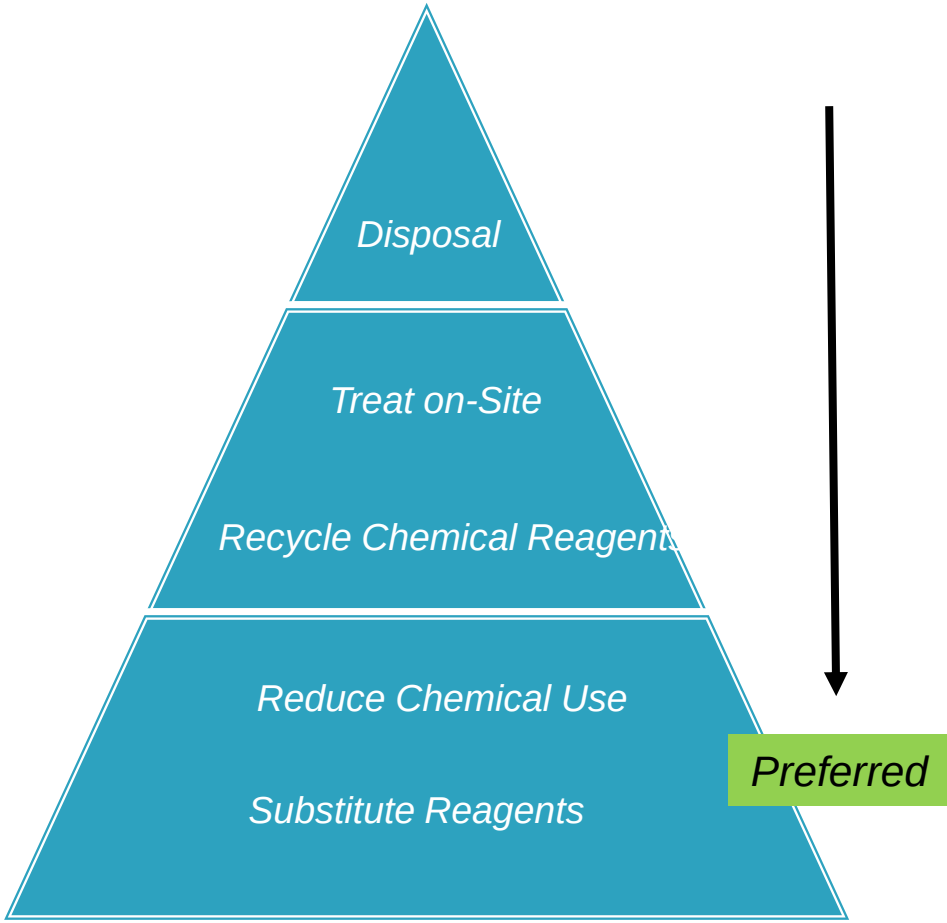


Chemical Waste Management

- Key Elements
  - Product substitution
  - Reduce use
  - Recycling
  - Treatment
  - Disposal

- *Chemical management is intrinsic to waste management*



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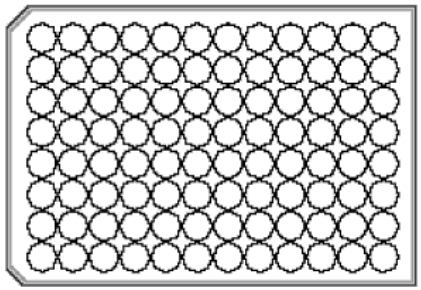
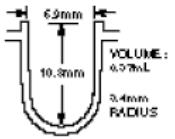
Laboratory Chemical Waste: Substitution and Reduction

- Substitution
  - Replace a hazardous solvent with a non-hazardous one

- When purchasing automated equipment think of chemical waste

- Reduction
  - Procure and use less
  - Control “orphan” chemicals
  - Use microscale instrumentation





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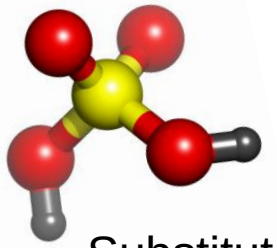

Industrial Chemical Waste Substitution and Reduction

- Substitute less hazardous raw materials for processes
- Improve process controls
  - -Separate waste streams
  - -Combine streams for waste neutralization (acid-base)
- Improve equipment design
- Perform regular preventive maintenance on process equipment
- Convert waste to energy when feasible

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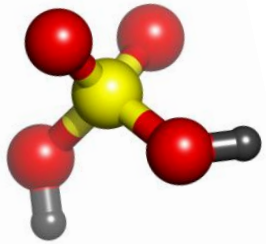

Laboratory Chemical Waste: Recycling

- Appropriate for laboratory or small facilities
- Create an active chemical exchange program
- Reuse by others in the university
- Beware of accepting unusable chemicals
- Exchange for credit with suppliers by agreement

Donated chemicals are not always "free"

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Laboratory Chemical Waste: Recycling

May Recycle (examples)

- Excess unopened chemicals
- Excess laboratory glassware (unused or clean)
- Consumables with no expiration
- Some precious or toxic metals
  - Hg, Ag, Pt, Pd, Au, Os, Ir, Rh, Ru
- Solvents that can be purified
  - Lower purity suitable for secondary use

Do NOT Recycle (examples)

- Gas cylinders past their pressure testing date
- Used disposable pipettes and syringes
- Chemicals and assay kits past their expiration
- Obviously degraded chemicals
- Used tubing, gloves and wipes

Do NOT recycle if it presents a safety or security hazard

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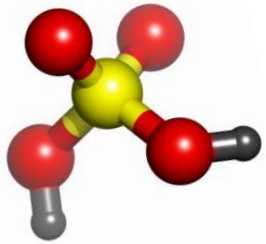
Laboratory Chemical Waste: Recycling

Laboratory Solvents

- May be distilled
- Keep solvents segregated prior to separation
- Avoid contamination due to careless handling
  - Requires good labeling
    - A small amount of the wrong chemical can ruin a desired separation
- Azeotropes may prevent separation
- Boiling points must be widely different

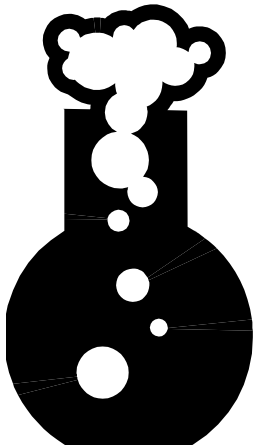
- Be aware of hazards
  - Do not evaporate or distill corrosive, radioactive, peroxides or peroxide formers
  - Beware of toxics and flammables
  - Use proper ventilation



Solvents that should not be recycled by distillation

Accidents have been reported for these distillations

- Individual Substances
  - Di-isopropyl ether (isopropyl alcohol)
  - Nitromethane
  - Tetrahydrofuran
  - Vinylidene chloride (1,1 dichloroethylene)
- Mixtures
  - Chloroform + acetone
  - Any ether + any ketone
  - Isopropyl alcohol + any ketone
  - Any nitro compound + any amine



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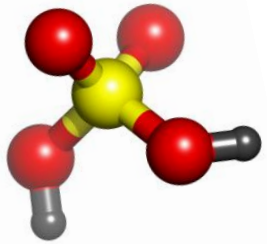
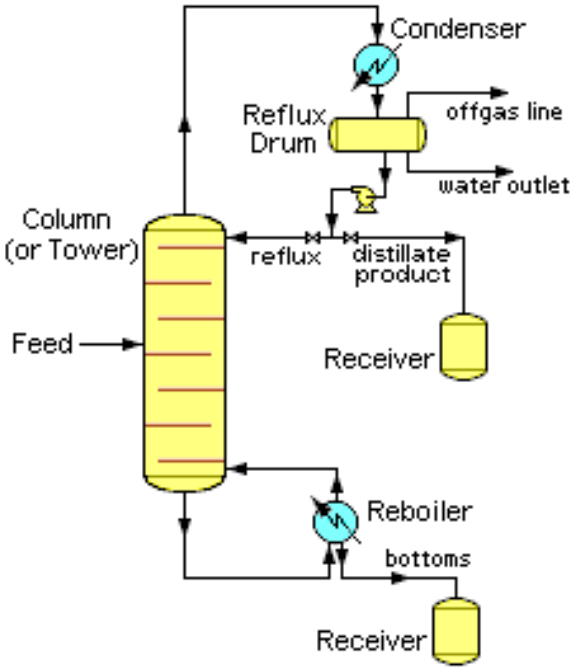
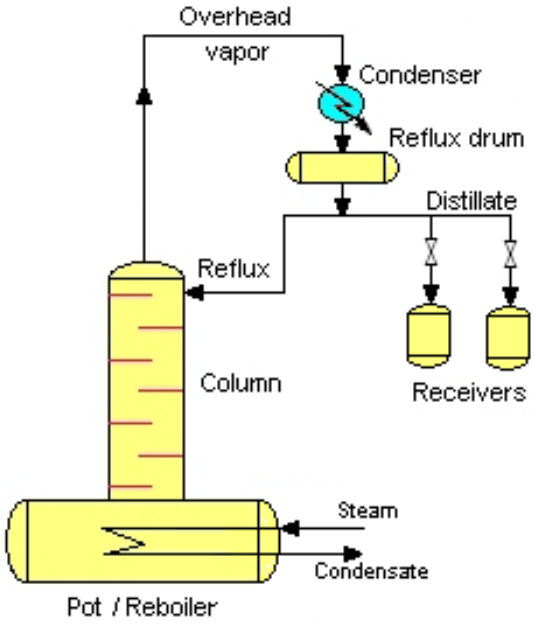


Industrial Waste Reduction: Large scale Distillation





Source :H. Padleckas-Wikipedia

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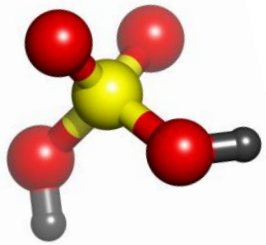

Industrial Waste Reduction: Distillation

- **Advantages**
  - Recovers useable organic solvents from wastes
  - Product purity of a range of levels can be designed into the distillation process, limited mainly by economic considerations

- **Disadvantages**
  - Complex operation with high capital costs, high energy costs
  - Columns can be large if a high degree of purity is required (200 feet)
  - Feed must be a free flowing fluid with low solids content
  - Must be custom designed for a given waste stream not for variable feed

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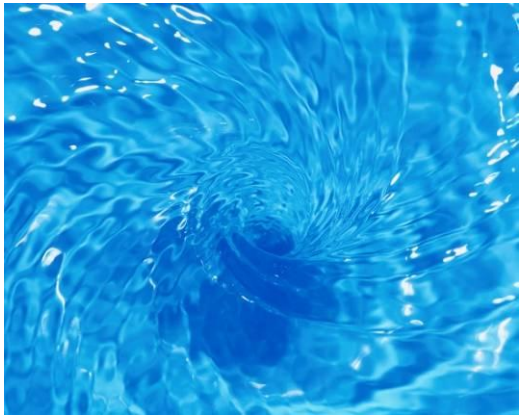
Laboratory Chemical Waste: Dilution

If legally allowed!

- Deactivate & neutralize some liquid wastes yourself
  - e.g., acids & bases
  - Don’t corrode drain pipes
- Dilute with lots of water while pouring down the drain
  - Be sure that you do not form more hazardous substances
  - Check reference books, scientific literature, internet



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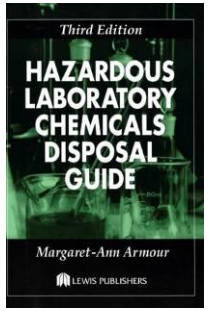
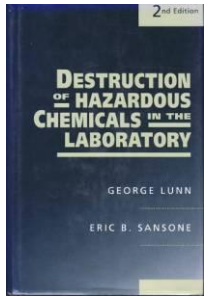
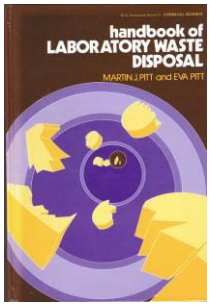
Laboratory Chemical Waste: Treatment References

- "Procedures for the Laboratory-Scale Treatment of Surplus and Waste Chemicals, Section 8.D in Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 2011, available online: http://dels.nas.edu/Report/Prudent-Practices-Laboratory-Handling/12654
- "Destruction of Hazardous Chemicals in the Laboratory, 2nd Edition", George Lunn and Eric B. Sansone, Wiley Interscience, 1994, ISBN 978-0471573999
- "Hazardous Laboratory Chemicals Disposal Guide, Third Edition", Margaret-Ann Armour, CRC Press, 2003, ISBN 978-1566705677
- "Handbook of Laboratory Waste Disposal", Martin Pitt and Eva Pitt, 1986, ISBN 0-85312-634-8







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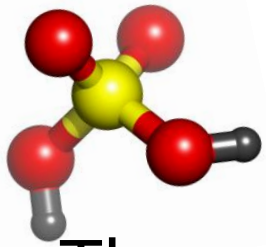

Industrial Hazardous Waste: Treatment Methods

- Thermal desorption
- Pyrolysis gasification
- Combustion
  - -Incineration
    - -Industrial furnaces
    - -Cement kilns
  - Molten glass solidification
  - Plasma
  - Stabilization
  - Waste to Energy

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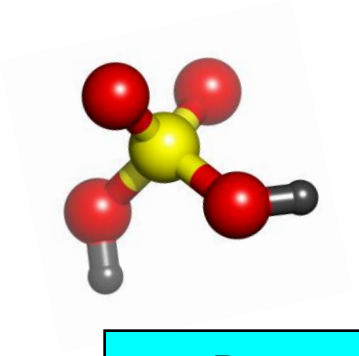
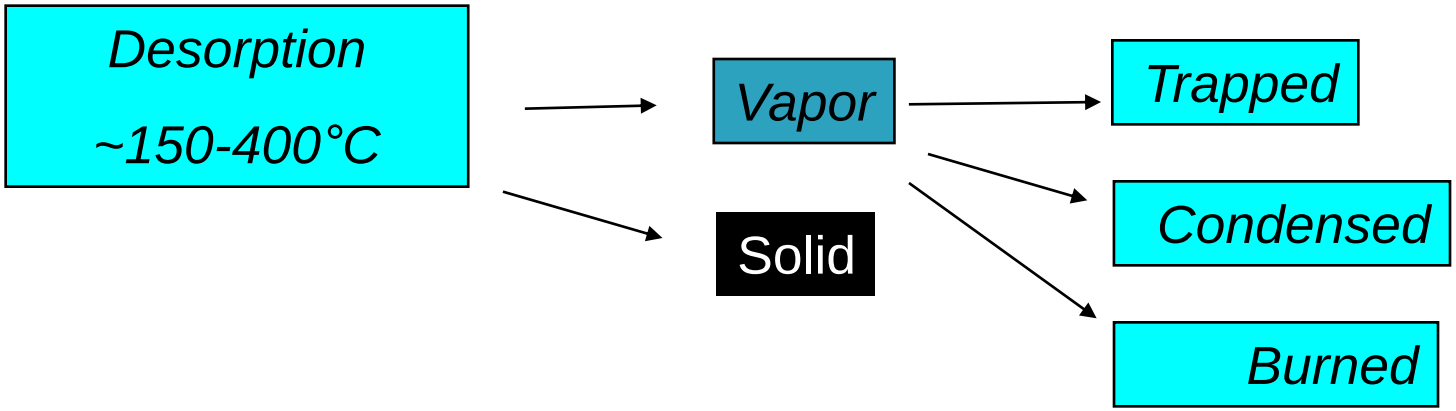


Thermal Desorption



- *Uses rotary kilns*
- *Mobile or stationary units*
- *Feed and product handling equipment*
- *Desorbed vapor*
- *Vapor is trapped onto activated carbon*
- *Vapor is condensed*
- *Burned in afterburner or with oxidizer*
- *Remaining solids are cleaned and disposed*

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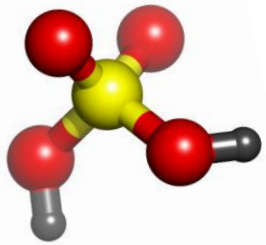

Thermal Desorption: Advantages-Disadvantages

- Advantages
  - Low $$ compared to other thermal technologies
  - Low regulatory hurdles for permitting
  - Can be applied in the field
  - Allows for both destruction and recovery of organic contaminants

- Disadvantages
  - Material larger than 2 inches needs to be crushed or removed
  - Plastic soils tend to stick to equipment and agglomerate
  - Highly contaminated soils will require multiple cycles
  - Not amenable to semi-volatile or non-volatile, chlorinated hazardous constituents. (Example: PCBs, pesticides)
  - Fugitive emissions
    - Exposure risk to workers and environment

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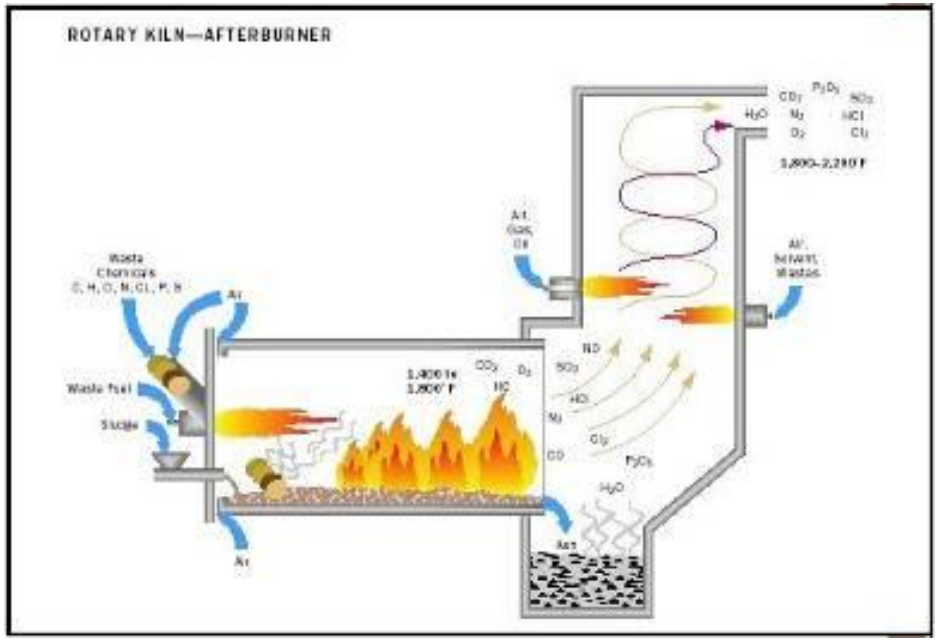
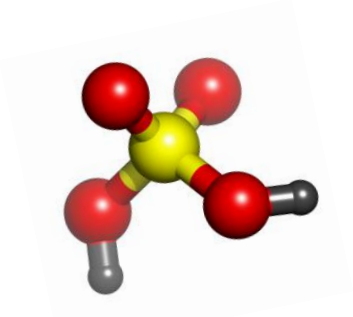
Incineration

- Incineration = “The controlled burning of waste”
- Requires 3 “T’s”:
  - Time: 2 seconds minimum
  - Temperatures: 1000°C-1200°C
  - Turbulence: Mixing during burn
- Rotary Kiln or Fixed Grate
- Secondary Combustion Chamber (afterburner)
- Rapid cooling of ash to prevent toxic air emissions (dioxins/furans)



Source :http://www.pollutionissues.com/



Incineration: Is not the same as Open Burning

	Open Burn (µg/kg)	Municipal Waste Incinerator (µg/kg)
PCDDs	38	0.002
PCDFs	6	0.002
Chlorobenzenes	424150	1.2
PAHs	66035	17
VOCs	4277500	1.2

Source: EPA/600/SR-97/134 March 1998

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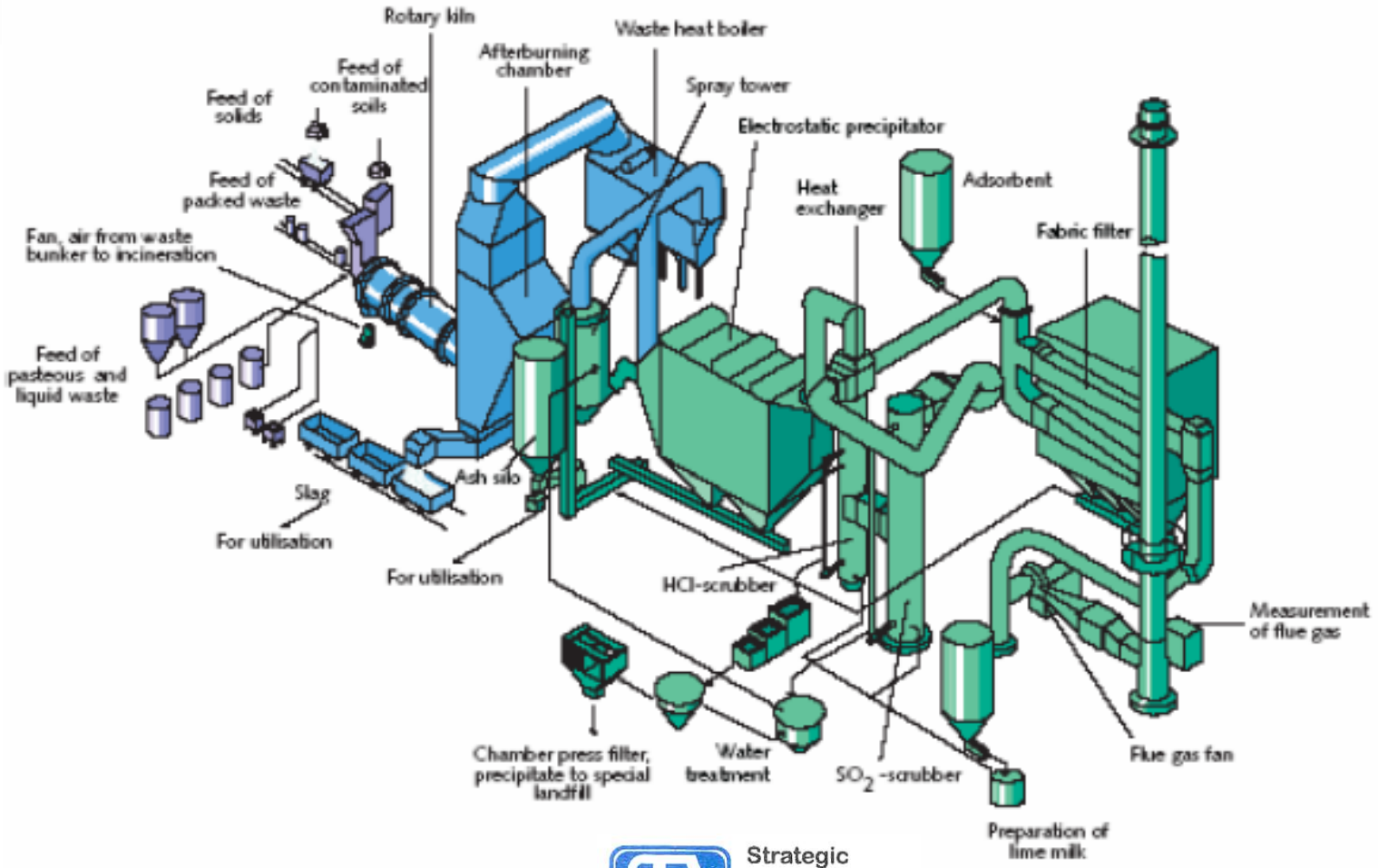
Example of Rotary Kiln Incineration for Hazardous Waste Disposal



Strategic Environmental Analysis, L.C.

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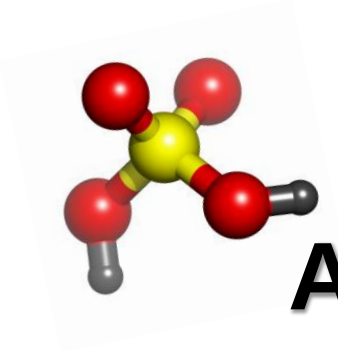

Incineration: Ash Treatment Standards

(US EPA regulates 200 constituents)

Pollutant	Standard
Benzene	<10 mg/kg
Trichloroethylene	<6 mg/kg
Cresols	<5.6 mg/kg
Dioxins	<0.0025 mg/kg
Pesticides	<0.087mg/kg
Leachable Metals	<0.1-0.75 mg/L*

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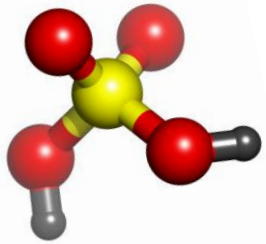

Incineration: Advantages-Disadvantages

- Advantages:
  - Can be applied to a wide variety of hazardous wastes
  - Provides destruction and volume reduction of the waste

- Disadvantages
  - Not amenable to waste containing high concentration of heavy metals (> 1%)
  - Waste feed mechanisms often complex
  - High capital cost due to extensive Air Pollution Control (APC) system and sophisticated controls required to meet emission standards
  - Ash must be treated for leachable metals prior to land disposal

Incineration : US Air Emission Standards

The following materials are regulated by the US EPA for air emissions:

- Particulate Matter
- Dioxin
- Lead
- Cadmium
- Arsenic
- Beryllium
- Chromium
- Hydrocarbons
- Hydrochloric acid
- Carbon monoxide
- Products of Incomplete Combustion (PICs) must be evaluated in a Human Health and Ecological Risk Assessment.

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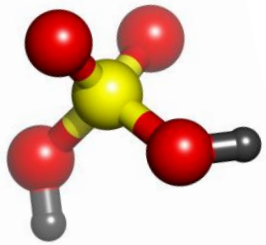

Industrial Furnaces: Kilns, Furnaces, and Boilers

Industrial Kilns, Furnaces, and Boilers may be used to incinerate hazardous waste if provided with air emissions controls

- Types of Kilns Used
  - Cement
  - Lightweight Aggregate
  - Lime
- Industrial furnaces
  - Halogen Acid
  - Sulfuric Acid
- Industrial boilers
- Waste types and amount limited to protect product and process quality
  - Cement and lightweight aggregate kilns may burn only liquid waste
  - Minimum heat must be > 5000 BTU/lb

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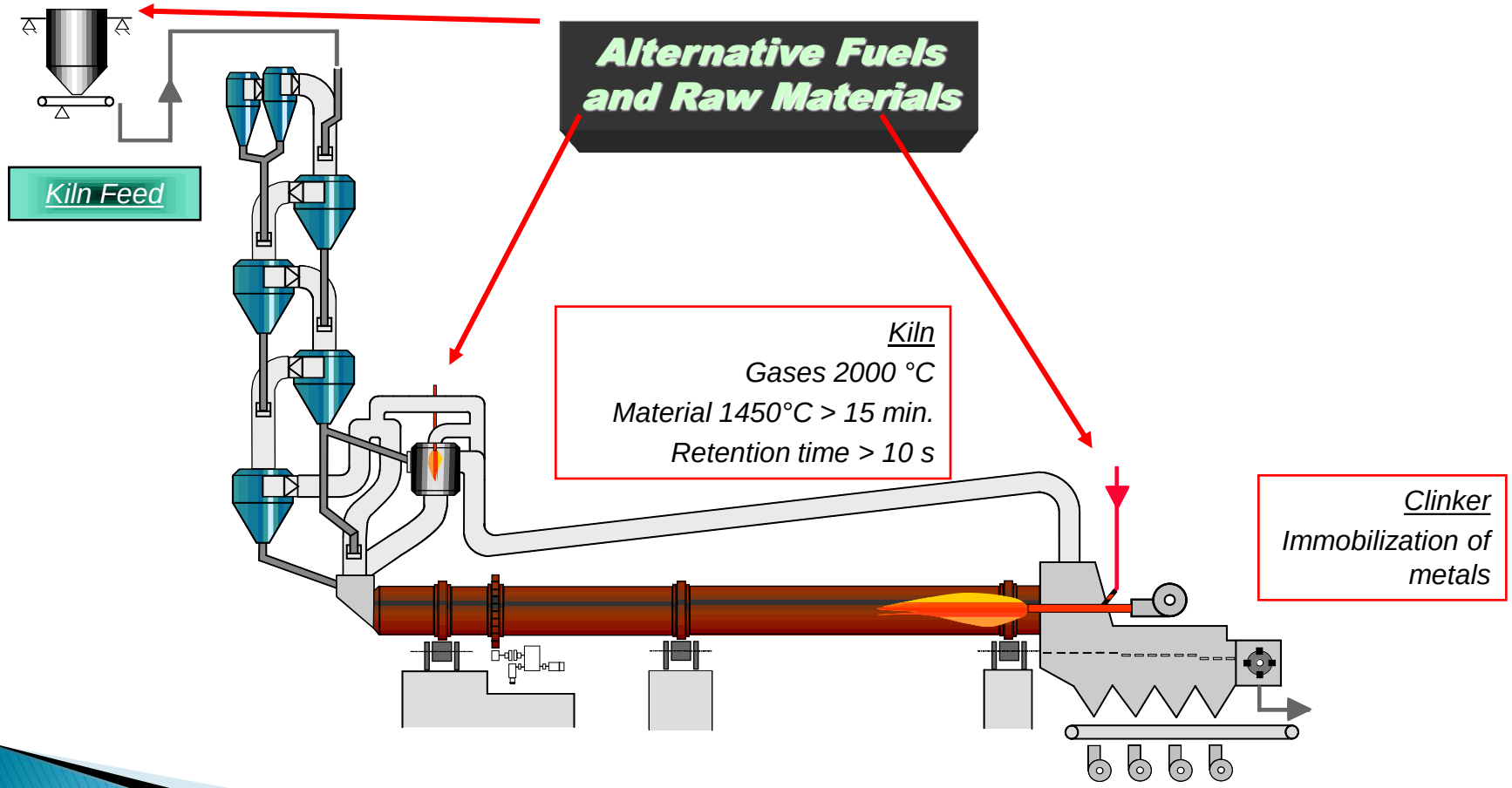
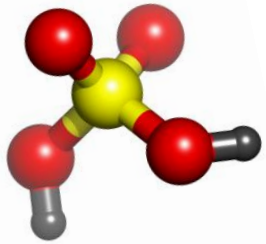
Typical Dry Process Cement Kiln





Industrial Furnaces: Kilns, Furnaces, and Boilers

- Advantages:
  - Owners of industrial furnaces make profit from treating waste
  - Air pollution control equipment is already in place
  - Cement kilns have a sufficient residence time and temperature for treating hazardous chemical waste
- Disadvantages
  - Some industrial waste may not be allowed
  - The waste feed mechanisms are complex
  - The admixture rate may be too low
  - Using industrial furnaces for waste treatment may interrupt industrial processes

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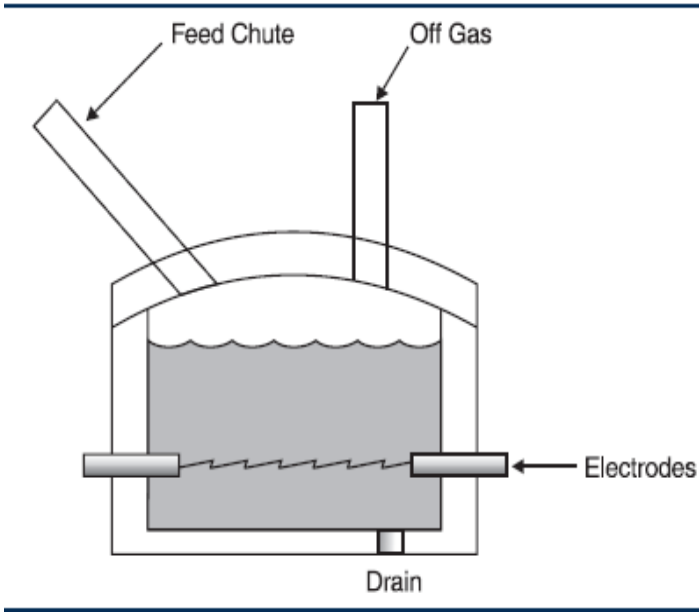
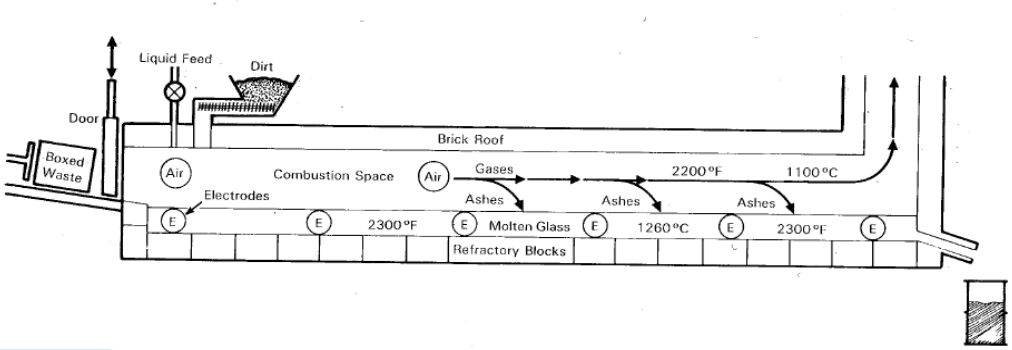
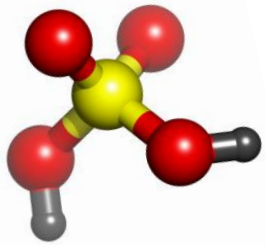
Molten Glass Processing: Joule Heating

- Electrical current produces melt
- Wastes fed to pool of molten glass (1000°C to 1200°C)
- Glass is contained within the melting cavity, airtight steel lined with insulating refractory.
- Initial heat-up of the melt cavity usesnatural gas burners or electric heaters
- The molten glass/encapsulated waste residual is drained through an overflow







Molten Glass Processes: Advantages-Disadvantages

- Advantages
  - Permanent treatment and encapsulation of waste in a stable form
  - Final material is delistable as “non-hazardous” under EPA regulations.
  - High degree of volume reduction; up to factors of 100.
  - No carbon monoxide is generated.

- Disadvantages
  - High capital and operating costs, because of electricity.
  - Costs for radioactive waste have been as high as $3.90/kilogram

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Plasma Arc Process: Waste Treatment

- Inert gas under pressure is injected into a sealed container of waste material
- Uses a high voltage arc
- Plasma temperature reaches 6,000 °C
- Plasma destroys the hazardous waste
- Residual gas is sent to air emissions equipment

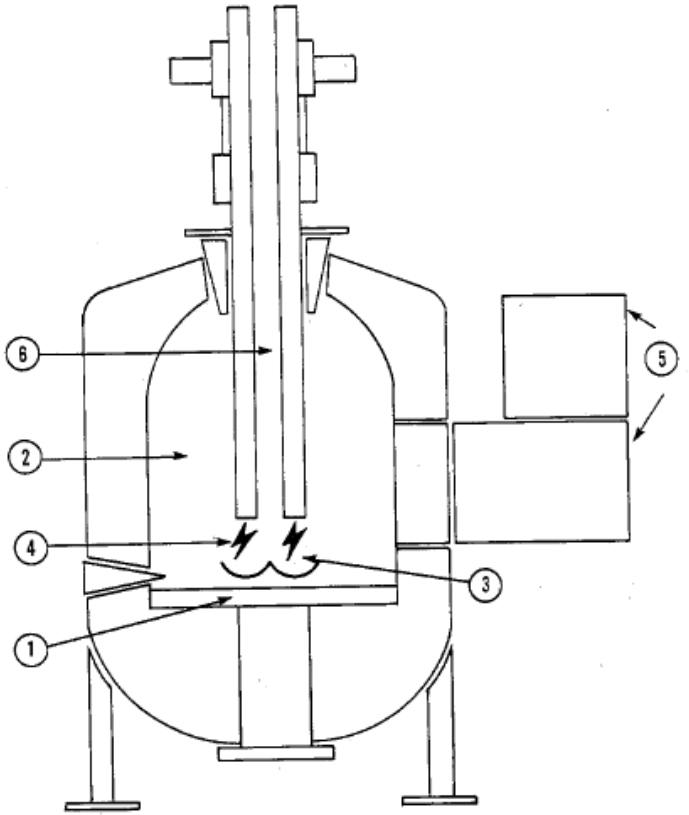

FIG. 8.12.4 Plasma-arc process for PCB destruction.[4] (1) Zone 1: molten metal, approx. 3000°F. (2) Zone 2: furnace chamber, approx. 3000°F. (3) Zone 3: plasma zone, approx. 11,000°F. (4) Zone 4: plasma arc >11,000°F. (5) Sealed loading system. (6) Gas exit.

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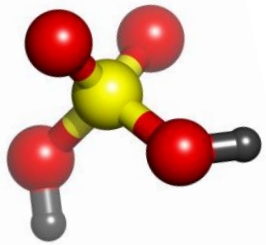
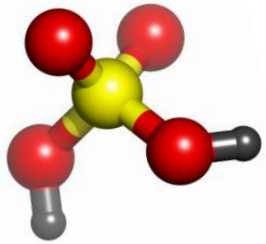


Plasma Arc Process: Advantages-Disadvantages

- Advantages
  - Plasma systems can transfer heat much faster than conventional furnaces.
  - Very effective for organic halogens, (PCBs and Dioxins).

- Disadvantages
  - Extremely high temperatures affects the durability of equipment
  - High capital costs due to requirement for electricity
  - Complex process control
  - Highly trained professionals are required



Stabilization Processes

- Stabilization techniques chemically treat hazardous waste by converting them into a less soluble, or less toxic form.
- Principally used for metal-bearing wastes
- Stabilization has a limited applicability to organic wastes
- Advantage
  - Low cost, simple technology, suitable for many types of hazardous waste
- Disadvantages
  - Increases waste volume

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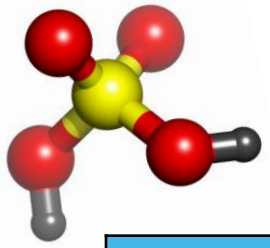

Waste to Energy:
An Alternative to Disposal

Pollutant	Average Emission	EPA standard	Unit
Dioxin/Furan (TEQ basis)	0.05	0.26	ng/dscm
Particulate Matter	4	24	mg/dscm
Sulfur Dioxide	6	30	ppmv
Nitrogen Oxides	170	180	ppmv
Hydrogen Chloride	10	25	ppmv
Mercury	0.01	0.08	mg/dscm
Cadmium	0.001	0.020	mg/dscm
Lead	0.02	0.20	mg/dscm
Carbon Monoxide	33	100	ppmv

Source: http://www.energyanswers.com/pdf/awma_final.pdf

Waste to Energy : Anaerobic Biosolid Digestion

Anaerobic sludge digestors produce methane

(65% CH_4 - 35% CO_2)

On-site electricity is produced with the methane 50% of plant power (2.2MW)

Source: Albuquerque NM Waste Water Treatment Plant

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Waste to Energy Example: Coconut Charcoal Waste

http://www.eurocarb.com/

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Waste to Energy Example: Palm Oil Mill Effluent

Fresh Fruit Bunches

Crude Palm Oil

Palm Oil Mill Effluent (POME) *

Empty Fruit Bunches

Fiber +Shell

Anaerobic lagoon/reactor

electricity

compost

electricity

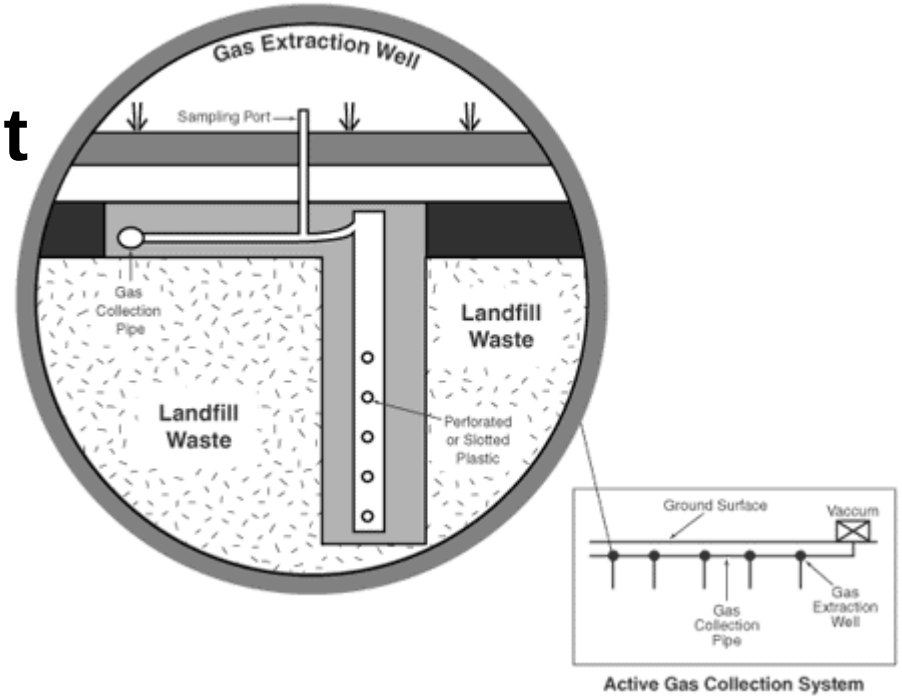
charcoal

methane

sludge

Waste Disposal Methods

- Landfills
- Surface impoundment
- Waste pile
- Land treatment unit
- Injection well
- Salt dome formation
- Salt bed formation
- Underground mine
- Underground cave



http://www.epa.gov/lmop/basic-info/lfg.html#01

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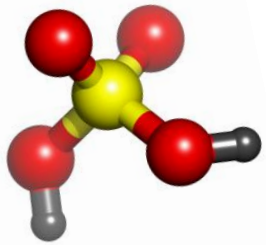
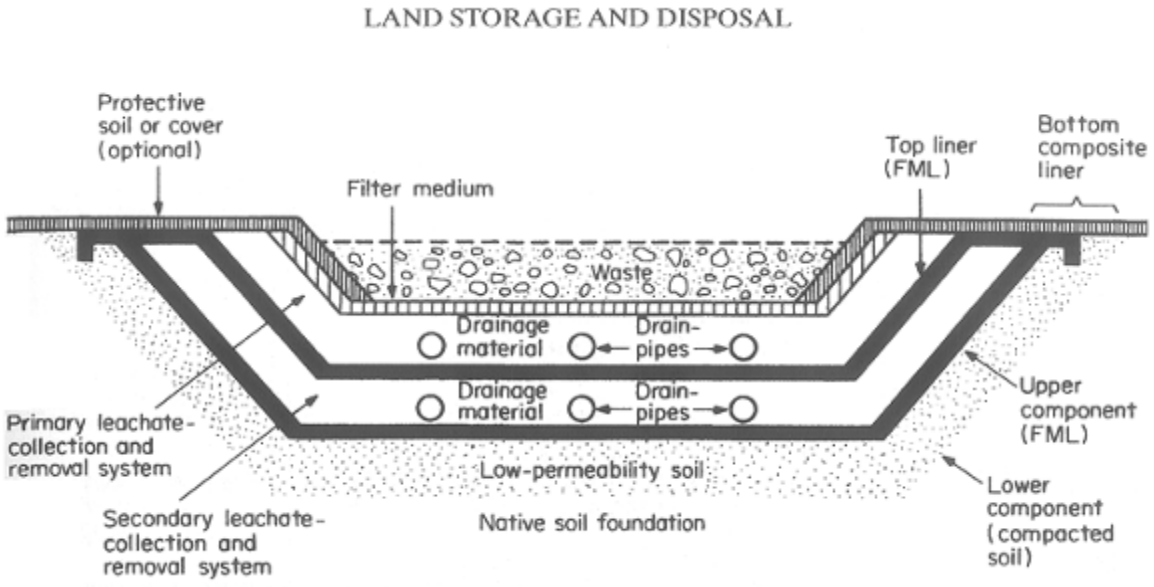


Waste Disposal: Landfills

- Design
- Must have liners compatible with waste
  - Clay, or
  - Flexible membrane
- Leachate
  - Primary and secondary collection systems
  - Removal system
  - Leak detection system
- Surface water collection
- Gas collection and removal
- Are capped and monitored

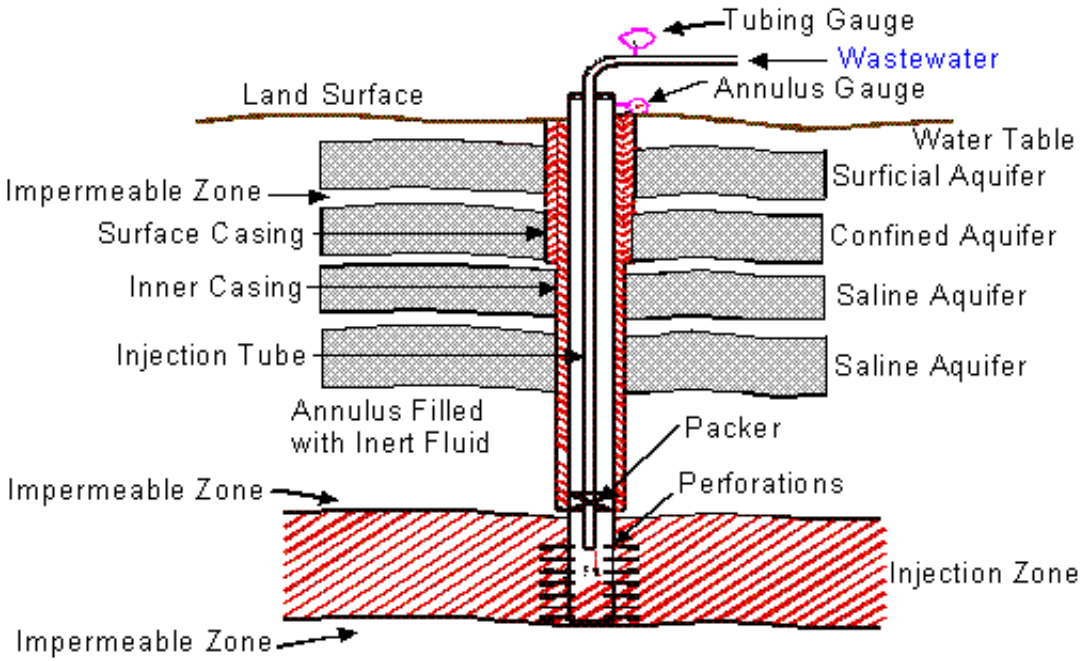
Example: Landfill Liner System



http://www.epa.gov/wastes/hazard/tsd/td/disposal.htm

Groundwater and leachate monitoring are essential

Disposal: Deep Well Injection



- *550 Class I wells in the United States*

- *43% of all hazardous waste in United States !!!*

http://www.epa.gov/safewater/uic/index.html

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Waste Disposal: Selection of Contractor

- Consider:
  - Disposal service licensed or compliant with your country's regulations
  - Employees are trained in handling and emergency response
  - Packaging requirements
    - Lab packs
  - How will waste be transported?
  - Where and how will waste be disposed?
  - Chain of custody
  - Always maintain records

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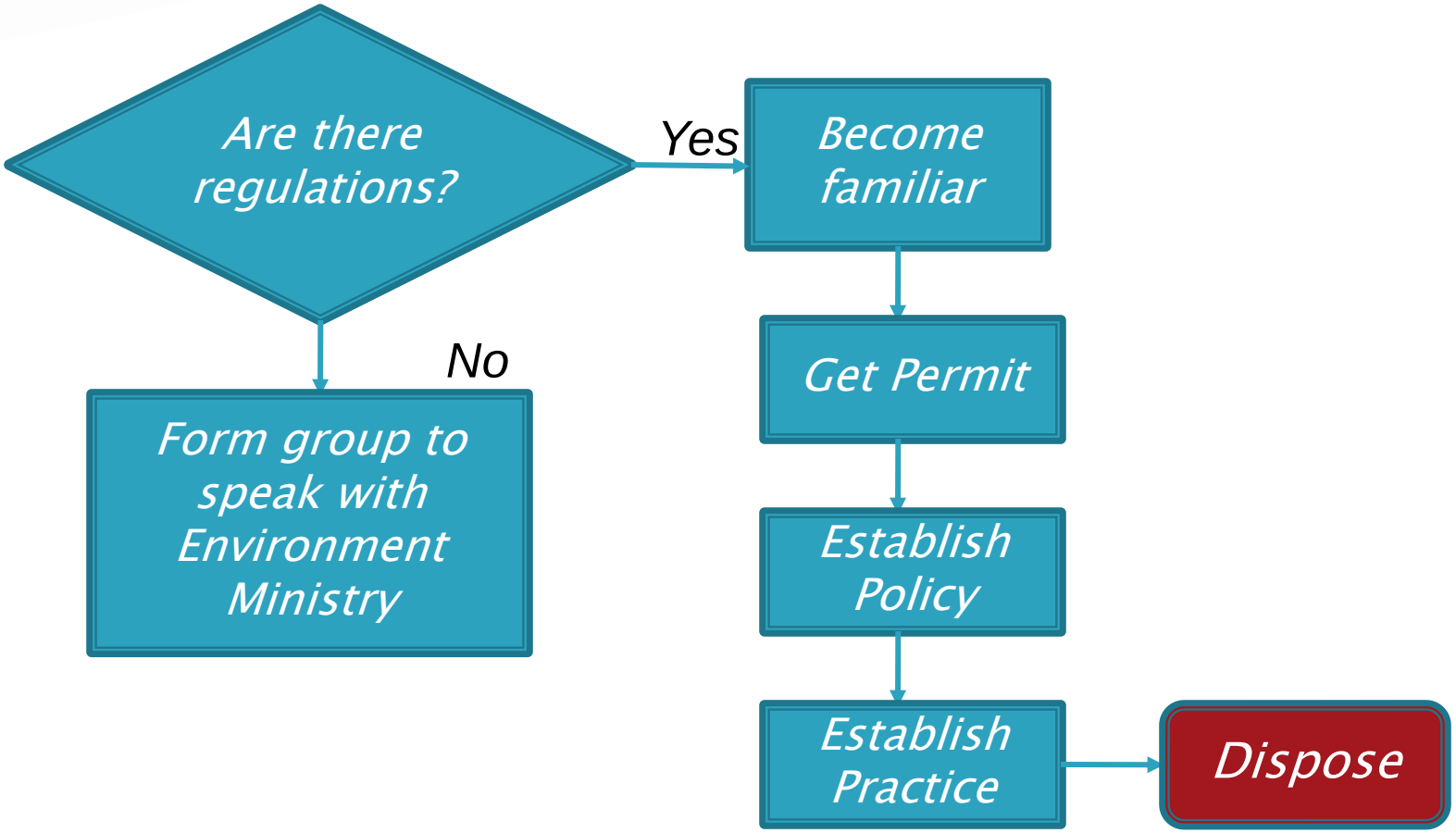
Waste Disposal Flow Chart



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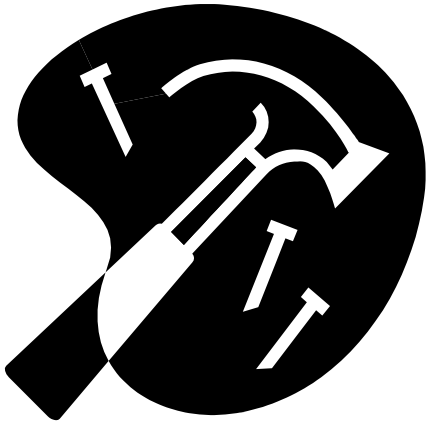
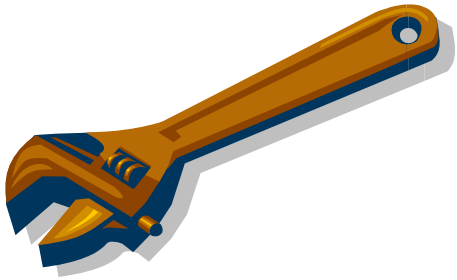
Waste Management: References

- "Training Resource Pack for hazardous waste management in developing economies", http://www.unep.fr/shared/publications/cdrom/3128/menu.htm
- "Microchemistry training curriculum", http://www.radmaste.org.za/amicrosciencematerialchemistry.htm
- "School cleanout campaign-US EPA",
  - http://www.epa.gov/epawaste/partnerships/sc3/index.htm
- "International Solid Waste Association"
  - http://www.iswa.org/





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Waste management: References

- "Less is Better," American Chemical Society, Washington DC, 2003, available online:
  - http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_SUPERARTICLE&node_id=2230&use_sec=false&sec_url_var=region1&__uuid=ef91c89e-8b83-43e6-bcd0-ff5b9ca0ca33
- "School Chemistry Laboratory Safety Guide," US NIOSH Publication 2007-107, Cincinnati, OH, 2006, available on-line:
  - http://www.cpsc.gov/CPSCPUB/PUBS/NIOSH2007107.pdf
- "Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 2011, available online:
  - http://dels.nas.edu/Report/Prudent-Practices-Laboratory-Handling/12654

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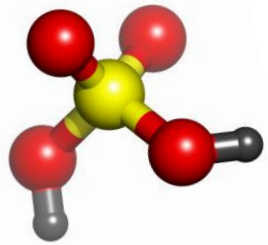
US Environmental Protection Agency Resources



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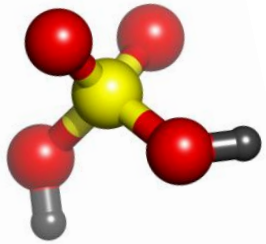

Summary of Discussion

- Gave definition of hazardous waste
- Provided reason for government regulation
- Discussed methods for reducing, treating, and disposing of laboratory waste
- Discussed methods for reducing, treating, and disposing of industrial waste
- Discussed the merits of using waste to energy technology Provided examples of hazardous waste methodologies

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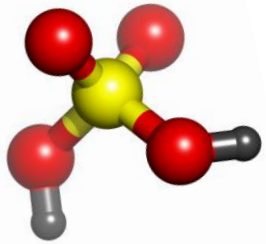

Breakout Sessions

- Break into three groups
  - University participants
  - Industry participants
  - Ministry participants

What are the "next steps" for achieving best chemical safety and security practices and a strategic approach to chemical management in Yemen?

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