Chemical

SAFETY AND SECURITY TRAINING

Safe Work Practices

SAND No. 2011-0785C
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.

Sandia National Laboratories

Process Safety Management

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

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

1. **Involve your employees!**
2. **List, rank, and set priorities for hazardous jobs**
3. **Review your accident history/lessons learned**
4. **Conduct a preliminary job review**
5. **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 Template

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

<u>Task Description</u>: 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 <u>equipment</u> hazards, the <u>material</u> hazards, and <u>ergonomic stressors</u>.**
- **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

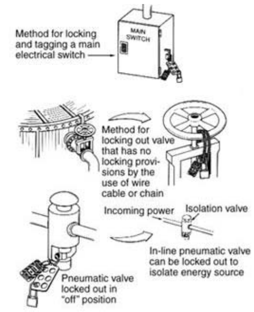
They are generally written methods outlining how to perform a task with minimum risk to people, equipment, materials, environment, and processes.

They are issued

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

Lockout-Tagout (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

Lockout-Tagout 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

Lockout-Tagout (LOTO)

- U.S. Department of Labor Statistics:
  - Approximately 3 million workers are at risk of injury if lockout-Tagout 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

1. Prepare for shutdown
2. Shutdown machine or piece of equipment
3. Isolate or block all hazardous energy sources for the equipment
4. Apply lockout or tagout devices
5. Release all stored energy
6. Verify energy isolation
7. Perform work

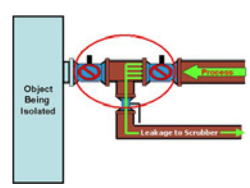
Steps to Release from LOTO

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

Isolation of Energy is the Key Principle

LOTO Practices-

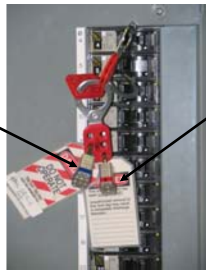
- Only one key for each lock the worker controls
- Only the worker who installs lock can remove it
- Shift changes- New lock added before old one removed
- *Authorized employee* for group lockout device
- LOTO program
  - Energy control procedures
  - Training
  - Periodic inspections
- Alternatives (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, hydraulic sources

Each Company Assigns Unique Locks and Tags



LOTO Locks and Tags

Lock Self Adhesive Band , IDEAL Part Number 34-003

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?

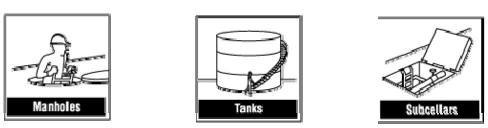
Confined Space

Confined space is any space that has:

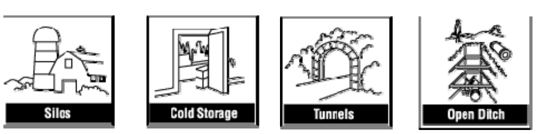
- Limited or restricted means of entry or exit;
- Is large enough for a person to enter to perform tasks and
- Is not designed or configured for continuous occupancy

OSHA 1910.146

Confined Space



All of these spaces constitute a confined 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 (CS) 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 Spaces Decision Tree (OSHA)

Does the work contain permit-required confined space ?
Will the permit space be entered?
Does the space have known or potential hazards?
Can the hazards be eliminated?

Can the space be maintained safe to enter by continuous forced air ventilation only? → Yes → Enter with ventilation

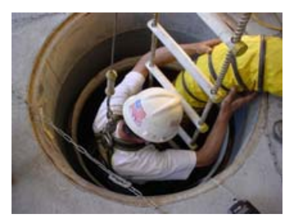
↓ No

Verify acceptable entry conditions (test the space, rescuers, communication, entrants equipped) → No → Permit not valid- no entry

Yes ↘ Permit issued, acceptable conditions maintained, work completed, permit returned and canceled.

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



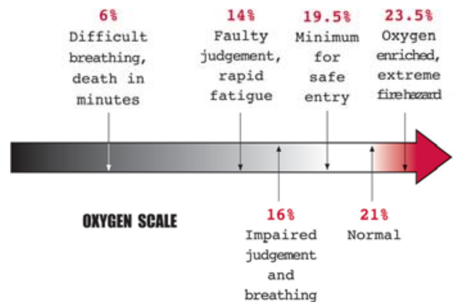
Credit: Utah Safety Council

Atmospheric Hazards in Confined Space

- 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

•If emergency exists (prohibited condition).
•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.**

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

- Keep all entrances and exits clear of obstructions such as vehicles, equipment and general clutter at all times.
- Correct poor housekeeping practices.
- Use appropriate shielding of flammable surfaces when performing hot work.
- Remember that grinders are capable of throwing red hot particles approximately 30 feet.
- Keep your work area free of unnecessary combustible materials.
- Use proper degreasing agents. Never use gasoline or other “flammable liquids” for degreasing or cleaning.
- Monitor the atmosphere-<10 % of Lower Explosive Limit (LEL)

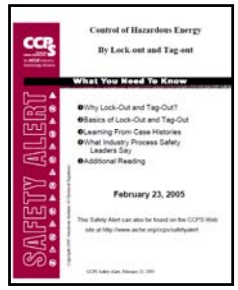
Fire Fighting Equipment and Procedures

- All workers should know the location of the fire fighting equipment in their area.
- Fire extinguishers are to be checked monthly.
- Never return an empty extinguisher to its fire station. Clearly mark it “empty” with chalk and exchange it for a charged unit.
- All fire extinguishers will be inspected on an annual basis by a certified company.
- All workers must 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

Resources for Control of Hazardous Energy


SAFETY ALERT

Control of Hazardous Energy

By Lock-out and Tag-out

What You Need To Know

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

February 23, 2005

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

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!

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

Chemical

SAFETY AND SECURITY TRAINING

Management of Change

SAND No. 2011-0550 C
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.

Key acronyms

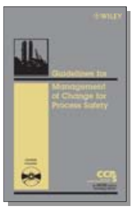
MOC = *management of change*

RIK = *replacement in kind*

PSSR = *pre-startup safety review*

MOC / PSSR resources

CCPS 2008c. **Center for Chemical Process Safety, *Guidelines for Management of Change for Process Safety*, NY: American Institute of Chemical Engineers.**



Chapter
1 Introduction
2 Relationship to Risk-Based Safety
3 Designing an MOC System
4 Developing an MOC System
5 Implementing and Operating an MOC System
6 Monitoring and Improving an MOC System
7 The Future of Change Management
CD-ROM (tools; example procedure, forms)

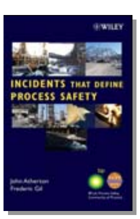
MOC / PSSR resources

CSB 2001. **Safety Bulletin No. 2001-04-SB, "Management of Change." Washington, DC: U.S. Chemical Safety and Hazard Investigation Board.**

(on course CD-ROM)

MOC / PSSR resources

CCPS 2008b. **Center for Chemical Process Safety, *Incidents that Define Process Safety*, NY: American Institute of Chemical Engineers.**

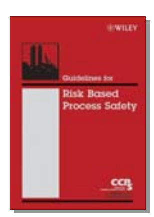


Chapter 8 Management of Change

- Chernobyl, USSR: How a safety enhancement experiment turned into a world-scale disaster, April 26, 1986
- Dutch State Mines Nypro Plant, Flixborough, UK, June 1, 1974

MOC / PSSR resources

CCPS 2007a. **Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*, NY: American Institute of Chemical Engineers.**

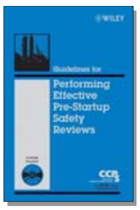


Chapter 15 Management of Change
Chapter 16 Operational Readiness

§ .1 Element Overview
§ .2 Key Principles and Essential Features
§ .3 Possible Work Activities
§ .4 Examples of Ways to Improve Effectiveness
§ .5 Element Metrics
§ .6 Management Review

MOC / PSSR resources

CCPS 2007b. **Center for Chemical Process Safety, *Guidelines for Performing Effective Pre-Startup Safety Reviews*, NY: Amer Inst of Chem Engineers.**



Management of Change

1. **Why manage change?**
2. **What is a "change"?**
3. **What types of changes need to be managed?**
4. **What is needed to manage changes?**
5. **What considerations need to be addressed?**
6. **What about temporary and emergency changes?**
7. **What information needs to be updated?**
8. **What else needs to be done pre-startup?**
9. **How are changes communicated?**

Management of Change

1. **Why manage change?**

> If you want to make enemies, try to change something.
>
> *- Woodrow Wilson*

REVIEW

During "**normal operation**," all hazards are contained and controlled, so the plant is operating safely.

Key concept

Changes

either

(1) shift the bounds of “Normal Operation”

or

(2) put the facility into an “Abnormal Situation”

Flixborough, England 1974

Process Safety Beacon
Special Issue
http://www.aiche.org/ccps/safetybeacon.htm
Messages for Manufacturing Personnel

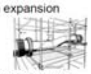
Sponsored by the 5th Global Congress on Process Safety

Flixborough — In June 2009 it will be 35 Years since the tragedy…

Originally published in June 2004, Re-issued April 7, 2009

What Happened?

One of the six reactors in series needed repairs. To minimize downtime, it was decided to bypass that one reactor and repair it off line. A temporary bypass line was installed using a pipe with an expansion bellows on each end and supported by scaffolding. Because of the rush to resume production, the new bypass was not tested prior to start up nor were engineering standards or manufacturer's recommendations considered.



Approximately three months later, the expansion bellows in the bypass line failed and released an estimated 30 tons of flammable cyclohexane. The resultant vapor cloud ignited killing 28 people and injuring 89 more. The entire plant was destroyed and hundreds of homes and stores were damaged.

See the Chemical Safety Board web site: http://www.csb.gov/safety_publications/docs/moc082801.pdf for MOC related accidents.

PSID Sponsors see: Free Search—Management of Change

Why this Happened

The temporary modification was not adequately reviewed for potential adverse consequences!

- The temporary bypass was made with two bends in it because the nozzles on the two tanks were at different levels. The impact of internal forces and flow stresses were not considered on the expansion bellows.
- Expansion bellows were left in place on each end of the bypass line. The suitability of this design and manufacturer's recommendations were not considered.
- The weight of the temporary bypass was not securely supported—it was simply placed on scaffolding. The amount of movement and the effect of that movement on the bellows were not considered.

What You Can Do

- Always follow your company's Management of Change (MOC) procedure. *Remember, temporary changes demand the same rigorous review as do permanent changes.* If you do not utilize a MOC procedure, discuss the value it could provide to your facility.
- Make changes only after thorough hazard reviews have been conducted and approved by qualified experts.
- Use good engineering practices and manufacturer's recommendations.

Evaluate Every change, even Temporary ones—for Expected and Unexpected Consequences

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DISCUSSION

Changes

either

(1) shift the bounds of “Normal Operation”

or

(2) put the facility into an “Abnormal Situation”

Which of these occurred at Flixborough?

Management of Change

1. Why manage change?
2. What is a "change"?

What is a “change”?

Definition:

Change. Any addition, process modification, or substitute item (e.g., person or thing) that is not a replacement-in-kind.

- CCPS 2008c Glossary

What is a “replacement-in-kind”?

Definition:

Replacement-in-kind (RIK). An item (equipment, chemicals, procedures, organizational structures, people, etc.) that meets the design specification, if one exists, of the item it is replacing.

- CCPS 2008c Glossary; see Appx. A for change vs RIK examples

What is a “replacement-in-kind”?

Additional information in RIK definition:

- This can be an identical replacement or any other alternative specifically provided for in the design specification, as long as the alternative does not in any way adversely affect the function or safety of the item or associated items.

What is a "replacement-in-kind"?

Additional information in RIK definition:

- For nonphysical changes (relating to procedures, personnel, organizational structures, etc.), no specification *per se* may exist.
- In these cases, the reviewer should consider the design and functional requirements of the existing item (even if nothing is written down) when deciding whether the proposed modification is an RIK or a change.

DISCUSSION

Is the following a *change* or a *replacement in kind*?

1 Adding a block valve beneath a pressure relief valve so the relief valve can be removed and tested while the system is still in operation.

2 Making minor editorial changes or typographical corrections to an operating procedure.

3 Adding a break room inside the control building.

DISCUSSION

Is the following a *change* or a *replacement in kind*?

4 Ordering the same chemical ingredient from a different supplier.

5 Bringing on board a new production supervisor.

6 Installing a gear pump with the same motor, flow capacity and materials of construction as the piston pump it is replacing.

DISCUSSION

Is the following a *change* or a *replacement in kind*?

7 Sampling a waste stream on Tuesday and Friday of each week instead of Monday and Thursday.

8 Replacing a section of piping with a higher grade of steel.

9 Going from 8 hour shifts to 12 hour shifts.

10 Changing a process setpoint within previously established safe operating limits.

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?

What is a "change"?

There are many types of changes, such as:

- Equipment changes
- Procedural changes
- Chemical changes
- Process changes
- Control / limit changes
- ITM changes
- Personnel changes
- Infrastructure changes

All must be managed !

DISCUSSION: *Give one example of each type of change.*

Equipment change -

- Procedural change -
- Chemical change -
- Process change -

DISCUSSION: *Give one example of each type of change.*

- Control / limit change -
- ITM change -
- Personnel change -
- Infrastructure change -

Reminder

* Changes that are proposed as improvements can have unintended consequences, so must be managed like all other changes! *

Example: Chernobyl disaster (see CCPS 2008b).

"Any change, even a change for the better, is always accompanied by drawbacks and discomforts." - Arnold Bennett

DISCUSSION

Give some reasons why a permanent change might need to be made to a process plant.

It is not necessary to change. Survival is not mandatory.

- W. E. Deming

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?
4. **What is needed to manage changes?**

MOC ingredients for success[1]

To manage change successfully and safely, you must have:

- **A robust management-of-change program in place**
- **Clear ownership of the program and its constituent parts**

[1]CCPS 2008b p. 193

MOC program essential elements[2]

Essential elements of a robust MOC program:

1 Agree on the technical justification for the change
- at the appropriate management level

2 Risk-assess the proposed change
- Using a multi-disciplined team of competent people
- Including specialists and vendors when needed

[2] CCPS 2008b pp. 193-194

MOC program essential elements

Essential elements of a robust MOC program (cont'd):

3 Put in place a rigorous design approval system
- To ensure that the proper engineering standards are applied to the design
- To ensure any deviations from design are approved by an engineering authority of sufficient knowledge and experience

4 Write formal operating procedures for the change
- Train all staff who are directly affected
- Obtain confirmation that training has been effective

MOC program essential elements

Essential elements of a robust MOC program (cont'd):

5 Carry out a pre-startup safety review to:
- Ensure all recommendations from the risk assessment process have been incorporated into the design
- Ensure any deviations from established standards or practices have been approved at the appropriate level
- Confirm that all integrity testing has been successfully completed
- Confirm that operating procedures and training are complete

MOC program essential elements

Essential elements of a robust MOC program (cont'd):

6 Monitor the period of change closely
- With people of sufficient knowledge and experience
- Feeding back any lessons learned for the benefit of future projects

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?
4. What is needed to manage changes?
5. **What considerations need to be addressed?**

MOC considerations

All staff must follow a written MOC procedure to assure that all of the following considerations are addressed prior to making any change:

- **Technical basis for the proposed change**
- **Impact of change on safety and health**
- **Modifications to operating procedures**
- **Necessary time period for the change**
- **Authorization requirements**

- U.S. OSHA Process Safety Management Standard, 29 CFR 1910.119(l)(2)

Written MOC procedure

Aids in developing/implementing an MOC procedure:

- **Workflow diagrams**
  - **See Simplified MOC Flowchart on last 2 slides**
- **Forms**
  - **Example forms given in CCPS 2008c appendices**
- **Electronic MOC tracking systems**
  - **From simple to sophisticated**
  - **Can tie into plant's work order system**
  - **Can inform personnel by email**
  - **Can route MOCs for approvals**

Written MOC procedure – typical outline

Title, Date, Revision No.

1.Purpose

2.Definitions (*change, RIK, emergency change,* etc.)

3.Responsibilities and Accountabilities

4.Initiating a Proposed Change

- Who can initiate a change
- Type of change (e.g., chemical, process, SOP, equipment, facilities)
- Technical basis for the change
- Necessary time period for the change

(continued)

5. Evaluating a Proposed Change

- How the impact on safety and health is evaluated and by whom
- How the safety and health evaluation is to be documented
- What actions are necessary to safely make the change

6. Authorizing a Proposed Change

- Who must approve the different types of changes
- Authorization of emergency changes
- Authorization requirements for extending a temporary change

(continued)

7. Implementing an Approved Change

- Making the physical changes
- Modifying operating procedures
- Reversing a temporary change and documenting the reversal
- Training and informing affected employees and contractors

8. Updating the Process Safety Information

9. Performing the Pre-Startup Safety Review

10. Recordkeeping Requirements

CCPS 20 Years — An AIChE Industry Technology Alliance

Process Safety Beacon

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

Messages for Manufacturing Personnel

Sponsored by CCPS Supporters

June 2005

Too Many Start-Stop Switches

PSID Members see: Free Search--Agitator

Here's What Happened

The evening shift was assigned to clean an agitated mixing vessel. The supervisor asked the lead operator to complete the "Lock out." The lead operator tagged and locked out the motor starter in the Motor Control Center, verified the motor would not start by pressing the Start button and put a lock and "Danger—Do Not Operate" tag on the Start-Stop station near the vessel. The supervisor then issued the Confined Space Entry permit and two workers entered the vessel and cleaned it for the rest of the shift.

The oncoming day shift needed to reissue the Confined Space Entry permit. When they tried the Start button on the Start-Stop station, the agitator started! The agitator motor was **NOT** locked out!

http://www.psidnet.com

How Did This Happen ?

Easier than you might imagine. Did the Lock-out undo itself? No, but the wrong motor was locked out. How can that happen when the starter was labeled the same as the agitator? And, why didn't the agitator start when the Start button was tested the first time?

Here's how. Several months before, the agitator motor was changed out to a larger size. The size increase required a larger motor starter and wiring. Because the plant might need the "old" system again some day, it was not removed. Instead, a new Start-Stop station was installed near the vessel, in fact, right next to the old Start-Stop station. The "old" Start-Stop station was on the flange part of a column next to the vessel and the "new" Start-Stop station was in the web of that same column. When the technician locked out and tested the system, he was testing the "old" system which was disconnected. The "new" system was still active!

What You Can Do

- Follow all safety procedures as written. Do not take short cuts or assign your duties to someone else.
- Keep abreast of changes in your unit. Know what has been changed and how that change might affect your job.
- Use your Management of Change procedures to ensure that all out-of-service equipment is labeled so that it cannot be confused with equipment being used.
- Consider disconnecting electrical leads whenever uncertainty exists.
- Check and re-check, especially where safety is concerned. Look around the area. Is anything unusual?
- Remember that your safety depends on others and your own personal actions. Don't bet your life on someone else's word. Verify safety checks yourself.

When you do a safety check, make sure it is on the right equipment !

DISCUSSION

Discuss the lockout near-miss situation.

- What could have happened?
- How could this been avoided?
- Where does this fit into Management of Change?

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?
4. What is needed to manage changes?
5. What considerations need to be addressed?
6. **What about temporary and emergency changes?**

What is a "temporary change"?

Definition:

Temporary change. A change that is implemented for a short, predetermined, finite period.

- CCPS 2008c Glossary

DISCUSSION

Give some reasons why a *temporary* change might need to be made to a process plant.

Temporary changes

“Temporary” changes have led to many severe process safety incidents.

- **Flixborough (1974) is an example of a temporary equipment modification**
- **See CSB 2001** (on CD-ROM) **for two incidents involving *deviations from normal operating procedures due to abnormal situations***


Safety Bulletin
Management of Change

Temporary changes

A temporary change must go through the same documentation, review and authorization procedure as a permanent change.

IN ADDITION:

- **Change is only authorized for a specific time period**
- **Plant must then be put back to its original state**

What is an “emergency change”?

Definition:

Emergency change. A change needed in a situation where the time required for following the normal MOC procedure could result in an unacceptable safety hazard, a significant environmental or security incident, or an extreme economic loss.

- CCPS 2008c Glossary

DISCUSSION

Give two reasons why an *emergency* change might need to be made to a process plant.

Emergency changes

Typical considerations for emergency changes:

- Have a procedure in place ahead of time to deal with emergency changes, including authorization requirements
- Obtain and document at least verbal approval from line management (often the plant manager or designee)
- Communicate the change to all affected persons
- Follow up through the normal MOC process as soon as possible

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?
4. What is needed to manage changes?
5. What considerations need to be addressed?
6. What about temporary and emergency changes?
7. **What information needs to be updated?**

Information updates

The MOC procedure needs to assure that <u>all information defining "normal operation"</u> is updated when changes are made; e.g.:

- **Process safety information**, including
  - Drawings
  - Chemical data
  - Equipment files
  - Process chemistry
  - Facilities design data
  - Material / energy balances
  - Safe upper and lower limits

Information updates

The MOC procedure needs to assure that <u>all information defining "normal operation"</u> is updated when changes are made; e.g.:

- Process safety information
- **Written procedures**
  - Operating
  - Maintenance
  - Emergency
  - Safe work practice

Information updates

The MOC procedure needs to assure that <u>all information defining "normal operation"</u> is updated when changes are made; e.g.:

- Process safety information
- Written procedures
- **Inspection / testing / maintenance schedules**

Information updates

The MOC procedure needs to assure that <u>all information defining "normal operation"</u> is updated when changes are made; e.g.:

- Process safety information
- Written procedures
- Inspection / testing / maintenance schedules
- **Control system documentation**

DISCUSSION

What are some challenges to getting the process safety documentation updated?

How can they be overcome?

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?
4. What is needed to manage changes?
5. What considerations need to be addressed?
6. What about temporary and emergency changes?
7. What information needs to be updated?
8. **What else needs to be done pre-startup?**

Pre-startup safety reviews

PSSR = *pre-startup safety review*

Pre-startup safety reviews

A PSSR confirms that, before re-starting a process:

- ☐ Construction and equipment is in accordance with design specifications
- ☐ Safety, operating, maintenance, and emergency procedures are in place and are adequate
- ☐ Training of each employee involved in operating a process has been completed
- ☐ Modified facilities have completed the MOC process
- ☐ For new facilities, a process hazard analysis has been completed and recommendations are resolved

- U.S. OSHA Process Safety Management Standard, 29 CFR 1910.119(i)(2)

Pre-startup safety reviews

Key elements of successful PSSRs:

- Performed by <u>team</u> of knowledgeable persons
- Includes a <u>field inspection</u> of modified facilities
- Uses a <u>checklist</u> to ensure completeness (see CCPS 2007b)
- Generates list of pre-startup <u>follow-up items</u>
- Is <u>integrated</u> with the MOC procedure

Pre-startup safety reviews

Note:

- Larger projects may require multiple PSSRs
- Non-physical changes, such as modifications to operating procedures, may not require PSSRs
- PSSRs are part of the more general idea of "operational readiness" (see CCPS 2007a)

Management of Change

1. Why manage change?
2. What is a "change"?
3. What types of changes need to be managed?
4. What is needed to manage changes?
5. What considerations need to be addressed?
6. What about temporary and emergency changes?
7. What information needs to be updated?
8. What else needs to be done pre-startup?
9. **How are changes communicated?**

Communication of changes

Inform of and train in the change:

WHO?

- Employees involved in operating a process
- Maintenance and contract employees whose job tasks will be affected by a change in the process

WHEN?

- before starting up the process or affected part of the process.

- U.S. OSHA Process Safety Management Standard, 29 CFR 1910.119(l)(3)

Communication of changes

Inform of and train in the change:

HOW?

- Train through plant training program when needed
  - Use appropriate techniques
  - Verify understanding
- Otherwise inform, such as by
  - Safety meetings
  - Beginning-of-shift communications
  - E-mail
- Document training / informing

Communication of changes

Inform of and train in the change:

WHAT?

- Physical changes
- Personnel or responsibility/accountability updates
- Operating/maintenance procedures
- Emergency procedures; Emergency Response Plan
- Safe work practice procedures
- Control limits or practices

DISCUSSION

A process manufactures a key chemical intermediate by an exothermic chemical reaction.

The plant chemist has an idea that if a particular new catalyst is used, the yield will be increased by 5%.

- *This change might lead to what kinds of process safety issues?*
- *What kind of training or informing might be needed?*

MOC "To Do" List

- ☐ **Regularly train all staff to recognize change.**
  - MOC awareness training
  - Changes vs RIKs
  - Refresher training

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ **Follow a written procedure to manage changes.**
  - Assign roles, responsibilities and accountabilities
  - Include temporary and emergency changes
  - Describe the entire process for managing changes

NOTE: Different procedures can be followed for different types of changes (equipment, personnel, control system, operating procedure changes, etc.)

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ Follow a written procedure to manage changes.
- ☐ **Review all proposed changes for safety impact.**

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ Follow a written procedure to manage changes.
- ☐ Review all proposed changes for safety impact.
- ☐ **Have all changes <u>approved</u> before making them.**

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ Follow a written procedure to manage changes.
- ☐ Review all proposed changes for safety impact.
- ☐ Have all changes approved before making them.
- ☐ **Properly <u>reverse</u> all temporary changes.**
  - Go back to exactly how it was before, or do a MOC
  - Don't exceed the authorized time limit
  - Go through the MOC process again to make permanent
  - Inform all affected persons of the reversal
  - Document the reversal

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ Follow a written procedure to manage changes.
- ☐ Review all proposed changes for safety impact.
- ☐ Have all changes approved before making them.
- ☐ Properly reverse all temporary changes.
- ☐ **<u>Update</u> all affected process safety information.**

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ Follow a written procedure to manage changes.
- ☐ Review all proposed changes for safety impact.
- ☐ Have all changes approved before making them.
- ☐ Properly reverse all temporary changes.
- ☐ Update all affected process safety information.
- ☐ **<u>Communicate</u> changes to all affected persons.**
  - Including reversal of temporary changes
  - Re-training may be required for some changes

MOC "To Do" List

- ☐ Regularly train all staff to recognize change.
- ☐ Follow a written procedure to manage changes.
- ☐ Review all proposed changes for safety impact.
- ☐ Have all changes approved before making them.
- ☐ Properly reverse all temporary changes.
- ☐ Update all affected process safety information.
- ☐ Communicate changes to all affected persons.
- ☐ **Field-inspect changes before re-starting.**

MOC "To Do" List

- ☐ **Regularly train all staff to recognize change.**
- ☐ **Follow a written procedure to manage changes.**
- ☐ **Review all proposed changes for safety impact.**
- ☐ **Have all changes approved before making them.**
- ☐ **Properly reverse all temporary changes.**
- ☐ **Update all affected process safety information.**
- ☐ **Communicate changes to all affected persons.**
- ☐ **Field-inspect changes before re-starting.**

Final suggestions

- **Assign an MOC Coordinator who is**
  - Knowledgeable
  - Conscientious
  - Persistent
  - Detail-oriented
  - Well-organized

Final suggestions

- Assign an MOC Coordinator
- **Keep an MOC Log**
  - E.g., spreadsheet by MOC number
  - Keeps track of status of all MOCs
  - Helps ensure temporary MOCs do not exceed authorized closure date
  - Helps report key MOC metrics to management

Final suggestions

- Assign an MOC Coordinator
- Keep an MOC Log
- **Complete PSSR follow-up items before restarting**
  - Signage
  - Painting
  - Insulation
  - Clean-up
  - Procedure revisions and approvals
  - Training and Communications
  - Paperwork
  - etc.

Final suggestions

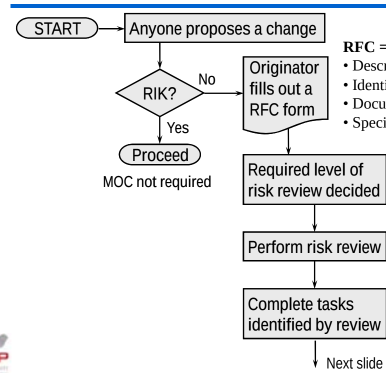
- Assign an MOC Coordinator
- Keep an MOC Log
- **Complete PSSR follow-up items before restarting**
  - Signage
  - Painting
  - Insulation
  - Clean-up
  - Procedure revisions and approvals
  - Training and Communications
  - Paperwork
  - etc.

Possible exception:
Red-lined P&IDs not re-drafted

Final suggestions

- Assign an MOC Coordinator
- Keep an MOC Log
- Complete PSSR follow-up items before restarting
- **Don't short-cut the safety & health review!**
  - (Same as the risk assessment)

Simplified MOC Flowchart

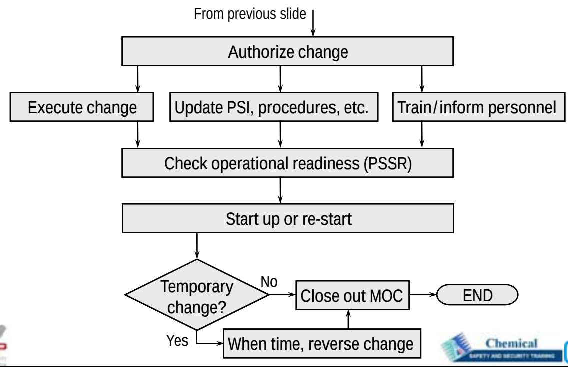


RFC = "Request for Change"
- Describe what is to be changed
- Identify the type of change
- Document the technical basis
- Specify a time limit if any

- What-If, HAZOP, Safety Review, etc.
- Use required participants per MOC procedure

- Answer questions raised
- Implement risk-control measures

Simplified MOC Flowchart (continued)



Tea Break

Chemical

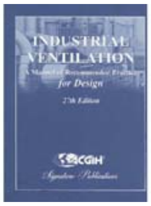
SAFETY AND SECURITY TRAINING

Industrial Ventilation

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

Industrial 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

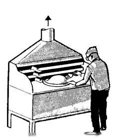
- **Duct velocity-velocity required to transport the contaminant**
- **Face velocity-velocity on the front of an enclosing hood**
- **Capture velocity-velocity required to capture contaminant at point of generation**

A = cross sectional area of hood opening in square meters

X = distance of ventilation from the source in meters

Purposes of Industrial 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

Laboratory Fume Hood

Purposes of Industrial 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

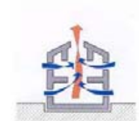
- What are the airborne contaminants?
  - Particles
  - Solvent vapors
  - Acid mists
  - Metal fumes

- How do to the workers interact with the 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 windows to create natural ventilation
  - Q = 0.2 AV
  - A = square meters (area of open doors)
  - V = wind speed in kilometers/hour
  - Q = estimates the flow rate through the building (m/s)

General Ventilation

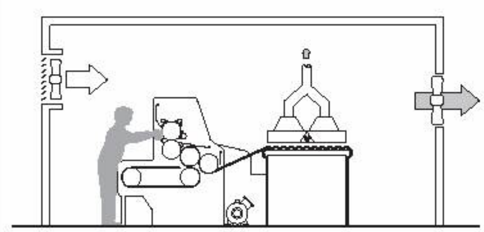
Dilution Ventilation

- Heat control
- Dilution of odors, flammables
- <u>Not</u> 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

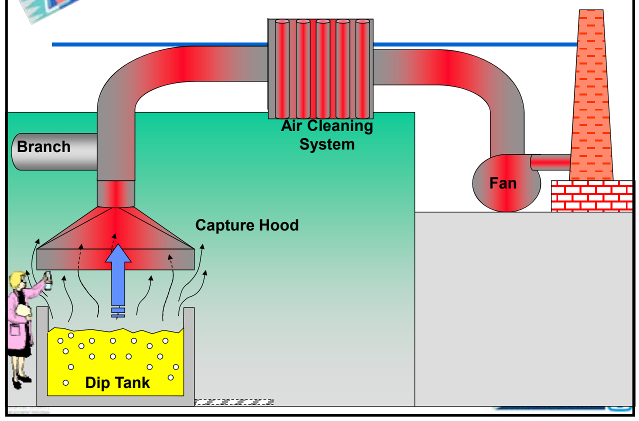


General ventilation for cleaning a printing press

Local Exhaust Ventilation (LEV)

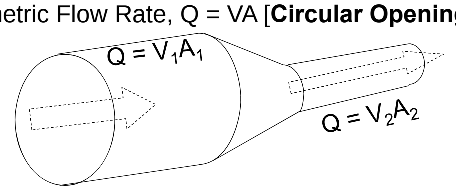
- Use when contaminant concentration cannot be controlled by dilution ventilation or other controls
- Select the type of LEV from hazard assessment
  - Which type is best to capture the contaminant?
    - Enclosed or capture hood?
    - Consider worker's needs
  - What duct transport velocity is required 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**]

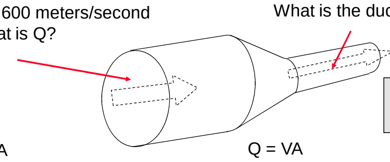


Q = Volumetric flow rate, in cubic meters/second
V = Average velocity, in meters/second
A = Cross-sectional area in square meters

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)(π[1m]^2/4)

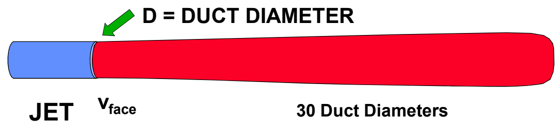
Q = **471 meters^3/second**

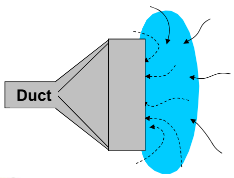
Q = VA

471 meters^3/s = V (π[0.5m]^2/4)

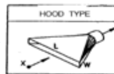
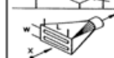
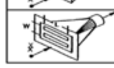
V = 2400 meters/second

Local Exhaust Ventilation





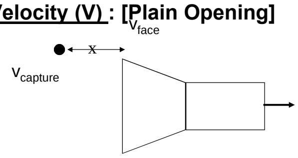
Capture of contaminant is only effective within one (1) duct diameter

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	$Q = 0.75V(10X^2 + A)$

ACGIH Ventilation Manual

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

ACGIH Ventilation Manual

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

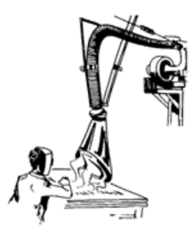
ACGIH Ventilation Manual

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

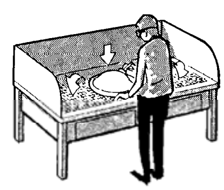
Local Exhaust Ventilation

- **"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



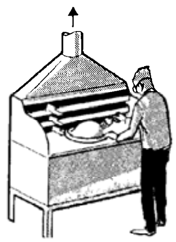
Local Exhaust Ventilation

- **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

Photo Credit: Spray Shield Industries

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

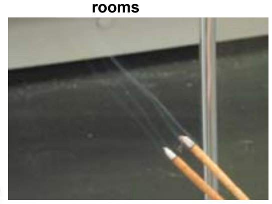
Exhaust Systems:

- 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.

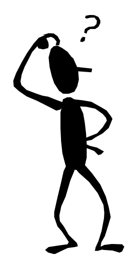


Ventilation System Evaluation

- 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/

LUNCH

Chemical
SAFETY AND SECURITY TRAINING

Personal Protective Equipment (PPE)

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

Personal Protective Equipment (PPE)

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

Limitations of PPE

- The least desirable control, but may be necessary if:
  - Engineering controls are being installed
  - Emergency response/spill cleanup
  - Non-routine equipment maintenance
  - To supplement other control methods
- Problems with PPE:
  - The hazard is still present with PPE
  - Use is very dependent on human behavior
  - Proper fitting is essential
- Can exposure be controlled by other means?

PPE Hazard Assessment

- 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

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 at your plant that uses PPE
- What is the hazard?
- What is the route of exposure? Inhalation, skin, eyes?
- 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 type of PPE required
- Inadequate employee 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

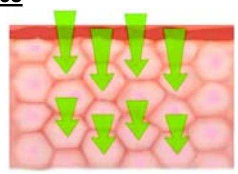


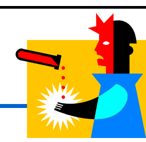
Photo credit: Permeation, http://www.cdc.gov/niosh/topics/skin/

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

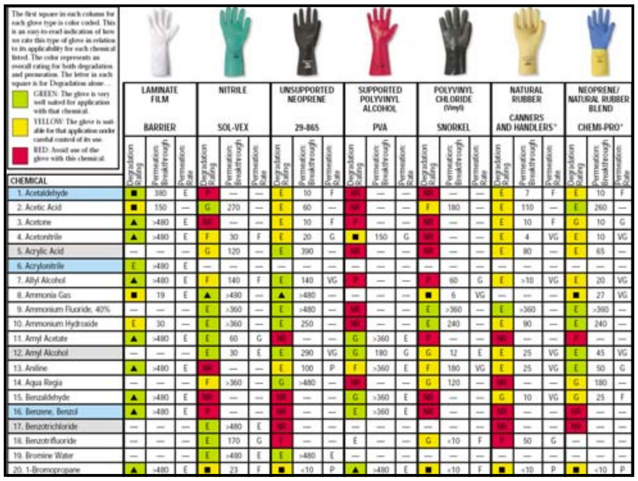
Protective Clothing

- 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.

	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*		
CHEMICAL	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	P	—	—	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.

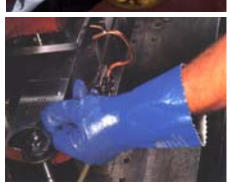
  NOT HYDROGEN FLUORIDE!

- 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.

Types of Gloves



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/

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>U.S. Respirator Requirements</u>

- 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. <u>ammonia</u>
  - <u>Never</u> use APR in oxygen deficient atmospheres
- APRs work by <u>filtering</u>, <u>absorbing</u>, <u>adsorbing</u> the contaminant or <u>chemical reaction</u>.
  - 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 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

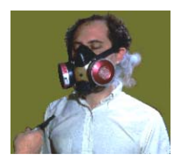
Full Face Respirator: MUC = 50 x 0.5 ppm = 25 ppm

Filtering Facepieces

Filtering Facepiece 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

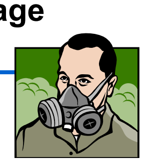
Supplied Air

- **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 $\leq$ 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 and Storage Procedures



- <u>Disposable filtering face-piece</u>:
  - Dispose after use
- <u>Air purifying respirators</u>:
  - 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
- <u>SCBA</u>:
  - Inspected monthly
  - Accessible and clearly marked

Exercise

- 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?**

Head Protection

Should meet or exceed ANSI Z89.1-2003

Types:

- Bump caps - don’t meet ANSI standard, provide minor protection
- Electrical protection to 2200-22,000 volts
- Mining protection
- Classic-- high impact general purpose protection.
- Impact 386 – 454 kilograms
- Penetration ~1centimeter

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.

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 <u>20 milligrams/cubic meter</u>.
- The short term exposure limit (15 minutes) for zinc oxide is <u>10 milligrams/cubic meter</u>.
- Zinc oxide powder is mildly irritating to the skin and eyes, but not toxic or corrosive.

What PPE should Worker C wear?

Behavior Based Safety (BBS)

SAND No. 2011-0487C
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.

What is Behavior Based Safety?

Behavior is "the manner of conducting oneself."*

Therefore, behaviors are <u>observable</u> acts.

Behavior Based Safety focuses on behaviors that promote safety.

* Merriam-Webster dictionary

Behavior Based Safety is <u>NOT</u>:

- A fully-developed safety program.
  - It is a process designed to eliminate behaviors that put workers at risk and enhance existing safety protocols.
- A process used to enforce safety rules, nor to correct hazardous conditions.
  - Safety rule violations and hazardous workplace conditions must be corrected outside of the BBS process.
- A process for assigning blame or criticizing workers.

How does BBS differ from traditional safety?

Traditional Safety…

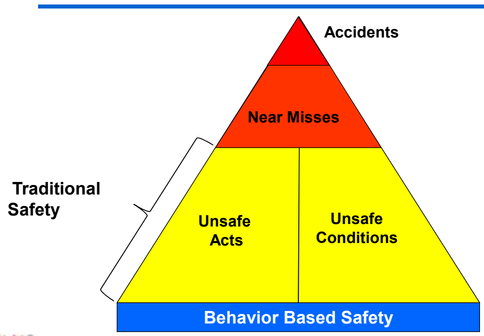
- Is *reactive* – focuses on correcting problems only after they have occurred.
- Searches for "root cause" of accidents
  - Using incident/accident data from investigations
    - e.g. Incident and Severity rate: TRCR/DART
- Focuses on making the working environment less hazardous.
- Sometimes assigns blame to individuals.
  - Emphasis on negative reinforcement.

How does BBS differ from traditional safety?

Behavior Based Safety…

- Is proactive – discourages 'at-risk' behaviors.
- Focuses on observing worker behavior.
  - Common behaviors that place employees at risk are noted and adjustments are made.
  - Data come from behavioral observations.
- Has a holistic understanding of worker behavior.
  - Notes the environment in which behavior occurs, the behavior itself, and consequences of this behavior.

Behavior Based Safety underlies and benefits Traditional Safety



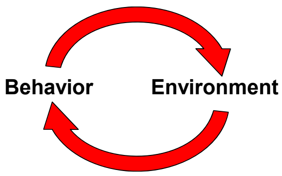
Always Keep in Mind…

BBS is focused on two concepts:

- BEHAVIOR
  - What is behavior?
  - What are the factors influencing "at-risk" behavior?
  - How can this behavior be discouraged?
- RISK
  - What is risk?
  - Why do people take risks?
  - What are the consequences of taking these risks?

Remember: Behavior is "the manner of conducting oneself"

Behaviors cannot be isolated from the environment in which they occur.



Therefore, if employees are expected to promote safe practices the working environment must encourage this behavior.

Risk = exposure x probability

Exposure – extent a person is involved in an activity.

Direct

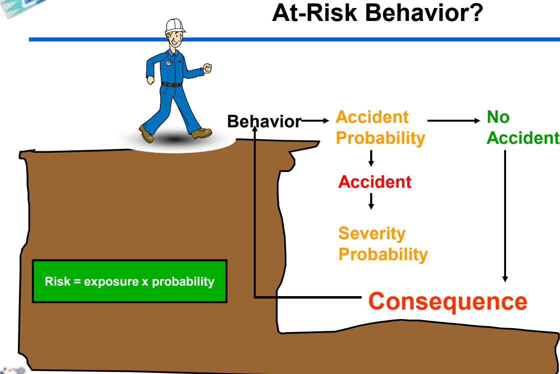
Indirect

Probability – the chances of an accident occurring during activity.

1 in 6

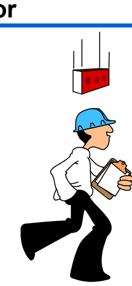
1 in 52

How do Consequences Affect At-Risk Behavior?



Positive Consequences Influence At-Risk Behavior

- Convenience
- Time savings
- Increased productivity
- Getting away with it
- Feeling bullet-proof

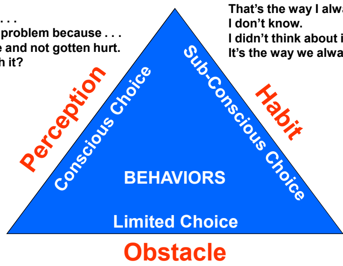


How does cheaper/better/faster influence taking risks?

Worker's reasons for taking a risk:

In my opinion . . .
In my experience . . .
I don't think it's a problem because . . .
I've done it before and not gotten hurt.
What's wrong with it?

That's the way I always do it!
I don't know.
I didn't think about it.
It's the way we always do it around here.



I can't do it any other way because . . .
It would be difficult to do it that way because . . .
If I do it that way, (this would happen).

Implementing Behavior Based Safety

Prior to Implementation

Important to develop a BBS Committee and working structure that persists after implementation:

- <u>Designs</u> the BBS process.
- <u>Develops</u> the implementation strategy.
- <u>Implements</u> the BBS process.
- <u>Steers</u> the BBS process.
  - Assures observation and data quality through a Quality Assurance Plan.
  - Champions worker involvement and completion of observations.
  - Analyzes observation data to identify the causes of at-risk behaviors and develops recommendations.
  - Facilitates removal of barriers to workers being able to easily perform work safely.
  - Reports the results of data analysis.

Responsibilities of Managers & Supervisors

- Understand the process (receive training)
- Establish BBS as a part of the job
- Help identify and correct systems issues
- Remove barriers
- Support:
  - Time for:
    - Training
    - BBS Committee duties and meetings
    - Observations
- Encourage and provide positive reinforcement: workers, observers, BBS Committee members

4 Steps of Implementation

The BBS implementation process consists of four steps we will discuss in further detail:

1. Establish Feasible Goals
2. Develop Observation Checklists
3. Take observations
4. Provide Feedback

Step 1: Establish Feasible Goals

The overall purpose of BBS is to establish a culture of safety in the working environment. However, attainable goals need to exist in working toward this. Make goals SMART:

Specific – Motivational – Attainable – Relevant – Trackable

e.g. A goal of "zero-injuries" is NOT SMART, but a goal of 80% participation in appropriate safety training is SMART.

Goals should focus on outcomes, NOT behaviors.

Step 1: Establish Feasible Goals

Employee participation in the goal-setting process is important, and must continue throughout the BBS process to ensure success. There are two broad reasons for this:

1. "Employee buy-in" – verbal and nonverbal support for change from those directly affected.
2. Interpersonal trust – trust among employees, and trust between employees and management.

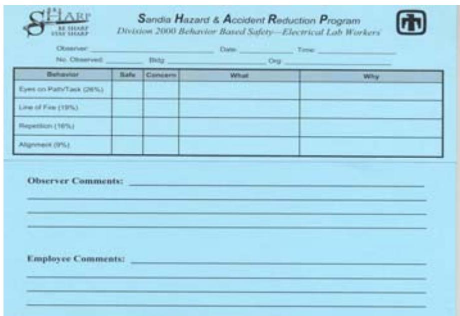
Step 2: Develop Observation Checklists

In looking for behaviors that encourage safe practice, there are several options:

- Review past accident/incident reports to identify behavior that could have prevented them.
  - Focus on those that could have prevented the largest number of accidents.
- Consult with employees and managers.
  - It is important for employees to take responsibility for their actions.
  - Beneficial for developing trust.
- Observe workers for a period of time.

Step 2: Develop Observation Checklists

Remember in developing the list that positive reinforcement is better for employee participation (i.e. specify criteria for good performance).


SHARP
Sandia Hazard & Accident Reduction Program
Division 2000 Behavior Based Safety—Electrical Lab Workers

Observer: ____ Date: ____ Time: ____
No. Observed: ____ Bldg: ____ Org: ____

Behavior	Safe	Concern	What	Why
Eyes on Path/Task (26%)				
Line of Fire (19%)				
Repetition (16%)				
Alignment (9%)				

Observer Comments: ____

Employee Comments: ____

Step 3: Observing

There are several decisions to be made when selecting an observation method or methods:

- **Who will observe?**
  - Self-observation
  - Peer-to-peer
  - Top-down
  - Working groups
- **Frequency of observations?**
  - Daily, bi-weekly, monthly
- **How will feedback be given?**
  - Immediately
  - Within a week

Observers Have…

Three main responsibilities:

- Gather data
  - Observation data (Safe/Concern)
  - Discussion data (What/Why)
- Give feedback
  - Positive reinforcement for safe behaviors
  - Provide coaching on concerns
- To remain objective/unbiased

Step 3: Observing

As an example, Sandia's method of observation is:

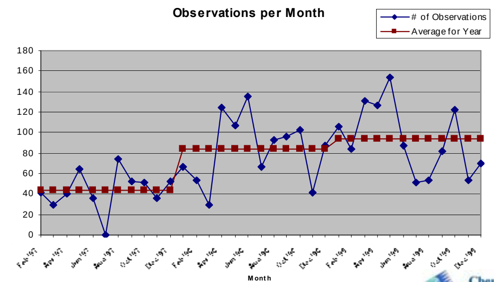
- Peer-to-peer
- Anonymous (No Names/No Blame)
- Announced
- 5 minutes or less
- Provide feedback:
  - Positive reinforcement for safe behaviors
  - Coaching for behaviors of concern
- Identify obstacles
- Foster safety communication

An Observer's Job is NOT:

- Ambush or spy on workers
- "Catch" people doing activities unsafely
- Criticize worker performance
- "Safety cop" (risks vs. rules; right vs. wrong; safe vs. unsafe)
- Watch a whole task or job
- Force people to change
- Turn people in for discipline
- Identify conditions that don't directly impact critical behaviors

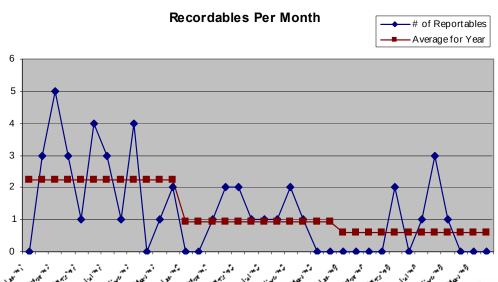
What happens with more observations?

Feedback Changes Behaviors



Fewer injuries!

Changed Behaviors Reduce Accidents



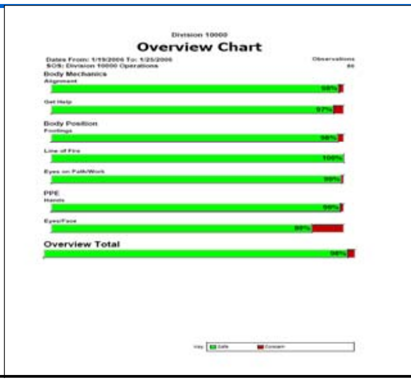
Step 4: Providing Feedback

Providing feedback to workers in a timely manner is important. Using multiple methods has proven beneficial:

- Verbal - Immediate feedback during observations.
- Through reports written after observation data collected.
- Posting graphs/charts where all can see.
- Having celebrations for milestones or providing other incentives.

NOTE: It is important that workers are allowed time to adjust their performance before being observed again.

An example of a "Green/Red" Chart from the Observations of a Division at Sandia



Why Implement Behavior Based Safety?

The BBS Process Closes the Gap to "Nobody Gets Hurt"

- Focuses on the critical few precautions that would prevent the most injuries
- Prioritizes actions to remove barriers
- Generates actionable data
- Provides positive reinforcement of safe behaviors
- Engages workers and management:

  Worker driven/Management supported

BBS is proven to reduce injuries

- At 850+ companies injuries were reduced by an average of:
  - 37% after 1 year
  - 66% after 2 years
  - 87% after 3 years
- Multisite Success – See case study of BP's Fabrics and Fibers Business Unit (FFBU) included in your extra materials.

The Benefits Outweigh the Costs

- What is the Return on Investment for BBS?
  - Saves time, money, energy, and can improve morale among employees and between employees and managers.
  - Costs of accidents/incidents are both direct and indirect:
    - Direct costs: investigation, production downtime, medical expenses, damage to equipment or product, repairs, legal costs, fines, etc.
    - Indirect costs: employer/public liability, business interruption, training replacements, loss of goodwill/employee morale, negative public image.

Why Implement Behavior Based Safety?

Remember:

The Iceberg Theory

For every accident, there are many “near misses” that go unnoticed.

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Tea Break

Chemical

SAFETY AND SECURITY TRAINING

Industrial Waste Management- I

SAND No. 2011-0486P
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.

Hazardous Waste Management

- **Hazardous Waste Definitions and Laws**
- **Hazardous Waste Management**
- **Waste Hierarchy**
  - **Reduce / Substitute**
  - **Reuse**
  - **Recycle / Recovery**
- **Hazardous Waste Treatment**
  - **Wastewater Treatment**
- **Case Study**

U.S. History of Hazardous Waste Pollution

- **In 1962, renowned author and naturalist, Rachel Carson, warned growing contamination "great underground seas" (i.e., groundwater) in "Silent Spring."**
- **Love Canal – New York, USA. Buried barrels of chemicals underneath new housing development (1950s). Became main cause for the Superfund legislation. Removed from Superfund in 2004.**
- **Valley of the Drums – Kentucky, USA, 23 acre site with a large number of leaking drums. Fire at site in 1966. Not completely cleaned up until 1990.**
- **Times Beach – Missouri, USA community where contaminated oil was used for dust control from 1972-1975.**

Relevant U.S. Environmental Legislation and UN Convention

Primary U.S. Legislation

- •Clean Air Act- 1970
- •Clean Water Act – 1972
- •Safe Drinking Water Act – 1972
- •Resource Conservation and Recovery Act- 1976
- •Comprehensive Environmental Response, Compensation and Liability Act of 1980 (Superfund)
- •Hazardous and Solid Waste Amendments - 1984 (Land Ban)
- •Pollution Prevention Act -1990

U.N. Convention

- •Basel Convention 1992- Control of Transboundary Movements of Hazardous Wastes and their Disposal

Definition of Waste

Definition of Wastes- Basel

"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 Wastes- 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 – Industrial source-Type

Organisation for Economic Co-operation and Development (OECD) Definition of Waste

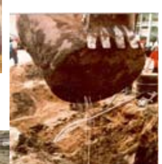
•Materials that are not prime products (i.e. products produced for the market) for which the generator has no further use for own purpose of production, transformation or consumption, and which he discards, or intends or is required to discard.
•Wastes may be generated during the extraction of raw materials during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity.

The following are excluded:
•Residuals directly recycled or reused at the place of generation (i.e. establishment);
•Waste materials that are directly discharged into ambient water or air.

Surface and Groundwater Contamination Leads to Health Problems, Water Shortage

- **Mining**
  - Acid mine drainage
  - Heavy metals – Hg, Cr, Pb
- **Industrial / Commercial Pollution**
  - Dyes and pigments
  - Petroleum / gasoline
- **Agricultural runoff**
  - Pesticides
  - Nutrients – nitrates, phosphates
  - Salinization – Sodium, chloride
- **Sewage**
  - Pathogens - Enteric
  - Nutrients – Nitrates, phosphates
  - Contaminated animal feed


Textile Waste


Petroleum


Mining Waste

Drinking Water, Wastewater Contaminants Directly Affect Public Health

Pathogens
Bacteria – Enteric, fecal
Protists – Cysts and spores
Virus - Enteric
Metals
Copper
Lead
Arsenic
Disinfection byproducts
Trihalomethanes - $CHCl_3$, CH_2Cl_2, CH_2ClBr
Haloacetic acid – CH_2ClCO_2H
NDMA
Pesticides

Solid Waste can Directly Impact Human Health

Solvents
- Gasoline, diesel, chlorinated

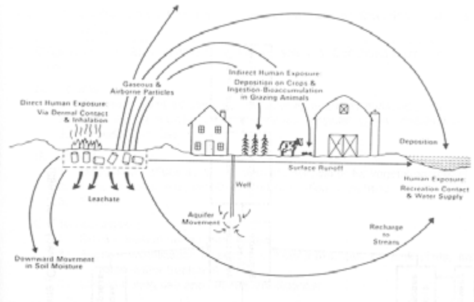
Leachates
- Acid waste, heavy metals

Hazardous waste
- Metals, paints, solvents, pesticides

Leaking fuel tanks
- Gasoline, diesel

Refuse
- Decaying animal and plant matter

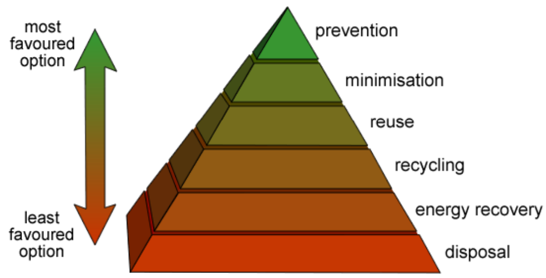
Various Pathways Exist for Contamination From Land Disposal



Effective Waste Management Program Involve Planning

1. Define Current Industrial Waste Management Practices.
2. Identify Industrial Waste Management Improvement Options.
3. Compile Findings / Assessment Report.
4. Evaluate Industrial Waste Program Scenarios.
5. Select Preferred Industrial Waste Program.
6. Start the Selected Program.

Solid Waste Hierarchy: Reduce, Reuse, Recycle, Treat and Dispose



Source: http://en.wikipedia.org/wiki/Waste_hierarchy

Industrial Hazardous Waste Reduction

- Reduce the amount of reactants necessary
- Incorporate green chemistry
  - 12 principles-reduce energy, catalysis, reduce derivatives, design to decompose….
- Improve recovery of product
- Reuse/recycle off-specification product
- Separate waste streams (cooling water, storm water, process water)
- Combine streams for neutralization

Industrial Hazardous Waste Reduction

- Improve process control
- Improved equipment design
- Use of different raw material
- Good housekeeping
- Preventive maintenance
- Industrial ecology
  - Co-locate plants
  - Waste exchange program
  - Waste heat as a resource
  - Beneficial use
  - Waste to energy

Substitution of Hazardous Materials

Substitution of hazardous substances is an innovation process

- Uncertainty of success
- Inertia
- Economic risk assumed to lower ultimate risk

Straightforward systems

Cement
Mineral fibers
Substitution and maintain technical effectiveness

Complex systems

Textile auxiliary agents
Supply chain globally interlinked, more complex products

Metals Recycling –Resource Recovery and Landfill Protection

Steel
Aluminum
Mercury recycling
Batteries
- **Lead**
- **Battery Acid**
- **Cadmium**

E-Waste

Off –Specification Materials Returned to Process

Industrial Byproducts can be Recycled

Construction and Demolition Wastes
Fly Ash, Bottom Ash, Slags
Flue Gas Desulfurization Gypsum
Phosphogypsum
Red Mud
Tires

Source: Wikipedia – Harvey Hinklemann

Example: Waste Tires - Technology in Recycling

Simple → Complex

- •Used to prevent erosion
- •Artificial reefs
- •Tire derived fuel- cement kiln
- •Crushed to crumb rubber for asphalt
- •Pyrolyzed to make oil
- •Cryogenic grinding- specialty
- •High recovery devulcanization

http://www.youtube.com/watch?v=Vgk1UZ242kM
http://www.youtube.com/watch?v=xmOkvUlpTL0

Example: Spent Catalyst Recovery and Disposal for Petroleum Refineries

•Catalytic cracking- Zeolites regenerated in process

•Hydrotreating – Ni, Mo, W, Co recovery
- •Acid and caustic metals separation and precipitation. (Hydrometallurgical)
- •High temperature fusion (Pyrometallurgical)

•Naptha reforming - Pt or Re on silica or silica alumina support (Recycled for precious metal-chlorinated precipitate)

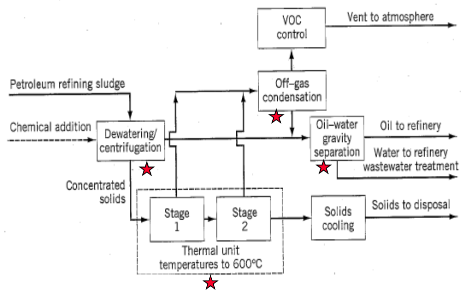
•Steam reforming - Ni oxide catalyst on alumina support (Nickel recovery Alumina + NaOH)

Source: www.matrostech.com

Thermal Technologies for Oily Waste-Recycling Options

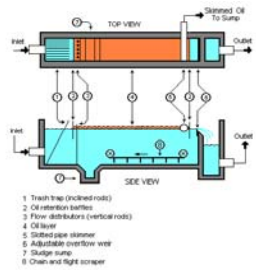
- **Separation - recycle**
  - Solvent Extraction
  - Centrifugation - Hydrocyclones
  - Air and Steam Stripping
  - Distillation
  - Recycle

Unit Operations for Product Recovery - Refinery Waste (Thermal Desorb)



Pretreatment of Petroleum Refinery / Oleo Waste

- **Heating and decantation with gravity separation**
- **De-emulsifying**
  - **Electrostatic coalescents**
  - **Oil in water**
  - **Water in oil**
- **Separation – Centrifugation- Filtration**
- **Solvent extraction**
- **Thermal distillation – Product recovery**



API Gravity Separator

Source: Milton Beychock Wikipedia

Oily Water Extraction, Separation and Treatment Processes

Solvent Extraction

- Preparation (sorting the contaminated material)
  - Extraction
  - Separation of concentrated contaminants from solvent
  - Removal of residual solvent
  - Contaminant recovery, recycling, or further treatment.

Air or Steam Stripping

- Similar to distillation – recovery and recycle of organics
- Steam stripping can recover low VP and soluble compounds

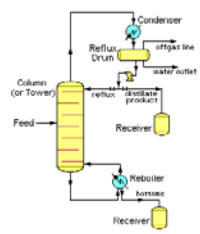
Centrifugation

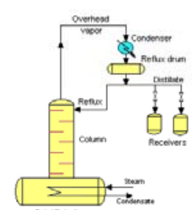
- Hydrocyclone: oil water separator
- Decanter: slop oil, 3 component sludge

Wet Air Oxidation

- Organic waste oxidation in water
- 150°C-325°C, 300psi-3000 psi

Distillation: Continuous and Batch





Source :H. Padleckas-Wikipedia

Distillation Pros and Cons

•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

–Costs of recovery often exceed cost of thermal destruction.

–Complex operation high capital cost, 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.

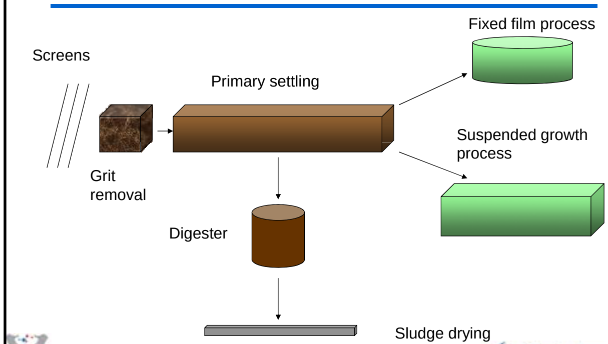
Water Pollution Treatment Processes are Well Established

Water Pollutant	Treatment
Organic chemicals	Air stripping, distillation, oil water separators, adsorption
Biological oxygen demand (BOD)	Aerobic digestion, activated sludge-fixed film and suspended
Chemical oxygen demand (COD)	Aerobic digestion, activated sludge-fixed film and suspended advanced oxidation
Suspended solids (turbidity)	Settling, coagulation, filtration
Color	Coagulation, filtration, adsorption
Metals	Coagulation , filtration, ion exchange, membranes
Microbes	Activated sludge, disinfection
Dissolved solids	Distillation, membranes, electrodialysis, ion exchange

Wastewater Treatment

- **Primary**
  - **Screening**
  - **Sedimentation /Flotation**
  - **Hydrocycloning**
- **Secondary**
  - **Activated sludge/ lagoons**
- **Tertiary**
  - **Oxidation / adsorption**
- **Dewater sludge**
- **Digest or incinerate**

Wastewater Treatment – Biological Processes



Wastewater-Fixed Film Biological Process

Trickling filter

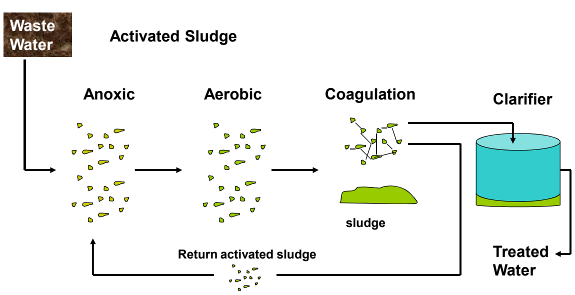
Rotating biological contactor (40% submerged rotates at 1-1.5 rpm)

Uses biofilm to treat water to remove BOD

Suspended Growth (activated sludge) Process Requires Energy

- Use forced air suspension of biological sludge to reduce BOD
- Largest expense for this process is the electrical energy required

Wastewater Suspended Growth Biological Process



Anoxic – no dissolved oxygen

Wastewater Treatment- Generic

- **Coagulation / Flocculation** – removes suspended solids whenever natural subsidence rates are too slow to provide effective clarification
  - Water clarification
  - Lime softening
  - Sludge thickening
  - Dewatering
- **Solids / Liquid Separation**
  - Sedimentation– gravitational settling
  - Air/Gas Flotation
  - Filtration
  - Centrifugation

Wastewater Treatment- Generic
(continued)

- **Precipitation (Softening)** – removes hardness by chemical reaction and settling
  - Lime softening
  - Silica removal
  - Heavy metals removal
- **Ion Exchange** – removes unwanted ions by transferring them to solid material
  - Anion exchange (weak base, strong base)
  - Cation exchange (weak acid, strong acid)
  - Regeneration with neutralization
  - Ion specific resins (boron removal)

Wastewater Treatment- Generic
(continued)

- **Neutralization** – acid / base addition to adjust pH
  - Neutral pH = 7
  - Neutral pH range = 6 - 9
- **Membrane Separation** – use membranes to remove suspended and dissolved solids
  - Microfiltration (MF) = removes suspended solids
  - Ultrafiltration (UF) = removes suspended solids
  - Reverse Osmosis (RO) = uses pressure to remove dissolved solids
  - Electrodialysis (ED) = uses electricity to remove dissolved solids

Wastewater Treatment- Generic
(continued)

- **Adsorption** – uses physical adhesion unto porous media to remove unwanted molecules
  - Activated carbon adsorption
  - Resin columns
  - Fluoride removal with alumina
- **Evaporation** – water vaporization / condensation
  - Flow configurations (rising film, falling film, forced circulation)
  - Energy configurations (multiple effect, vapor recompression)
- **Oxidation / Reduction** – uses oxidation / reducing agents to remove unwanted constituents
  - Iron & manganese removal
  - Cyanide removal
  - Sulfide removal

US Environmental Protection Agency Resources

Chemical
SAFETY AND SECURITY TRAINING

Industrial Waste Management - II

SAND No. 2011-0486P
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.

Hazardous Waste Management

Hazardous solid waste treatment
•Thermal desorption
•Pyrolysis gasification
•Combustion
Incineration
Industrial furnaces/ Cement kiln
Molten glass / Plasma
Waste to Energy
Solidification-Stabilization
Land Disposal

Transitioning from Land Disposal To Treatment

Government policy is essential for managing hazardous waste (HW)

•Alone HW will be handled in cheapest way
•No natural market forces for HW
•Government provides incentive for management
•Without regulation dumping will prevail
•Even the best designed landfills leak
•Cleanup is always more costly than proper management

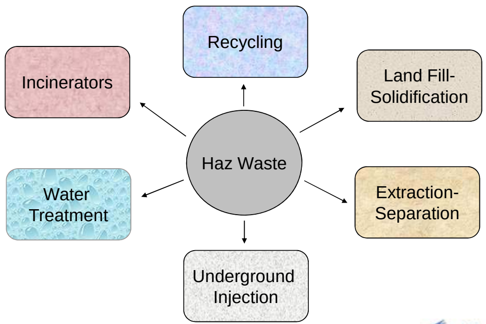
283

Industrial and Agricultural Solid Waste are Application Specific

Industrial Solid Waste
- Petroleum waste
- Packaging waste
- Metal waste
- Hazardous waste

Agricultural Solid Waste
- Cellulosic-plant waste
- Manure - high nitrogen
- Food waste

Hazardous Waste Treatment and Disposal is Multifaceted



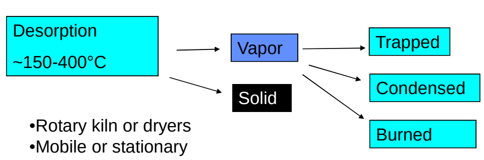
Thermal Hazardous Waste Treatment Technologies

Thermal Desorption
Incineration
- •Dedicated (no power or product)
- •High temperature oxidation
- •Air pollution control (APC)

Industrial Furnaces
- •Boilers – produces steam for power
- •Kilns – produces product and reduces fuel
- •Furnace – provides process heat
- •APC part of industrial process

Pyrolysis Gasification
Specialized Methods
- •Molten glass
- •Plasma arc

Thermal Desorption Very Flexible for Petroleum Waste Solids



- •Rotary kiln or dryers
- •Mobile or stationary
- •Co-current or countercurrent
- •Feed and product handling equipment

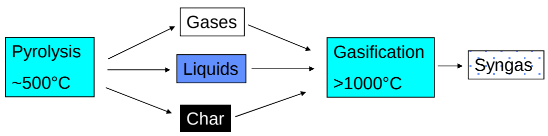
•Desorbed vapor
- •Trapped onto activated carbon
- •Condensed
- •Burned in afterburner or oxidizer

•Remaining solids cleaned

Thermal Desorption Pros and Cons

- **Advantages**
  - **Low capital operating cost 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.**
  - **Pretreatment- shredding- blending with friable soils/ gypsum.**
  - **Highly contaminated soils will require multiple cycles.**
  - **Not amenable to semi-volatile or non-volatile, chlorinated hazardous constituents. (Example: PCBs, pesticides)**
  - **Fugitive emissions may present exposure risk to workers and environment.**

Syngas Formation from Waste Involves Pyrolysis and Gasification



Gas %	Purox (FB-MSW)
H_2	23.4
CO	39.1
CO_2	24.4
CH_4	5.5

Higher Heating Value ~ 19 MJ/kg

Waste Management 24 (2004) 633–639

Pyrolysis Pros and Cons

- **Advantages**
  - Lower temperature process compared to incineration, increasing refractory life and reducing costs.
  - High feed rates, up to 5 tons/hour.
  - Downstream APC equipment needs reduced since metals and PM tend to be retained in char.
  - Degree of pyrolytic reaction can be controlled to yield synfuel or products for recovery. Condensable vapors with economic value can be recovered. Non-condensable vapors can be used for energy.
- **Disadvantages**
  - High capital cost.
  - Char still retains hazardous constituents and metals, requiring subsequent treatment and controlled disposal.
  - Fume incineration needed to destroy Products of Incomplete Combustion (PICs), and other hazardous organic constituents.

Gasification Pros and Cons

- **Advantages**
  - Beneficial use of waste to produce syngas, energy or useable products.
  - High temperature process provides for destruction of hazardous constituents.
- **Disadvantages**
  - Extremely high capital cost $30 – 50M. Large scale operation required to make economics work.
  - Must be integrated into a chemical or petroleum refining plant. Not a free-standing technology like incineration.
  - Off-gas treatment still required, including downstream fume incineration.
  - Residues are generated which, like pyrolysis, may contain hazardous metals that require subsequent managed treatment and disposal.

Reactions Occurring in the Gasifier

Reaction			ΔH
$C + O_2$	→ CO_2	Combustion	-
$C + CO_2$	→ 2 CO	Boudouard	+
$C + H_2O$	→ $CO + H_2$	Carbon-steam	+
$CO + H_2O$	→ $CO_2 + H_2$	Water-gas Shift	-
$C + 2H_2$	→ CH_4	Hydrogenation	-

Synthesis Gas Reactions

Combustion

$H_2 + CO \rightarrow CO_2 + H_2O$

Fischer Tropsch Synthesis

$(2n+1)\ H_2 + n\ CO \rightarrow C_nH_{(2n+2)} + n\ H_2O$

Direct Methanol Synthesis

$2\ H_2 + CO \rightarrow CH_3OH$

$3\ H_2 + CO_2 \rightarrow CH_3OH + H_2O$

$H_2 + CO_2 \rightarrow CO + H_2O$

Incineration is the Controlled Combustion of Waste

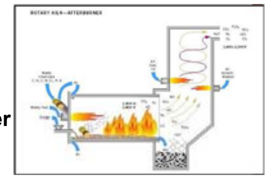
Requires 3 "T's":

- 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 PCDD and PCDF



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

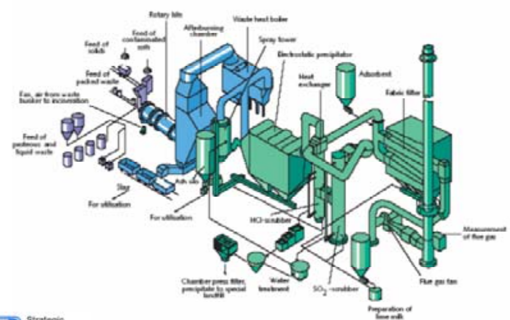
Incineration is not the Same as Open Burning

	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

Waste to Energy =WTE

Rotary Kiln Incineration Specifically for Waste Disposal

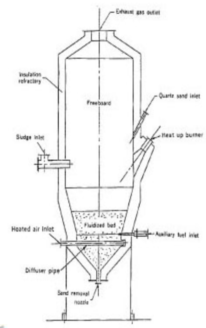


Strategic Environmental Analysis, L.C.

Incineration Pros and Cons

- **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.

Fluidized Bed Combustion



- Fluidized sand recirculated
- 1,000 units operated world wide
- Up to 140 million Btu/hr (2460 MJ/min)
- **Transportable** fluidized bed systems
- Halogenated waste (> 99.99% DRE at 1300 F)
- Lower capital and operating than rotary kiln
- Refractory life longer than rotary kiln

Fluidized Bed Combustion Pros and Cons

- **Advantages**
  - Well suited to refinery waste, pumpable sludges and halogenated waste.
  - Excellent contact between gas and solid high DRE.
  - Stable control temperature, residence time
  - vary air velocity at the bottom of bed.
  - Better than other thermal methods for heat recovery.
- **Disadvantages**
  - Cannot feed containerized waste directly or non-pumpable solids.
  - Pre-processing (homogenization) of waste is required so that all solids are less than ½ inch.
  - Waste must have heat content > 3500 BTU/lb.
  - Bed agglomeration and failure of the fluidized system can occur in the presence of > 2% sodium or other alkali salts.

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*

* Toxic Characteristic Leaching Procedure (TCLP)

Incineration : Air Emission Standards

- Particulate Matter < 34 mg/dscm
- Dioxin < 0.2 ng TEQ/dscm
- Pb&Cd < 240 ug/dscm
- As, Be & Cr < 87 ug/dscm
- HCl < 77 ppm
- Hydrocarbons < 10 ppm
- CO < 100 ppm
- DRE > 99.99%
- PCB and Dioxin waste incinerators must demonstrate a minimum of 99.9999% Destruction Removal Efficiency (DRE)
- Products of Incomplete Combustion (PICs) must be evaluated in a Human Health and Ecological Risk Assessment.

Air Pollution Control Equipment Essential for Hazardous Waste Incineration

Fabric filters – fly ash – 99% efficient
Electrostatic precipitators – fly ash - 99% efficient

Absorbers – Liquid /gas-70-99% acid gases
Adsorbers – Activated carbon/gas -95-98% organics
Wet Scrubbers-
Flue gas desulfurization – 80-90% SO_2
Selective Catalytic Reduction -80-90% NO_x

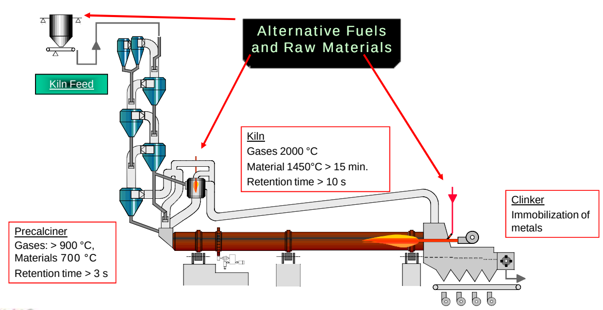
Emissions also affected by feed and combustion conditions

Industrial Furnaces: Kilns and Boilers

(APC part of industrial process)

- Kilns
  - Cement
  - Lightweight Aggregate
  - Lime
- Furnaces
  - Halogen Acid
  - Sulfuric Acid
- Industrial boilers.
- Waste types and amount limited
  - Protect product and process quality
  - Cement and lightweight aggregate kilns only liquid waste
  - Minimum heat content > 5000 BTU/lb
  - Thermal substitution rate is limited to 50%.

Typical Dry Process Cement Kiln



Boiler, Furnace and Cement Kiln Pros and Cons

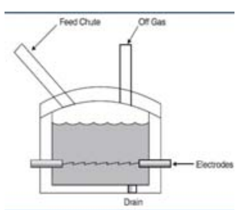
- Advantages:
  - Displace other fuels improve economics
  - Waste producers may pay for service
  - Can be applied to a waster oils and other solid waste (tires).
  - APC equipment in place
  - Residence times in kilns are high
  - Steady state is the rule
- Disadvantages
  - Industrial process and products may not permit
  - Waste feed mechanisms add complexity
  - Admixture rate may be low
  - Waste destruction may upset industrial process

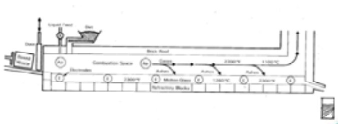
Molten Glass Processes

- Used for the destruction and/or immobilization of hazardous wastes, particularly mixtures of hazardous waste and radioactive wastes;
- Destroy combustible hazardous constituents and simultaneously encapsulate residuals (ash and metals) into a stable glass form.
- Molten Glass process is known as "joule heating"
- Electrodes in the molten glass apply a voltage passing current through alkaline ionic components in the glass. Electric resistance of the glass creates heat which is distributed evenly by convective currents in the fluid.
- Two main applications:
  - Joule-heating glass melters
  - In situ vitrification.

Glass Processes can use 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 uses natural gas burners or electric heaters
- The molten glass/encapsulated waste residual is drained through an overflow



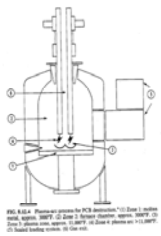


Molten Glass Processes Pros And Cons

- Advantages
  - Permanent treatment and encapsulation of waste in geologically stable form
  - Final material is delistable as "non-hazardous" under EPA regulations.
  - High degree of volume reduction; up to factors of 100.
  - No CO is generated.
  - DRE's of 99.9999% demonstrated for PCBs.
- Disadvantages
  - High capital and operating costs, because of electricity.
  - Costs for radioactive waste have been as high as $3.90/kg.

Plasma Arc System-Batch Process

•High voltage arc - two electrodes
•Inert gas under pressure injected sealed container of waste material
•Plasma temperature 6,000 °C
•Furnace chamber 1,800 °C
•Plasma destroys HW
•Operates at a slightly negative pressure
•Gas removal system to APC and/or production of syngas.



309

Plasma Arc Pros and Cons

- **Advantages**
  - **Plasma systems can transfer heat much faster than conventional flames.**
  - **Very effective for organic halogens, (PCBs and Dioxins). Eight "9's" DRE has been observed.**
- **Disadvantages**
  - **Extremely high temperatures, material durability of equipment**
  - **High capital costs .**
  - **Complex process control and highly trained professionals are required.**
  - **Electricity is required as an energy source. This is more expensive than most thermal processes.**

310

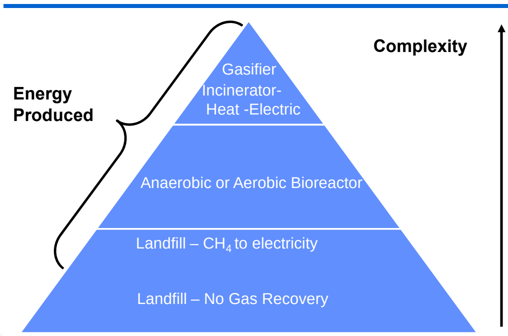
Solidification and Stabilization Processes

- **Solidification methods physically encapsulate hazardous waste into a solid material matrix of high structural integrity.**
- **Stabilization techniques chemically treat hazardous waste by converting them into a less soluble, mobile or toxic form.**
- **Principally used for metal-bearing wastes.**
- **Limited applicability to organic wastes.**
- **2 Main types of processes: cement and pozzolanic.**

•Advantages: low cost, low technology, suitable for many types of waste
•Disadvantages: increases volume, may leak

311

Waste Treatment Options –Energy Considerations



Comparison of 95 U.S. WTE plants with EPA Standard - *(2001Success story!)*

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

TEQ: Toxic Equivalents are used to report the *toxicity-weighted masses* of mixtures of dioxins
(ng/dscm or mg/dscm): nanograms or milligrams per dry standard cubic meter
(ppmv): parts per million by volume - Waste to Energy =WTE

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

Example: Anaerobic Biosolid Digestion Reduces Solids - Makes Methane

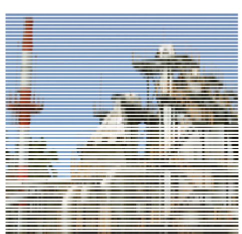
Anaerobic sludge digestors produce methane

(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

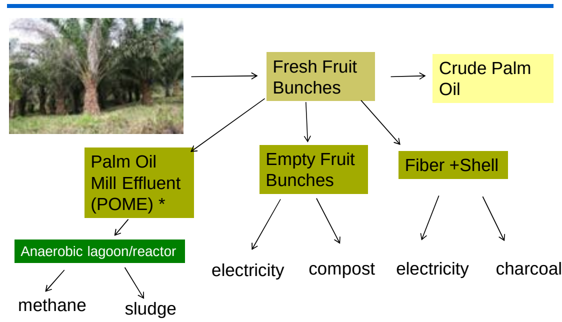
Example: Coconut Charcoal (WTE) Reduces Air Pollution Makes Electricity



Recogen-Badalgama Sri Lanka-8 MW

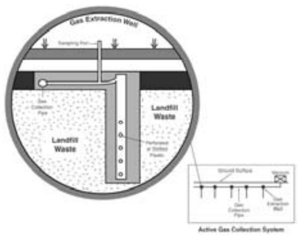
http://www.eurocarb.com/

Example: Palm Oil Mill Effluent and Waste to Energy Plant



Land Disposal Units (LDUs) Consist of Landfills, Surface Impoundments and Underground Units

- •Landfill
- •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

Landfill Design and Construction

Landfill Liners
- Clay
- Flexible membrane
- Liner/waste compatibility

Landfill Cap

Leachate
- Collection-Removal-Recirculation
- Primary leachate
- Leak detection

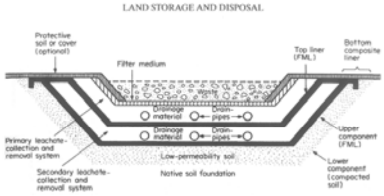
Surface water collection

Gas collection and removal

No free or bulk liquids
- •Mixed with sorbent
- •Small ampoules
- •Container is item–battery
- •Container is lab pack

Landfill with Flexible Membrane Liner Plus Compacted Soil Double Liner

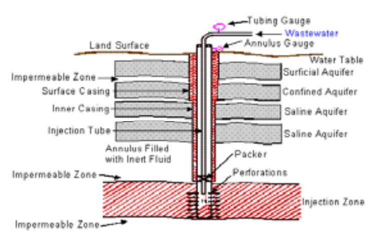
LAND STORAGE AND DISPOSAL



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

Groundwater and leachate monitoring important

Deep Well Injection is an Important Technology



•550 Class I wells in the United States (22% for HW)

•43% of all HW in United States !!!

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