Chemical
SAFETY AND SECURITY TRAINING

Safe Work Practices

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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

Safe Work Practices are a Subset of Process Safety Management

- Material hazard
- Energy hazard
- Chemical interaction hazard

Hazards

- Safe operating procedures (SOPs)
- Safety Audits
- Training
- Job Hazard Analysis
- Safe Work Practices

Job Hazard Analysis

Job Hazard Analysis is a technique that 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.

Essential Steps in Job Hazard Analysis

1. Involve your employees.
2. Review your accident history.
3. Conduct a preliminary job review.
4. List, rank, and set priorities for hazardous jobs.
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, even if there is no history of previous accidents;
- 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?**
- **How likely is it that the hazard will occur?**

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		

Safe Work Practices Apply to a Variety of Jobs/ Hazards

Hazards

- **Elevated work**
- **Hoisting, rigging**
- **Cranes- forklifts**
- **Heavy equipment**
- **Trenches, excavation**
- **Pressurized vessels**
- **Energized equipment**
- **Chemical reactivity**

Specialty PPE

- **Safety Vests**
- **Face Shields/ goggles**
- **Gloves**
- **Respiratory Protection**
- **Safety Harnesses**
- **Hearing Protection**

Definition of Safe Work Practices

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

- **Lockout - Tagout**
- **Confined space entry**
- **Opening process equipment or piping**
- **Hot work**
- **Control over entrance by support personnel.**

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**

Safe Work Practices Go Beyond SOPs

OSHA PSM Standard- Nonroutine Work Authorizations

- **Lockout - Tagout (energy control)**
- **Confined Space Entry**
- **Initial Opening of Process Lines and Vessels**
- **Hot Work**

Some procedures require permits for more than one of the above categories

Lockout-Tagout Addresses all Forms of Hazardous Energy

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

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

Hazardous Energy Management Involves the Following Steps

- Identify tasks that may expose workers to hazardous energy.
- Identify and de-energize *all hazardous* energy sources, including those in adjacent equipment.
- Lockout and tagout *all energy-isolating* devices to prevent in advertent or unauthorized reactivation or startup.
- Isolate, block, and/or dissipate *all haz*ardous sources of stored or residual energy, including those in adjacent equipment.
- Before beginning to work, verify energy isolation and de-energization, including that in adjacent equipment or energy sources.
- After work is complete, verify that all personnel are clear of danger points

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-

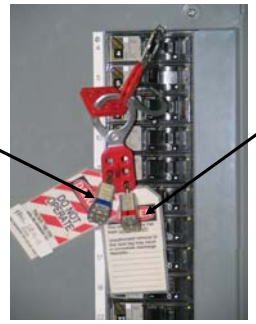
•LOTO is not just closing valves or unplugging machinery
•Only one key for each lock the worker controls
•Each lock labeled with durable tag
•Only worker who installs lock can remove
•Shift change- New lock added before old one removed
•Key control for group lockout device
•Procedures must be specific not generic
•Periodic inspections
•LOTO alternatives- machine guarding, cord and plug, control circuitry

Lock Self Adhesive Band, IDEAL Part Number 34-003

Examples of LOTO-

•Blanking: installing flange with blank
•Line breaking - misalignment
•Remove stored energy-springs, hydraulic, pneumatic, counterweighted flywheel,
•Install chocks, cribbing
•Remove belt and chains
•Clamping

Company Assigns Unique Lock to LOTO



Which of these locks is an administrative lock?

General LOTO Devices and Tags

Lock Self Adhesive Band , IDEAL Part Number 34-003

Other LOTO Devices

BALL VALVE LOCKOUTS - Brady Catalog #65668 & #65669 Panduit Catalog #PSL-BV1 & #PSL-BV2 (Similar)

GATE VALVE LOCKOUT - Brady Catalog #65560 to 65564

Circuit Breaker LOCKOUT...OPEN

Circuit Breaker LOCKOUT...LOCKED

Other LOTO Devices

120 VOLT PLUG EXCLOSURE - Brady Catalog #65674

SINGLE-POLE CIRCUIT BREAKER LOCKOUT - Brady Catalog #65688

WALL STATION LOCKOUT Brady Catalog #65696

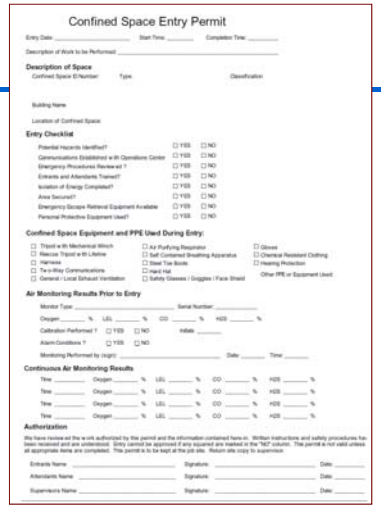
MULTI-POLE BREAKER LOCKOUT Brady Catalog #65694

Confined Space Definition

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 Entry Permit

Entry Date _____ Start Time _____ Completion Time _____

Description of Work to be Performed _____

Description of Space

Confined Space ID Number: Type: Classification:

Building Name

Location of Confined Space

Entry Checklist

Potential Hazards Identified?	☐ YES	☐ NO
Communications Established w/ Operations Center	☐ YES	☐ NO
Emergency Procedures Reviewed ?	☐ YES	☐ NO
Entrants and Attendants Trained?	☐ YES	☐ NO
Isolation of Energy Completed?	☐ YES	☐ NO
Area Secured?	☐ YES	☐ NO
Emergency Escape Retrieval Equipment Available	☐ YES	☐ NO
Personal Protective Equipment Used?	☐ YES	☐ NO

Confined Space Equipment and PPE Used During Entry:

☐ Tripod w/ Mechanical Winch	☐ Air Purifying Respirator	☐ Gloves
☐ Rescue Tripod w/ Bi Lifeline	☐ Self Contained Breathing Apparatus	☐ Chemical Resistant Clothing
☐ Harness	☐ Steel Toe Boots	☐ Hearing Protection
☐ Two-Way Communications	☐ Hard Hat	
☐ General / Local Exhaust Ventilation	☐ Safety Glasses / Goggles / Face Shield	Other PPE or Equipment Used:

Air Monitoring Results Prior to Entry

Monitor Type _____ Serial Number: _____

Oxygen _____ % LEL _____ % CO _____ % H2S _____ %

Calibration Performed ? ☐ YES ☐ NO Initials _____

Alarm Conditions ? ☐ YES ☐ NO

Monitoring Performed by (sign) _____ Date _____ Time _____

Continuous Air Monitoring Results

Time _____ Oxygen _____ % LEL _____ % CO _____ % H2S _____ %

Time _____ Oxygen _____ % LEL _____ % CO _____ % H2S _____ %

Time _____ Oxygen _____ % LEL _____ % CO _____ % H2S _____ %

Time _____ Oxygen _____ % LEL _____ % CO _____ % H2S _____ %

Authorization

We have reviewed the work authorized by this permit and the information contained here-in. Written instructions and safety procedures has been received and are understood. Entry cannot be approved if any squared are marked in the "NO" column. This permit is not valid unless all appropriate items are completed. This permit is to be kept at the job site. Return site copy to supervisor.

Entrants Name _____ Signature _____ Date _____

Attendants Name _____ Signature _____ Date _____

Supervisors Name _____ Signature _____ Date _____

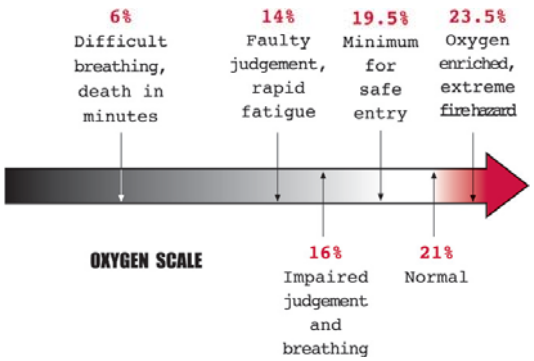
Confined Space Definition (cont)- plus One of These

- 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.
- In addition to the hazards posed by the design of the space, work activities can also pose serious safety hazards (heat, noise, vapors, etc.)

Hazards in Confined Space

- **Atmospheric Hazards**
- **Oxygen Deficiency/Enrichment; Combustible/Flammable/Explosive Gases and Vapors;**
- **Combustible Dust; Toxics; Safety Data Sheets (SDS); Monitoring-Air**
- **Physical Hazards- Collapse, Thermal**
- **Mechanical; Entrapment; Engulfment; Other Types of Hazards**

Oxygen Concentration is a Fundamental Aspect of Confined Space Work



Confined Space Controls

- **Controls for Atmospheric Hazards**
  - **Ventilation; Respiratory Protection; Other Control Measures**
- **Controls for Physical Hazards**
  - **Isolation**
    - **Mechanical, Electrical, Pressurized Lines, Ducts, or Pipes**
    - **Other Control Measures**
- **Personal Protective Equipment and Tools**
- **Communication System**

Testing the Confined Space

1.Oxygen is tested first because most combustible gas and toxic atmosphere meters are oxygen-dependent and will not provide reliable readings when used in oxygen-deficient atmospheres. In addition, both oxygen-deficient and oxygen enriched atmospheres are *extremely hazardous to workers' health and safety.*

2. Combustible gases and vapors are tested next because the threat of fire and explosion is both more immediate and more life-threatening, in most cases, than exposure to toxic gases and vapors.

3. Toxic atmospheres are tested last.

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

Confined Space Entry Process

Administrative

- Space to be entered
- Purpose of entry
- Date and duration
- Authorized entrants
- Personnel attendants
- Entry supervisor

Work Procedures

- Hazards of permit space
- Measures used to isolate the space
- Acceptable entry conditions
- Safety retrieval line
- Periodic rests during entry
- On-site rescue team
- Communication procedures
- Certified and calibrated equipment
- Permits for other hazardous procedures in area

Confined Spaces Decision (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.

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 emended. (May require new program.)

Opening Lines and Vessels "Line Breaking" Definition

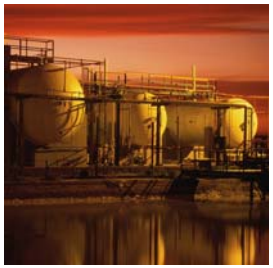
Line breaking means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

Hazards of Opening Lines and Vessels

Toxic release and exposure
- Ammonia
- Hydrogen Sulfide

Fire and explosion
- Hydrocarbons
- Pyrophoric materials
- Moisture sensitive materials

Pressure release
- Pipeline pigging



Consideration for Line Breaking/Line Opening Procedures

Identify the Hazard
Develop Permit
Appropriate PPE
Barricades
Isolating system
Cooling system
Depressurizing system
Flushing system
LOTO of electrical / valving

Step by step procedure
Emergency equipment
Emergency plan
Testing

Line Breaking Procedure Example: Ammonia Refrigeration

A line break permit shall be obtained.

Only qualified Refrigeration personnel shall perform the work

The line to be opened shall be isolated, and isolation valves secured with locking devices appropriate to type shall be applied. Isolation valves must be logged by number, and a *copy* of this log kept in the maintenance office to preclude loss.

The portion of the line to be opened shall be evacuated (pumped down, into a vacuum). Operators shall test that the vacuum condition is holding, and hold the level of vacuum for a minimum of 30 minutes.

Prior to the opening of the line, operators shall don appropriate PPE, (APR), and wear the PPE until it is evident to the senior operator that no danger of ammonia flow exists.

Line Breaking Procedure Example: Ammonia Refrigeration

Mechanical integrity of all lines, valves, and other component parts affected by the line break related work shall be maintained.

At the conclusion of the work process, the assembled line, valves, or other constituent parts shall be first vacuum tested, then pressure tested.

When such testing is successfully completed, all valves shall be restored to the original alignment conditions. The original log shall be consulted to ensure that all valves originally listed have been returned to original alignments, and all tags and biscuits have been removed, and the work area restored to previous conditions.

The area of the line break shall be observed periodically to ensure leakage-free operation, and proper refrigeration function.

LINE BREAK PERMIT

☐ Contractor Name: _____ Plant Location: _____
☐ Sub-Tier Contractor Name: _____
Project Name: _____ Contract PO No.: _____
Date of Line Break: _____ Time: _____
Service Being Broken: _____ Line Number: _____
Location (i.e., building, area, etc.): _____

Hazards (for all types of potential hazardous energy; slip for all hazardous chemicals/material thought to ever have been in the line): _____
Special Instructions: _____

PROTECTIVE MEASURES

Personal Protective Equipment (PPE) Required	Yes	No	Date Complete	Other Protection Methods	Yes	No	Date Complete
Boots – Rubber	☐	☐		Barricade – R. Radius (describe/sketch)	☐	☐	
Coveralls – Cloth	☐	☐		Blanks to be Installed	☐	☐	
Coveralls – Tyvek	☐	☐		Block Valve Shut	☐	☐	
Dosimetry – Chemical (specify)	☐	☐		Fire Extinguisher	☐	☐	
Gloves – Leather	☐	☐		Grating, Floor Opening Covered	☐	☐	
Gloves – Long	☐	☐		Lock/Tag/Verify Plan Required	☐	☐	
Gloves – Rubber	☐	☐		Monitoring (specify)	☐	☐	
Goggles	☐	☐		Nonsparking Tools	☐	☐	
Hood – Acid	☐	☐		Piping Support Installed	☐	☐	
Respirator – Full Face	☐	☐		Pump Locked Out	☐	☐	
Respirator – Half Face	☐	☐		Spark Proof Tiles	☐	☐	
Respirator – Air Supplied	☐	☐		Standby Person (respect the line line broke)	☐	☐	
Respirator – SCBA	☐	☐		System Flushed	☐	☐	
Shield – Face	☐	☐		System Less than 100 °C	☐	☐	
Shield – Special Shielding	☐	☐		System Vented	☐	☐	
Suit – Acid	☐	☐		Valve Locked Out	☐	☐	
Suit – Hot	☐	☐		Ventilation – Exhaust	☐	☐	
Suit – Rain	☐	☐		Ventilation – Dilution	☐	☐	
Spill Containment	☐	☐		Water Hose	☐	☐	

PLANNING ITEMS FOR LINE BREAKS

Items	Description
1. Depressurizing, Cleaning, and Venting Check	
2. Nearest Safety Shower Location (if greater than 50 feet, water hose must be provided)	
3. Nearest Eyewash Location	
4. Cold Pak Location	
5. Emergency Respirator Location	
6. Fire Extinguisher Location	
7. Fire Alarm Location	
8. Shelter Location	
9. Planned Escape Route	

Hot Work Definition

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

OSHA 1910.252

Hot Work Permit

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

WARNING!
HOT WORK IN PROGRESS
WATCH FOR FIRE!

PART 2

INSTRUCTIONS

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

HOT WORK BEING DONE BY:
☐ EMPLOYEE _____ LIFE NO. _____
☐ CONTRACTOR _____ CO. _____
DATE _____ JOB NO. _____
LOCATION/BUILDING & FLOOR _____
NATURE OF JOB _____
NAME OF PERSON DOING FIRE WATCH _____

I verify the above location has been examined, and permission is authorized for this work.
SIGNED: FIRESAFETY OFFICER _____
DATE: _____

PERMIT EXPIRES	DATE	TIME AM PM

I verify that the List of Precautions is Understood and work will proceed only if precautions are followed:
Signed: (Supervisor) _____

FIRE WATCH SIGNOFF
Work area and all adjacent areas to which sparks and heat might have spread were inspected during the fire watch period and were found fire safe.
Signed: _____

FINAL CHECKUP
Work area was monitored following Hot Work and found fire safe.
Signed: _____

Required Precautions Checklist

MAY BE RETAINED AS RECORD OF HOT WORK ACTIVITY

☐ Available sprinklers, hose streams and extinguishers are in service/operable.
☐ Hot Work equipment in good repair.

Requirements within 35 ft (10m) of work
☐ Flammable liquids, dust, lint and oil deposits removed.
☐ Explosive atmosphere in area eliminated.
☐ Floors swept clean.
☐ Combustible floors wet down, covered with damp sand or fire-resistive sheets.
☐ Remove other combustibles where possible. Otherwise protect with fire-resistive tarpaulins or metal shields.
☐ All wall and floor openings covered.
☐ Fire-resistive tarpaulins suspended beneath work.

Work on walls or ceilings
☐ Construction is noncombustible and without combustible covering or insulation.
☐ Combustibles on other side of walls moved away.

Work on enclosed equipment
☐ Enclosed equipment cleaned of all combustibles.
☐ Containers purged of flammable liquids/vapors and monitored for vapor buildup.

Fire watch/Hot Work area monitoring
☐ Fire watch contractor/department will supply during and for 60 minutes after work, including any coffee or lunch breaks.
☐ Fire watch is supplied with suitable extinguishers, charged small hose.
☐ Fire watch is trained in use of this equipment and in sounding alarm (telephone, alarm box, radio).
☐ Fire watch may be required for adjoining areas, above, and below (see other precautions).
☐ Monitor Hot Work area for 4 hours after job is completed.

Other Precautions Taken
☐ False alarm with detection systems considered.
☐ _____

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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.

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 "MT" 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

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

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

Chemical
SAFETY AND SECURITY TRAINING

Chemical Safety and Security Program Organization and Responsibilities

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.

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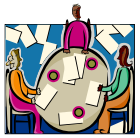
Chemical Safety and Security (CSS) Program Purpose

- Ensure a safe and secure workplace.
- Ensure a sustainable environment.
- Prevent/reduce release of hazardous substances in plant and in community.
- Prevent/reduce exposure to staff.
- Enhance community relations.
- Comply with regulations.
- Enable crisis management.

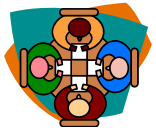
Crisis Management: Prevention & Response

- Facility crisis
  - Fire
  - Explosion
  - Chemical release
  - Evacuation
  - Remediation
- Natural disaster
  - Earthquakes
  - Hurricane/typhoon
  - Tsunami
- Security Incidents
  - Disgruntled personnel
  - Employees
  - Ex-workers
  - Contractors
- Demonstrations, protests
- Terrorism
- Theft

Chemical Safety and Security Applies to Everyone



Administration
Management
Human Resources
Purchasing
Facilities
Construction
Police/Security
Employees
Contractors
All visitors



Senior Management

has the responsibility

to *teach*, *model* and *encourage* good Chemical Safety and Security practices

Operational Management Chemical Safety & Security (CSS) Responsibilities

- Develop procedures with Safety Officer for unique hazards and chemicals (toxic, flammable)
- Develop proper control practices with Safety Officer
- Participate in developing CSS Plan, CSS Committee, accident investigation procedure
- Ensure CSS documents and records are maintained
- Maintain plant chemical inventory
- Ensure Safety Data Sheets are available
- Facilitate compliance with policies, guidelines and regulations

Operational Management Responsibilities (cont'd.)

- Ensure workers know and follow policies and practices
- Ensure equipment and controls are properly maintained
- Ensure all workers received proper training and refreshers
- Ensure new workers receive proper training before starting work
- Inform Safety Officer of any accidents and incidents
- Follow-up on accidents and incidents

Employees

have a responsibility

to *actively* support and participate in the CSS Program.

Employee Responsibilities

- **Understand and act in accordance with policies/rules and practices.**
  - **Participate in and learn from required training**
  - **Learn about hazards of specific chemicals/processes**
  - **Read & understand related documents (SOPs, OPs).**
- **Follow good chemical safety practices**
  - **Wear and maintain Personal Protective Equipment (PPE)**
  - **Use engineering controls properly**
  - **Work safely/behave responsibly (i.e. don't put others at risk).**
- **Proactively encourage safety and security**
  - **Participate willingly in the CSS Program**
  - **Report accidents, incidents/near misses, problems**
  - **Suggest changes and improvements**

The Safety Officer

has the responsibility

to provide expertise and information so that a safe and healthy workplace is present and maintained.

Safety Officer Training, Experience, Skills

- **Chemistry**
  - Nomenclature
  - Physical properties
  - Reactive substances
  - Chemical compatibilities
- **Health and Safety (industrial hygiene)**
- **Security**
  - Facility
  - Chemicals
  - Equipment
  - Personnel
- **Psychology**
  - Interpersonal skills
- **Physics**
  - Ventilation
  - Electrical
- **Biology**
  - Biosafety
  - Blood borne pathogens
- **Administration**
- **Writing**
- **Speaking/presentations/training**

Safety Officer Duties and Responsibilities

- **Report s directly to higher management**
- **Provides leadership in safety and security**
  - **Advise administration, management, workers**
  - **Know legal regulations and ensure compliance**
  - **Establish Safety and Security Committee**
  - **Consult/advise project management on CSS concerns**
  - **Respond to problems and concerns of workers**
  - **Coordinate with facilities and security**
- **Writes and revises CSS Plan**
  - **Develop CSS training plans**
  - **Trains, documents and ensures training is performed**

Safety Officer
Duties and Responsibilities

- Ensures documentation, records and metrics are maintained.
  - Draft a safety budget
  - Set criteria for exposure levels
  - Coordinate and facilitate medical surveillance
  - Ensure plans and manuals are written and updated
- Oversees procurement, use, storage & disposal of hazardous materials
- Performs risk assessment and monitoring
  - Conducts audits and inspections
  - Interacts with staff to correct deficiencies
  - *Follows up* to ensure correction and resolution of issues
- Investigates accidents and incidents

Safety Officer
Duties

Surveys
Job Hazard Analysis
Inspections
Training
Medical Monitoring
Investigations

The Function of the Safety Officer is to Act as a Collaborator, *NOT* as a Policeman

The Safety Committee

has the responsibility

to oversee and monitor the CSS Program for management so that a safe and healthy workplace is maintained.

Safety Committee Responsibilities

- Reports directly to senior management
- Endorses policies
- Meets regularly (2 – 4 times/yr) with agendas
- Reviews accidents and incidents, may investigate, write reports with recommendations
- Establishes appropriate subcommittees on specific topics

Safety Committee Composition

- Chaired by committed staff
- Safety Officer is ex-officio member
- Includes representatives from:
  - Facilities Management
  - Security
  - Administration and General Management
  - Shops/Unions
- Representatives should rotate after a few years

Management Responsibilities

Commitment:

- Establish a formal CSS Program
- Announce formation of a CSS Program
- Create a written policy statement
- Designate a Safety Officer
- Endorse a written CSS Plan (Manual)
- Participate and intervene as needed

Support:

- Financial support (budget)
- Staffing
- Response/resolution of problems by
  - Establishing a CSS Committee
- Stipulates CSS is part of everyone's job
  - CSS applies to everyone
  - Specifies CSS orientation for new employees
- Supports CSS staff

Management Responsibilities

POLICY STATEMENT

Documents and describes
the commitment and support
from the highest management level
for the Chemical Safety and Security Program

Policy Statement Purpose

Establish and provide for maintenance of an effective Chemical Safety and Security Program to protect:

- Employees
- Facility
- Community
- Environment

…and to comply with all regulations.

Policy Statements

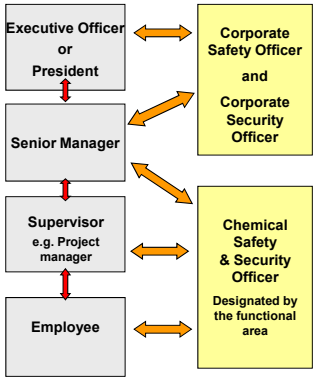
- Come from senior management
- Are typically brief
- Set clear goals
- Establish commitment
- Define employee role
- Identifies resources and staff
- Are signed by person in authority

Example Policy Statement

"It is the policy of XYZ Company to protect our workers and the public, prevent incidents, protect the environment through integration of environmental stewardship and sustainability throughout the life-cycle of its activities, and ensure regulatory compliance."

Chemical Safety and Security Program Ideal Roles

- Culture of Chemical Safety and Security should exist at all levels of the organization.
- Top management sets policy, provides resources.
- Workers must understand and implement.
- Many organizational interactions are important for chemical safety and security

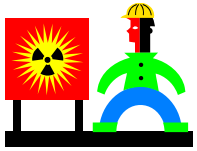


Program Evaluation

- Management leadership
- Employee involvement
- Administrative controls
- Security controls
  - Access to buildings, materials
- Engineering controls
- Accident/incident investigation
- Training
- Use of Personal Protective Equipment (PPE)
- Emergency Response Program
- Medical Surveillance Program
- Work site analysis
  - Inspections, surveys, hazard analysis

Hazard Survey

- Baseline measurements
- Periodic inspections
- Identify potential job hazards, material hazards, and process hazards



Hazard Survey Process

- Prepare survey form
- Perform walk-through
- Take measurements
  - Sample if necessary, monitor exposure (e.g., formaldehyde, radiation)
- Perform data analysis
- Write and deliver report

Job Hazard Analysis (JHA)

Hazards associated with a particular task become apparent from a brief survey:

- Compile steps needed to complete job.
- Analyze each step in detail.
  - Could exposure occur?
  - Could an accident occur?
  - Could a change in processes create hazard?
- Develop recommendations on precautions to eliminate/minimize hazard.

Periodic Inspections

- **Performed by Safety Officer**
- **Team may include:**
  - **Employees**
  - **Process Supervisor**
  - **Facilities representative**
- **Frequency determined by hazards present and local practices**
  - **2 - 4 times/yr**
- **Look for:**
  - **both good and bad practices**
  - **new hazards**
  - **new security issues**

Sample Plant Survey/Inspection Checklist

- **Date of Inspection:_____**
- **Conducted by:_____**
- **Location (room and building):_____**
- **Supervisor:_____**

- **Work Practices**
  - PPE available/properly used, stored, maintained
  - Work conducted under ventilation if airborne hazard
  - Housekeeping
  - Work instructions present and used

Survey/Inspection Checklist, cont'd.

- **Hazard Communication**
  - Warning signs ***posted*.**
  - SDS available.
  - All chemical containers/tanks/piping labeled.
- **Personal Protective Equipment**
  - Available for each specific hazard.
  - Eye protection available, when & where required & *posted.*
  - Other PPE available as necessary.
  - Visitor requirements for PPE ***posted*.**

Survey/Inspection Checklist, cont'd.

- **Plant Safety Equipment**
  - Fire pull stations & telephones appropriately placed and labeled
  - Adequate number of fire detection and control devices.
  - Emergency shut-down equipment present and routinely tested.
  - Emergency chemical release equipment available, maintained, labeled.
  - Eyewashes & safety showers present, unobstructed, in good working order, routinely tested and maintained.
- **General Facility**
  - Exits marked
  - Access controls
    - Hazardous areas
    - Proprietary processes

Survey/Inspection Checklist, cont'd.

- **Chemical Storage/Warehouse**
  - Area secured
  - Chemicals inventory list or database
  - All containers labeled
  - Incompatible chemicals segregated
  - Volatile, flammable material keep away from ignition sources
  - Fire protection
    - Barriers, sprinkler system, extinguishers, alarms
  - Emergency release equipment present
    - PPE
    - Spill equipment

Survey/Inspection Checklist, cont'd.

- **Ventilation**
  - **Ventilation for airborne hazards available**
  - **Ventilation labeled with static pressure or airflow**
  - **Ventilation equipment intakes not blocked**
- **General**
  - **Aisles & exits unobstructed.**
  - **Work areas clean with no chemical contamination.**
  - **Mechanical hazards guarded with barriers**

Training Program

- **Identify training needs**
- **Identify Goals & Objectives**
- **Develop training activities**
- **Identify resources**
- **Conduct training**
- **Evaluate effectiveness**
- **Continuous Improvement**

Employee Training Topics

- **New employee orientation**
- **Special processes and procedures**
- **Hazard communication/ labeling, Safety Data Sheets**
- **Occupational Exposure Limits (OEL) for hazardous chemicals;**
- **PPE use, storage and maintenance (especially respirators)**
- **Fire safety and fire extinguisher use**
- **Emergency plans, evacuation procedures & routes**
- **Non-ionizing radiation, lasers, microwaves**
- **Hazardous waste procedures**
- **Facility security requirements**

Training Documentation: Sample

- **Employee name: _____**
- **Department: _____**
- **Date: _____**

- **Training Subject: _____**
- **Training Date: _____**
- **Re-instruction date: _____**

- **Employee Signature: _____**
- **Date Signed: _____**
- **Supervisor's signature: _____**
- **Date: _____**

Guidelines for Incident Investigation

- **Description/report of incident**
- **Review of organizational policy**
- **Start an investigation**
- **Determine cause of incident**
  - Emphasis is prevention, ***NOT*** blame
  - Timely report with recommendations to all responsible parties including senior management
- **Make timely response to recommendations**
  - Correction
  - Follow-up
  - Action taken
  - Additional training required

Chemical Safety and Security Plan

- **Includes policy statements from senior management.**
- **Describes the entire Program.**
- **Describes the organization of the Program.**
- **Explains everyone's responsibilities.**
- **Describes in general terms policy and specifically who, what, where and why a safety or security task or job is performed.**

Standard Operating Procedures (SOP)

- **An SOP explains *concisely and precisely* how, where and who performs a task.**
- **It does *not* explain why the task is done.**
- **The Safety and Security Plan explains policy and why a task is performed**

Standard Operating Procedures (SOP), cont'd.

- SOPs are:
  - Dated
    - When issued
    - When reviewed
    - When revised
  - Have: subject, title and identification code
  - Officially reviewed by management
  - Signed by all responsible parties
  - Written in a consistent and official format with numbered pages

Standard Operating Procedures (SOP)

Consider written SOPs on:

- Security clearance and visitor access
- Employee training
- Medical surveillance
- Respiratory protection and fit
- Eye protection
- Ventilation system maintenance
- Storage, receipt, transport and shipping of hazardous materials
- Accident and emergency response including natural disasters
- Spill cleanup
- Waste management
- Hazardous material handling
- Special operations

TEA BREAK

Chemical
SAFETY AND SECURITY TRAINING

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…

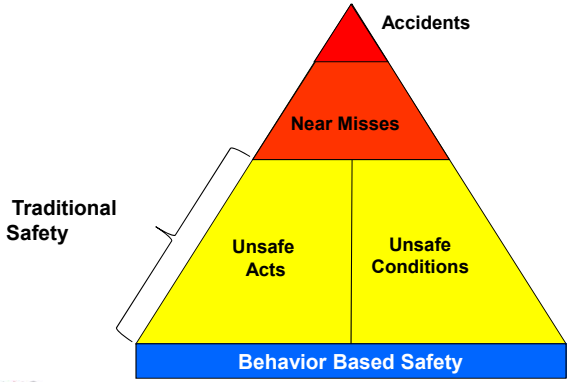
- **Is *reactive* – focuses on correcting problems only after they have occurred.**
- **Searches for "root cause" of accidents**
  - **Using incident/accident data from investigations**
    - e.g. Incident and Severity rate: TRCR/DART
- **Focuses on making the working environment less hazardous.**
-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



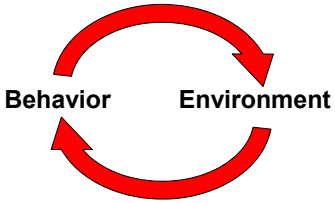
Always Keep in Mind…

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

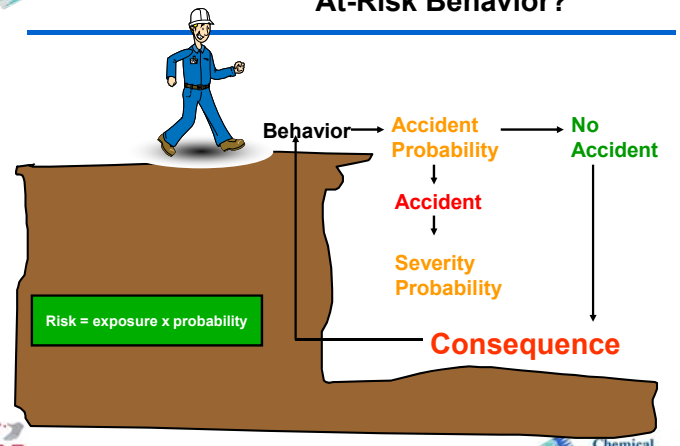
Indirect

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

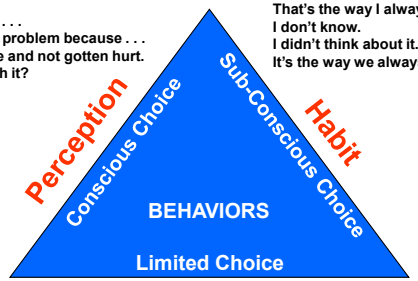
- Convenience
- Time savings
- Increased productivity
- Getting away with it
- Feeling bullet-proof

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:

- Designs the BBS process.
- Develops the implementation strategy.
- Implements the BBS process.
- Steers 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.

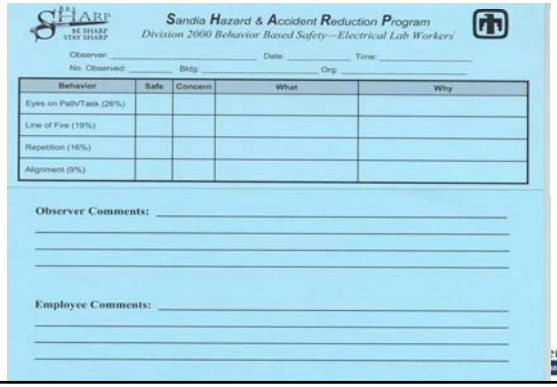
Step 2: Develop Observation Checklists

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).



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:

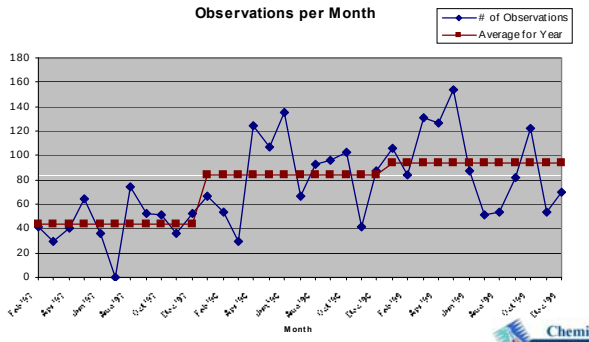
- Peer-to-peer
- Anonymous (No Names/No Blame)
- Announced
- 5 minutes or less
- Provide feedback:
  - Positive reinforcement for safe behaviors
  - Coaching for behaviors of concern
- Identify obstacles
- Foster safety communication

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

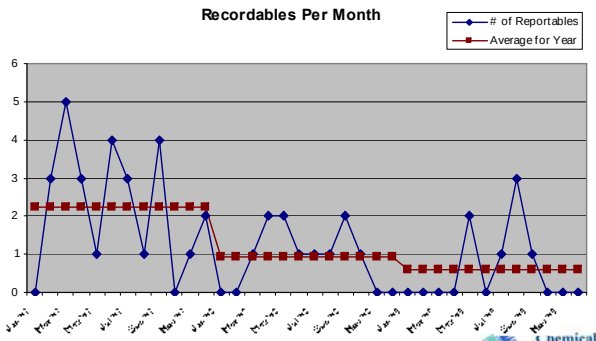
What happens with more observations?

Feedback Changes Behaviors



Fewer injuries!

Changed Behaviors Reduce Accidents



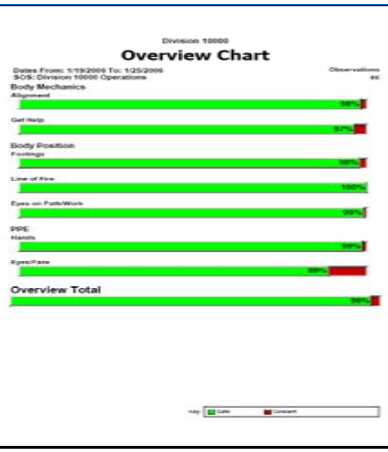
Step 4: Providing Feedback

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

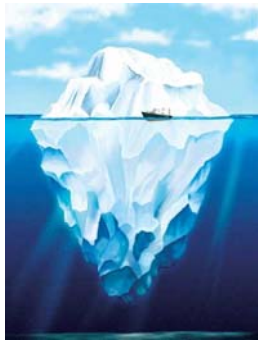
BBS is proven to reduce injuries

- 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.

Sources

- M. Dominic Cooper. "Behavioral Safety Interventions: A review of process design factors." *Safety Management*. Feb 2009.
- Thomas E. Boyce and Horacio R. Roman. "Institutionalizing behavior-based sastey: Theories, concepts, and practical suggestions." *The Behavior Analyst Today*. Vol 3, No 1. April 2002.
- Jason DePasquale and E. Scott Geller. "Critical success factors for behavior-based safety: A study of twenty industry-wide applications." *Journal of Safety Research*. Vol 30, No 4. 1999.
- Beth Sulzer-Azaroff and John Austin. "Does BBS Work? Behavior-Based Safety & Injury Reduction: A Survey of the Evidence." *Professional Safety*. July 2000.
- E. Scott Geller. "How to Get More People Involved in Behavior-Based Safety: Selling an Effective Process." Cambridge Center for Behavioral Studies. Accessed 12/2010. <http://www.behavior.org/resource.php?id=332>.
- "Introduction to BBS." Cambridge Center for Behavioral Studies. Accessed 12/2010. <http://www.behavior.org/resource.php?id=330>.
- Byron Chandler and Thomas A. Huntebrinker. "Multisite Success with Systematic BBS." *Professional Safety*. June 2003.
- D. Cooper. "The return on investment of the B-BS process." *Giornale Italiano di Medicina del Lavoro ed Ergonoima*. Vol 32, No 1. 2010.
- M. D. Cooper Ph.D. "Towards a model of safety culture." *Safety Science*. Vol 36. 2000.

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.

Sandia National Laboratories

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 hazards 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

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

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

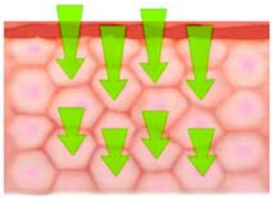


Photo credit: Permeation, http://www.cdc.gov/niosh/topics/skin/

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

Level A Protective Suits

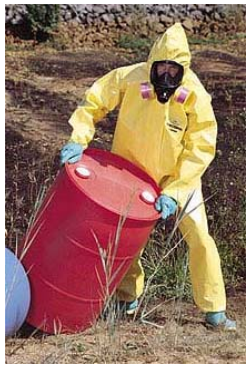
- Emergency operations
- Hazardous waste cleanup
- The contaminant is unknown
  - Positive-pressure self contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA.
  - Totally encapsulated chemical and vapor protective suit.
  - Inner and outer chemical resistant gloves
  - Inner and outer chemical resistant boots.

Level B Protective Suits

- Contaminant known
- High airborne hazard
  - Positive-pressure, full face-piece self contained breathing apparatus (SCBA) or positive pressure supplied air respirator with escape SCBA
  - Hooded chemical resistant clothing
    - Coated fabric
  - Inner and outer chemical-resistant gloves
  - Inner and outer chemical-resistant boots

Level C Protective Suits

- Known airborne contaminant concentration
- Clothing selected on basis of dermal exposure
  - Full-face air purifying respirator
  - Chemical resistant clothing
    - Coated Tyvek SL™, Saranex™
  - Inner and outer chemical-resistant gloves
  - Disposable chemical-resistant outer boots



Level D Protective Suits

- No airborne hazards:
  - PPE may include protection against incidental skin or eye contact or mechanical hazards.
    - Gloves
    - Safety glasses, face shield
    - Steel-toe boots or shoes
    - Hardhat
- Other:
  - Lab work
  - Chemical splash
    - Aprons
      - Vinyl, PVC, Polyethylene

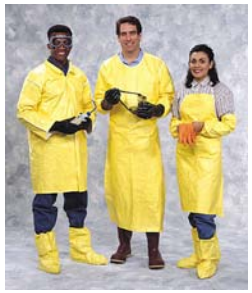


Photo credit: Lab Safety Supply

Protective Clothing

- Special Applications
  - Hot processes
  - High voltage/arc flash
    - NFPA 70E
  - Foundries/molten metal
  - Refineries
    - OSHA/NFPA 2112
- Select flame resistant clothing
- May add chemical resistant coating to flame resistant clothing

Gloves

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

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

GREEN: The glove is very well suited for application with that chemical.

YELLOW: The glove is suitable for that application under careful control of its use.

RED: Avoid use of the glove with this chemical.

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

Butyl Rubber

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

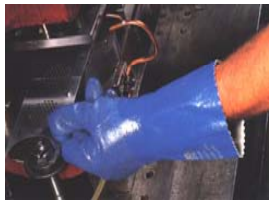
Types of Gloves

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/

Types of Eye Hazards

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

Examples of Eye & Face Protection

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

Respiratory Protection

Respirator Requirements

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

Basic Types of Respirators

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

Air Purifying Respirators (APR)

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

Types of Respirator 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

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 30 ppm. OEL is 1 ppm. What respirator should you choose?

Maximum Use Concentration (MUC) = APF x OEL

Half Face Mask: MUC = 1 ppm x 10 = 10 ppm

PAPR (LFF): MUC = 1 ppm x 25 = 25 ppm

Full Face Respirator: MUC = 1 ppm x 50 = 50 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 employee
- Examples:
  - SCBA
  - Airline
- Must use Grade D Air
- Limitations

Breathing Air Quality and Use

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

Maintenance and Storage Procedures

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

Foot Protection

Types:

- **Impact,penetration, compression, steel toe, etc.**
- **Non-skid, with slip resistant soles.**
- **Chemical resistant** (rubber, vinyl, plastic, with synthetic stitching to resist chemical penetration).
- **Anti-static**
- **Temperature resistant (high or low extremes).**
- **Electrical protection (non-conducting).**
- **Water resistant**

Head Protection

Should meet or exceed 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.**
- **There is also a possibility that the acetone may splash in the worker's face during pouring.**

What PPE should Worker A wear for this task?

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 every day.
- The safety officer has determined that the airborne concentration during this task is 20 milligrams/cubic meter.
- The short term exposure limit (15 minutes) for zinc oxide is 10 milligrams/cubic meter .
- Zinc oxide powder is mildly irritating to the skin and eyes, but not toxic or corrosive.

What PPE should Worker C wear?

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.

Sandia National Laboratories

Key Acronyms

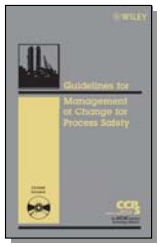
MOC = *management of change*

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)

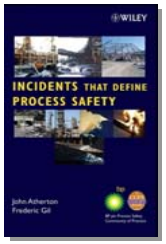
MOC / PSSR Resources

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.

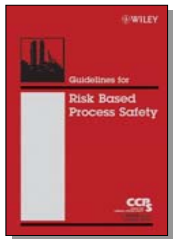


Chapter 8 Management of Change

- 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.

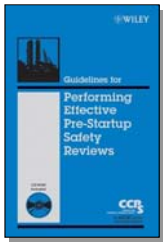


Chapter 15 Management of Change
Chapter 16 Operational Readiness

§ .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.**



Chapter

1 Introduction
2 What Is a Pre-Startup Safety Review?
3 Regulatory Issues
4 A Risk-Based Approach to PSSR
5 The Pre-Startup Safety Review Work Process
6 Methodologies for Compiling and Using a PSSR Checklist
7 Continuous Improvement

CD-ROM

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

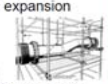
Sponsored by the 5th Global Congress on Process Safety

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.*

- 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 <u>follow a written MOC procedure</u> 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)

MOC considerations

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**

Process Safety Beacon

CCPS 20 YEARS — An AIChE Industry Technology Alliance

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

Messages for Manufacturing Personnel

Sponsored by CCPS Supporters

June 2005

Too Many Start-Stop Switches

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!

PSID Members see: Free Search--Agitator

http://www.psdnet.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 !

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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***

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 some 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 all information defining "normal operation" 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
- Impact of change on safety and health
- Modifications to operating procedures
- Necessary time period for the change
- Authorization requirements

Information updates

The MOC procedure needs to assure that
all information defining "normal operation"
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
all information defining "normal operation"
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
all information defining "normal operation"
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 team of knowledgeable persons
- Includes a field inspection of modified facilities
- Uses a checklist to ensure completeness (see CCPS 2007b)
- Generates list of pre-startup follow-up items
- Is integrated 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

For 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 approved 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 reverse 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.
- **Update 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.
- **Communicate** 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.

CSP Chemical Safety and Security Training

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.

CSP Chemical Safety and Security Training

Final Suggestions

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

CSP Chemical Safety and Security Training

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

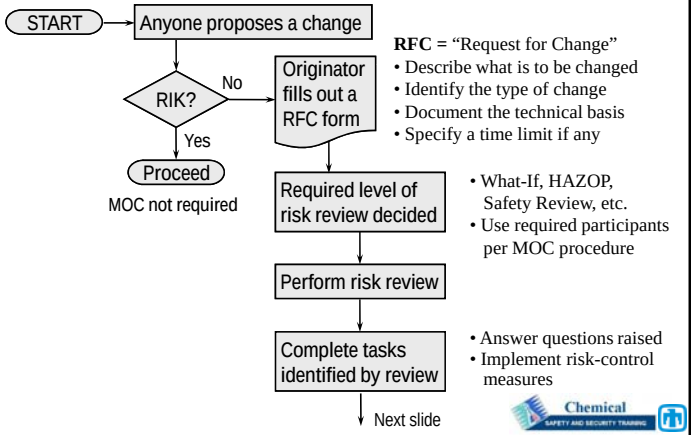
- Assign an MOC Coordinator
- Keep an MOC Log
- Complete PSSR follow-up items before restarting
  - Signage
  - Painting
  - Insulation
  - Clean-up
  - Procedure revisions and approvals
  - Training and Communications
  - Paperwork
  - etc.

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

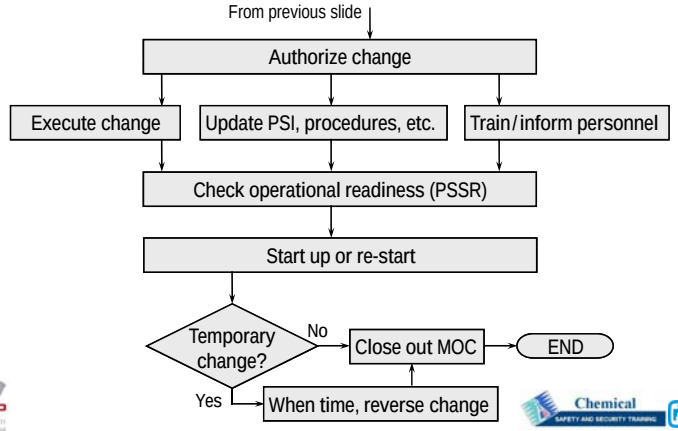


RFC = "Request for Change"
- Describe what is to be changed
- Identify the type of change
- Document the technical basis
- Specify a time limit if any

- 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

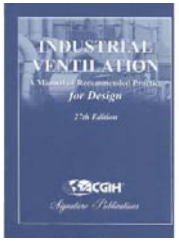
Industrial Ventilation

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

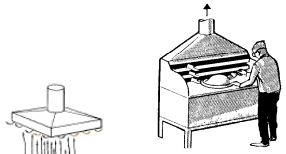
- Duct velocity-velocity required to transport the contaminant
- Face velocity-velocity on the front of an enclosing hood
- Capture velocity-velocity required to capture contaminant at point of generation

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***



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: Advanced Specialty Gas Equipment

Photo credit: Emergency Responder Products

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)

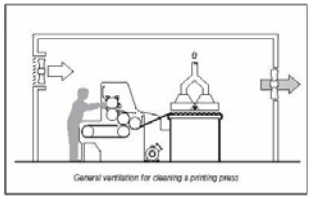
  V = wind speed in kilometers/hour

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

General Ventilation

Dilution Ventilation
- Heat control
- Dilution of odors, flammables
- Not for control of toxics

Principles
- Contaminant emissions must be widely dispersed
- Exhaust openings must be near contaminant source
- The worker must not be downstream of contaminant
- Air flow over worker should not exceed 3.5 meters/sec

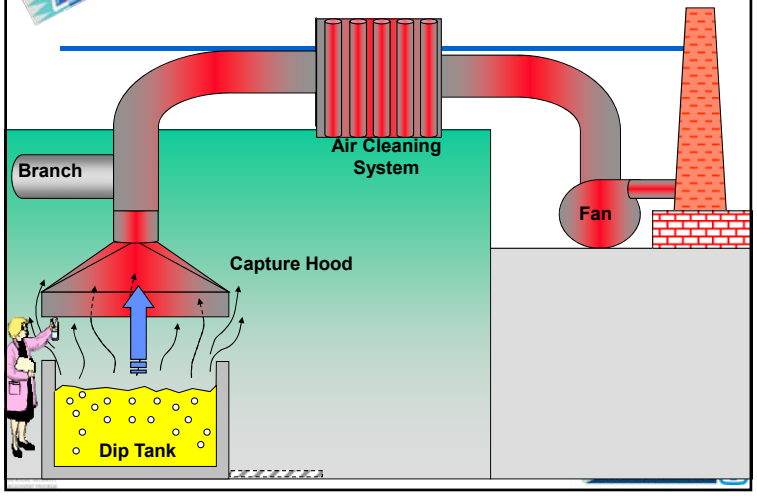


Picture Credit: safeworkaustralia.gov.au

Local Exhaust Ventilation (LEV)

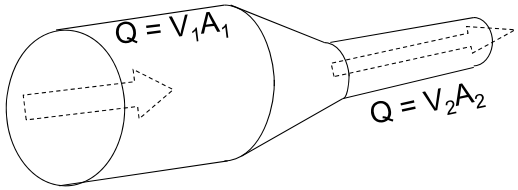
- Use when contaminant concentration cannot be controlled by dilution ventilation or other controls
- Select the type of LEV from hazard assessment
  - Which type is best to capture the contaminant?
    - Enclosed or capture hood?
    - Consider worker's needs
  - What duct transport velocity is required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

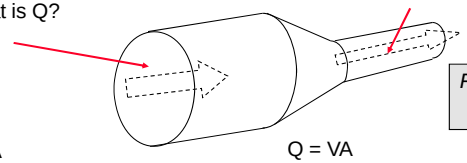


Q = Volumetric flow rate, in cubic meters/second
V = Average velocity, in meters/second
A = Cross-sectional area in square meters

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)

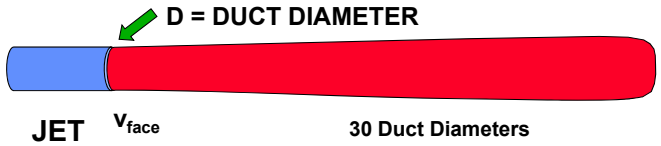
Q = **471 meters^3/second**

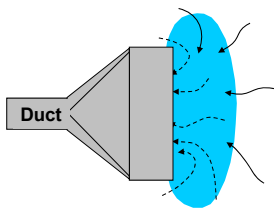
Q = VA

471 meters^3/s = V (π[0.5m]^2/4)

V = 2399 meters/second

Local Exhaust Ventilation



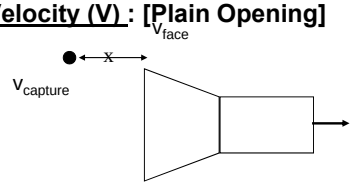


Capture of contaminant is only effective within <u>one (1) duct diameter</u>

HOOD TYPE	DESCRIPTION	ASPECT RATIO, W/L	AIR FLOW
	SLOT	0.2 OR LESS	Q = 3.7 LVX
	FLANGED SLOT	0.2 OR LESS	Q = 2.6 LVX
	PLAIN OPENING	0.2 OR GREATER AND ROUND	Q = V(10X² + A)
	FLANGED OPENING	0.2 OR GREATER AND ROUND	Q = 0.75V(10X² + 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(10X² + A)
	FLANGED MULTIPLE SLOT OPENING 2 OR MORE SLOTS	0.2 OR GREATER	Q = 0.75V(10X² + A)

Local Exhaust Ventilation

<u>Capture Velocity (V)</u> : [Plain Opening]



Q = V (10x² + A)
X = distance of source from hood face

Recommended Capture Velocities

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

Recommended Duct Velocities

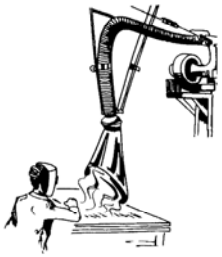
CONTAMINANT	EXAMPLES	DUCT VELOCITY Meters/second
Vapors, gases, smoke	Vapors, gases, smoke	5.0 – 10.1
Fumes	Welding	10.1 – 12.7
Very fine dust	Cotton lint	12.7 – 15.2
Dry dusts & powders	Cotton dust	15.2 – 20.3
Industrial dust	Grinding dust, limestone dust	17.8 – 20.3
Heavy dust	Sawdust, metal turnings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

Local Exhaust Ventilation

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

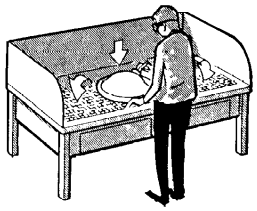
Local Exhaust Ventilation

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



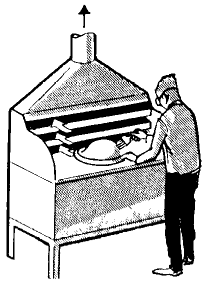
Local Exhaust Ventilation

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



Local Exhaust Ventilation

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



Local Exhaust Ventilation

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

Local Exhaust Ventilation

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

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 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 best ventilation system for the following situation?
  - Dilute non-toxic odors in the warehouse

A) General ventilation
B) Local exhaust ventilation

Exercise

- What is the best 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 best 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 best 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 best 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/

Chemical
SAFETY AND SECURITY TRAINING

Incident Investigation and Reporting

SAND No. 2011-1036C

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

Key Acronym

RCA = *root cause analysis*

Incident investigation resources

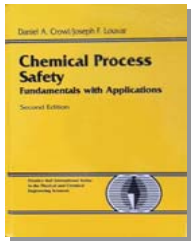
CCPS 2003. Center for Chemical Process Safety, *Guidelines for Investigating Chemical Process Incidents, 2nd Edition*, NY: American Institute of Chemical Engineers.

Chapter

1 Introduction
2 Designing an incident investigation management system
3 An overview of incident causation theories
4 An overview of investigation methodologies
5 Reporting and investigating near misses
6 The impact of human factors
7 Building and leading an incident investigation team
8 Gathering and analyzing evidence
9 Determining root causes – structured approaches
10 Developing effective recommendations
11 Communication issues and preparing the final report
...

Incident investigation resources

D.A. Crowl and J.F. Louvar 2001. *Chemical Process Safety: Fundamentals with Applications, 2nd Ed.*, Upper Saddle River, NJ: Prentice Hall.

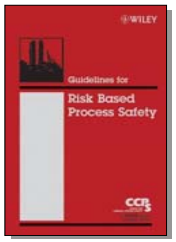


Chapter 12 • Accident Investigations

12.1 Learning from accidents
12.2 Layered investigations
12.3 Investigation process
12.4 Investigation summary
12.5 Aids for diagnosis
12.6 Aids for recommendations

Incident investigation resources

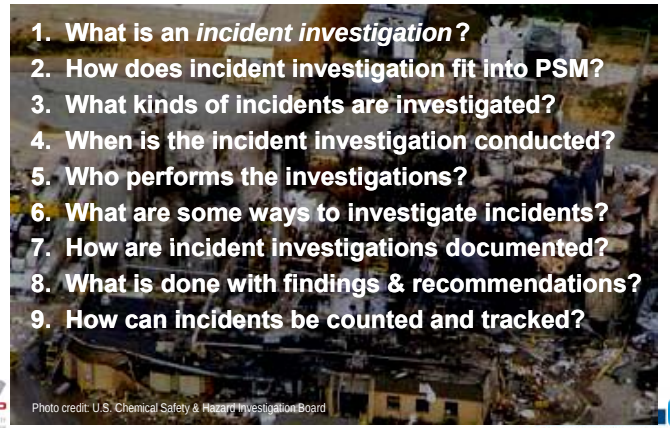
CCPS 2007a. Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*, NY: American Institute of Chemical Engineers.



Chapter 19 • Incident Investigation

19.1 Element Overview
19.2 Key Principles and Essential Features
19.3 Possible Work Activities
19.4 Examples of Ways to Improve Effectiveness
19.5 Element Metrics
19.6 Management Review

Incident Investigation and Reporting



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8. What is done with findings & recommendations?
9. How can incidents be counted and tracked?

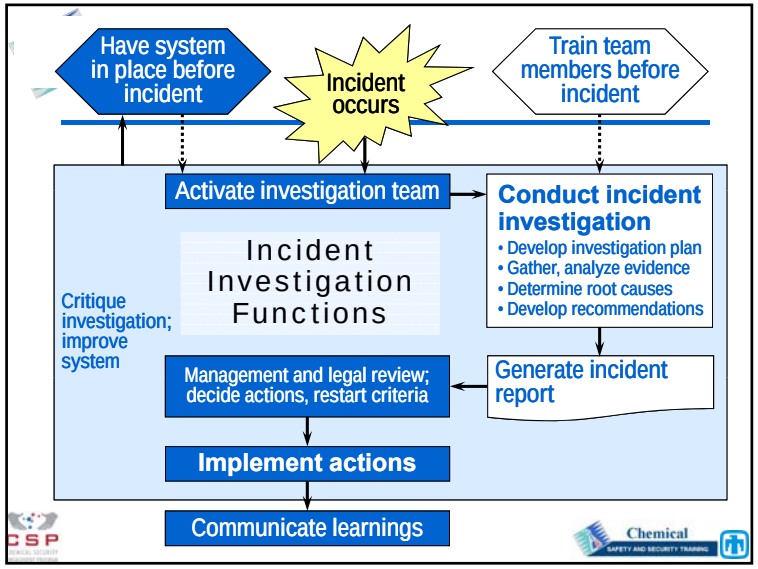
Photo credit: U.S. Chemical Safety & Hazard Investigation Board

Incident Investigation and Reporting

What is an *incident investigation*?

An *incident investigation* is the management process by which underlying causes of undesirable events are uncovered and steps are taken to prevent similar occurrences.

- CCPS 2003



Learning from incidents

Investigations that will enhance learning

- **are fact-finding, not fault-finding**
- **must get to the *root causes***
- **must be reported, shared and retained.**

Definition - Root cause

Root Cause: **A fundamental, underlying, system-related reason why an incident occurred that identifies a correctable failure or failures in management systems.**

There is typically more than one root cause for every process safety incident.

- CCPS 2003

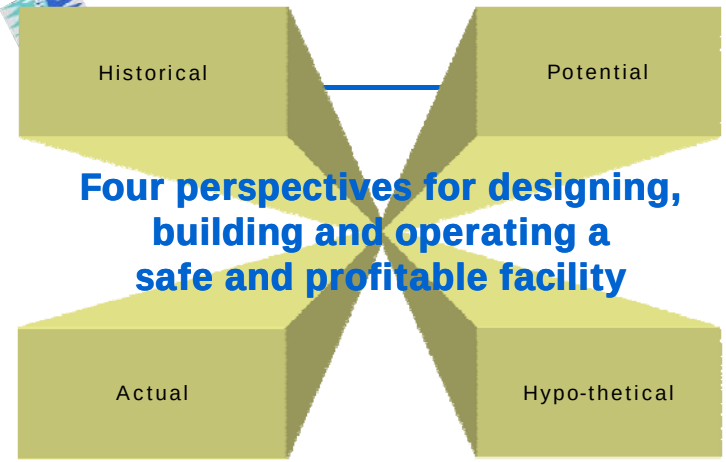
Incident Investigation and Reporting

1. What is an *incident investigation*?
2. How does incident investigation fit into PSM?

How does incident investigation fit into PSM?

Risk-Based Process Safety (CCPS 2007a)

Commit to Process Safety	Understand Hazards and Risks	Manage Risk	Learn from Experience
• Process safety culture • Compliance with standards • Process safety competency • Workforce involvement • Stakeholder outreach	• Process knowledge management • Hazard identification and risk analysis	• Operating procedures • Safe work practices • Asset integrity and reliability • Contractor management • Training and performance assurance • Management of change • Operational readiness • Conduct of operations • Emergency management	• Incident investigation • Measurement and metrics • Auditing • Management review and continuous improvement



Historical

Codes, Standards, RAGAGEPS

- The historical perspective tells us what to do based on codes, standards and best practices that represent our accumulated experience and lessons learned from previous industry incidents.

Potential

Hazards, Consequences

- The potentials are physically measurable quantities, relative to a zero energy state or ambient condition, and what could happen if containment or control was lost.

- The hypothetical, or predictive, perspective looks at what could go wrong, even if it has never happened before. This is a probabilistic perspective, based on hypothetical loss event scenarios.

Hypothetical

What-If, HAZOP, Risk Analysis

- The actual or real-time perspective can inform us of previously unrecognized or uncorrected problems, as they are manifested in actual incidents and near misses, as well as by ongoing inspections and tests that can detect incipient problems.

Actual

Incidents, Inspections, Tests

Incident Investigation and Reporting

What kinds of incidents are investigated?

- The first step in an incident investigation is recognizing that an "incident" has occurred!

What kinds of incidents are investigated?

- The first step in an incident investigation is recognizing that an "incident" has occurred!

Yes

What kinds of incidents are investigated?

- The first step in an incident investigation is recognizing that an "incident" has occurred!

?

Definitions

Incident: **An unplanned event or sequence of events that either resulted in or had the potential to result in adverse impacts.**

Incident sequence: **A series of events composed of an initiating cause and intermediate events leading to an undesirable outcome.**

Source: CCPS 2008a

Incident types

Three categories of incidents, based on outcomes:

Accident | **Near miss** | **Operational interruption**

Incident types

Three categories of incidents, based on outcomes:

Accident

- **Actual loss or harm occurs**

Near miss

Operational interruption

- **Actual impact on production or product quality occurs**

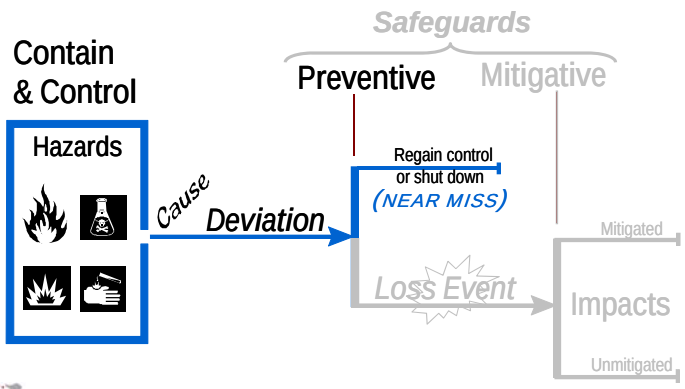
Incident types

Three categories of incidents, based on outcomes:

Accident | **Near miss** | **Operational interruption**

Near miss: **An occurrence in which an accident (i.e., property damage, environmental impact, or human loss) or an operational interruption could have plausibly resulted if circumstances had been slightly different.** - CCPS 2003

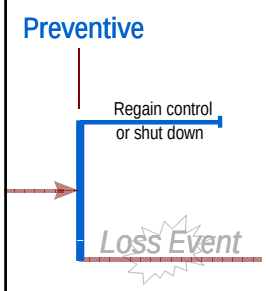
One type of near miss



DISCUSSION

Give some examples of simple near-miss scenarios that would fit the graphic on the previous slide.

Preventive safeguards revisited



Operational Mode: **Abnormal operation**

Objective: **Regain control or shut down; keep loss events from happening**

Examples of Preventive Safeguards:

- Operator response to alarm
- Safety Instrumented System
- Hardwired interlock
- Last-resort dump, quench, blowdown
- Emergency relief system

Incident Investigation and Reporting

When is the incident investigation conducted?

- Basic answer: **As soon as possible.**
- Reasons:
  - Evidence gets lost or modified
    - Computer control historical data overwritten
    - Outside scene exposed to rain, wind, sunlight
    - Chemical residues oxidize, etc.
  - Witness memories fade or change
  - Other incidents may be avoided
  - Restart may depend on completing actions to prevent recurrence
  - Regulators or others may require it
    - E.g., U.S. OSHA PSM: Start within 48 h

When is the incident investigation conducted?

Challenges to starting as soon as possible:

- Team must be selected and assembled
- Team may need to be trained
- Team may need to be equipped
- Team members may need to travel to site
- Authorities or others may block access
- Site may be unsafe to approach/enter

DISCUSSION

What might be done to overcome some of the challenges to starting an investigation sooner?

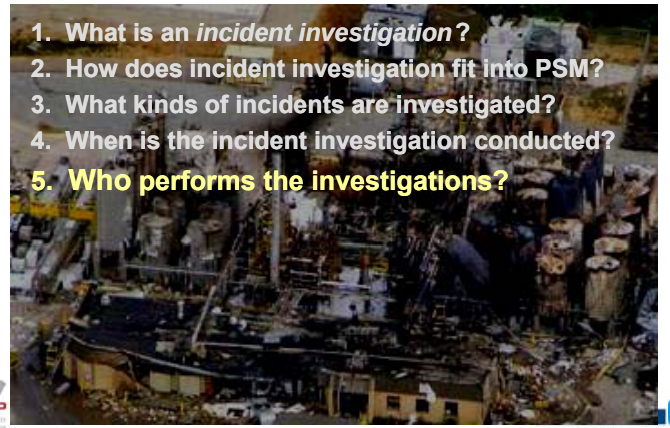
–

–

–

–

Incident Investigation and Reporting



Who performs the investigations?

Options:

- **Single investigator**
- **Team approach**

Who performs the investigations?

Options:

- Single investigator
- **Team approach**

Advantages of team approach: (CCPS 2003)

- Multiple technical perspectives help analyze findings
- Diverse personal viewpoints enhance objectivity
- Internal peer reviews can enhance quality
- More resources are available to do required tasks
- Regulatory authority may require it

Who performs the investigations?

The "best team" will vary depending on the severity and complexity of the incident.

Some possible team members:

- Team leader / investigation method facilitator
- Area operator
- Process engineer
- Process safety specialist
- I&E / process control support
- Union safety representative
- Contractor representative
- Other specialists (e.g., metallurgist, chemist)

Training site management, potential team members and support personnel ahead of time will speed up the start of the investigation.

- **Larger companies may have one or more specially trained persons available for major incident investigations**
- **<u>All personnel</u> need to be familiar with the basic incident recognition and reporting requirements**

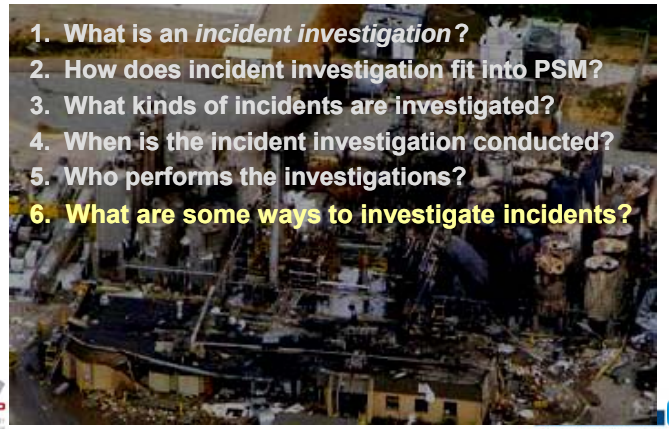
Train team members before incident

Conduct incident investigation

- Develop investigation plan
- Gather, analyze evidence
- Determine root causes
- Develop recommendations

Generate incident report

Incident Investigation and Reporting



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6. What are some ways to investigate incidents?

Older investigations

- Only identified obvious causes; e.g.,
  - "The line plugged up"
  - "The operator screwed up"
  - "The whole thing just blew up"
- Recommendations were superficial
  - "Clean out the plugged line"
  - "Re-train the operator"
  - "Build a new one"

Layered investigations

- Deeper analysis
- Additional layers of recommendations:
  1. Immediate technical recommendations
     - *e.g., replace the carbon steel with stainless steel*
  2. Recommendations to avoid the hazards
     - *e.g., use a noncorrosive process material*
  3. Recommendations to improve the management system
     - *e.g., keep a materials expert on staff*

Investigation process

1. Choose investigation team
2. Make brief overview survey
3. Set objectives, delegate responsibilities
4. Gather, organize pre-incident facts
5. Investigate, record incident facts
6. Research, analyze unknowns
7. Discuss, conclude, recommend
8. Write clear, concise, accurate report

Discovery phase

- Develop a plan
- Gather evidence
  - Take safety precautions; use PPE
  - Preserve the physical scene and process data
  - Gather physical evidence, samples
  - Take photographs, videos
  - Interview witnesses
  - Obtain control system charts and data

Analysis of facts

- Develop a timeline
- Analyze physical evidence
  - Chemical analysis
  - Mechanical testing
  - Computer modeling
  - etc.
- Conduct multiple-root-cause analysis

Some analysis methods

- Five Why's
- Causal Tree
- RCA (Root Cause Analysis)
- FTA (Fault Tree Analysis)
- MORT (Management Oversight and Risk Tree)
- MCSOII (Multiple Cause, Systems Oriented Incident Investigation)
- TapRooT®

Some analysis methods

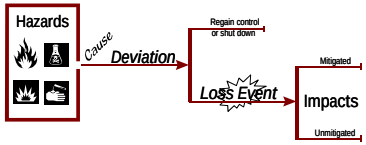
General analysis approach:

- Develop, by brainstorming or a more structured approach, possible incident sequences
- Eliminate as many incident sequences as possible based on the available evidence
- Take a closer look at those that remain until the actual incident sequence is discovered (if possible)
- Determine the underlying root causes of the actual incident sequence

Incident sequence questions

Determine, for the incident being investigated:

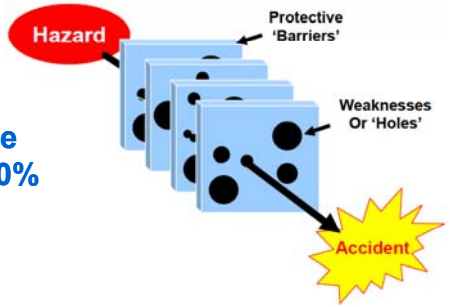
- **What was the *initiating cause* that changed the situation from "normal" to "abnormal"?**
- **What was the actual (or potential, if a near miss) *loss event*?**
- **What safeguards failed? What did not fail?**



"Swiss cheese model" revisited

REMEMBER:

No protective barrier is 100% reliable.



EXERCISE

Conduct "Five Why's" on the most recent loss event that has happened to you personally.

Why did the loss event happen? Because _____

_____

Why? Because _____

Why? Because _____

Why? Because _____

Why? Because _____

Discuss, conclude, recommend

- **Find the most likely scenario that fits the facts**
- **Determine the underlying management system failures**
- **Develop layered recommendations**

Aids for diagnosis

- Location of fire ignition?
- Deflagration or detonation?
- Hydraulic or pneumatic failure?
- Pressure required to rupture containment?
- Medical evidence?

See Crowl and Louvar 2001 Section 12.5 for details

Incident Investigation and Reporting

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How are incident investigations documented?

A written report documents, as a minimum:

- Date of the incident
- When the investigation began
- Who conducted the investigation
- A description of the incident
- The factors that contributed to the incident
- Any recommendations resulting from the investigation

Typical report format

1. Introduction
2. Process and equipment description
3. Incident description
4. Investigation results
5. Discussion
6. Conclusions
7. Layered recommendations

Investigation summary

- The investigation report is generally too detailed to share the learnings to most interested persons
- An **Investigation Summary** can be used for broader dissemination, such as to:
  - Communicate to management
  - Use in safety meetings
  - Train new personnel
  - Share lessons learned with sister plants

(See also: Crowl & Louvar 2001, Figure 12-1 and Example 12-2)

Accident involving contractors' injury during the operation of opening of a vessel for standard maintenance

Description: This accident occurred in May 2003 during repair work in a propylene reactor at a European Petrochemicals site. The cover of a manhole was ejected 5 metres by a residual pressure inside the reactor.

Consequences: 5 operators from the maintenance department were rushed to hospital. Nobody was seriously injured.

History: Work had to be done in the vessel. Before the work could start, the vessel must be put into safe conditions and the manhole must be opened. That has been decided during the safety preparation meeting.

Preparation: The putting into safe conditions started on Wednesday. The drawings of this part of the plant have been taken; the valves to be closed are noted on the drawing and then closed in the field. Then, a nitrogen flush is installed in the entire installation (vessel and lines) to ensure that all flammable gases are removed from the system. Flushing means that nitrogen pressure is applied and then the wash out is released to a safe location. This operation goes on for several days.

After that, on Friday, before opening the vessel, blinds had to be placed into the lines (to ensure that no product could enter the vessel). The entire system has been depressurised. These blinds are indicated on the drawing and the maintenance people started to put in the blinds (opening the lines to put them in).

The accident: Having started this operation, all of a sudden, they smell some gas odour and called the shift supervisor. They find out that a valve on a small line has not been closed. They close the valve and decided to flush 5 additional times. After that and while monitoring the depressurisation of the vessel via the manometer on the outside of the tank (from zero to 25 bars, impossible to read lower that 0.5), they opened the manhole. A whistling sound has been heard indicating a residual pressure in the vessel. When the noise was ended, they continued to open the manhole. At a certain moment the manhole was sprang heavily out by the residual pressure in the vessel, it was ejected and fell to the ground striking two employees.

Lesson Learned:
- The application of the procedure has to be strictly followed and supervised.
- Monitoring has to be done using multiple devices or means, so as to be sure of the indicators.
- The equipment handling has to be done using the principles of inherent safety.

Investigation summary example

Source: **S2S** - A Gateway for Plant and Process Safety, www.safety-s2s.eu

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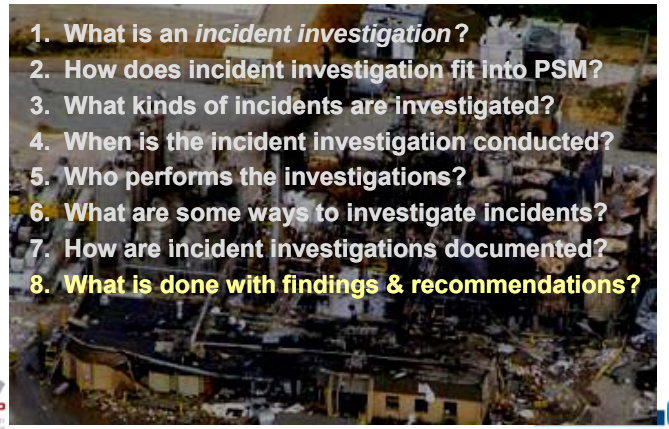
Incident Investigation and Reporting



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Findings and recommendations

What is the most important product of an incident investigation?

1. The incident report
2. Knowing who to blame for the incident
3. Findings and recommendations from the study

Findings and recommendations

What is the most important product of an incident investigation?

1. The incident report
2. Knowing who to blame for the incident
3. Findings and recommendations from the study
4. The actions taken in response to the findings and recommendations from the study

Findings and recommendations

Example form to document recommendations:

ORIGINAL STUDY FINDING / RECOMMENDATION			
Source:	☐ PHA ☐ Incident Investigation ☐ Compliance Audit ☐ Self-Assessment ☐ Other		
Source Name			
Finding No.		Risk-Based Priority *(A, B, C or N/A)*	
Finding / Rec-ommendation			
Date of Study or Date Finding / Recommendation Made			

Aids for recommendations

Overriding principles (Crowl and Louvar 2001, p. 528):

- Make safety investments on cost and performance basis
- Improve management systems
- Improve management and staff support
- Develop layered recommendations, especially to eliminate underlying causes

Aids for recommendations

Overriding principles:

- Make safety investments on cost and performance basis
- Improve management systems
- Improve management and staff support
- Develop layered recommendations, especially to eliminate underlying causes **and hazards**

CCPS Center for Chemical Process Safety — An AIChE Industry Technology Alliance

Process Safety Beacon

http://www.aiche.org/CCPS/Publications/Beacon/index.aspx

Messages for Manufacturing Personnel

Sponsored by CCPS Supporters

How Can You Use "The Beacon"?

February 2008

One important issue in maintaining a good process safety culture in any organization is to maintain a sense of vulnerability. In other words, we must always remember, and respect, the hazards associated with our processes and materials. If we have good and effective process safety management systems, one result is that we will have fewer incidents. This can lead to complacency - we forget why we are doing all of the activities in the process safety management system which result in good performance and few or no incidents. So, it is important to use resources like "The Beacon" to remind ourselves of what can happen if we don't do those activities – such as Hazard Identification and Risk Analysis (including assigning our most knowledgeable people to Process Hazard Analysis studies), Operating Procedures, Asset Integrity and Reliability, Management of Change, Emergency Management, Incident Investigation, Auditing, and others. In all of the incidents we discuss in the Beacon, there has been a failure in one or more of these important process safety management systems.

(continued from previous slide)

Did you know?

- Nearly all incidents are the result of more than one failure. Some failures result in near misses - that is they did not cause an incident this time, but could have.
- Almost every month, "The Beacon" receives a number of emails pointing out other lessons that can be learned from the incident discussed, which have not been included in the Beacon.
- Because of the limited space available in "The Beacon", we must pick one of the many lessons from each incident, and focus the Beacon on that lesson. But there are always other lessons.
- Whenever possible, if the reports on the incidents described are publicly available, we will provide a reference in the Beacon cover email note.

What can you do?

- Good – post the Beacon in places where workers will see it and read it – for example, bulletin boards, locker rooms, lunch rooms, control rooms, the gate house.
- Better – use the Beacon as the basis for safety meetings or other safety discussions with operators and other workers.
- Better yet – Develop additional information which relates the topic in the Beacon to the operations in your own plant, including any similar incidents or near misses in your company, and discuss this information with workers.
- Best – Unit or plant management leads a discussion of the Beacon with workers and challenges them to find other lessons in the incident described, beyond those discussed in the Beacon. Challenge plant safety committees to use the Beacon in their work.

Learn from the experience of others!

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Implementation

As for PHA action items,

a system must be in place to ensure all incident investigation action items are completed on time and as intended.

- Same system can be used for both
- Include regular status reports to management
- Communicate actions to affected employees

Incident Investigation and Reporting

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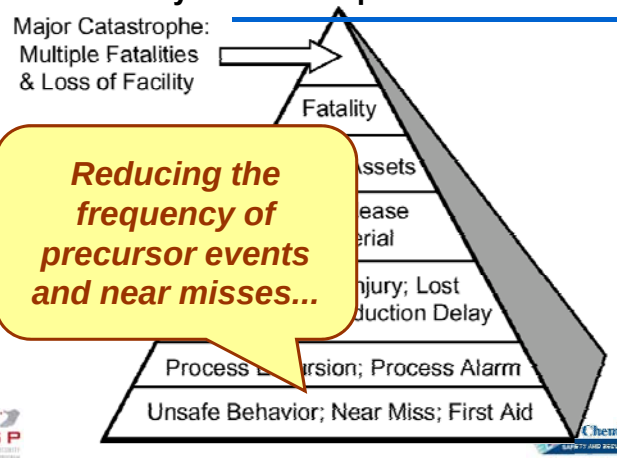
How can incidents be counted and tracked?

- "Lagging indicators" — *actual loss events*
  - Major incident counts and monetary losses
  - Injury/illness rates
  - Process safety incident rates

How can incidents be counted and tracked?

- "Lagging indicators" — *actual loss events*
  - Major incident counts and monetary losses
  - Injury/illness rates
  - Process safety incidents rate
- "Leading indicators" — *precursor events*
  - Near misses
  - Abnormal situations
    - E.g., Overpressure relief events
    - Safety alarm or shutdown system actuations
    - Flammable gas detector trips
  - Unsafe acts and conditions
  - Other PSM element metrics

Pyramid Principle revisited



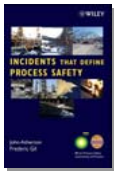
Reducing the frequency of precursor events and near misses...

Pyramid Principle revisited

... will reduce the likelihood of a major loss event

Additional resources

- **AIChE *Loss Prevention Symposium*, Case Histories session (every year)**
- **www.csb.gov reports and videos**
- **CCPS 2008b, Center for Chemical Process Safety, *Incidents that Define Process Safety*, NY: American Institute of Chemical Engineers**
- **CCPS, "Process safety leading and lagging metrics – You don't improve what you don't measure,"** available at



www.aiche.org/uploadedFiles/CCPS/Metrics/CCPS_metrics%205.16.08.pdf