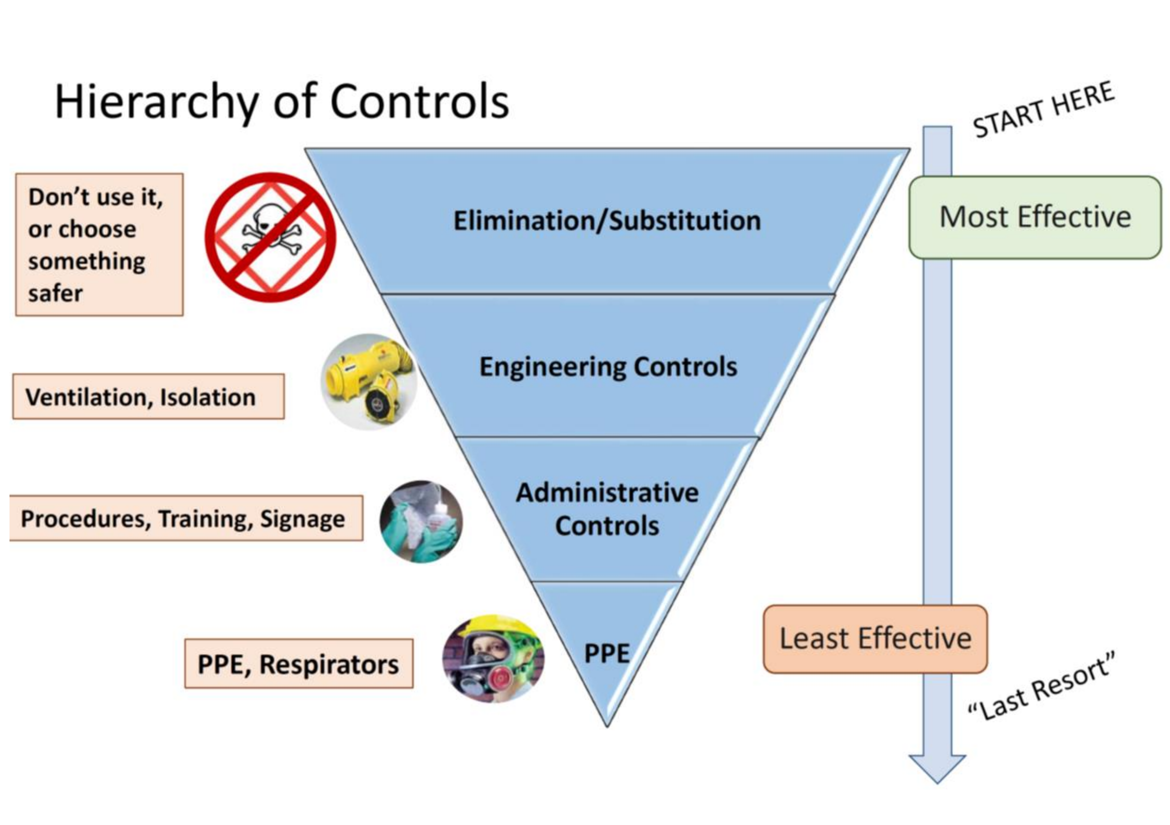
Module 4: Hazard Prevention and Control

Module 3 focused on identification of hazards. However, simply identifying a hazard is not enough to prevent it from causing an injury or illness.

Hierarchy of Controls

A "control" is used to prevent or reduce a hazard in order to prevent or limit impacts to human health and well being. However, not all controls are equally effective, or equally feasible. Traditionally, a hierarchy of controls is used when considering effectiveness of hazard controls. Controls at the top of the hierarchy are more effective than controls lower on the hierarchy.



1. <u>Elimination or Substitution</u>

Elimination is the most effective means to control a hazard. If the hazard is gone, it cannot cause injury. Elimination is a simple control when projects are at the design stage. However, for an existing process, elimination of a hazard may require significant change to equipment or work processes, and can become fairly costly disruptive to the point that it is less feasible as an option.

The National Institute for Occupational Safety and Health (NIOSH) has launched an initiative called Prevention Through Design (PtD) to promote the concept of designing out hazards to minimize risks. NIOSH is working with stakeholders to develop practices and educational materials to support efforts to eliminate hazards in the design, redesign and retrofit of work and workplaces.
https://www.cdc.gov/niosh/topics/ptd/

NIOSH Prevention through Design Initiative

May 2016

What are our priorities?

The National Institute for Occupational Safety and Health (NIOSH) Prevention through Design (PtD) Initiative works with partners in industry, labor, trade associations, professional organizations, and academia. The program focuses on preventing illness, injury, and fatality by "designing out" occupational hazards and risks.

What do we do?

- **Research** the effectiveness of current PtD interventions, investigate additional solutions for existing design-related challenges, and identify future research needs.
- **Educate** and motivate others to use PtD priorities and processes in collaborative design and redesign of facilities, work processes, equipment and tools by:
  - Helping universities integrate PtD principles into engineering curricula.
  - Encouraging professional accreditation bodies to include PtD in their assessments.
  - Making business leaders aware of potential cost savings from PtD.
- Increase **practice** of PtD by sharing case-studies of real-life PtD solutions, and encouraging stakeholders to apply them and share further.
- Encourage business, labor, government, academic, and consensus standards organizations to integrate PtD into **policy** revisions.
- Produce concise, practical PtD guides and checklists for **small businesses**, their insurers, and the publishers of code books used by their local municipalities.

What have we accomplished?

- The U.S. Green Building Council published a *Leadership in Energy & Environmental Design (LEED) PtD pilot credit* for building certifications after four years of **policy** work with the NIOSH PtD and Construction programs. The pilot credit, developed by NIOSH, prompts the use of PtD methods to design out worker hazards for both the construction phase and operations & maintenance phase of a building's life cycle.
- Completed **research** and development of a Business Case Developer software tool that helps business managers and safety and health professionals develop proposals on the business advantages of transitioning to a PtD design process.
- Provided **education** in PtD methods at 17 events to over 1,000 influencers in business, safety, health, government, academia, and labor.
- Published safe **practice** outcomes of the 2012 "Safe Nano Design" workshop organized by the NIOSH PtD program, the NIOSH Nanotechnology Research Center, and the State University of New York at Albany. The focus is on safer design of both molecules and manufacturing processes.
- Published two Workplace Design Solution documents on PtD business value and noise reduction. These brief documents are especially helpful to **small businesses**.

What's next?

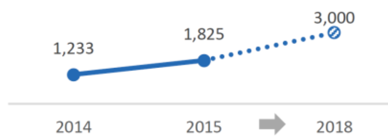
- Publish Capital Projects Processes web site with checklists and case studies showing how to incorporate PtD methods in large building projects, including Green Building.
- Publish a Business Case journal article that shows how to use the free Business Case Developer software. It can be used to make financial and non-financial proposals for adoption of PtD processes in a business.
- Develop 8 or more case studies that provide more examples of how to use the Business Case Developer software.
- Publish 3 educational slide decks with speaker notes and instructor guides on PtD for Engineering undergrad programs in:
  - Agricultural Engineering
  - Capital Projects Process
  - Manufacturing and Industrial Engineering
- Develop model language for incorporating PtD into liability insurance policies for designers and constructors.
- Develop model contract language that incorporates PtD roles and responsibilities into design and construction contracts.
- Serve on the American Society of Safety Engineers' workgroup to revise the ANSI/ASSE z590.3 Prevention through Design standard. Revisions will provide guidance to better enable businesses to use PtD design methods.
- Publish two Workplace Design Solutions for nanotechnology manufacturing with the NIOSH Nanotechnology Research Center.

DHHS (NIOSH) Publication No. 2016-130

At-A-Glance

The Prevention through Design (PtD) Initiative's mission is to prevent or reduce occupational injuries, illnesses, and fatalities through the inclusion of prevention considerations in all designs that impact workers. This snapshot shows recent accomplishments and upcoming work.

Visits to PtD topics/publications web page

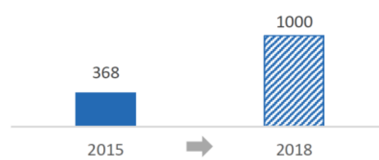


Source: NIOSH program records

Projects using PtD LEED® Credits

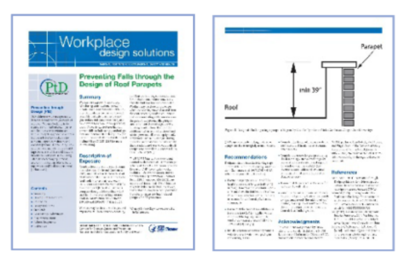
Source: NIOSH program records

PtD LEED® Webinar Participants



Source: NIOSH program records

Publication Spotlight:
Workplace Design Solutions



If the hazard cannot be eliminated, it may be possible to substitute the hazard with something less hazardous. This is one of the central principles of green chemistry and transitioning to safer chemicals. However, when evaluating substitutes, it is important that the replacement is actually less hazardous than the hazard that originally existed.

For example, methylene chloride is commonly used in paint strippers. It is strongly irritating, a carcinogen, and is regulated by OSHA (29 CFR 1910.1052). Thirteen bathtub refinishers died in the United States between 2000 and 2013 from overexposure to methylene chloride. Therefore, there is much interest in identifying alternatives to methylene chloride for stripping paint and other surfaces. Mechanical methods for paint removal, such as sanding, eliminate the risk of methylene chloride exposure, but introduce risks from particulate inhalation and musculoskeletal injuries.

N-methyl-pyrrolidone (NMP) is a widely used chemical alternative to methylene chloride. However, NMP is a skin and eye irritant, and is a reproductive and developmental toxicant.

If these hazards are less serious, or easier to control through other methods on the hierarchy of controls, these substitutions would be preferable to continued use of methylene chloride. However, alternate hazards are introduced that need to be addressed.

The best substitute is one that does not introduce significant alternate hazards. Washington State Labor and Industries, Safety and Health Assessment and Research for Prevention (SHARP) has identified benzyl alcohol based paint strippers as a safe alternative for methylene chloride.

OSHA 7225, Transitioning to Safer Chemicals, provides students with additional resources for selecting safe chemical substitutions.

SHARP Safety & Health Assessment & Research for Prevention

Washington State Department of Labor & Industries

Bathtub Refinisher Deaths from Methylene Chloride (MC)*

(*also known as Dichloromethane)

MC-based paint strippers are an EXTREME hazard

Thirteen bathtub refinishers from ten states have died (2000 - 2011) after inhaling toxic methylene chloride while stripping residential tubs[1]. Ten different products, containing 60 to 100% MC, were associated with the deaths. Products included Klean-Strip Premium Stripper and Tal-Strip II Aircraft Coating Remover[1]. In each case, ventilation and respiratory protection were absent or inadequate[2].

Stripping with MC can have deadly consequences because:

MC vapor is absorbed quickly by the lungs at low concentrations that you cannot smell.
MC vapor is heavier than air. Vapor can sink and remain low in the bathtub and breathing area during stripping.
Bathrooms are difficult to ventilate *effectively*. Standard ceiling bathroom fans cannot remove MC vapor from low inside the bathtub where you are breathing. Ventilation is needed to both suck contaminated air out of the bathtub and to push fresh air into the space. Small bathrooms with limited windows are difficult to ventilate without air turbulence.
Filter and respirator cartridges don't protect you from MC vapor. Instead, you need a full-face supplied air respirator.

DO NOT use MC-based strippers on bathtubs

There are safer alternatives to MC-based strippers.

Alternative paint strippers formulated with benzyl alcohol are less toxic than MC-based strippers and may work best[3,4].

All paint strippers have hazards, even those marketed as "green". Alternative formulations may contain N-methylpyrrolidone (NMP), a reproductive hazard, which should be avoided.

Read and follow the Material Safety Data Sheet (MSDS). Follow a comprehensive safety program for all chemicals used, incorporating ventilation and a respiratory protection program. **Washington employers can call the SHARP Program for help finding alternative strippers (1-888-66-SHARP).**

If you continue to use MC-based strippers

Small businesses who use MC should get help. Because it is a carcinogen, MC has an extensive safety standard (WAC 296-62-07470 "Methylene Chloride") that users must follow. The rule requires:

- air monitoring for MC (possibly *routine*)
- effective ventilation
- employer-paid doctor visits (possibly *routine*) for medical assessment of exposed employees
- protective clothing
- a respiratory protection program

To use MC-based strippers you need:

Ventilation that both pulls MC vapor out of the *bathtub* as you apply it and pushes fresh air towards the bathtub.
A full-face supplied air respirator. Half-face respirators DO NOT protect the eyes and cannot be used with MC. Cartridge respirators DO NOT protect because MC goes through the filter.
Polyvinyl alcohol (PVA) or Silver Shield 4H® gloves. Latex, nitrile, neoprene, polyethylene and butyl rubber gloves DO NOT protect you. Protective coveralls include Tychem® models BR/LV, TK, Responder, and Trellchemn® HPS.

Choosing a paint stripper that is free of MC would lessen some of the above burdens and associated costs

Get Help from WA State Department of Labor & Industries: For free assistance call the SHARP Program, 1-888-66-SHARP or L&I's Division of Occupational Safety and Health (DOSH) Consultation 1-800-423-7233

**This bulletin was developed by the Safety and Health Assessment and Research for Prevention (SHARP) Program, 1-888-667-4277.*

[1]Centers for Disease Control and Prevention, Fatal Exposure to Methylene Chloride Amoung Bathtub Refinishers – United States, 2000-2011. MMWR 2012; 61(7): pp119-122. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6107a2.htm?s_cid=mm6107a2_w. Accessed March 21, 2012.
[2]Michigan Fatality Assessment and Control Evaluation. Methylene Chloride Causes Death of 3 MI Bathtub Refinishers. HA #14. Available at http://www.oem.msu.edu/userfiles/BathtubRefinishingHA14.pdf. Accessed March 21, 2012.
[3]California Department of Public Health. Occupational Health Hazard Alert: Methylene Chloride in Paint Strippers and Bathtub Refinishing. Available at: http://www.cdph.ca.gov/programs/hesis/Documents/MethyleneChlorideAlert.pdf. Accessed March 21, 2012.
[4]Institute for Research and Technical Assistance. Methylene Chloride Consumer Product Paint Strippers: Low-VOC, Low Toxicity Alternatives, May 2006. Available at http://www.irta.us. Accessed March 21, 2012.

SHARP Publication #81-8a-2012

Successful Bathtub Stripping with Benzyl Alcohol as an Alternative to Methylene Chloride (MC)

Washington State Department of Labor & Industries

MC paint stripper results in OSHA citations

In a 2005 Washington-OSHA inspection, Bathcrest of Seattle was assessed over $10,000 for 15 violations related to the use of Klean-Strip Aircraft Remover (containing up to 85% MC) during bathtub stripping.

Bathcrest of Seattle's owner, Lorelei, realized the health hazards and costs of working with MC required them to find an alternative product free of MC. Finding a safe but *effective* stripper for use on residential bathtubs has not been easy. After trying several different paint strippers, Bathcrest's 3 full-time technicians now use water-based **Smart Strip with benzyl alcohol (30-50%) by Dumond Chemicals**.

Benzyl alcohol-based paint stripper works

Since Bathcrest of Seattle began using Smart Strip, they have successfully and competitively stripped over 1,000 tubs in the past 2 years. Half-face air purifying respirators are worn when working with Smart Strip. Bathcrest's tried-and-true success with benzyl alcohol-based strippers is supported by research that tested MC-free paint strippers and concluded that benzyl alcohol based products are the best choice (IRTA 2006)[1].

Lorelei admits that Smart Strip requires more surface contact time in comparison to MC-based products. During the hour that Smart Strip is left to penetrate the surface, portable ventilation is setup and the room is prepped for work. In unoccupied homes, the stripper may be applied the night before and left overnight. Stripper may also be applied early in the morning, errands run, and then stripped hours later.

Alternatives that did not work

Bathcrest used Turco 6776-LO with success for over a year. With the active ingredients benzyl alcohol and formic acid, this stripper has a sharp odor and is highly corrosive with a pH of 2.0, requiring a portable eye wash. Because of its high corrosion, Turco 6776-LO is marketed and distributed for industrial use only. It was difficult to purchase and required shipping through a private carrier. While strong odor was a disadvantage, the large packaging quantity (5 gallons) and high shipping cost eventually forced Bathcrest to look for an alternative paint stripper that was more readily available.

Bathcrest also tried Ready-Strip Plus Safer Paint & Varnish Remover by Sunnyside Corporation, sold through a local hardware store. It contains the solvents dimethyl glutarate and N-Methylpyrrolidone (NMP), a reproductive hazard. However, it did not perform well as it dried quickly and was difficult to scrape off. In a follow-up with Sunnyside Corporation, they did not recommend the product as a bathtub stripper stating the formulation would not be effective for this use. From a health perspective, products with NMP should be avoided.

Smart Strip is a better choice than either of these alternatives because it does not contain formic acid or NMP.

Exhaust ventilation essential in bathtub refinishing

Lorelei holds the view that "money spent on ventilation is affordable to save lives". Bathcrest of Seattle has been using the Coppus® Portable Ventilator (Cadet model by Dresser-Rand; ¼ HP and 1300 CFM) for the last 9 years. Too big to sit in a windowsill, the ventilator is set in the bathroom doorway and used with 25 foot lengths of flexible exhaust duct to route contaminated air outside the home. In a windowless bathroom, plastic is hung from the top of the doorframe to about 6 inches above the ventilator to create a source of make-up airflow. The flexible exhaust ducts fit into customized five gallon buckets for easy storage and handling into client's homes. The system has proven very durable and requires almost no maintenance. The ventilator effectivley controls solvents and dust and keeps the home clean. The combined noise generated from sanding plus the ventilator requires that technicians use earplugs.

Quick Facts

- MC-based strippers are severely toxic and have caused the death of 13 bathtub refinishers in the U.S. in the last 12 years[2].
- Cartridge respirators (all types) **DO NOT** protect against MC. You need a supplied air respirator.
- MC is heavier than air and will accumulate in the tub where you are breathing.

Get Help: Free assistance is available from WA State Department & Industries' SHARP Program, 1-888-66-SHARP or L&I's Division of Occupational Safety and Health (DOSH) Consultation at 1-800-423-7233.

[1]Institute for Research and Technical Assistance. Methylene Chloride Consumer Product Paint Strippers: Low-VOC, Low Toxicity Alternatives, May 2006. Available at http://www.irta.us. Accessed August 21, 2012.
[2]CDC, Fatal Exposure to Methylene Chloride Among Bathtub Refinishers – United States, 2000-2011. MMWR 2012; vol 61(7): pp119-122. Search for it at http://www.cdc.gov/mmwr. Accessed August 21, 2012

SHARP Publication #81-8b-2012

2. Engineering Controls

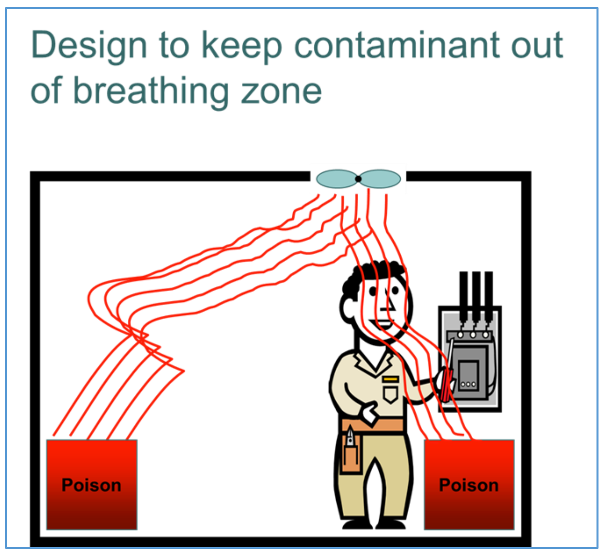
If the hazard cannot be eliminated, or substituted with something less hazardous, engineering controls are considered next. Engineering controls isolate people from the hazard. Examples of engineering controls include:

- Guards around moving equipment
- Local exhaust ventilation to remove airborne contaminants
- An air conditioned room where operating controls are located to protect workers from heat exposure
- Vibration dampening to reduce noise generation

Several OSHA standards require engineering controls as the first line of defense against hazards, including:

- Airborne Contaminants
- Lockout/Tagout
- Respiratory Protection
- Confined Space Entry
- Bloodborne Pathogens
- Hearing Conservation
- Laboratory Chemical Hygiene.

Engineering controls effectively protect people from hazards; however, they are often expensive to implement.



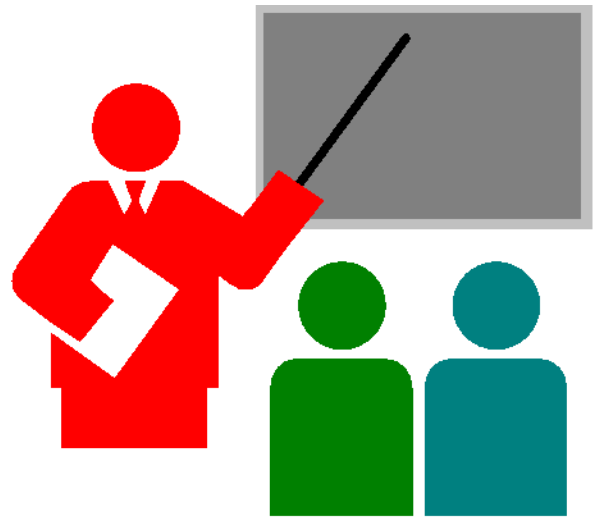
When considering engineering controls, it is important to select a control that actually reduces the hazard. A poorly thought out engineering control may fail to reduce the hazard, or as a worst case, actually increase a worker's exposure to the hazard.

NIOSH conducts research on engineering controls through their Engineering Controls Research Program (https://www.cdc.gov/niosh/engcontrols/)

Engineering controls can be expensive. They are less costly when worked into the design of the equipment or process. OSHA's $afety Pays website can be used to calculate direct and indirect costs of injuries in order to provide a cost benefit analysis for incident prevention through use of controls.

- https://www.osha.gov/dcsp/smallbusiness/safetypays/index.html

3. Administrative Controls



Administrative controls change the way people work. Administrative controls document processes that a company follows to eliminate hazards and/or minimize employee exposures;

Examples of administrative controls include:

- Signs
- Training
- Job Rotation
- Work Practices
- Procedures/Standard Operating Procedures
- Established Safe Work Routines

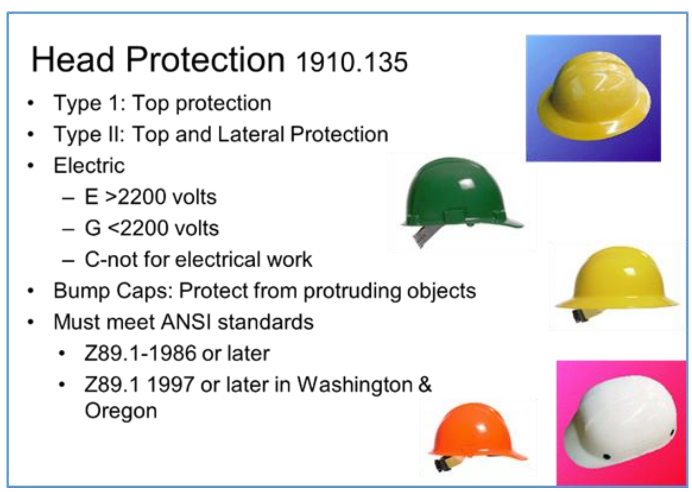
Administrative controls are less costly than engineering controls, and generally faster to implement. However, they rely on people to following the administrative controls. If that does not happen, the administrative control does not effectively protect workers from the hazard.

4. Personal Protective Equipment

Personal Protective Equipment (PPE) is equipment that is worn by the worker to protect from hazards. Examples of PPE include:

- Hard hats
- Gloves
- Safety glasses or goggles
- Safety shoes
- Visibility wear
- Personal Flotation Devices

NIOSH has developed a database for verifying PPE: https://wwwn.cdc.gov/PPEInfo/



29 CFR 1910.132 Personal Protective Equipment and related state standards establish requirements for PPE programs in the workplace. Before providing PPE, an employer must conduct a hazard assessment. PPE is then selected to match the hazards. The hazard assessment must identify specific PPE, including specific ratings for the selected PPE.

For example, hard hats are given ratings on whether they provide impact protection from the top as well as from the sides (lateral protection) as well as for electrical conductivity. If an employee is exposed to a head impact hazard from the side, they would need a Type II hardhat that provides top and lateral protection. If they wore a Type I hardhat, it would not provide protection from side impact hazards. However, the worker would have a false sense of security.

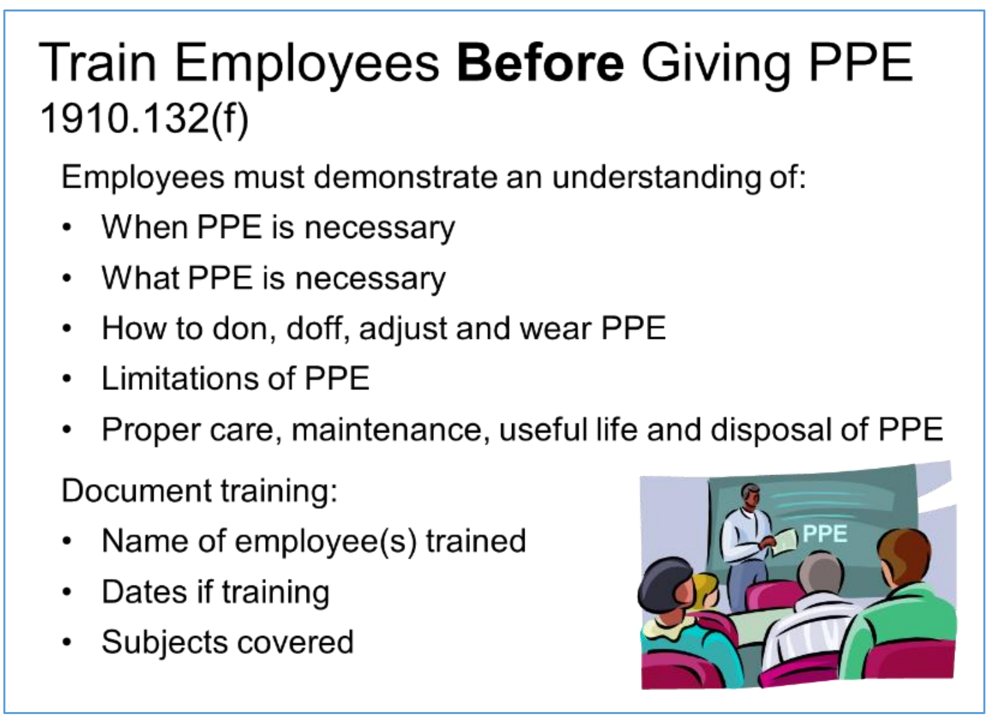
If an employee works with chemicals, gloves can protect the hands from direct contact with the chemicals. However, the glove material must be resistant to the chemical. If that is not the case, the chemical can react with the glove and leak onto the employee's hands.

PPE that is not properly selected will not protect employees from the hazard. PPE can fail if not used or maintained correctly. Employees who have a false sense of security may take risks they would not otherwise take, and actually increase their exposure to the hazard.

OSHA requires that an employer must train employees before providing them with PPE. Employees who use PPE must understand why the PPE is needed, what the hazard is that the PPE is intended to protect them from, how to use and maintain the PPE, and the limitations of PPE.

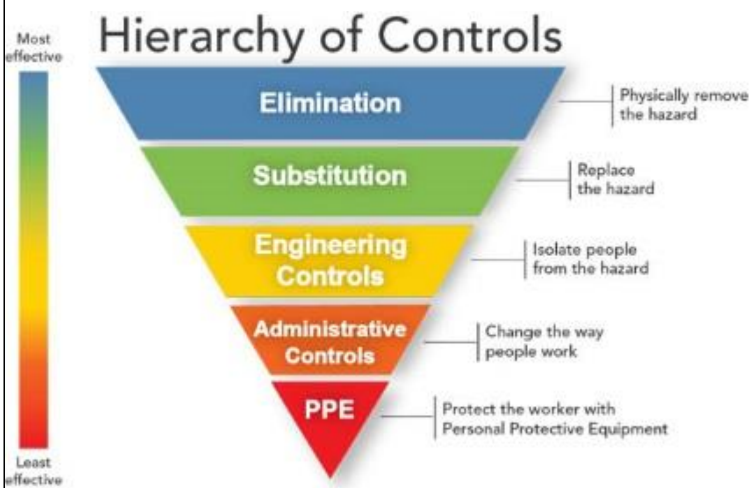
PPE is sometimes thought of as an attractive hazard control because it is viewed as inexpensive and easy to implement. However, replacement of PPE over time can add to the cost, in addition to the cost of running a comprehensive PPE program. The entirety of the program must be considered when selecting PPE as a control.

PPE is less desirable than other controls because PPE can fail, may not be properly selected, and workers may fail to use or maintain the PPE in a manner that provides continued protection.



Exercise: Behavior Based Safety (BBS) programs center on having employees provide positive recognition to their co-workers when they see the co-worker working safely, and are popular with many employers.

1. Where would you place BBS on the hierarchy of controls?



2. How does the effectiveness of BBS compare to other controls on the hierarchy?

Develop and Update a Hazard Control Plan

Once controls are identified, they must be implemented. Not surprisingly, some controls will be easier to implement than others, and some will be costlier and take more time to achieve. Since very few employers have unlimited resources to implement controls, it is necessary to develop a risk ranking so that the highest hazards are addressed first, and all hazards are addressed as time and resources allow. Hazards are analyzed by:

- Severity of hazard (outcome)
- How many employees are exposed to the hazard
- How frequently employees are exposed to the hazard

It is also important to assign responsibilities and timelines for implementing hazard controls. Timelines should be realistic and reflect the realities of available resources.

Exercise: In your workgroup, review the Job Hazard Analysis you completed in Module 3. Considering the Hierarchy of Controls, would you change any of your control recommendations?

List the controls you decide on, then rank them by severity of the uncontrolled hazard, number of employees exposed, and frequency. Assign a numerical value of 3 for the highest degree of hazard, and a value of 1 for the lowest hazard. Add the numbers, and put the sum in the Total Risk column. Assign a responsible person from your group for each control and list a date by which the control will be completed.

Control	Severity	# employes	Frequency	Total risk	Responsible Person	Date to be completed

It is important to establish a process to track implementation of identified controls, and to evaluate the controls after they are implemented to ensure that they provide the intended protection.

The last exercise asked you to develop a hazard control plan for a single JHA. In the workplace, a control plan would be comprehensive, and would include hazards from multiple JHAs, incident investigations, safety inspections, employee reports of hazards, and After Action Reports from emergency responses and exercises. Newly identified hazards would be added to the list as others are completed and removed. Implementation of hazard controls is an ongoing process.

Sample Action Item Tracking Log:

Hazard:	**Corrective Action**	**Responsible Person**	**Status (date)**	**Assigned Completion Date**

Management of Change

Work environments are not static. Work processes change. Equipment changes. Personnel and staffing assignments change. Work changes. This is to be expected. When changes happen in the workplace, workplace hazards change as well.

Many employers in OSHA's VPP programs have adopted Management of Change, or MOC, as a best practice. MOC is an element of Systems Safety, which is a specialty within system engineering to support program risk management and optimize safety. MOC is required under OSHA's Process Safety Management Standard, and is an element of System Safety Programs that are required by the Federal Aviation Administration, the Federal Transportation Administration, Federal Railroad Administration for the industries that they regulate. MOC is also an important component of pharmaceutical and food manufacturing, power generation, pipeline systems, and other industries in which failure to anticipate and control hazards can lead to serious consequences. The same principles can be applied to all areas of workplace safety.

ANSI Z10 follows principles of Systems Safety, and includes Management of Change as a component of an effective Occupational Health and Safety Management System. ANSI Z10 defines "Management of Change" as the process to identify and manage changes to minimize the introduction of new hazards and risks into the work environment. Components of Management of Change as defined by ANSI include:

- Design Review:
    - Identification of hazards
    - Recognition of hazards caused by design deficiencies that could lead to human error
    - Review of regulations, codes, standards, internal and external guidelines
    - Application of control measures, based on the hierarchy of controls
    - Determination of scope and degree of the management of change process
    - Employee participation
- A review of hazards throughout the life cycle, including
    - Concept design stage
    - Preliminary design
    - Detailed design
    - Build or purchase process
    - Commissioning, installing, and debugging processes
    - Production and maintenance operations
    - Decommissioning
- Process Verification
    - A process to verify that changes are implemented as intended, evaluated, managed, and that hazards are controlled

The International System Safety Society provides additional information on Systems Safety: https://www.system-safety.org/

Washington State Department of Labor & Industries
Division of Occupational Safety and Health

BEST PRACTICES
Washington State VPP

Management of Change

What is Management of Change (MOC)?

Management of Change, or MOC, is a best practice used to ensure that safety, health and environmental risks are controlled when a company makes changes in their facilities, documentation, personnel, or operations.

Process Safety Management at the Tenaska Ferndale Cogeneration Plant.

When decisions and changes are made rapidly, safety and health risks can increase resulting in disasters such as explosions at the oil refinery and detergent plant described in the U.S. Chemical Safety and Hazard Investigation Board's 2001 "Management of Change" safety bulletin. There are many other notable examples of how even simple changes at a worksite have led to tragedy.

At worksites where highly hazardous chemicals are used, the Process Safety Management (PSM) rules apply and proper application of Management of Change is not just a best practice, but is actually a requirement. In these cases, a MOC program is used to ensure all changes to a process are properly reviewed and any hazards introduced by the change are identified, analyzed, and controlled before resuming operation.

MOC often seems deceptively simple in concept, but can be very effective in the prevention of accidents and can be used as a best practice at worksites where the Process Safety Management rule doesn't apply.

When is MOC used?

Generally, a business need or opportunity becomes a project or business solution and requires changes in the workplace that can affect processes, systems, people, or organizational structure. Think about whether implementing this change improves your safety program and makes good business sense.

One obvious benefit Management of Change gives is avoiding the consequences of unforeseen safety and health hazards through planning and coordinating the implementation of change in your facility. This is why Management of Change is required in the PSM rules when highly hazardous chemicals are used.

Other formats for persons with disabilities are available on request. Call 1-800-547-8367. TDD users, call 360-902-5797. L&I is an equal opportunity employer.

Workplace Safety and Health STAR Voluntary Protection Program

The *Standard of Excellence* in Workplace Safety and Health

The Department of Labor & Industries, Division of Occupational Safety and Health (DOSH), administers VPP in Washington State.

Which Washington Voluntary Protection Program (VPP) sites use MOC?

Dow Chemical, Elma
Honeywell Aerospace, Redmond
Honeywell, Spokane
Monsanto Company, Othello
Nucor Steel, Seattle
Solvay Chemicals, Longview
Tenaska Cogeneration Station, Ferndale
Trident Seafoods, Anacortes
Weyerhaeuser Company, Longview

What are the benefits of MOC?

- It minimizes unplanned adverse impacts on system integrity, security, stability, and reliability for the business process being altered or added.
- It maximizes the productivity and efficiency of staff planning, coordinating, and implementing the changes.
- It provides a stable production environment.
- It ensures the proper level of technical completeness, accuracy of modifications, and testing of systems before implementation.
- It provides an appropriate level of management approval and involvement.

How do you effectively design and implement MOC?

Managing change begins with a discussion of the types of changes being considered that could affect workplace safety and health, including effects that may not be obvious.

Procedures for managing these changes should be written and regularly reviewed to reduce the risk associated with any changes.

Changes being considered must be thoroughly evaluated for how they affect employee safety and health. Sometimes there is a domino effect, where one change leads to more changes, and you will need to determine if the changes being considered prompt additional changes to operating procedures.

Your MOC program must specify what types of changes are to be managed, for example, physical alterations to equipment or new operating procedures.

A proper MOC system also requires that any change be evaluated before implementation. The level of evaluation can depend on the degree of change and how critical it is to the safety of your operations.

Employees, as well as maintenance and contract workers whose work will be affected by the change, must be informed and trained on the new equipment, process or whatever the change includes. This must be done before startup of the process or startup of the affected part of the process.

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Managing change also means updating any safety information, operating procedures or practices related to the new procedures.

Elements of an effective MOC Program:

- Procedures that consider:
  - The technical basis for the proposed change.
  - Impact of the change on employee safety and health.
  - Modifications to operating procedures.
  - Time needed for the change.
  - Authorization required for the proposed change.
- Steps to identify hazards before the changes are made.
- Methods to screen and classify changes.
- Keys to identifying hazards in changes.
- Methods for documenting MOC reviews.
- Procedures to make approvals and authorizations workable.
- Plans to inform and train personnel about the changes.
- Methods for updating Process Safety Information, procedures and other Process Safety Management information.
- Steps for effective implementation.
- Procedures for reviewing and revising any existing MOC Program.

Best Practices in MOC

1. Compile safety information on the products, equipment, materials or processes that are changing and write policies and procedures to incorporate the new information. Be sure to include information on how to investigate accidents, audit compliance with safety procedures and plan for emergency responses.
2. Establish a way to gather employee input on the changes, such as interviews, group discussions or surveys. Incorporate employee comments and suggestions into your draft policy and procedures.
3. Write instructions for all employees on every process in which changes are involved. The procedures must be clear, include steps for performing every operation, cover safety information, state what to do in the case of an emergency and be readily available to the employees performing the procedures.
4. Train employees on the changes. Emphasize any safety and health hazards and what to do in the case of an emergency. The training must take place before an employee is allowed to operate the equipment or perform the job that the changes were related to.
5. Establish written procedures for what you will do the next time you have a change in safety management.

The Voluntary Protection Program Participant's Association (VPPPA) has compiled a directory of best practices. The directory can be obtained through the VPPPA website at www.VPPPA.org under news and publications.

Safety Bulletin

U.S. Chemical Safety and Hazard Investigation Board

Management of Change

No. 2001-04-SB | August 2001

Introduction

The U.S. Chemical Safety and Hazard Investigation Board (CSB) issues this Safety Bulletin to focus attention on the need for systematically managing the safety effects of process changes in the chemical industry. This bulletin discusses two incidents that occurred in the United States in 1998. Each case history offers valuable insights into the importance of having a systematic method for the management of change (MOC). An MOC methodology should be applied to operational deviations and variances, as well as to preplanned changes—such as those involving technology, processes, and equipment.

Case No. 1

Background

On November 25, 1998, a fire at the Equilon Enterprises oil refinery delayed coking unit in Anacortes, Washington, caused six fatalities (Figure 1). A loss of electric power and steam supply approximately 37 hours prior to the fire had resulted in abnormal process conditions.

Process Description

A delayed coker converts heavy tar-like oil to lighter petroleum products, such as gasoline and fuel oil. Petroleum coke is a byproduct of the process. Drums[1] of coke are actually produced in batches, though the operation is conducted continuously.

After a drum is filled, the flow of oil is diverted to a freshly emptied vessel. The full drum contains a tarry mass, which solidifies to a coal-like substance (coke) when cooled by the addition of steam and then water. The top and bottom of the drum are opened at the completion of the cooling cycle, and the solid mass of coke is then cut into pieces and removed from the vessel.

Incident Description

Pre-Incident Activity— A severe storm on November 24 caused an electric power outage in the refinery. The storm interrupted process operations and also stopped the production of steam. At the delayed coking unit, the on-line drum had been filling for about an hour and was approximately 7 percent full. The other drum was full and was being cooled.

Although electric power was restored after 2 hours, an additional 10 hours passed before steam production was re-established. During the interim, the tarry oil in the piping between the furnace and the partially filled drum cooled and started to solidify.

Once steam was restored, the operators were unsuccessful in attempting to inject it into the drum through the normal route because

● Figure 1. Equilon Enterprises oil refinery fire.

[1] Within the oil industry, a drum is a tower or vessel in which materials are processed, heated, or stored. Coke drums can be very large and typically stand several stories high.

of the plugged piping. (When normally injected, steam creates passages in the tarry mass through which cooling water can later flow. It also drives off remaining residual volatile petroleum and sulfur compounds from the coke.)

A process interruption in 1996 had also resulted in a partially filled drum. At that time, water was injected into the drum to cool the material inside. However, when the drum was opened, a torrent of water, heavy oil, and coke spewed out—which created a hazard and required a major cleanup. An internal investigation team recommended that procedures be written for cooling/emptying partially filled drums. However, this task was not completed.

On the day of the fire, neither the process supervisor nor the operators had any written procedures for handling partially filled drums. The process supervisor was aware of the seriousness of the previous incident. He left instructions directing the night shift not to add any water, and instead to allow the drum and its contents to simply stand and cool overnight. On the following morning, he met with the operators to determine how to empty the partially filled drum. No engineers, who could have provided technical support, were present at this meeting.

Preliminary Operations—The supervisor and operators observed that the exposed part of the bottom flange of the drum felt cool to the touch. They also noted that temperature-sensing devices located beneath the insulation on the outside surface of the drum indicated approximately 230 degrees Fahrenheit (°F), as compared to the 800°F of a typically full drum.

One operator suggested adding 100 barrels of water to the drum. However, the supervisor was concerned about such a course of action because of the previous incident. Upon further discussion, they decided—because part of the drum felt cool, and the temperature-sensing devices read only 230°F—that it was not very hot inside and it was safe to open the vessel as long as they first injected some steam.

An operator connected a steam hose to the oil inlet piping at the bottom of the drum. Several witnesses said that the steam warmed the top of the piping, but the bottom remained cool. It is likely that steam flow had been established, but the rate of flow was low.

Opening the Vessel—Personnel expected a tarry mass to drain from the drum. The supervisor and process operator directed that the drum be opened with a minimum number of people present. Because they were also concerned that the limited flow of steam might not sufficiently strip all the toxic compounds from the tar inside the vessel, they required that the workers removing the bolts on the drum heads wear self-contained breathing apparatus.

The top head was unbolted and lifted from the drum. The bottom head was also unbolted and held in place by a hydraulic dolly. The operator then activated a release mechanism to lower the dolly. Witnesses reported hearing a whooshing sound and seeing a white cloud of vapor emanate from the bottom of the drum. The hot petroleum vapor burst into flames. The process supervisor, an operator, and the four contract personnel assisting were caught in the fire and did not survive (Figure 2).

After the incident, Equilon relocated the controls for the hydraulic dolly to allow workers to position themselves farther from a drum when opening it.

Followup Analysis—The supervisor and operators analyzed the situation and devised process changes to empty the drum. The relative coolness of the bottom flange erroneously suggested to them that the temperature inside the drum was also cool—when, in

CSB Safety Bulletins offer advisory information on good practices for managing chemical process hazards. Actual CSB case histories provide supporting information. Safety Bulletins differ from CSB Investigation Reports in that they do not comprehensively review all the causes of an incident.

U.S. Chemical Safety and Hazard Investigation Board
Office of Investigations and Safety Programs
2175 K Street NW, Suite 400
Washington, DC 20037
202-261-7600
http://www.chemsafety.gov

● Figure 2. Fire control efforts at Equilon refinery.

Matt Wallis, Skagit Valley Herald

The relative coolness of the bottom flange erroneously suggested . . . that the temperature inside the drum was also cool—when, in fact, only the material adjacent to the inside walls had cooled.

fact, only the material adjacent to the inside walls had cooled.

Unknown to the coker unit personnel present, the core of the mass remained insulated from heat loss. Within the core, residual heat continued to break down the petroleum, creating a pocket of hot pressurized volatile oil. Had the limitations of temperature- sensing devices been better understood, personnel may have realized that the low temperature readings were not representative of the hot core.

It was assumed that the entire drum contents had cooled to safe levels during the 2 days since the power failure. However, heat transfer calculations would have indicated that weeks would be required for the drum contents to cool sufficiently via heat losses to the ambient environment.

Lessons Learned

Chemical processing enterprises should establish policies to manage deviations from normal operations. Systematic methods for managing change are sometimes applied to physical alterations, such as those that occur when an interlock is bypassed, new equipment is added, or a replacement is "not in kind." However, the Equilon incident underscores the need to have MOC policies that include abnormal situations, changes to procedures, and deviations from standard operating conditions.

For an MOC system to function effectively, field personnel need to know how to recognize which deviations are significant enough to trigger further review. It is essential to prepare operating procedures with well-defined limits for process variables for all common tasks. Once onsite personnel are trained on MOC policy and are knowledgeable about normal limits for process variables, they can make informed judgments regarding when to apply the MOC system.

. . . the Equilon incident underscores the need to have MOC policies that include abnormal situations, changes to procedures, and deviations from standard operating conditions.

Once a deviation is identified that triggers the MOC system, it is management's responsibility to gather the right people and resources to review the situation. The skills of a multidisciplinary team may be required to thoroughly identify potential hazards, develop protective measures, and propose a course of action.

The Equilon incident could have been avoided if the "change" was managed by a team experienced in hands-on operations, safety procedures, and engineering calculations. Written procedures for cooling and emptying partially filled drums, as recommended by an Equilon investigation team in 1996, might also have reduced the likelihood of this incident.

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The Center for Chemical Process Safety, an industry-sponsored organization affiliated with the American Institute of Chemical Engineers, offers this useful guidance in its publication, *Guidelines for Technical Management of Chemical Process Safety* (1989):

> In any operation, situations will arise that were not foreseen when the operating procedures were developed. At such times, personnel may want to conduct operations in a way that differs from, or contradicts, the process technology or the standard operating procedures.
>
> To assure that these deviations from normal practice do not create unacceptable risks, it is important to have a variance procedure, or to have incorporated the same means of control into other management systems. The variance procedure will require review of the planned deviation, and acceptance of the risks it poses. The variance procedure should require the explanation of the deviation planned; the reasons it is necessary; the safety, health, and environmental considerations; control measures to be taken; and duration of the variance. Variances should require the approval by a suitable level of management, based on the process risks involved. Also, they should be documented to assure consistent understanding by all affected individuals and departments of what specific departure from normal practice is to be allowed.

A formal hazard analysis may be appropriate depending on the complexity of the change or variance. A hazard analysis for the Equilon situation would have likely determined the limitations of the temperature readings and that it was unsafe to open the drum. It would have also identified the possible release of a large volume of very hot liquid as a significant risk.

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Case No. 2

Background

On October 13, 1998, a reaction vessel explosion and fire at the CONDEA Vista Company detergent alkylate plant in Baltimore, Maryland, injured four people (Figure 3).

Process Description

Linear alkyl benzene is used to produce biodegradable detergents, which are widely used in industrial, commercial, and residential cleaners. At CONDEA Vista, this chemical was manufactured by mixing powdered aluminum chloride (the catalyst) with liquid hydrocarbons, chlorinated hydrocarbons, and benzene.

Incident Description

Pre-Incident Activity—About 3 months prior to the incident, the Baltimore facility changed its process technology and discontinued the direct addition of aluminum chloride to the reactor. Instead, powdered aluminum was added to the reactor, where it combined with hydrogen chloride to form the necessary aluminum chloride. Shortly after the plant switched to the new process, the reactor became fouled with a sludge-like catalyst residue.

When the process was shut down for maintenance, the operators were unable to empty the liquid that remained in the reactor. Sludge had settled in the vessel, plugging the bottom outlet nozzle.

● Figure 3. Site of ruptured reactor, CONDEA Vista Company detergent alkylate plant.

Unsuccessful attempts were made to clear the nozzle by injecting high-pressure nitrogen into the piping. The reactor was also flushed with a high flow of oil for several hours, but this too failed to clear the plugging.

The following day, excess liquid was removed from the reactor through a side nozzle, and a sample of the remaining sludge was extracted. The next morning, the sample was given to a plant chemist, who was asked for advice on dissolving the remaining sludge.

Reactivity Testing — The chemist first conducted a laboratory experiment to check whether fresh powdered aluminum catalyst reacted with water. He concluded that it did not. (Facility personnel were aware that aluminum chloride reacts with water, releasing heat.) When the sludge sample was tested, it reacted with water, yielding a white gas (hydrochloric acid) and generating heat. Although the chemist tested various aqueous solutions, he concluded that water—in spite of its reactivity with the sludge—was an appropriate solvent for clearing the sludge from the reactor.

Later that morning, the technology manager assigned an engineer to work with the chemist in solving the plugging problem. The engineer estimated the volume of solid in the reactor and performed some calculations for potential energy release and for the ability of water to absorb the heat generated. Together, the chemist and the engineer recommended that water be added to the reactor to dissolve the solids. They suggested an 8:1 ratio, with the water added at as fast a rate as possible. This approach was based on the idea that rapidly adding a surplus volume of water would absorb the energy released by the reaction and minimize the temperature rise.

Addition of Water and Steam to Reactor — Water was added to the reactor while the vessel agitator was running. A temperature indicator in the control room recorded a 5 to 10 degree Celsius (°C) temperature rise. After observing the reactor temperature stabilize, the chemist and the engineer went home for the night.

Because the process supervisor had not been in the plant that day, the shift supervisor spoke to him by telephone and suggested injecting a short burst of steam at the bottom nozzle of the reactor. The process supervisor agreed. The shift supervisor wrote a one-line instruction for the night shift to use steam to clear the plugging.

The two shift supervisors had a brief conversation at shift turnover. The night shift supervisor understood that he was to use steam to break up the plug. However, the procedure intended by the day shift supervisor and the process supervisor—though not detailed—was to inject a short burst of steam, not to apply it continuously.

The night shift supervisor instructed an operator to add steam to the reactor. Minutes after the operator started to continuously inject the steam, it reacted with the metallic aluminum and the aluminum chloride residue in the sludge. The reactor vessel exploded (Figure 4).

Effects of Explosion and Fire— No one was present in the immediate vicinity of the reactor when it exploded, and there were no fatalities. Two employees and one contractor received first- and second-degree burns; they were wearing fire-resistant work clothing, which provided a measure of protection. Another contractor injured his back when he fell. Property damage was estimated at $13 million.

Lessons Learned

From both a project and an operational standpoint, the incident at CONDEA Vista emphasizes the importance of systematically managing changes. Post-incident investigations noted that the density of the new catalyst (powdered aluminum) was higher than that of aluminum chloride. The higher density material—combined with problems related to initial overfeeding of the aluminum—overtaxed the mixing capability of the agitator and allowed aluminum to settle in the bottom of the reactor, where it plugged the lower nozzle and accumulated as sludge.

The plan devised by the chemist and the engineer for dissolving the sludge posed hazards. Of particular concern were the following:

- Gases[2] that evolved during the bench-scale tests could vent freely. However, the reactor—though equipped with vent piping and a relief system—presented a much more contained environment. The amount of reactive material involved was much greater; the scale-up factor was large.
- The concept of absorbing the energy of reaction by means of quickly adding a surplus of a reactive substance (water) was potentially hazardous. Although the concept was feasible, it required precise execution. The water would have to be added quickly and without interruption to avoid a significant heat release.
- The temperature-sensing device did not accurately indicate the process temperature because it was located in a stagnant pipeline between the reactor and another vessel. The chemist and the engineer relied on misleading temperature indications when they noted the stabilization of the reactor temperature before leaving for the day.

A hazard analysis of the proposed procedure could have assisted in the identification of potential safety issues. Ideally, the extent of analysis undertaken should be tailored to the degree of risk.

The CONDEA Vista incident also highlights the importance of preparing written procedures for

[2] At higher temperatures, water can react with aluminum to form hydrogen. Water can also react with aluminum chloride to produce hydrogen chloride, which—in turn—can react with aluminum to produce hydrogen.

- Figure 4. CONDEA Vista plant fire.

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variances in operating conditions and practices. In this case, the absence of written instructions increased the likelihood of miscommunication between the two shift supervisors, which led to the unsafe application of steam in the reactor vessel.

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Another lesson learned is the value of having an authorization or approval step as part of an MOC system for abnormal situations. If such a procedure had been in place, a technical manager would have reviewed the proposed procedure and may have detected its deficiencies.

Summary

Neither the Equilon Enterprises oil refinery fire nor the CONDEA Vista Company explosion and fire involved emergencies that required rapid decision making. In each instance, time was available to look into the circumstances more thoroughly. Each situation could have been avoided with a more analytical and structured approach to problem solving.

Neither the Equilon Enterprises oil refinery fire nor the CONDEA Vista Company explosion and fire involved emergencies that required rapid decision making . . . Each situation could have been avoided with a more analytical and structured approach to problem solving.

The Occupational Safety and Health Administration's (OSHA) Process Safety Management standard and the U.S. Environmental Protection Agency's (EPA) Risk Management Plan require covered facilities to manage changes systematically. It is good practice to do so, irrespective of the specific regulatory requirements.

If your organization has an MOC policy, review it to be sure that it covers operational variances in addition to physical alterations. If you do not have a systematic method for handling changes, develop and implement one.

If your organization has an MOC policy, review it to be sure that it covers operational variances in addition to physical alterations.

To maximize the effectiveness of your MOC system, include the following activities:

- Define safe limits for process conditions, variables, and activities—and train personnel to recognize significant changes. Combined with knowledge of established operating procedures, this additional training will enable personnel to activate the MOC system when appropriate.
- Apply multidisciplinary and specialized expertise when analyzing deviations.
- Use appropriate hazard analysis techniques.
- Authorize changes at a level commensurate with risks and hazards.
- Communicate the essential elements of new operating procedures in writing.
- Communicate potential hazards and safe operating limits in writing.

Define safe limits to process conditions, variables, and activities—and train personnel to recognize significant changes.

- Provide training in new procedures commensurate with their complexity.
- Conduct periodic audits to determine if the program is effective.

For Further Reading

Center for Chemical Process Safety (CCPS), 1992. *Guidelines for Hazard Evaluation Procedures, 2nd Edition With Worked Examples*, American Institute of Chemical Engineers (AIChE).

CCPS, 1989. *Guidelines for Technical Management of Chemical Process Safety*, AIChE.

Sanders, Roy E., 1999. *Chemical Process Safety – Learning From Case Histories,* Butterworth-Heinemann, pp. 215-247.

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Information about available publications may be obtained by contacting:

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Standard Number: 1910.119
March 31, 2009
MEMORANDUM FOR: REGIONAL ADMINISTRATORS

THROUGH: DONALD G. SHALHOUB
DEPUTY ASSISTANT SECRETARY

FROM: RICHARD E. FAIRFAX, DIRECTOR
DIRECTORATE OF ENFORCEMENT PROGRAMS

SUBJECT: Management of Organizational Change
This memorandum addresses the application of 29 CFR 1910.119 (l), Process Safety Management (PSM) - Management of Change (MOC), to covered processes potentially impacted by changes in facility organization, staffing, and policies (Organizational Changes). It does not add to or modify the types of changes subject to MOC; rather, it is intended to increase CSHO awareness of potential sources of changes covered under the PSM standard. The MOC provisions of the PSM standard apply only to changes, including organizational changes, that impact safety in PSM covered processes.

The PSM standard requires employers to develop and implement written MOC procedures to address the safety and health impacts of contemplated changes, including organizational changes, as they relate to process chemicals, technology, equipment, procedures and facilities (29 CFR 1910.119(l)(1)). Some organizational changes, such as changes resulting from mergers, acquisitions, reorganizations, staffing changes, or budget revisions, may affect PSM at the plant level and would therefore trigger a PSM MOC procedure. Some examples of these include:

personnel changes, including changes in staffing levels, staff experience, or contracting out that directly impact PSM covered processes; and
policy changes such as budget cutting that impact PSM covered processes.
The PSM standard's MOC provisions act as a control point when organizational changes result in or could be reasonably expected to result in, changes that can affect covered processes. In other words, if organizational changes necessitate changes to process chemicals, technology, equipment, procedures, or facilities, an MOC procedure would be required to ensure that resulting changes are managed and implemented in a manner that assures continued safe operations. However, management changes that do not impact PSM covered processes are not affected by the MOC provisions of the PSM standard.

For example, when the number of employees operating a process is to be reduced due to an organizational change, operators may not be able to continue implementation of existing operating procedures. An MOC procedure must be implemented to manage the change, possibly by modifying existing operating procedures to reflect the new, reduced staffing level, and to ensure that operations remain safe under normal production and emergency upset conditions.

Budgetary changes can have a similar effect. For example, a significant cut in a maintenance department's budget could require an employer to alter its mechanical integrity procedures concerning the timeliness or frequency of tests, inspections, repairs, or replacements of PSM-covered equipment. Because this represents a change to mechanical integrity procedures, an MOC procedure must be established and implemented to ensure the ongoing integrity of the process.

Other organizational changes may not impact any of the five elements listed in 29 CFR 1910.119 (l)(1) and therefore would not trigger PSM MOC. Organizational changes that have no relationship to plant-level PSM processes, as in the case of changes to corporate or administrative personnel whose duties do not relate to operations or maintenance functions, do not trigger PSM MOC procedures.

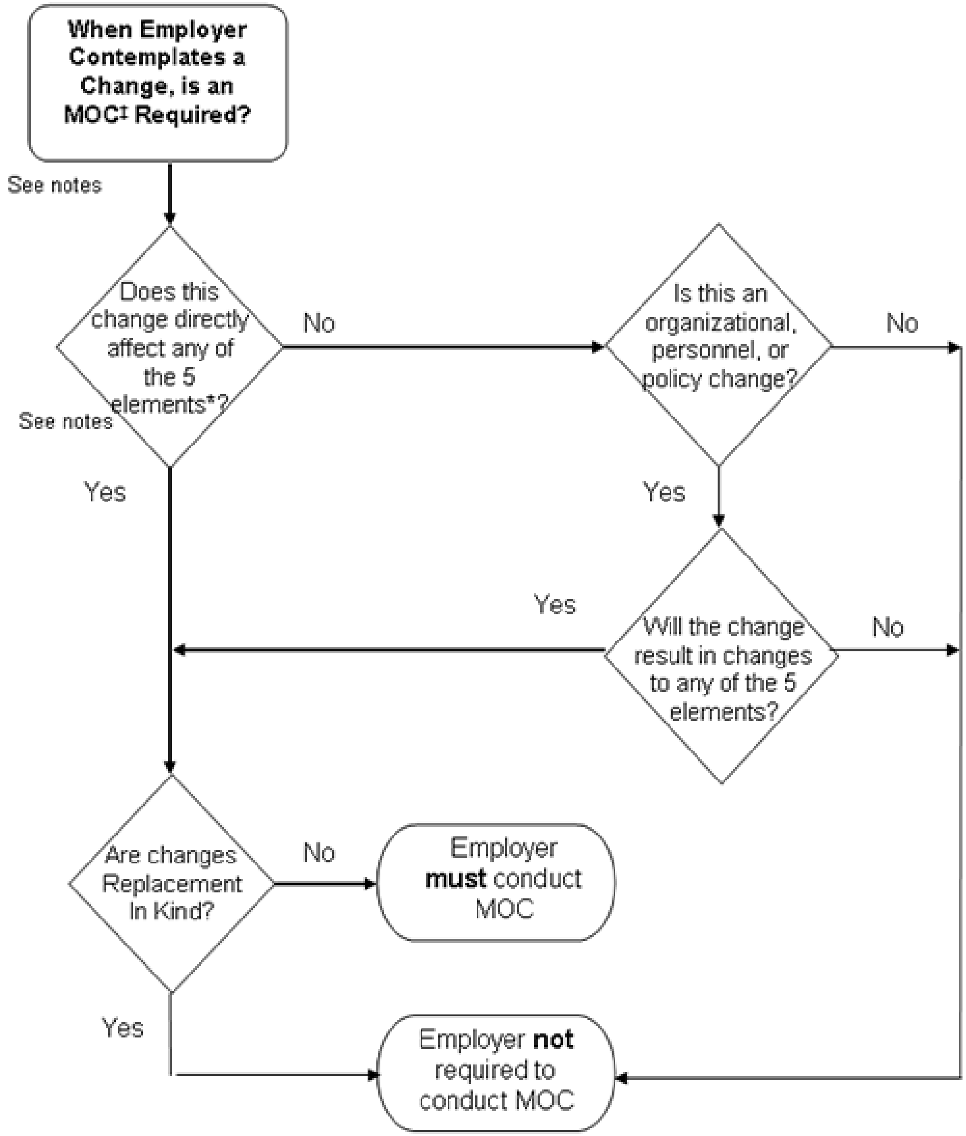
The attached flow chart illustrates the decision making process for determining if an MOC is required for an organizational, personnel, or policy change.

When enforcing the PSM Standard, CSHOs should consider issuing a citation for a violation of 29 CFR 1910.119(l) whenever an employer has made a change, or is in the process of making a change, to process chemicals, technology, equipment, procedures and facilities, without having established or implemented written procedures to manage the change. As discussed above, this applies to such changes even when they result from organizational, personnel, or policy changes. A citation should also be considered if a Management of Change review has been performed in response to an identified hazard, but necessary safety actions have not been performed in a timely manner to control the hazard.

It is also important that the written MOC procedures address all of the considerations listed in 1910.119(l)(2), that the employees involved in the process are trained in accord with 1910.119(l)(3), and that related process safety information and operating procedures are updated as appropriate in accord with 1910.119(l)(4) and (l)(5).

If you have any questions call the Office of General Industry Enforcement at 202-693-1850.

Organizational Change



‡If at any point in the decision making process the employer decides not to implement the contemplated change, there is no requirement to conduct an MOC.

*Contemplated changes to the following 5 elements trigger MOC review in 1910.119 (l)(1), except for Replacement In Kind (RIK):

- Process chemicals
- Technology
- Equipment
- Procedures
- Facilities

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