Emergency Management

SAND No. 2011-0722C
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.

Overview

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

Emergency Defined

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

"An urgent need for assistance or relief"

"May occur without advance warning"

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

Emergencies

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

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

Emergency Management

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

Emergency Planning

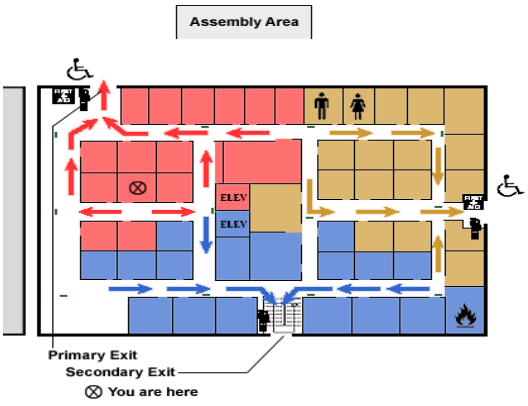
General Plant Emergency Plan

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

Emergency Planning

Have an evacuation map for all buildings and areas and

POST IT



Emergency Planning

Post each area with:

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

Location	
Hazards Within:	
Primary Contact:	
Second Contact:	
Building Monitor/Safety:	
Department Head:	
Fire/Police/Ambulance:	911
Envir. Health & Safety (or RSO, if needed):	646.3327

Emergency Planning

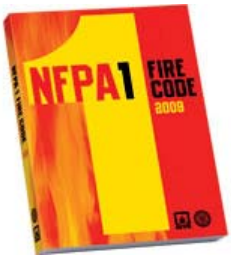
Plant Emergency Response Procedures

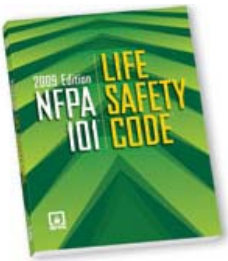
- Evacuate or shelter in place?
- Respond?
- Who will respond?
  - On-site HAZMAT team?
    - Require training
  - Community fire department?
    - Establish memorandum of understanding
- Medical support
  - In-house?
  - When to call for outside assistance
- Emergency shutdown procedures
- Decontamination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

Emergency Planning

General Fire Protection

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





Emergency Planning

Post exit signs

Keep exits unlocked or equipped with panic bars.

Emergency Planning

<u>Detection & Mitigation Equipment</u>

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

Emergency Planning

Response Equipment

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

Emergency Planning

American Industrial Hygiene Association Emergency Response Planning Guidelines

- *ERPG-1*

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

- *ERPG-2*

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

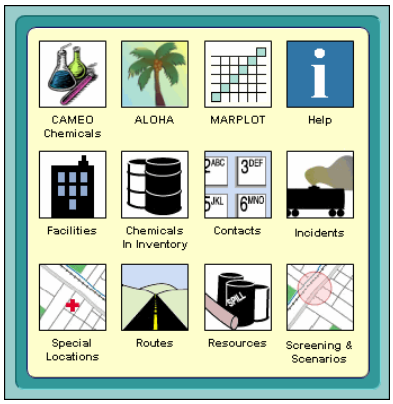
- *ERPG-3*

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

Emergency Planning

Software Applications

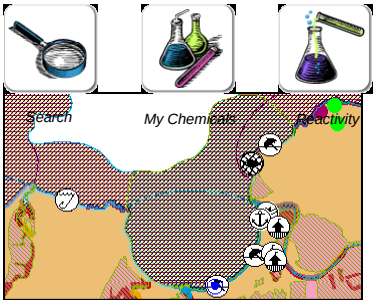
- Assist first responders with accessible and accurate response information
  - Interactive *Cameo* software modules
  - *Cameo Data Management*
    - Location of chemicals
    - Chemical quantities
    - Storage conditions



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

Emergency Planning

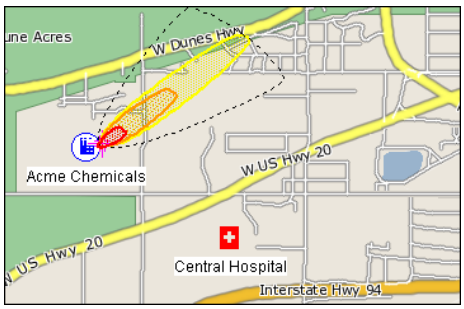
- Cameo Chemicals
  - Supplies information on the substance released and safe response actions
  - Outputs *chemical response datasheets*
  - http://cameochemicals.noaa.gov
- Mapping applications
  - *MARPLOT*
  - Can overlay a contaminated area over a map
  - Displays threat zones



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

Emergency Planning

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



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

Emergency Planning

Aloha Software:

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

Emergency Planning

Unity of Effort:

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

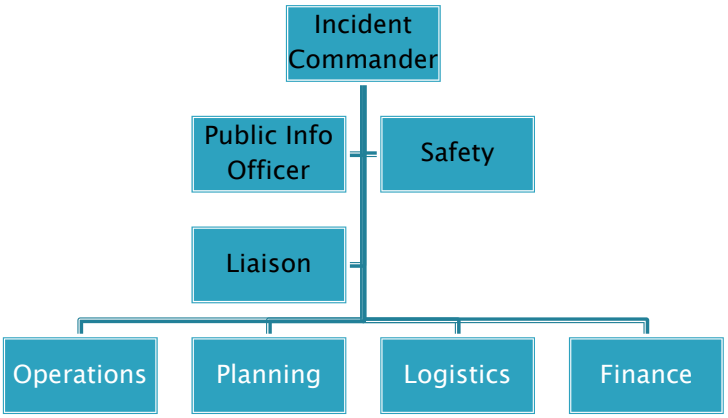
Emergency Planning

Incident Command System:

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

Photo credit: http://www.savelives.com

Incident Management System

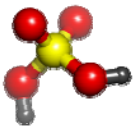


Emergency Planning

Community Involvement

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

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



Emergency Response

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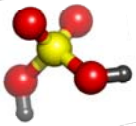


Response to Hazardous Materials Incidents

What makes hazardous materials incidents so dangerous?

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

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

Who Will Respond?

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

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

Emergency Response Decision Making

DECIDE Process

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

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

Emergency Response Decision Making

<u>Detect Hazmat Presence</u>

- Worker reports incident/spill/injury
- Odors, smoke, flames, reactions
- Response team detection
  - Instrumentation must be calibrated!
  - Direct reading instruments
    - LEL, oxygen monitors
    - Photoionization detectors
    - Gas detectors-methane, NH_3,, CO, Cl_2, H_2S
  - Personal sampling and analysis

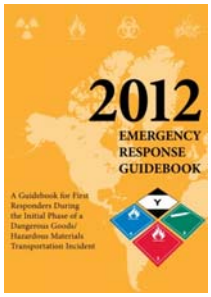
Industrial Scientific. http://www.indsci.com/products/#multi
RAE Instruments. http://www.raesystems.com/products
Sensidyne Air pumps. http://www.sensidyne.com

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Emergency Response Estimate Likely Harm

- Material properties
  - Safety data sheets
  - Emergency Response Guidebook
  - ERPGs
- Site conditions
  - Size of spill / release
  - Weather
  - Models
    - Cameo software



CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Emergency Response
Estimate Likely Harm

Evaluate chemical(s) released:

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

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

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Emergency Response
Decide on Objectives

Priorities

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

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Emergency Response

Initiate the Incident Command System:

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

Identify Action Options- Size of spill may determine response

Emergency Response Identify Action Options

Large Catastrophic Incidents

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

Defensive or Offensive Approach?

Identify Action Options
Defensive Options Large Event

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

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

Identify Action Options
Offensive Options Large Event

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

Offensive Options-Small Spills

- Spills of < 4 liters
- Must have appropriate PPE, spill equipment and training
- Do not clean up small spills of :
  - Acutely toxic (Low LD_{50}) chemicals
  - Carcinogens
  - Flammable liquids or metals
  - Chemicals of unknown toxicity or hazards

Offensive Options Small Spills

- Perform a risk assessment of potential spills
- Have a written procedure
  - Who responds to spill?
  - Identify all chemicals and their hazards
  - Identify and purchase appropriate PPE and emergency equipment
  - Describe procedures for:
    - Emergency shutoffs, circuit breakers, valves
    - Injuries and exposures
    - When and how to evacuate

Offensive Options Small Spills

Minimal equipment:

- Plastic pail/bucket(s) with lids (large enough to contain spill and cleanup material)
- Plastic dust pan
- Broom or brush
- Plastic bags
- Sealing tape
- pH paper
- Sign(s):

"Danger Chemical Spill"

"Keep Out"

Offensive Options Small Spills

Maintain complete Spill Kits

- Absorbent material
  - Absorbent pillows or powders
  - Activated carbon for organic solvents
- Neutralizing agents
  - Acid Neutralizers –e.g., sodium bicarbonate ($NaHCO_3$) powder
  - Base Neutralizers-e.g., citric acid powder
  - Solvent Spills-activated carbon

Emergency Response Restoring Processes

Backup power

Does power switch-over automatically?

How long will it run?

How much fuel do you have?

What areas will it support?

How often is it tested and maintained?

Post-Incident Follow-up

- Debriefing
- Post-incident investigation
  - Prepare a report of the incident
  - Revise response plans/lessons learned
  - Share lessons learned
  - Keep all records
  - Correct response deficiencies
  - Mitigate identified hazards

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

Apex Hazardous Waste Site Fire -
Video file = EmergencyinApe_pdl.wmv 17 min

Emergency Management Exercise

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Emergency Management Exercise

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

Photo of Chlorine Release

Summary of Incident

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

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

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

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

*continued on next slide

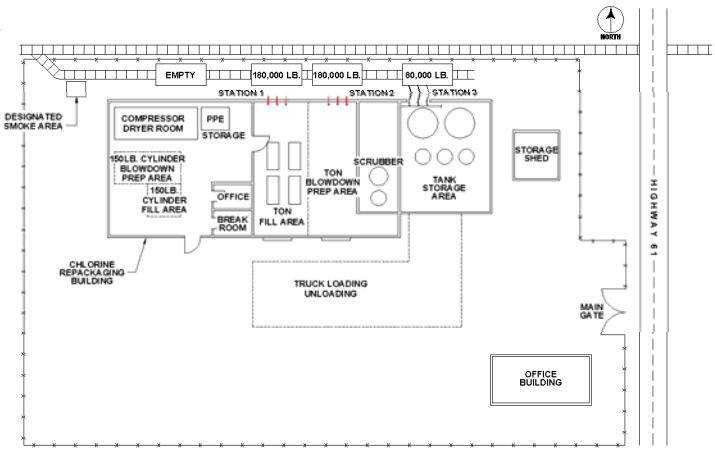
Summary of Incident, continued

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

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

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

Facility Map



Tanker Hose Rupture

Photo credit: US Chemical Safety Board

Emergency Management Exercise

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

Emergency Management Exercise

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

Emergency Management Exercise

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

Emergency Management Exercise

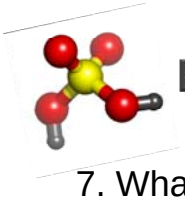
4. How could the Local HAZMAT team be better prepared?

Emergency Management Exercise

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

Emergency Management Exercise

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



Emergency Management Exercise

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

Security Considerations with Industrial Fire Protection

Eric D. Branson
Sandia National Laboratories

Bandung, Indonesia

SAND No. 2012-1755C

Primary Course Objectives

- Provide a broad overview of industrial fire protection
  - *Apply engineering principles to generic industrial fire protection issues*
  - *Discuss historical examples of industrial fire protection hazards*

  - *Develop security related scenarios which may be compromised by fire, explosion, or inadvertent chemical release*

Key Terms

- Siting – fix or build something in a particular place
- Egress – pathways for entering and exiting
- Suppression – extinguishing or containing of fire
- Extinguishability – ability to completely disrupt fire process
- Compartmentation – ability to isolate particular areas from other area

Course Structure

- Introduction
- Perspectives and statistical overview
- Facility/Plant siting and location
- Construction considerations
  - Fire resistant construction
  - Smoke control
  - Fire suppression systems
- Storage of flammable liquids
- Ignition Sources
- Security considerations and scenarios

http://www.draegerdive.com

Introduction to Industrial Fire Protection

For common workplace conditions, fire safety may be achieved by simple methods

- Enforcement of approved fire codes and standards
  - National Fire Protection Association (NFPA)
    - http://www.nfpa.org/index.asp
  - International Building Codes (IBC)
    - http://www.iccsafe.org/Pages/default.aspx
- Local or national fire officials and chiefs

National Fire Protection Association
The authority on fire, electrical, and building safety

INTERNATIONAL CODE COUNCIL
People Helping People Build a Safer World™

Introduction to Industrial Fire Protection

- Industrial facilities have unique hazards
  - Chemical production or use
  - Storage of flammable or volatile materials
  - Access controls or personnel restrictions
- Unique operations require additional considerations included with simpler methods

superstock.com

news.thomasnet.com

kellerfencenorth.com

www.archiexpo.com

Introduction to Industrial Fire Protection

- Additional considerations require the use of an engineering approach
- Steps for an engineering approach include
  - Identification of possible accident scenarios
  - Analysis of consequences resulting in accidents
  - Evaluation of alternative protection methods

Introduction to Industrial Fire Protection

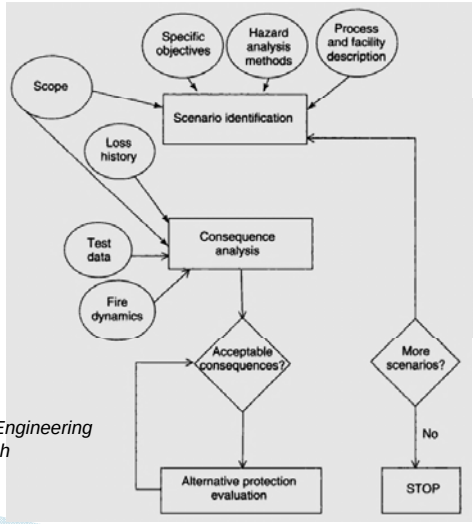
Scenario Identification

- Pre-incident situations (start-up, maintenance, shutdown)
- Ignition source
- Ignited material
- Flaming or smoldering combustion
- Fire spread and heat release rates of ignited material
- Fire spread to secondary combustibles

Introduction to Industrial Fire Protection

- *Consequence Analysis*
  - *Property damage or loss*
  - *Personnel injury or fatality*
  - *Interruption of operation continuity*
  - *Explosion damage (i.e., surrounding community)*
- *Evaluation of alternative protection methods*
  - *Effectiveness (e.g., prevention of life/property loss)*
  - *Benefits (e.g., financial, continuity of operation, environmental)*

Introduction to Industrial Fire Protection



Industrial Fire Protection Engineering
Robert G. Zalosh

Perspectives and Statistical Overview

- Types of facilities involved in large monetary loss fires
  - US industrial fires with >$30M US property damage
  - European large-loss fires
- Types of fires and explosions in large industrial losses
- Industrial fires with most fatalities

http://www.safety-s2s.eu

Perspectives and Statistical Overview

- Ignition sources in large loss fires
- Time of fire initiation
- Presence of automatic detection and suppressions systems
- Effectiveness of detection and suppression systems

Perspectives and Statistical Overview

Type of Facility	Number of >$30M Losses	% of U.S. Large Loss Fires
Warehouses	17	27%
Petroleum Refineries	12	19%
Power Plants	5	8%
Chemical Plants	5	8%
Grain Elevators	3	
Textile Plants	2	
Telephone Exchanges	2	
Ink Manufacturing	2	
Aluminum Plants	2	

Historic data on US fires prior to 2003

Perspectives and Statistical Overview

Type of Fire/Explosion	% of Incidents	Example
Flammable Liquid	17%	GM Livonia, Sandoz Basel
Plastic Storage	12.5%	Ford Cologne Warehouse
Dust Explosion	9%	Malden Mills
Vapor Cloud Explosion	8%	Phillips Petroleum
Gas Explosion	5%	Ford Rouge Powerhouse
Electrical Cable	5%	Ameritech Hinsdale
Aerosol Products	5%	K Mart
Gas Fires	5%	Gas Turbine Fire, VA

Historic data on US fires prior to 2003

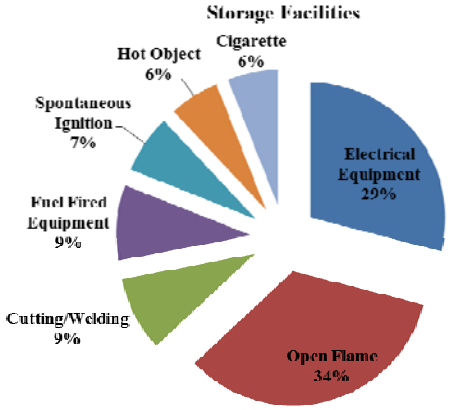
Perspectives and Statistical Overview

Type of Facility	# of Incidents	# of Fatalities	Example
Petrochemical Plant	10	726 – 967	Pemex, Mexico City
Factories	9	549 – 606	Garment Factory in Bangladesh
Offshore Oil/Gas Platforms	2	203	Piper Alpha, North Sea
Fireworks Facility	5	145	Jennings, Oklahoma USA

- *Multiple Fatality (>20)*
- *Industrial fires and explosions between 1981 - 2000*

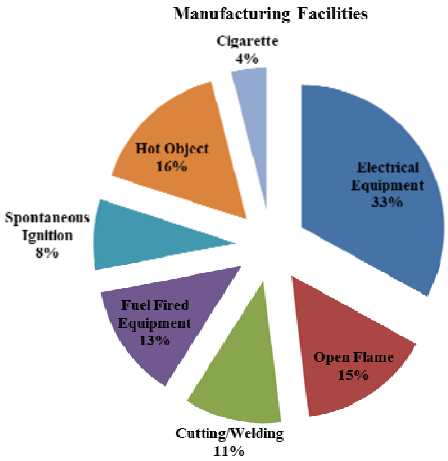
Perspectives and Statistical Overview

Ignition sources in large loss fires



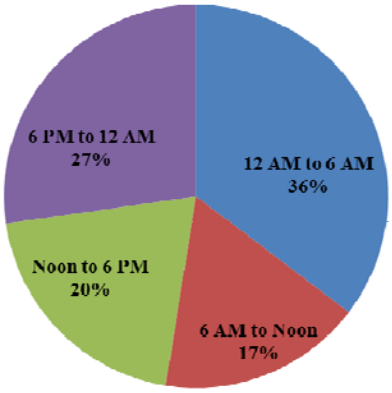
Perspectives and Statistical Overview

Ignition sources in large loss fires



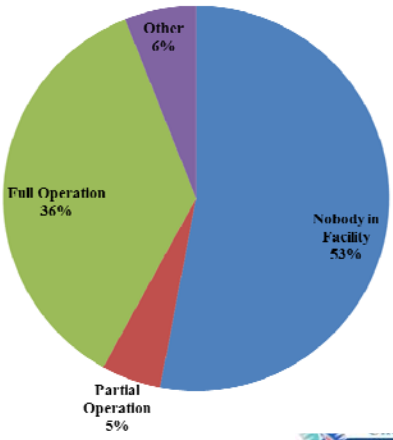
Perspectives and Statistical Overview

Time Distribution of large loss fires from NFPA data on 338 Fires in 1985



Perspectives and Statistical Overview

Operational status of facilities in large loss fires



Perspectives and Statistical Overview

Automatic Sprinkler System Status	Number of Fires
Not Installed	14
Overpowered by Fire	7
System Shut Off Before Fire	2
Not in Area of Fire Origin	3
Damaged by Explosion	1
Unknown	1
Total	**28**

Status of automatic suppression systems in 1987 large loss fires (NFPA Journal, 1988)

Perspectives and Statistical Overview

Automatic Detection System Status	Number of Fires
Not Installed	19
Functioned as Designed	4
Not in Area of Fire Origin	1
Installation Incomplete	1
Unknown	3
Total	**28**

Status of automatic detection systems in 1987 large loss fires (NFPA Journal, 1988)

Facility Siting and Location

- *Safe separation distances*
  - *Flame radiation*
  - *Toxic and/or flammable vapor clouds*
  - *Blast waves*
- *Water supply access and reliability*
  - *Susceptibility to drought*
  - *Robust supply of water*

Facility Siting and Location

- Safe egress, rescue, and manual fire fighting
  - Egress to adjacent protected building or designated area
  - Distance from fire department
  - Site accessibility
- Hazard segregation and isolation
  - Grouping similar hazardous chemicals
  - Isolating and protection special or targeted dual use chemicals
  - Isolation and elimination of ignition sources

Facility Siting and Location

Miscellaneous considerations

- Environmental (e.g., flooding, drought)
- Naturally occurring hazards (e.g., earthquake)
- Water run-off with the possibility of contamination
  - Waterways such as rivers, lakes, ponds
  - Underground aquifer
  - Food supplies

Facility Siting Incident

- Sandoz Basel Fire, 1986 in Switzerland
- Textile and agrochemical manufacturing facility
- Structural steel framed building that was 90m long, 50m wide with two 12m high peaks. 12cm brick wall in the middle to create two separate buildings

http://www.swissinfo.ch/eng

http://www.novaquatis.eawag.ch/media/2006/20061101/index_EN

Facility Siting Incident

- Original use was for machinery storage, converted over to flammable liquids storage
  - Explosion-proof electrical fixtures
  - Sealed sewer drains
  - Installed three water curtains to be operated by plant fire brigade
- No automatic sprinklers or smoke detectors
- Chemicals stored in plastic bags, plastic and steel drums
- Materials stacked to maximum height of 8m

Facility Siting Incident

- Storage at the time of incident
  - 859 metric tons of organophosphate insecticide
  - 12 metric tons of a phenyl-urea derivative used for weed control
  - 73 metric tons of di-nitrocresol derivative herbicide
  - 26 metric tons of fungicide
  - 11 metric tons of water soluble organic mercury compounds
  - 5.6 metric tons of misc. agrochemicals
  - 364 metric tons of various formulating agents
- Most have flash points of 30°C and higher

Facility Siting Incident

- Incident occurred on October 31, 1986
- Key points to the incident
  - Palletized chemicals were plastic shrink wrapped and then finished by using a blow torch
  - Plastic wrap could ignite if exposed for sufficient duration
  - Chemicals in the warehouse (e.g., Prussian Blue dye) could burn flamelessly, smokelessly, and slowly thus eluding early detection by workers
  - No automatic suppression or smoke detection

Facility Siting Incident

- Initial fire responders determined that fire spread was too rapid to control
  - Fire foam was used, but proved to be ineffective
  - Responders directed to cool surrounding buildings
  - Limited success as steel drums were propelled from the building of fire origin to adjacent structures
- Water was applied at 30 cubic meters per minute
- Containment basins filled quickly and toxic chemicals flowed into the Rhine River

http://www.rockwool.com

http://www.swissinfo.org/en/

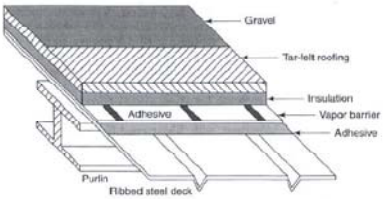
Facility Siting Incident

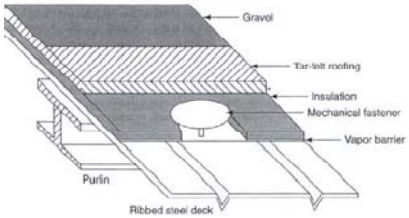
- Extensive environmental impacts
  - Most fish were killed by mercury poisoning in a 250km section of the Rhine downstream of Basel
  - Subsoil water levels had to be pumped away to preserve the municipal underground water supply
  - Wind carried the smoke produced by the fire over residential communities causing eye and respiratory issues
- *Extensive financial impacts*
  - *$60M US in settle charges*
  - *Figure does NOT include environmental clean-up and restoration efforts*

http://www.novaquatis.eawag.ch/media/2006/20061101/index_EN

Construction Considerations

- Fire resistant construction
  - Fire walls – hour rating
  - Fire doors – prevents smoke form passing under
  - Roofing – connecting areas, fastened to fire walls
- Smoke control
  - Isolation
  - Ventilation
- Fire suppression systems
  - Not only water but could include foams, dry chemical, carbon dioxide, halon, etc.

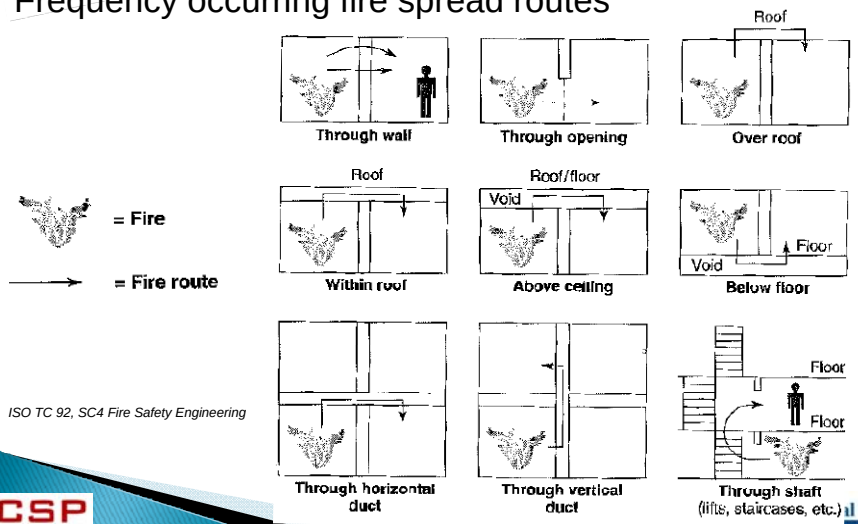




Industrial Fire Protection Engineering
Robert G. Zalosh

Construction Considerations

Frequency occurring fire spread routes



ISO TC 92, SC4 Fire Safety Engineering

Construction Considerations

- Structural and thermal properties of construction material
- Fire resistance analytical calculations
- Fire resistance testing for listing
- Fire wall design and loss experience
- Insulated metal deck roofing
- Water spray protection of structural steel
- Protective insulation materials on structural steel

Protective spray insulation material for structural steel
www.barrierst.com

Storage of Flammable Chemicals

- Chemical properties must be considered
  - Flash point
  - Auto-ignition temperatures
  - Extinguishability
- Storage tanks
  - Capacity
  - Tank spacing
  - Emergency ventilation
  - Fire suppression
  - General designs should be approved to meet specifications (such as FM Global – Factory Mutual)

FM APPROVED

Ignition Sources

- Sparks produced during welding or maintenance
  - General Motors Livonia Fire, 1953
  - 6 fatalities, $35M US property loss
- Discarded cigarette
  - Ford Cologne Fire, 1977
  - $100M US property loss
- Open flame
  - Sandoz Basel Fire, 1986
  - $60M US property loss,
  - Thousands experienced health issues
- Electrical arc in wiring
  - Hinsdale Telephone Office Fire, 1988
  - Between $40 – 60M US property loss

Security Considerations

- Access of fire fighting personnel into secured areas
- Cable fire affecting security system reliability
  - Effects pumps, lights, cameras, security gates, etc.
- Occupant load of security personnel in spaces with insufficient exits
- Fire as a means of distraction
  - Pulls resources away

Lessons Learned

- Need for fire walls and other passive barriers
- Need for roof deck fire spread tests
- Need to regularly test sprinkler water flow rates and to fixed known impairments
- Need for fire resistant electrical cables
- Need for containment of contaminated water run-off

Lessons Learned

- Need to upgrade warehouse sprinkler protection to accommodate storage of more combustible commodities
- Need for smoke control in facilities with equipment vulnerable to damage from smoke and corrosive combustion products
- Need for adequate emergency egress provisions for large number of workers
- Need for improved protection of flammable liquid warehouse

Areas Needing Improvement

- Need for automatic detection and suppression systems in areas containing large quantities of electrical equipment and cables
- Need for adequate emergency egress provisions for large numbers of workers
- Effective sprinkler protection for flammable liquids in plastic containers

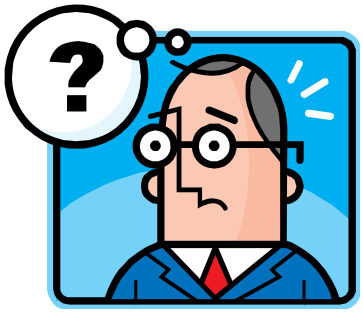
Areas Needing Improvement

- Need for compartmentation via reliable fire walls and doors in large manufacturing facilities
- Need to restrict storage of special hazard commodities in general purpose warehouses
- Problems caused by residue of flammable liquids on building walls, ceilings, and floors

Summary of Key Points

- Broad overview of industrial fire protection
- Engineering based methodology to identify potential fire hazards
- Context of historic fires
- Security considerations which may be compromised by fire or explosion

Questions?



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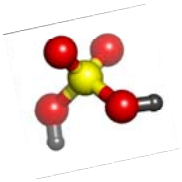
edbrans@sandia.gov *jbrown2@sandia.gov*

References and Additional Sources

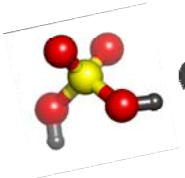
- *Industrial Fire Protection*, Robert Zalosh
- *SFPE Handbook of Fire Protection Engineering*
- *Fire Dynamics*, Dougal Drysdale
- *Principles of Smoke Management*, John Klote and James Milke
- *Ignition Handbook*, Vytenis Babrauskas



Chemical Toxicity, Health Hazards, Exposure Standards

2012-1601C
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

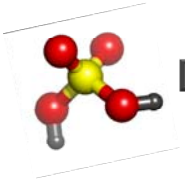


Overview

- Definitions
- Exposure
- Dose response
- Industrial exposures
- Health effects
- Exposure limits
- Evaluating exposure
- Control banding

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

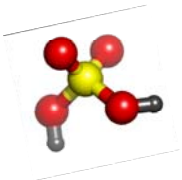
Chemical SAFETY AND SECURITY TRAINING



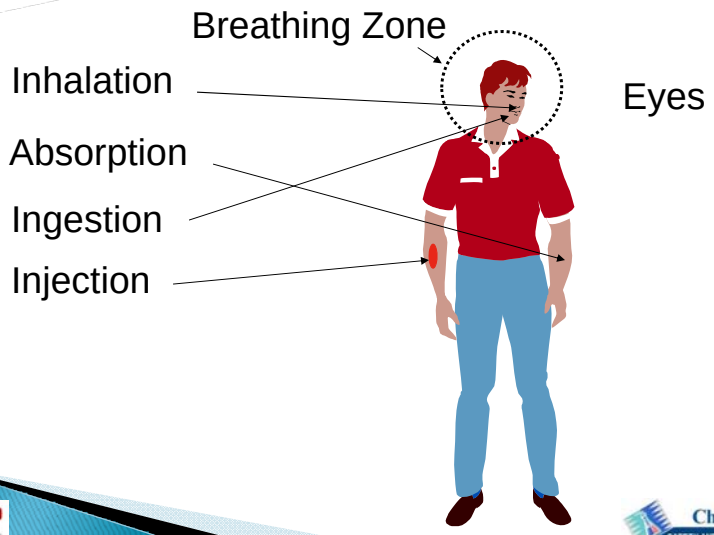
Definitions

- Toxicology: the study of the adverse effects of chemicals (xenobiotics) on living organisms.
- Toxicity: ability of a chemical to produce an unwanted effect.
- Hazard: presence of an agent that has inherently hazardous properties and the potential to cause harm.
- Exposure: Contact with the chemical substance.
- Dose: the amount of the chemical that has the potential to produce injury or death.

Klassen, C. (2001). Casarett and Doulls Toxicology
Plog, B. (2002). Fundamentals of Industrial Hygiene



Exposure



Exposure: Inhalation

- Most important route of exposure for workers
  - Gases, solvent vapors, acid mists, dusts, particles, and metal fumes
- Exposure is dependent on:
  - Duration and frequency of task
  - Breathing rate
  - Concentration of the chemical
  - Particle size
    - Inhalable size = 0.1 μm to 10 μm
  - Solubility of gases & vapors
    - Formaldehyde versus chloroform

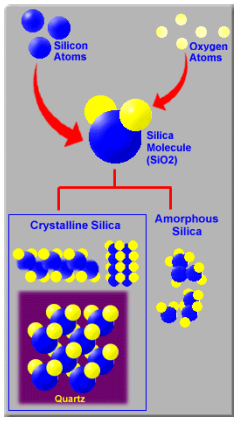
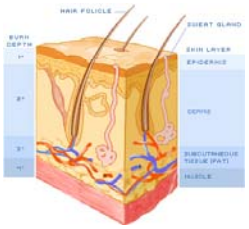


Photo Credit: US OSHA

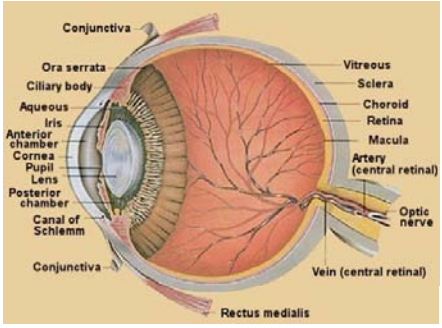
Exposure: Skin Absorption

- Depends on skin *location* and *thickness*
  - Palms of the hands are thickest
  - Skin on abdomen is thin
- Depends on skin *condition*
  - Dry and broken skin more susceptible
  - Sweat increases absorption
- Duration of contact
- Properties of the chemical
  - Concentration
  - Solubility (in fat or water)
  - Molecular size (nanoparticles)



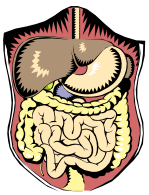
Exposure: Eyes

- Corneal irritation or trauma
  - Gases, particles
- Corneal burns
  - Acids, ammonia
  - Mustard agents
- Optic nerve damage
  - Thallium, methanol (ingested)



Exposure: Ingestion

- Rare exposure route, but possible
  - Swallow chemicals after inhaling
  - Eating, drinking, smoking in work areas
- Factors affecting absorption
  - Ionized versus nonionized form of compoun
  - Weak base absorbed in intestines
  - Weak acid absorbed in stomach



Pharmakokinetics

- Absorption
  - Chemical enters the body by exposure route
- Distribution or storage
  - Distributed to organs, or
  - Stored in bone, proteins, fat
- Metabolism
  - Liver, kidney enzymes
  - May metabolize to a more toxic chemical
- Excretion
  - Sweat, urine, feces

Dose Response

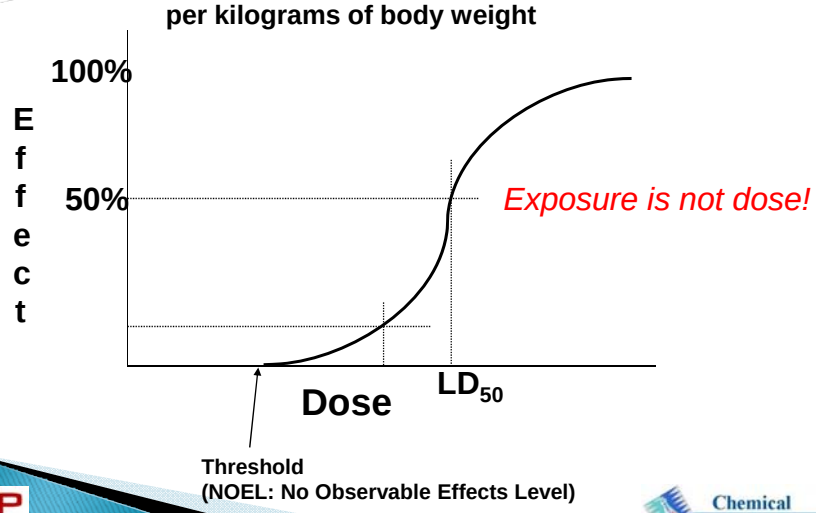
"All substances are poisons;
There is none which is not a poison.
The right dose differentiates a
poison from a remedy…"
-Paracelsus (1493-1541)

Dose Response Terminology

- TD_{lo} – Toxic dose low – lowest dose for effect
- LD_{50} – Lethal dose 50% – dose that causes death in 50% of the test population
- TC_{lo} – Toxic concentration low – used to express toxic concentration *via* inhalation
- LC_{50} – Lethal concentration 50% – concentration that causes death in 50% of the test population *via* inhalation

Dose Response

Dose is measured in milligrams of toxicant per kilograms of body weight



Exposure is not dose!

Health Effects

- Acute Health Effects–severe injury or death
  - High concentration of chemical over short time period
  - Chemicals with acute effects:
    - Toxic gases: hydrogen sulfide, phosgene
    - Asphyxiants gases: nitrogen, methane
    - Corrosive gases and liquids: chlorine, acids
- Chronic Health Effects–chronic disease
  - Low concentration over long time period
  - Chemicals with chronic effects:
    - Carcinogens: benzene, asbestos, arsenic
    - Reproductive agents: glycol ether acetates, lead, carbon disulfide
    - Sensitizers–glutaraldehyde, toluene diisocyanate

Health Effects

- Local
  - Effect occurs at site of contact
  - Skin rash, burns, coughing
  - Chemicals with local effects:
    - Cutting oils, solvents, acids
    - Cotton dust, aluminum oxide
- Systemic
  - Chemical distributed by circulation
  - Effect occurs in body organs
  - Chemicals with systemic effects:
    - Methylene chloride to heart muscle
    - Lead to bone and brain

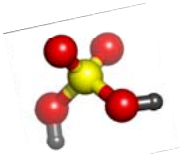
Health Effects

Chemicals affect people differently:

- Age
- Gender
- Genetic makeup
- Disease or stress
- Nutrition
- Lifestyle
- Interactions between chemical toxicants

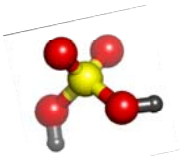
Health Effects
Chemical Interactions

- Additive Effect
  - Combined effect of 2 chemicals equals sum of each agent alone…(2 + 3 = 5)
  - Example: Parathion, methyl-parathion pesticides
- Synergistic Effect
  - Combined effect of 2 chemicals is greater than sum of each agent alone…(2 + 3 = 20)
  - Example: Carbon tetrachloride & ethanol



Health Effects
Chemical Interactions

- Potentiation
  - One substance does not have toxic effect on certain organ or system, but when added to another chemical, it makes the latter more toxic…(0 + 2 = 10)
  - Example: Isopropanol & carbon tetrachloride
- Antagonism
  - 2 chemicals, when given together, interfere with each other's actions or one interferes with the action of the other chemical…(4 + 6 = 8)
  - Example: BAL (chelating agent) and lead



Industrial Exposures

Industrial Exposures: Metals

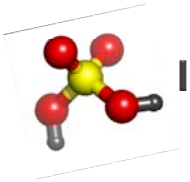
Exposure primarily by inhalation:

- Particulates
  - Processes: grinding, cutting, sanding, mixing
  - Examples: copper, nickel, zinc
- Fumes
  - Processes: welding, smelting
  - Examples: lead, manganese, hexavalent chromium, zinc
- Mists (soluble metal compounds)
  - Processes: spraying anticorrosives, metal plating
  - Examples: hexavalent chromium, nickel chloride

http://www.millerwelds.com/

Health Effects: Metals

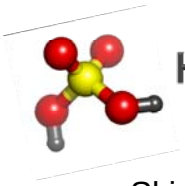
- Sensitizers (skin and lungs)
  - Nickel, beryllium, chromium
- Metal fume fever
  - Oxides of zinc, magnesium, and copper
- Organ toxicity
  - Arsenic—neurotoxicity, liver injury
  - Cadmium—kidney, lung fibrosis
  - Lead-nervous system, blood, kidney, reproductive
- Carcinogens
  - Arsenic, soluble nickel, hexavalent chromium



Industrial Exposures: Solvents

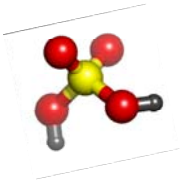
Exposure by inhalation and skin absorption:

- Process: transfer, mixing, spraying, high vapor pressure solvents
  - Examples: ethers, ketones, chloroform, benzene
- Process: Heating solvents
  - Examples: styrene, dimethyl formamide
- Process: skin immersion in process baths, parts cleaning
  - Examples: acetone, trichloroethylene, dimethyl sulfoxide (DMSO)



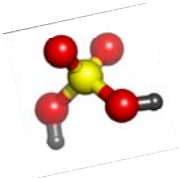
Health Effects: Solvents

- Skin irritants, dermatitis
  - Acetone, alcohols
- Organ toxicity
  - N-hexane—neurotoxicity
  - Chloroform, vinyl chloride—liver toxicity
  - Methylene chloride—heart toxicity
- Carcinogens
  - Benzene, formaldehyde
- Reproductive toxicants
  - Glycol ether acetates



Occupational Exposure Limits:

Evaluating Exposure



Occupational Exposure Limits (OELs)

- Government regulation or professional standard organizations set OELs
- OELS apply to workers only, NOT the general public
- Primarily limits for inhalation exposure
- Expressed in milligrams/cubic meter (mg/m^3) or parts per million (ppm)
- Exposure must be measurable for comparison with the OEL
- Some publish exposure standards for noise, lasers, non-ionizing radiation, heat & cold stress, as well as chemicals

International Occupational Exposure Limits

- Indicative OEL Values (IOELVs)
  - Specified by the Council of the European Union
  - Based on advice from Scientific Committee on Occupational Exposure Limits (SCOEL)
  - 2009 -Third list of IOELVs published
  - Member states have until 12/2011 to implement legislation
- European Union Reach
  - Worker derived no-effect levels (DNELs)
  - Must be calculated for quantities >10 tons/year
  - Safety margins higher than the IOELVs
- German Exposure Limits
  - DFG MAK – Maximum Workplace Concentrations

U.S. Exposure Limits

- PEL – Permissible Exposure Limits
  - Occupational Safety and Health Administration (OSHA)
  - USA legal limits
- REL – Recommended Exposure Limits
  - National Institute of Occupational Safety & Health (NIOSH)
  - Recommended, not legal limits
- ACGIH TLV® – Threshold Limit Values®
  - American Conference of Governmental Industrial Hygienists
  - Recommended, not legal limits
- AIHA WEEL – Workplace Environmental Exposure Limits American Industrial Hygiene Association (AIHA)
  - Recommended, not legal limits

Exposure Limits

Permissible Exposure Limit (PEL)

- Exposure limits are published by the U.S Occupational Safety and Health Administration (OSHA)
- Intended to control health effects from exposures to "air contaminants"
- Applies only to workplaces covered by OSHA
- Action Levels published for highly toxic chemicals
  - ½ the PEL
  - Benzene, asbestos, vinyl chloride, formaldehyde

Exposure Limits

ACGIH TLVs®:

- ACGIH is a private, non-governmental corporation
- ACGIH TLVs are published as guidelines
- Not legal standards
- ACGIH TLVs are usually lower than PELs
- Reviewed and revised annually

Exposure Limits

ACGIH TLVS®:

- 8 Hour time-weighted average (TWA)
- 15 minute short-term exposure limit (STEL)
- Ceiling value (C)

- TLV Examples:
  - Carbon dioxide = 5000 ppm TWA
  - Osmium tetroxide = 0.0002 ppm TWA
  - Hydrogen chloride = 2 ppm ceiling
  - Ammonia = 35 ppm STEL

Time Weighted Average (TWA)

Average exposure for an individual over a working period of time, determined by taking one or more samples during the working period:

$$\text{TLV} - \text{TWA}^* = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{T_1 + T_2 + \ldots + T_N}$$

Where:
C = airborne concentration
T = time

*** A TLV expressed as a TWA**

8-Hr Time Weighted Average

Average exposure for an individual over an 8-hr working period of time, determined by taking one or more samples during the 8-hr working period:

$$\text{TLV} - \text{TWA}_8 = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{8 \text{ hrs}}$$

Example:

A degreaser operator is monitored for exposure to Stoddard solvent. The monitoring data is:

TIME PERIOD (NUMBER)	*CONCENTRATION (PPM)*	*TIME (HOUR)*
1	80	2
2	110	4
3	55	2

Solution

$$TLV - TWA_8 = \frac{C_1T_1 + C_2T_2 + \ldots + C_NT_N}{8 \text{ hrs}}$$

$$TLV - TWA_8 = \frac{(80 \times 2) + (110 \times 4) + (55 \times 2)}{8 \text{ hrs}}$$

EIGHT HOUR TLV-TWA = 89 ppm

Over exposed?

(TLV-TWA = 100 ppm)

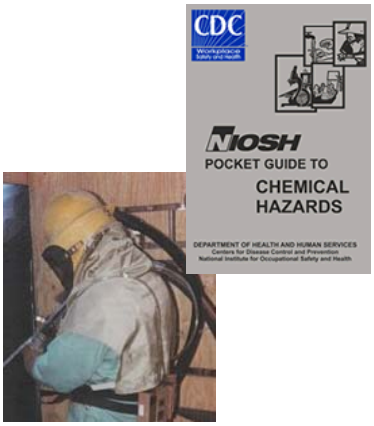
Other ACGIH TLV Notations …

- "Skin" potential exposure by the dermal route, including mucous membranes and the eyes
  - Examples: some solvents, phenol, pesticides
- "SEN" potential to produce sensitization
  - Example: toluene diisocyanate

Evaluating Exposure

- Qualitative assessment
  - Observe task
    - Airborne contaminants ?
    - Skin immersion ?
  - Evaluate toxicity
    - Safety data sheets
    - NIOSH Pocket Guide

    http://www.cdc.gov/niosh/npg/
- Quantitative
  - Model exposure
  - Perform air sampling



Evaluating Exposure

- Quantitative
  - Model the contaminant concentration in the room
  - Example: What concentration, in mg/m^3 would be produced by the release of 1 gram (g) of benzene in a 125 cubic meter room (m^3)?

Mass of contaminant/volume of room

1 g/125 m^3 = 1000 milligrams/125 m^3 = 8 mg/m^3

Calculation for PPM Concentration

$$\frac{(8\ mg/m^3)\quad(24.45)}{(78.11\ MW)} = 2.5\ ppm$$

ACGIH STEL for benzene is 2.5 ppm
(15 minute short term exposure)

Evaluating Exposure

Air monitoring:

- Results must be analyzed
- Results are compared against a standard OEL
- Methods:
  - Air sampling pump and media or badges
    - Filters-for metals, particulates
    - Charcoal tubes-for solvents
    - Silica gel tubes-for acids

Evaluating Exposure

Other air monitoring methods:

- Direct reading instruments
  - Photoionization detectors-solvents
  - Particle counters-dusts
  - Portable gas detection
    - Operate with hand pump
    - Color coded detector tubes
    - Detect 500 gases and vapors

Evaluating Exposure: Control Banding

- Initiatives:
  - World Health Organization (WHO)
  - International Labor Organization (ILO)

- Over 17 million organic and inorganic substances
- 170,000 chemicals may require registration under EU REACH regulations
- Shift in traditional industrial hygiene approach towards exposure

Evaluating Exposure: Control Banding

- Qualities of Control Banding
- A complementary approach to traditional industrial hygiene
- Focuses resources on exposure controls rather than exposure assessment
- Provides technical expertise to chemical users through simplified guidance

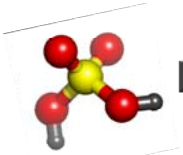
Evaluating Exposure: Control Banding

- Web Page: National Institute of Occupational Safety and Health (NIOSH)
  - www.cdc.gov/niosh/topics/ctrlbanding/
- Publications:
- AIHA (2007)
  - *Guidance for Conducting Control Banding Analysis*
- ACGIH (2008)
  - *Control Banding: Issues and Opportunities*
- NIOSH (2009)
  - *Qualitative Risk Characterization and Management of Occupational Hazards*

http://www.cdc.gov/niosh/docs/2009-152/

Management of Change

Bandung, Indonesia
March 2012



Key acronyms

MOC = *management of change*

RIK = *replacement in kind*

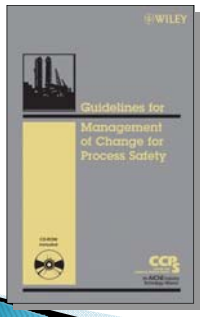
PSSR = *pre-startup safety review*

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

MOC / PSSR resources

CCPS 2008c. Center for Chemical Process Safety, ***Guidelines for Management of Change for Process Safety***, New York: AIChE.



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)*

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

MOC / PSSR resources

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

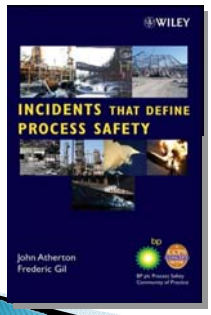
(on course CD-ROM)

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

MOC/PSSR resources

CCPS 2008b. Center for Chemical Process Safety, ***Incidents that Define Process Safety***, New York: AIChE.



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 2007b. Center for Chemical Process Safety, ***Guidelines for Performing Effective Pre-Startup Safety Reviews***, New York: AIChE.

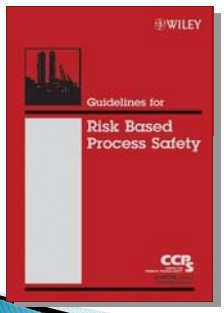
Chapter

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

MOC/PSSR resources

CCPS 2007a. Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*, New York: AIChE.



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

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

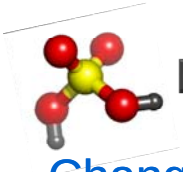
1. Why manage change?

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”

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Chemical SAFETY AND SECURITY TRAINING

Flixborough, England 1974

CCPS Center for Chemical Process Safety

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

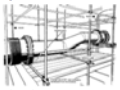
Sponsored by the 5th Global Congress on Process Safety

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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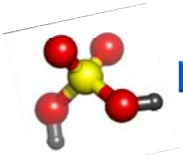


DISCUSSION

Changes

either

(1) shift the bounds of "Normal Operation"

or

(2) put the facility into an "Abnormal Situation"

Which of these occurred at Flixborough?

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

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 work shifts.

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

Management of Change

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

What is a "change"?

There are many types of changes, such as:

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

All must be managed !

DISCUSSION

Give one example of each type of change.

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

DISCUSSION

Give one example of each type of change.

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

Caution

* 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 each change

2 **Risk-assess** the proposed change

- Use a multi-disciplined team of competent people
- Include 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)

Written MOC procedure

Aids to develop/implement 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

Typical MOC procedure outline

Title, Date, Revision No.

1. Purpose
2. Definitions (*change, RIK, emergency change,* etc.)
3. Responsibilities and Accountabilities
4. Initiating a Proposed Change
   - Who can initiate a change
   - Type of change (Chemical, Process, SOP, Equipment, Facilities…)
   - Technical basis for the change
   - Necessary time period for the change

(continued)

5. Evaluating a Proposed Change
   - How the safety/security impact is evaluated and by whom
   - How the safety and health evaluation is to be documented
   - What actions are necessary to safely make the change
6. Authorizing a Proposed Change
   - Who must approve the different types of changes
   - Authorization of emergency changes
   - Authorization requirements for extending a temporary change

(continued)

7. Implementing an Approved Change
   - Making the physical changes
   - Modifying operating procedures
   - Reversing a temporary change; documenting the reversal
   - Training and informing affected employees and contractors
8. Updating the Process Safety Information
9. Performing the Pre-Startup Safety Review
10. Recordkeeping Requirements

CCPS 20 YEARS
An AIChE Industry Technology Alliance

Process Safety Beacon

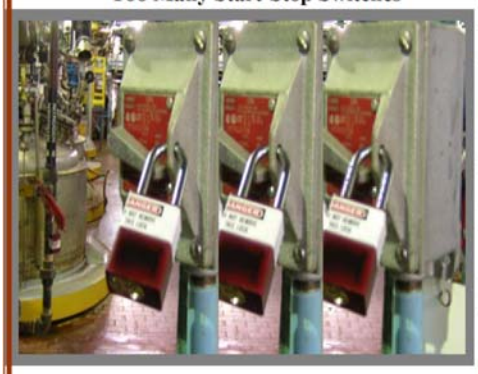
http: //www.aiche.org/ccps/safetybeacon.htm

Messages for Manufacturing Personnel

Sponsored by CCPS Supporters

June 2005

Too Many Start-Stop Switches



PSID Members see: Free Search--Agitator

Here's What Happened

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

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

http://www.psidnet.com

How Did This Happen ?

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

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

What You Can Do

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

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

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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, emergency changes?**

What is a "temporary change"?

Definition:

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

- CCPS 2008c Glossary

DISCUSSION

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

Temporary changes

"Temporary" changes have led to many severe process safety incidents.

- Flixborough (1974) is an example of a temporary equipment modification

  - ***See CSB 2001*** *(on CD-ROM)* ***for two incidents involving deviations from normal operating procedures due to abnormal situations***

Safety Bulletin

U.S. Chemical Safety and Hazard Investigation Board

MANAGEMENT OF CHANGE

Introduction

Case No. 1

Background

Process Description

Incident Description

Temporary changes

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

IN ADDITION:

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

What is an "emergency change"?

Definition:

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

- CCPS 2008c Glossary

DISCUSSION

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

Emergency changes

Typical considerations for emergency changes:

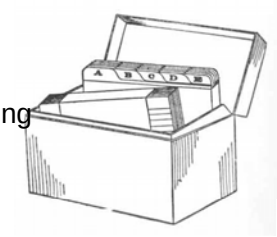
- Have a procedure in place ahead of time to deal with emergency changes, including authorization requirements
- Obtain and document at least verbal approval from line management (often the plant manager or designee)
- Communicate the change to all affected persons
- Follow up through the normal MOC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

Management of Change

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

Information updates

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



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

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Information updates

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

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

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

Information updates

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

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

Information updates

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

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

Information updates

The MOC procedure needs to assure that 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 starting up 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?

- 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; Response Plan
- Safe work practice procedures
- Control limits or practices

DISCUSSION

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

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

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

MOC "To Do" List

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

MOC "To Do" List

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

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MOC "To Do" List

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

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

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- ☐ Have all changes approved before making them.
- ☐ Properly reverse all temporary changes.
- ☐ Update all process safety information.
- ☐ **Communicate changes to all affected persons.**
  - Including reversal of temporary changes
  - Re-training may be required for some changes

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- ☐ Update all process safety information.
- ☐ Communicate changes to all affected persons.
- ☐ **Field-inspect changes before start-up.**

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- ☐ Update all process safety information.
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- ☐ Field-inspect all changes before start-up.

Final suggestions

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

Final suggestions

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

Final suggestions

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

CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM
Chemical SAFETY AND SECURITY TRAINING

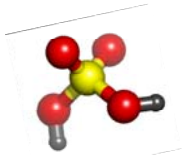
Final suggestions

- Assign an MOC Coordinator
- Keep an MOC Log
- Complete **PSSR follow-up items before start-up**
  - 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 start-up
- Don't short-cut the **safety & health review**!
  - (i.e., the risk assessment)
  - Team-based reviews work best

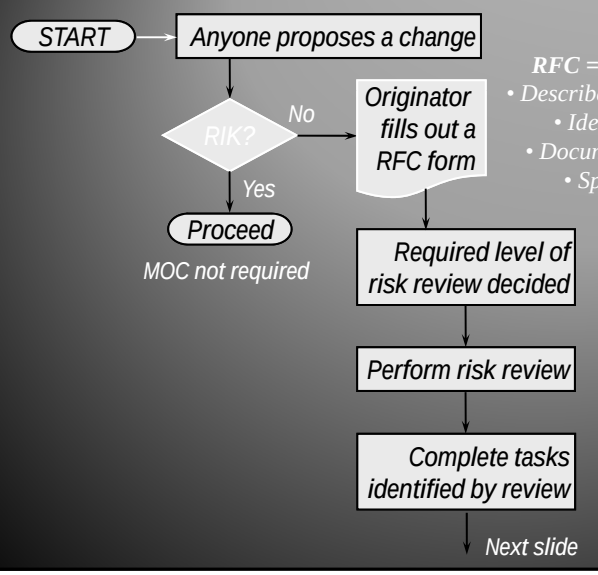


DISCUSSION

Identify a recent or proposed change at your facility or within your organization, and answer the following questions for that change:

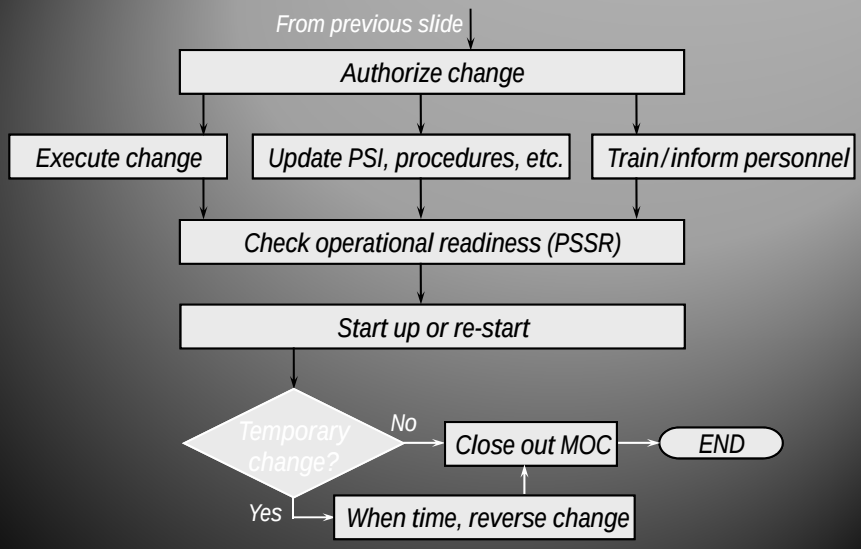
1. What is the technical basis for the change?
2. How might the change impact safety?
3. How might the change impact security?
4. Is it a temporary or permanent change
5. Who should review & authorize the change?
6. Who needs to know about the change?

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)