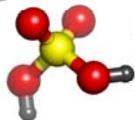


# Chemical Safety and Security Workshop for Chemical Engineering Faculty

Bandung, Indonesia  
March 12-16, 2012



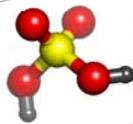
SAND No. 2011-9012P  
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



## Workshop Overview & Introductions

- CSP Sponsorship
- Purpose of Workshop
- Overview of Workshop
- Introductions

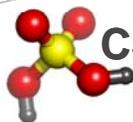




## Chemical Security Engagement Program (CSP)

### U.S. Department of State: CSP Program Objectives

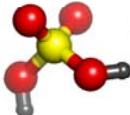
- ▶ Raise awareness about the dual-use nature of chemicals
- ▶ Foster collaboration among chemical professionals worldwide
- ▶ Provide training opportunities and technical assistance and improve chemical risk management in academic laboratories
- ▶ Provide facilities site assessment and training to improve chemical risk management in the chemical industry



## CSP Activities

- Work with host countries to assess their current needs and priorities in chemical risk management
- Partner with :
  - National and regional chemical organizations (HKI, IKM)
  - Universities
  - International chemical organizations (OPCW, IUPAC, UNFAO)
  - Chemical industry associations (CICM, KN-RCI)
- CSP engages ministries/regulatory agencies in countries with:
  - Regional security concerns
  - Active producers/exporters of industrial chemicals





# CSP Website – log in



Home



Home Workshops Share Your Training Discussion Board Resources Contacts

Please log in

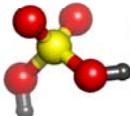
Login Name

Password

Log in

**Forgot your password?**  
If you have forgotten your password, [click here to retrieve it.](#)

©1997-2011 Sandia Corporation | [Questions and Comments](#) | [Privacy and Security](#)

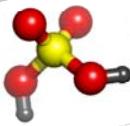


# CSP Website

<https://chemsecurity.sandia.gov/>

- Offers networking opportunities
- Provides resources
- Discussion boards
  - Share best practices
  - Ask questions/get answers
- Upload/view photos from workshops
- View/download training materials
- See upcoming and past events





# CSP Website – Workshops



Home > Workshops > 2011 Workshops > Indonesia & Malaysia- June 2011



**CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

Home Workshops **Share Your Training** Discussion Board Resources Photos Con

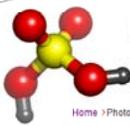
**Workshops** Please tell us about a safety and security training you taught.

Click on the workshop name to view presentation materials used for that event. To view or upload photos of an event you attended, click on the Photo Gallery link and login with your username and password. To request a username and password, please email us at [chamsecurity@sandia.gov](mailto:chamsecurity@sandia.gov).

Please scroll down to the bottom to view document links.

- Presentations
- Materials
- PowerPoint Presentation Files
- Trainer Bios
- Participant List
- Participant List
- Test





# CSP Website – Photos



Home > Photo Gallery Connie Stewart Log out



**CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

Home Workshops Share Your Training Discussion Board Resources **Photos** Contacts

[Add, edit or remove a portlet above the content](#)

View Edit Criteria Subfolders Sharing

## Photo Gallery



Makong Delta Photos (18)



Indonesia/Malaysia Trainings (5)



Malaysia Workshop (12)



Photo Gallery (3)



Photo Gallery (3)



Photo Gallery (1)

Search Site  Search

**Workshops**

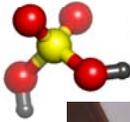
- Photo Gallery

**Workshops by year**

- 2011
- 2010
- 2009
- 2008

**Where We've Been**



# CSP Website – Past event photos



## CSP Website - Share Your Training

Home | Share Your Training | CSP Chemical Security Engagement Program | Home | Workshop | [Share Your Training](#) | Information Board | Register | Profile | Contact

[Add, edit or remove a post on the content](#)

### Add Training Course

**Title - (Required)**  
Title is required, please correct.

Trainer's First Name:

Trainer's Last Name:

Email Address:

Phone:

Training Location/Venue:

Training Date:

Participant's Institution:

Number of Participants:

Type:  
 Academic  
 Industry  
 Other

If Other, please identify:

Upload Agenda (Word or PDF file):

Will you allow your information to be shared?  
 Yes  
 No

Additional Comments:



Search Site

### Map of Participant Countries



[Click on image for large, interactive map.](#)

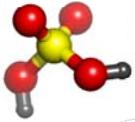
### Current Events

- October 2011 | Ukraine - Industry Chemical Safety and Security Training
- October 2011 | Jordan - Industry Chemical Safety and Security Training
- October 2011 | Egypt - Chemical Safety and Security Training
- October 2011 | Jordan - Chemical Safety and Security Officer Training
- October 2011 | Ukraine - Industry Chemical Safety and Security Training
- December 2011 | Congo - Chemical Safety and Security Officer Training

### Partners

- Chemical Industry and Industrial Organizations
- American Chemistry Council
- Chemical Industry Safety Council of Ukraine (CISCU)
- Chemical Industry Association of the Philippines
- Chemical Professionals and Professionals Organization
- International Union of Pure and Applied Chemistry (IUPAC)
- Department of State Chemical Institute





**CSP Website – Discussion Board**

Home > Discussion Board > [-]

**CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

Home Workshops Share Your Training **Discussion Board** Resources Photos

**Discussion Board**

[Add, edit or remove a portlet above the content](#)

**Add File**

**Title**

**Description**  
A short summary of the content.

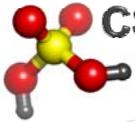
**File** \*

[Add, edit or remove a portlet below the content](#)

[Add, edit or remove a portlet in the footer](#)

**CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

**Chemical**  
SAFETY AND SECURITY TRAINING



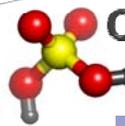
**CSP Website**

**Example: Discussion Board**

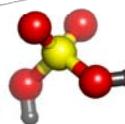
- ▶ I have post video showing the hood in our laboratory which was not working . After the training, I decided to check for all our hoods. We have about 10 hoods but only three of them are working and the other do not. so I have dismantled one. I was surprised that the motor is located at the top of the hood not abroad which Mr Douglas told us. I have discovered that the most of the breakdown in Hoods is at the motor which my be stop Due to deposition of layers of rust on. I myself have replaced the old motor with new one so It becomes working again and I have also found that it easy to designed hood for your lab. if you do not have more money to buy one.

**CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

**Chemical**  
SAFETY AND SECURITY TRAINING

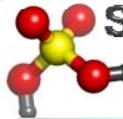


## CSP Discussion Board Photo of Fume Hood Motor

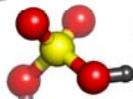


## Sandia National Laboratories Sandia supports the CSP Program



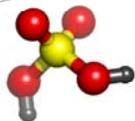


# Sandia National Laboratories Albuquerque, New Mexico, USA



## Past CSP Workshops





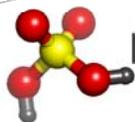
## CSP Program Growth

### University Labs:

- Chemical management
- Incompatible chemical storage
- Security issues with dual-use chemicals
- Orphan chemicals, waste issues

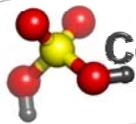
### In Industry:

- Concerns with dual-use chemical theft
- Chemical management
- Security concerns affecting business capability
- Lack of adequate response capabilities



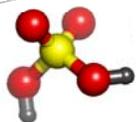
## Purpose of this Workshop

- **Provide practical chemical risk management tools for use by chemical engineering faculty and students**
- **Provide information on identifying, evaluating, and controlling chemical hazards and threats**
- **Promote a culture of excellence in chemical risk assessment, mitigation, and management**
- **Determine needs for future training and support**



## Course Outline

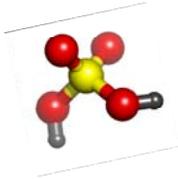
- ▶ **Day 1: Introduction to Chemical Management**
- ▶ **Day 2: Process Safety Management/Site Visit**
- ▶ **Day 3: Hazard Mitigation and Control**
- ▶ **Day 4: Principles of Chemical Security**
- ▶ **Day 5: Emergency Management, Toxicology, Fire Protection, Management of Change**



## Workshop Speakers Introductions

- ▶ Ms. Linda Stiles
- ▶ Mr. Robert W. Johnson
  - ▶ Mr. Eric Branson
  - ▶ Mr. Steven Iveson



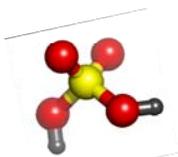


# Chemical Safety and Security Overview



SAND No. 2012-1606C

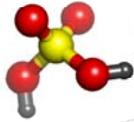
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



## Why practice chemical safety?

- ▶ Health and safety of the workers
- ▶ Prevent accidental releases
  - Potential regulatory fines, lawsuits
- ▶ Relationship with the local community
- ▶ Ensure a sustainable environment





## Industrial Safety Incidents

### Catastrophic process incidents:

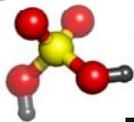
- ▶ 1976 Seveso Italy
- ▶ 1984 Bhopal India
- ▶ 2005 Texas City Texas

### More recently:

- ▶ 2009-Fertilizer tank collapses
  - 2 critically injured
  - Responders exposed to ammonia
  - 760cm<sup>3</sup> released
  - River contaminated
- ▶ 2007-Fire and Explosion
  - Filling ethyl acetate storage tank
  - Equipment not bonded and grounded



Photo credit. U.S. Chemical Safety Board. <http://www.csb.gov/>

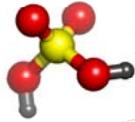


## U. S Chemical Safety Board Video



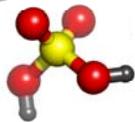
CSB Video – Reactive Hazards 20 minutes  
Reactives\_clipped.mpg





## Center for Chemical Process Safety

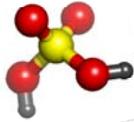
- ▶ Anyone can subscribe
- ▶ Delivers monthly process safety messages to plant operators and other manufacturing personnel.
- ▶ Presents a real-life accidents, lessons learned, and practical means to prevent accidents at your plant.
- ▶ Published in 29 languages,
  - <http://www.aiche.org/CCPS/Publications/Beacon/index.aspx>



## Regulations and Standards

- ▶ Individual country regulations
  - EU REACH
  - U.S. OSHA Process Safety Standard
- ▶ International chemical & labor organizations
  - ICCA Responsible Care
  - International Labor Organization
- ▶ International standards
  - ISO 14001:2004
  - OHSAS 18001
  - United Nations-GHS
  - SAICM



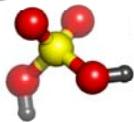


## What about chemical security?

- ▶ Chemical theft
  - Precursors for drugs
  - Precursors for chemical weapons
  - Dual-use chemicals
    - Industrial chemicals
      - Flammable/toxic gases
      - Ammonium nitrate
      - Chlorine
      - Pesticides
- ▶ Plant sabotage
  - Deaths, injuries
  - Economic and environmental impact



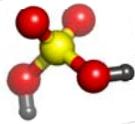
Abandoned Bhopal Plant  
Photo credit: AP/Saurabh Das



## What are the threats to chemical security?

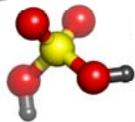
- ▶ Unlimited access to facilities
  - Chemical storage areas
  - Analytical laboratories
  - Waste storage
  - Construction sites
- ▶ No controls or security checks on chemical procurement
- ▶ Shipping and receiving areas not protected
- ▶ Recruit young chemists
  - Tokyo subway Sarin attack





## Threats to Cyber Security

- SCADA control software is used by one-third of industrial plants
- Security technology may not work on plant proprietary networks
- Attacks may result in:
  - Loss of process control
  - Loss of production
  - Process safety incidents
- Examples:
  - 2005-Zolob worm shuts down 13 Daimler Chrysler plants

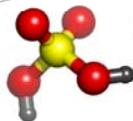


## International Resolutions & Organizations Related to Chemical Security

- UN Security Council Resolution 1540
- Australia Group
- Organization for the Prohibition of Chemical Weapons
- American Chemistry Council

*Responsible Care Security Code*

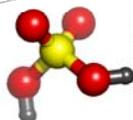




## How are chemical safety and chemical security related?

Both Ensure Protection of:

- ▶ Workers
- ▶ Plant facilities
- ▶ Plant processes
- ▶ Community
- ▶ Environment
- ▶ Economy



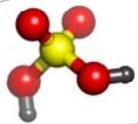
## Reflect and Consider

**What chemical safety and security practices are required at your university?**

**...Are they effective?**

**...Could they be improved?**

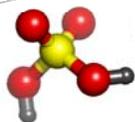
**...How?**



# Chemical Safety Principles & Management



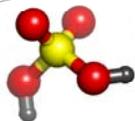
SAND No 2012-1606C  
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,  
for the United States Department of Energy's National Nuclear Security Administration  
under contract DE-AC04-94AL85000.



## Topics

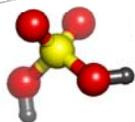
- Definition of chemical safety
- Hazard vs Risk
  - Assessment Process –
    - anticipation, recognition, evaluation and controls
- Chemical Management
  - Benefits
  - Procurement
  - Storage
  - Inventory Systems
  - Hazard Communications
  - Waste Management





## Chemical Safety Defined

- ▶ **Safety:** “The condition of being safe from undergoing or causing hurt, injury, or loss”
  - Merriam-Webster  
<http://www.merriam-webster.com/dictionary/safety>
- ▶ **Chemical Safety:** “Practical certainty that there will be no exposure of organisms to toxic amounts of any substance or group of substances: This implies attaining an acceptably low risk of exposure to potentially toxic substances.”
  - IUPAC Glossary of Terms Used in Toxicology  
<http://sis.nlm.nih.gov/enviro/iupacglossary/glossaryc.html>
- ▶ **Also:**
  - Process Safety
  - Inherent Safety



## Hazard versus Risk

- ▶ Hazard – *the inherent potential to harm*
- ▶ Risk – *the probability that harm will result*



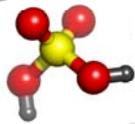
## Chemical Hazards

### ▶ *Chemical hazards*

- Health hazards: toxics, corrosives, carcinogens
- Physical hazards: flammables, explosives, reactives

### ▶ *Other industrial hazards*

- Mechanical—unguarded moving parts, belts, fans
- Electrical
- Pressure & temperature extremes
- Elevated surfaces
- Noise
- Non-ionizing radiation—lasers, ultraviolet light, radiofrequency
- Ergonomic hazards



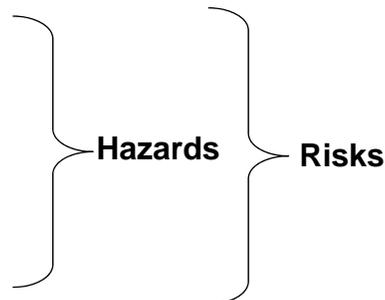
## Risk Assessment Process

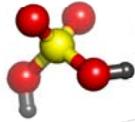
**Anticipation**

**Recognition**

**Evaluation**

**Control**





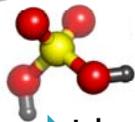
## Anticipation

Anticipation = Advance Planning:

- Team with process engineers, plant facility team leaders, workers, environmental, health & safety professionals, fire protection engineers



- Acquire process information, drawings, equipment requirements and specifications, chemical information, safety data sheets, plant safety procedures, and regulatory requirements



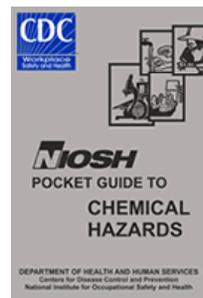
## Recognition/Identification

### ► Identify each chemical hazard

- Quantity of each process chemical
- Identify intermediates, by-products
- Acquire toxicity information
- Solid, liquid, or gas?
- Flashpoint
- Vapor pressure
- Air or water reactivity

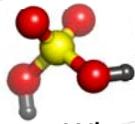
### ► Identify process hazards

- Upper and lower limits of temperature, pressure, flow
- Mechanical hazards
- Electrical hazards



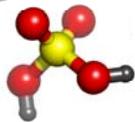
[http://www.ilo.org/safework/info/databases/lang--en/WCMS\\_145760/index.htm](http://www.ilo.org/safework/info/databases/lang--en/WCMS_145760/index.htm)





## Evaluation

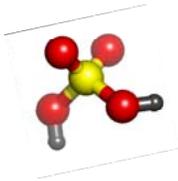
- ▶ What are the tasks in the process? How are chemicals used?
  - Filling, spraying, reacting, mixing?
- ▶ What are the controls for over-pressurization or elevated temperature conditions?
- ▶ Process equipment inspected & maintained?
- ▶ Barriers and guards in place?
- ▶ Workers properly trained?
- ▶ What are the consequences of process deviations?
- ▶ Emergency shut-down equipment or ventilation?



## Controls

How are the risks controlled?

- Eliminate the hazard
- Substitute process materials
- Engineering controls
- Administrative controls/operational practices
- Personal Protective Equipment (PPE)

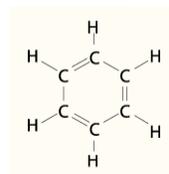
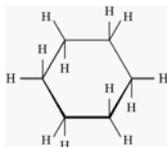


## Controls

**Change the process**

**eliminate the hazard**

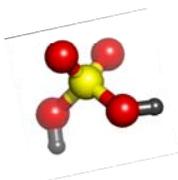
(e.g. Lower process temperature)



## Substitution

**less-hazardous substance**

(e.g. - cyclohexane for benzene)



## Engineering Controls

**Enclose the hazard,**

**Use a barrier,**

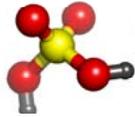
**Or,**

**Ventilate**

**-Dilution ventilation**

**-Local exhaust ventilation (LEV)**

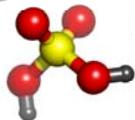




## Administrative Controls

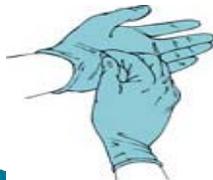


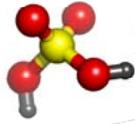
*Organizational safety policies,  
Standard operating procedures,  
Task-specific procedures*



## Personal Protective Equipment – PPE

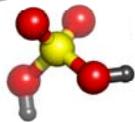
PPE is the *least* desired control  
Does not eliminate the hazard  
Depends on worker compliance  
May create heat stress





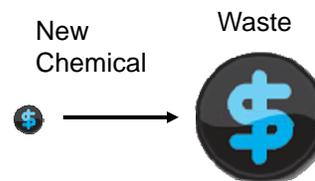
## Chemical Management

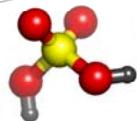
- ▶ Benefits
- ▶ Cradle to Grave Model
- ▶ Procurement
- ▶ Storage
- ▶ Use
- ▶ Disposal



## Chemical Management Benefits

- Reduces cost of:
  - Raw materials
  - Hazardous waste disposal
- Facilitates plant sustainability
- Protects the environment
- Improves security
  - Theft
  - Sabotage





## Chemical Management Cradle-to-Grave Model



Procure



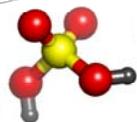
Store



Use



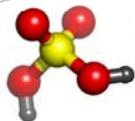
Disposal



## Chemical Procurement

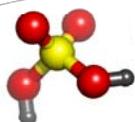
Institute a *procurement approval system*

- Written procedure
  - Document who orders chemicals
  - Document what chemicals require approval
  - Who approves
- Link ordering to a product review system
  - Engineering, Environmental Health & Safety, Facility & Fire Protection Staff
- Track “chemicals of concern”



## Discussion

- ▶ How are chemicals procured at your university?
  - What are the rules about who can order chemicals?
  
- ▶ How do you track the purchase of –
  - highly toxic,
  - flammable, or
  - reactive chemicals?



## Chemicals Storage

- ▶ Where are chemicals stored?
- ▶ Consider unusual storage sites
  - Loading docks
  - Outside locations
  - Waste storage facility
  - Chemicals contained in equipment
- ▶ Resource

*Guidelines for Safe Warehousing of  
Chemicals*, Center for Chemical  
Process Safety,  
ISBN: 978-0-8169-0659-8

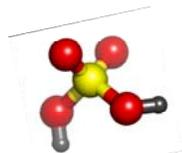




## Chemical Storage

### Design and Construction:

- Building and fire codes are specific for each country
- U.S. uses International Code Council  
<http://www.iccsafe.org/>
- Combines many building, fire, and energy codes
- Incorporates by reference
  - National Fire Protection Association (NFPA) Codes
  - NFPA Electric Code (70)

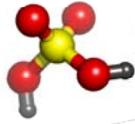


## Chemical Storage

### Best Practices:

- ▶ Safe path during normal and emergency conditions
- ▶ Determine travel distance to exits
- ▶ Separate personnel areas from chemical storage
- ▶ Adequate aisle spacing
- ▶ Exit signage
- ▶ Emergency lighting

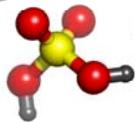




## Chemical Storage

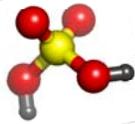
### Design and Construction:

- ▶ Spill containment
  - Maximum probable spill plus fire sprinkler water
  - Primary containment
    - Drains, trenches
  - Secondary containment
    - Recessed loading dock
    - Concrete berms, grates
- ▶ Separate incompatible chemicals
  - Oxidizers, corrosives, flammables



## Chemical Storage

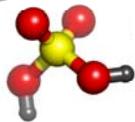




## Chemical Storage

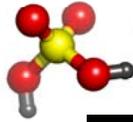
### Gas Cylinders:

- ▶ Separate incompatible gases
- ▶ Secure all gas cylinders
- ▶ Store in well-ventilated area
- ▶ Provide protection from direct sunlight
- ▶ Screw down cylinder caps when not in use



## Chemical Storage

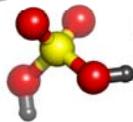




## CSB Video: Compressed Gas Cylinder Fire



Danger of Propylene Cylinders in hot weather -  
Video file = Praxair Clip (small).mpg 8.5 min

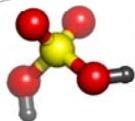


## Chemical Storage

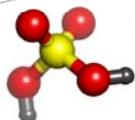
### Tank Storage:

- ▶ Tank material **compatible** with the chemical stored
  - Mild Steel
  - Stainless steel
  - Cross-linked high density polyethylene
- ▶ Spill containment
  - Double walled or lined tanks
  - Berms
- ▶ Security/Impact protection



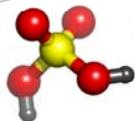


## Collapsed Fertilizer Tank



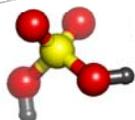
## Discussion

What safeguards does your university have in place to prevent, mitigate, or respond to a release in a chemical storage area?



## Chemical Inventory Systems

- Home made – Access or Excel programs
- Commercial – Chemical inventory linked to Safety Data Sheets (SDS)
- Freeware – Web-based, Hypertext Preprocessor (PHP) software
- Radiofrequency Identification (RFID) tracking



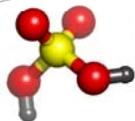
## Chemical Inventory Systems Barcode Systems

- System of tracking is container-based or static inventory
- Each container, tank, or cylinder is provided with a barcode sticker
- Barcode labels may be printed using a direct thermal printer



Photo credit: Fabian M. Dayrit and  
Jaclyn Elizabeth R. Santos

Chemistry Department  
Ateneo de Manila University  
Loyola Heights, Quezon City



## Chemical Inventory Systems Barcode Systems

### Advantages:

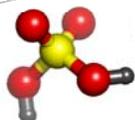
- Query for container location
- Link a chemical container to safety data sheet
- Track chemicals of concern
- Document disposal or waste transfer

### Recommendations:

- Perform a periodic site inspection
  - Assures accuracy of the inventory
  - Provides visual inspection of container condition



Photo credit: Fabian M. Dayrit and  
Jaclyn Elizabeth R. Santos

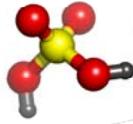


## Chemical Inventory Systems

System should be able to query for the following:

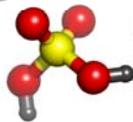
- Barcode number
- Trade or IUPAC name
- Chemicals in a mixture
- CAS number
- Location (process unit)
- Quantity
- Shelf life/expiration date
  - Lab chemicals





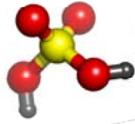
## Example: Barcode System for Static Inventory

Barcode	Location	Depart.	Quantity	Purchase Date	Expiration Date	Name	State	Waste Disposal
XX00187	110/111 1	02712	40 liters	8/01/2007		BKC 20121	Liquid	
XX00172	110/111 1	02712	80 liters	7/31/2007		DIETHANO LAMINE	Liquid	
XX00173	110/111 1	02712	20 liters	11/18/2010	1/30/2011	ACETONE	Liquid	x
XX00174	110/111 1	02712	28 liters	12/15/2010		ACETONE	Liquid	
XX00175	110/111 1	02712	40 liters	10/17/2010		ISOAMYL ACETATE	Liquid	
XX00176	110/111 1	02712	20 liters	11/18/2010		SOLVENT 25	Liquid	



## Commercial Inventory Systems

- ▶ Commercial systems typically include:
  - Barcode Scanner
  - Database
  - Link to safety data sheets
- ▶ May also include:
  - Link to chemical suppliers
  - Report function
    - Reportable chemicals
      - Community Right-to-Know, air emissions, etc.
    - Internal reports



## Using Chemicals Hazard Communication

### Globally Harmonized System (GHS)

- Hazard pictograms
- Signal words
- Hazard statements

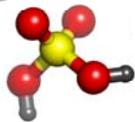
### U.S. OSHA

- Label all chemical containers
  - Product or chemical name
  - Supplier name/contact information
  - Hazard



**Danger**  
**Flammable Liquid**

A Guide to The Globally Harmonized System of Classification and Labeling of Chemicals:  
<http://www.osha.gov/dsg/hazcom/ghs.html>



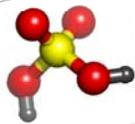
## Using Chemicals Hazard Communication

### Pipe Labeling

- 2007 ANSI/ASME A13.1  
*Scheme for the Identification of Piping Systems*
- Does not apply to buried pipelines or electrical conduit
- Label must state contents, hazard, direction of flow
- May use color coding

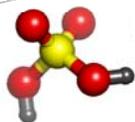






## Discussion

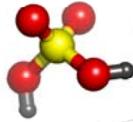
- ▶ What chemical labeling system does your university use?
- ▶ Is the labeling system the same for all containers?
- ▶ How do workers and emergency response staff access safety data sheets in the event of an incident?



## Chemical Waste Management

- ▶ Substitute chemicals when process permits
- ▶ Recycle
- ▶ Dispose by incineration, if allowed in your country
- ▶ Injection wells used in U.S.
- ▶ Incineration is NOT the same as open burning



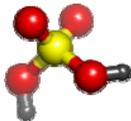


## Summary

- Hazard versus Risk
  - Assessment Process –
    - anticipation, recognition, evaluation and controls
- Chemical Management
  - Benefits
  - Procurement
  - Storage
  - Inventory Systems
  - Hazard Communications
  - Waste Management



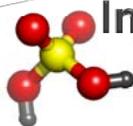
# International Safety Management Systems Standards & Approaches



SAND No. 2011-7069C

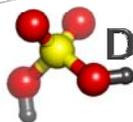
Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.





## International Safety Management Systems

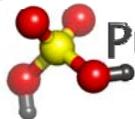
- ▶ Definitions
- ▶ Purpose
- ▶ Safety Concepts
- ▶ Standards
  - BS 8800
  - OHSAS 18001
  - ILO-OSH 2001
- ▶ Approaches
  - SAICM



## Definitions

- ▶ Safety: “The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management. “ (U.S. Federal Aviation Administration, 2009)
- ▶ A Safety Management System (SMS) is a systematic way to identify hazards and control risks while maintaining assurance that these risks are effective.
  - Provides for goal setting, planning, and measuring performance
  - SMS is a business imperative: ethical, legal and financial reasons for establishing a SMS (ICAO, 2009)

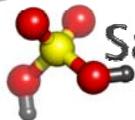
Reference: International Civil Aviation Organization (ICAO), Safety Management Manual, 2009;  
U.S. Federal Aviation Administration, System Approach for Safety Oversight, 2009



## Purpose

- ▶ Ever-increasing pace of worldwide trade and economies
- ▶ Increase in occupational accidents and diseases
  - Over 1.2 million workers are killed due to work-related accidents and diseases annually
  - ~250 million occupational accidents annually
  - ~160 million work-related diseases annually
- ▶ The economic loss is estimated to be 4% of the world gross national product

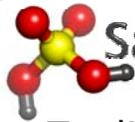
Reference: International Labour Organisation, 2001



## Safety Concepts

- ▶ Freedom from hazards
- ▶ Zero accidents or incidents?
- ▶ Instill safety culture towards unsafe acts and conditions
- ▶ Error avoidance
- ▶ Regulatory compliance

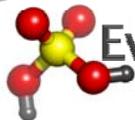
Reference: International Civil Aviation Organization, Safety Management Manual, 2009



## Safety Concepts

- ▶ Traditional approach – prevent accidents
  - Focus is on outcomes (causes)
  - Focus is on unsafe acts by operational personnel
  - Assign blame/punish for failure to “perform safely”
  - Address identified safety concerns exclusively
  
- ▶ Traditional approach: WHAT? WHO? WHEN,  
but NOT: WHY? HOW?

Reference: International Civil Aviation Organization, Safety Management Manual, 2009

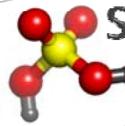


## Evolution of Safety Concepts

- ▶ Change in approach to incident causation:
  - 1950s to 1970
    - Technical factors
  - 1970s to 1990s
    - Human factors
  - 1990s to present time
    - Organizational factors

Reference: International Civil Aviation Organization, Safety Management Manual, 2009

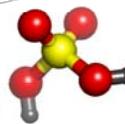




## Safety Management Standards

### BS (British Standard) 8800

- ▶ BS (British Standard) 8800 (1996)
  - A guide to occupational health & safety management systems
  - Emphasizes good working practices to prevent accidents and ill health
  - Goal is to improve business performance and responsible image
  - Assists in continuous improvement beyond regulatory compliance

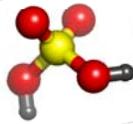


## Safety Management Standards

### BS (British Standard) 8800

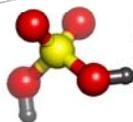
- ▶ Last edition: July 2004
- ▶ New and improved annexes cover:
  - Hazardous event investigation
  - Risk assessment and control
  - Integration with other quality and environmental management systems into an overall management system





## Safety Management Standards OHSAS 18000

- ▶ OHSAS 18000 system specification comprises both OHSAS 18001 and OHSAS 18002.
- ▶ Created by leading national standards bodies, certification bodies, and specialist consultancies
- ▶ Intent—to remove confusion from the proliferation of certifiable occupational health & safety (OHS) specifications
- ▶ OHSAS publishes *The Essential Health and Safety Manual* for purchase.
- ▶ Emphasis is on policy and procedures

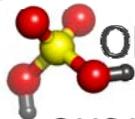


## Safety Management Standards OHSAS 18001

### Requirements:

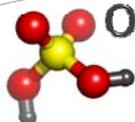
- ▶ Identify occupational health and safety (OHS) hazards
- ▶ Assess the risks associated with OHS hazards
- ▶ Determine the controls necessary to reduce OHS risks to acceptable levels
- ▶ Proactive v.s. reactive approach to safety and health hazards





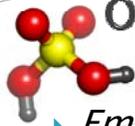
## OHSAS 18001 Relationships to ISO

- ▶ OHSAS 18001 developed to be compatible with ISO 9001 and ISO 14001
- ▶ Facilitates the integration of quality, environmental, and OHS management systems
  - Document and data control
  - Auditing
  - Process controls
  - Record controls
  - Training
  - Corrective and preventive actions



## OHSAS 18001 Elements

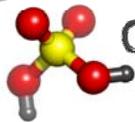
- ▶ *OHS Management Program*
  - Designates responsibility and authority
  - Defines means through which objectives are to be achieved, and timeline for achieving them
  - Must be reviewed at regular, planned intervals
  - Must be amended to address relevant changes in activities, products/services or operating conditions
  - Top management must provide necessary resources



## OHSAS 18001 Elements

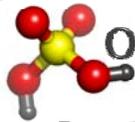
- ▶ *Employee Awareness*
  - Importance of conforming to OHS management system
  - Health & safety consequences of their work activities
  - Individual roles & responsibilities
  - Potential consequences of non-conformance to operating procedures
- ▶ Employees should be involved in review of policies/procedures for managing risks and consulted on changes that affect workplace.

**Employee involvement is KEY.**



## OHSAS 18001 Elements

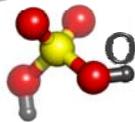
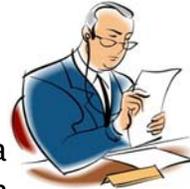
- ▶ *Document Control*
  - Document procedures established and maintained
  - Can be readily located
  - Legible, identifiable and traceable
  - Are reviewed periodically and updated if necessary
  - Are available at all locations where the OHS management system operates
  - Documents may be integrated with other corporate documents where appropriate



## OHSAS 18001 Elements

### ▶ *Records and Reviews*

- Compliance records
- Training records
- Accident Information
- Inspection, maintenance and calibration
- Contractor and supplier information
- Incident reports
- Hazard analyses
- Audit results
- Management review records

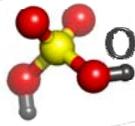


## OHSAS 18001 Elements

### ▶ *Emergency Situations*

- Identify potential emergency situations and response measures
- There must be review of response measures after any incidents occur
- Emergency response measures must be tested periodically

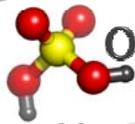




## OHSAS 18001 Elements

### ▶ *Audit Program*

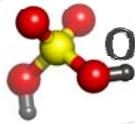
- Determines whether OHS management plan has been properly implemented and maintained and meets policy and objectives
- Reviews results of previous audits
- Provides audit information to (top) management
- Should be conducted by independent (not necessarily external) personnel



## OHSAS 18001 Elements

### ▶ *Management Reviews*

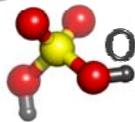
- Should be at specified periodic intervals, documented, and cite any need for changes to policy or objectives
- Should include:
  - Audit results
  - Extent to which objectives are met
  - Confirmation of continued suitability of OHS management system
  - Concerns from any relevant interested parties



## OHSAS 18001 Certification

Steps to certification are similar to those for ISO 9001/14001:

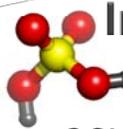
- ▶ Commit to developing OHSAS 18001 system.
- ▶ Develop plan for implementation.
  - Understand legal/regulatory requirements.
  - Identify risks/hazards, and controls for them.
- ▶ Implementation and training.
  - Training for management/employees can be done in-house or through consultants.
  - Allow enough time for system to be correctly/effectively implemented.
- ▶ Once system is in place, consider options for certification.



## OHSAS 18001 Certification

Developing a program can be done with or without consultation:

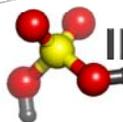
- ▶ Without consultants:
  - Literature can be purchased to help guide through the process of designing and implementing the program.
- ▶ With consultants
  - Some consultants perform initial set-up, through development and implementation and certification.
  - Other consultants offer preliminary audits to diagnose implementation problems, and perform audits post-certification to monitor progress.



## International Labour Organisation (ILO)

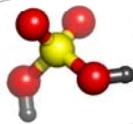
### OSH2001 Guidelines on Occupational Safety and Health Management Systems

- ▶ Voluntary guidelines
- ▶ Do not require certification
- ▶ Basic Components
  - Safety Management Policy
  - Organization
  - Planning and Implementation
  - Evaluation
  - Action for Improvement



## ILO: OSH 2001

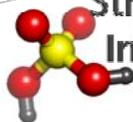
- ▶ Policy statement– state requirements in terms of resources, management commitment, and define OSH targets
- ▶ Organizing – describe organizational structure, responsibilities and accountabilities
- ▶ Planning and Implementation – define regulations and standards that are applicable and how they will be implemented
- ▶ Evaluation – define how OSH performance measured and assessed
- ▶ Continuous improvement processes described



## Strategic Approach to International Chemical Management (SAICM)

- ▶ Adopted by the International Conference on Chemicals Management (ICCM), 2006
- ▶ Policy framework to foster safe management of chemicals
- ▶ Multi-sectoral, multi-stakeholder
- ▶ Goal: ensure that by 2020, chemicals are produced and used in ways that minimize the significant adverse impacts on the environment and human health (ICCM, 2006)

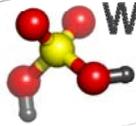
<http://www.saicm.org/index.php?q=h&content=home>



## Strategic Approach to International Chemical Management (SAICM)

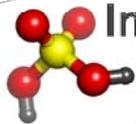
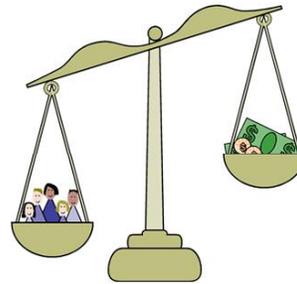
- ▶ Quick Start Programme:
  - A voluntary, time-limited trust fund for developing countries, and economies in transition
  - Priorities:
    - Development or updating of national chemical profiles
    - Identify capacity needs for sound chemicals management
    - Development and strengthening of national chemicals management institutions, plans, programmes and activities
    - Enable SAICM by integrating the sound management of chemicals in national strategies





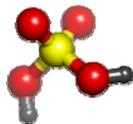
## Why Implement Safety Management Standards?

- ▶ Safety of workers
- ▶ Quality of product
- ▶ Increased efficiency
- ▶ Business image



## Integrated Management Systems

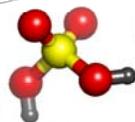
- ▶ Integrated management systems combine quality, environmental *and* OHS management systems
- ▶ Integration may vary from:
  - Increasing compatibility of system elements, to
  - Embedding an integrated management system (IMS) in a culture of learning and continuous improvements
- ▶ Some national integrated management standards are being developed (ISO (2008). Integrated Use of Management System Standards).
- ▶ For business sustainability an IMS needs to include the entire product chain and all stakeholders
- ▶ Jorgensen, et al. (2006). *Integrated management systems – three different levels of integration*. Journal of Cleaner Production, 14(8), 713–722.



# Chemical Management Programs

SAND No. SAND No. 2012-1605C

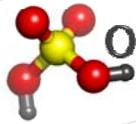
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



## Learning Objectives

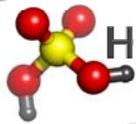
- ▶ Understand the hierarchy of controls for establishing a chemical management program
- ▶ Understand the organizational roles in a chemical management program
- ▶ Understand the purpose of developing and implementing a chemical management program
- ▶ List the elements of a chemical management program
- ▶ Understand the principal components of a simple chemical facility site assessment





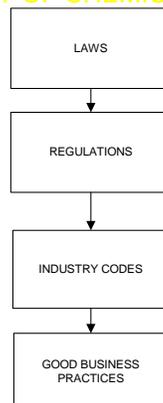
## Overview of Presentation

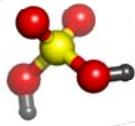
- ▶ Hierarchy of regulatory controls/industry standards for chemical management programs
- ▶ Personnel roles in a chemical management program
- ▶ Purpose of a chemical management program
- ▶ Elements of a chemical management program
- ▶ Examples of site assessment checklists



## Hierarchy of Controls

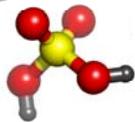
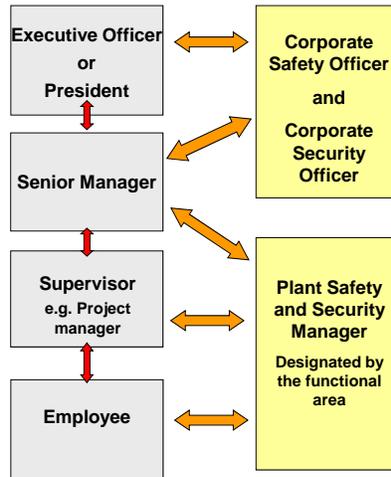
### HEIRARCHY OF CHEMICAL CONTROLS





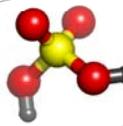
## Chemical Management Program Organizational Roles

- ▶ Culture of chemical safety and security should exist at all levels of the organization
- ▶ Top management sets policy, provides resources
- ▶ Workers must understand and implement
- ▶ Many organizational interactions are important for an effective chemical management program



## Purpose of a Chemical Management Program

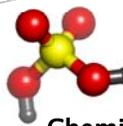
- ▶ Prevent and/or mitigate release of hazardous substances within the facility and in the nearby community
  - *Protect people*
  - *Protect the environment*
- ▶ Prevent theft of chemicals or process information
- ▶ Prevent chemical exposure to workers
- ▶ Comply with laws and regulations
- ▶ Provides for incident management response



## Elements of a Chemical Management Program

The written program should include a *policy statement* endorsed by the plant's management.

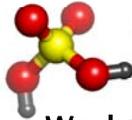
***“It is the policy of our company to protect our workers and the public, prevent incidents, protect the environment through integration of environmental stewardship and sustainability throughout the life-cycle of its activities, and ensure regulatory compliance.”***



## Elements of a Chemical Management Program

### Chemical inventory/Material Accountability

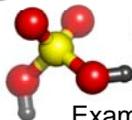
- Describe the process for tracking chemical inventory:
  - “All chemicals will be procured through *Corporate Process XXX*,
  - All chemical containers, process units, & piping will be labeled,
  - All chemical containers/process units will be bar-coded,
  - All chemicals will have safety data sheets,
  - Safety data sheets will be accessible to all employees and regulatory authorities,
  - Chemicals of concern will be secured and access limited, and
  - Chemical quantities will be tracked from procurement to disposal.”



# Elements of a Chemical Management Program

## ▶ Worker health and safety

- Describe the process for identifying, evaluating, and controlling worker exposure:
  - "All chemicals associated with processes will be identified,
  - Potential worker airborne or dermal exposure to identified chemicals will be evaluated,
  - All workers exposed to hazardous chemicals will be subject to medical surveillance, and
  - All documented exposures will be controlled by
    - Engineering controls, personal protective equipment or administrative controls, in that order."



# Elements of a Chemical Management Program

## Example of Personal Protective Equipment Assessment Form

### Work Place Hazard Assessment Certification

Date:	Site/TA:	Building or Activity Location:	Room (if applicable):	Activity FOC/Department:
-------	----------	--------------------------------	-----------------------	--------------------------

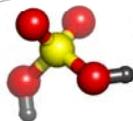
#### Workplace Hazards:

- |                                   |                     |                     |                    |                           |
|-----------------------------------|---------------------|---------------------|--------------------|---------------------------|
| A. Chemicals                      | B. Thermal Extremes | C. Flying Particles | D. Falling Objects | E. Over head bump hazards |
| F. Rolling Objects                | G. Biohazards       | H. Molten Metals    | I. Dust and Debris | J. Sharp Edges or Points  |
| K. Abrasive Surfaces or Materials |                     |                     |                    |                           |

**Note:** Respiratory hazards, laser hazards, electrical hazards, welding hazards and radiation hazards must be assessed through the appropriate program documents. Refer to Sections 6C – Respiratory Protection, 4B – Electrical Safety Practices, 6G – Laser and Intense Light, 4E – Hot Work Safety and/or Chapter 8 – Occupational Radiation Protection of the ES&H Manual for guidance.

Task/Activity	Hazard(s) identify by letter
1	
2	
3	
4	

Task #	Personal Protective Equipment Needed					
	Eye and Face	Head	Hand	Foot	Hearing	Torso/Body
	<input type="checkbox"/> Safety Glasses w/ side shields <input type="checkbox"/> Splash goggles <input type="checkbox"/> Face Shields <input type="checkbox"/> Other:	<input type="checkbox"/> Hard Hat <input type="checkbox"/> Bump Caps <input type="checkbox"/> Other:	<input type="checkbox"/> Latex <input type="checkbox"/> Nitrile <input type="checkbox"/> Butyl <input type="checkbox"/> Leather work gloves <input type="checkbox"/> Cryogenic <input type="checkbox"/> Temperature resistant gloves <input type="checkbox"/> Other:	<input type="checkbox"/> Safety Shoes <input type="checkbox"/> Shoe covers <input type="checkbox"/> Other:	<input type="checkbox"/> Ear plugs – NRR _____ <input type="checkbox"/> Ear Muffs – NRR _____ <input type="checkbox"/> Other:	<input type="checkbox"/> Lab coat <input type="checkbox"/> Chemical resistant apron <input type="checkbox"/> Coveralls <input type="checkbox"/> Tyvek™ <input type="checkbox"/> Simons™ <input type="checkbox"/> Other:



## Elements of a Chemical Management Program

### Example of Job Hazard Analysis Form:

Date: \_\_\_\_\_

JHA Number: \_\_\_\_\_

Location of Task: \_\_\_\_\_

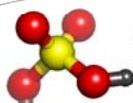
Task # 1 Description: \_\_\_\_\_

Hazards: \_\_\_\_\_

Preventive Measure(s): \_\_\_\_\_

Safe Job Procedures: \_\_\_\_\_

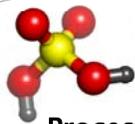
Retrieved February 27, 2012 from, U.S. Occupational Safety and Health Administration.  
<http://www.osha.gov/Publications/osa3071.pdf>



## Elements of a Chemical Management Program

### Exercise:

- ▶ Describe an activity in one of your chemical engineering laboratories.
  - Example: Testing solvents for Lower Explosive Limit
- ▶ List all chemicals and their hazards
  - Example: methanol
  - Flammable, toxic by ingestion, skin irritant
- ▶ List all possible ways a lab worker might be exposed
  - Example: Inhaling vapors, skin exposure
- ▶ List how the exposure will be controlled
- ▶ List current lab procedures to protect the student

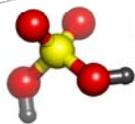


## Elements of a Chemical Management Program

### Process Hazard and Threat Risk Assessment

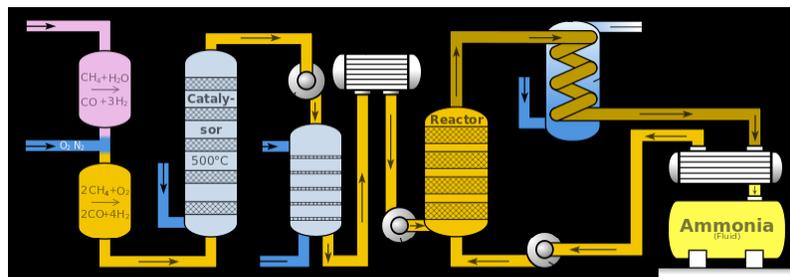
- Describe the process for identifying, evaluating, and controlling chemical hazards from catastrophic incidents and security threats:
  - “All processes will undergo an initial and periodic *hazard analysis* to include, identification of process chemicals, process conditions (pressure, temperature), fire, explosive and reactivity hazards, process equipment, and measures to control unplanned releases.”
  - All changes to process chemicals, processes, equipment, or facility modifications will be subject to evaluation through a *management of change* procedure.”

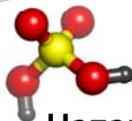
Note: Indicate industry codes and standards that will be followed; for example, National Fire Protection Association (NFPA), American Society for Testing and Materials (ASTM)



## Elements of a Chemical Management Program

### Hazard Analysis of Fertilizer Process Process Flow Diagram

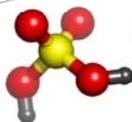




## Elements of a Chemical Management Program

### ▶ Hazard and Threat Risk Assessment, continued

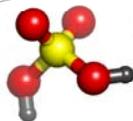
- Describe the process for identifying, evaluating, and controlling security threats from theft and sabotage:
  - “All processes will undergo an initial and periodic *security vulnerability assessment* to include, identification of chemicals of concern and their properties, and measures to control their theft or unplanned release.”
  - All employees procuring, storing, processing, or disposing of chemicals of concern will be subject to a *personnel reliability program*.
  - All chemicals of concern will be managed under a *material accountability program* which will include access control as well as inventory tracking.”



## Elements of a Chemical Management Program

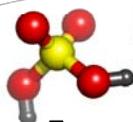
### ▶ Training program

- Describe the process for developing, auditing, and maintaining a safety and security training program:
  - “All employees handling or disposing of chemicals will take training in *hazard communication* and if applicable, *respiratory protection*, *confined space*, *hazardous waste operations*, and *emergency response*.”
  - All employees procuring, storing, handling or disposing of chemicals of concern will take *Security 100 training*.”



## Training Documentation: Sample

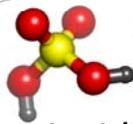
- ▶ Employee name: \_\_\_\_\_
- ▶ Department: \_\_\_\_\_
- ▶ Date: \_\_\_\_\_
  
- ▶ Training Subject: \_\_\_\_\_
- ▶ Training Date: \_\_\_\_\_
- ▶ Re-instruction date: \_\_\_\_\_
  
- ▶ Employee Signature: \_\_\_\_\_
- ▶ Date Signed: \_\_\_\_\_
- ▶ Supervisor's signature: \_\_\_\_\_
- ▶ Date: \_\_\_\_\_



## Elements of a Chemical Management Program

- ▶ **Emergency and Incident Management Plan**
  - ▶ Pre-emergency planning with outside authorities
  - ▶ Personnel roles, lines of authority, communication
  - ▶ Site security and control
  - ▶ Evacuation routes and procedures
  - ▶ Personnel protective and emergency equipment
  - ▶ Decontamination procedures
  - ▶ Emergency medical treatment and first aid
  - ▶ Emergency response and alerting procedures
  - ▶ Critique of response

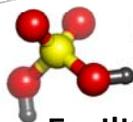
U. S. 29 Code of Federal Regulations, 1910.120. HAZWOPER Standard



## Elements of a Chemical Management Program

### ▶ Incident Investigations

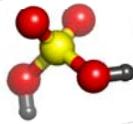
- All incidents, regardless of severity, must be investigated – and lessons learned used for prevention in the future
- Formal investigation of serious incidents
- Accountability at all levels
  - Management, employees, and the investigation team.



## Elements of a Chemical Management Program

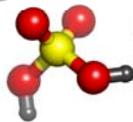
### ▶ Facility site inspections:

- “The chemical shipping and receiving warehouse will be physically inspected quarterly for potential safety hazards and security threats. The inspection will include a walk-down of the warehouse. The following will be reviewed.
  - Access control
  - Chemical inventory records
  - Chemical container labels and SDSs
  - Chemical storage containment and chemical compatibility
  - Emergency procedures and signage
  - Worker PPE
  - Local exhaust ventilation flow rates and maintenance records
  - Training records”



# Elements of a Chemical Management Program

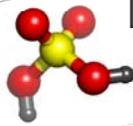
Example: Facility Site Inspection



# Elements of a Chemical Management Program

Example: Facility Site

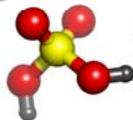




## Elements of a Chemical Management Program

### Inspection Checklist:

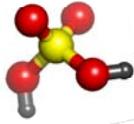
- ▶ Date of Inspection:\_\_\_\_\_
- ▶ Conducted by:\_\_\_\_\_
- ▶ Location (building/process unit):\_\_\_\_\_
- ▶ Supervisor:\_\_\_\_\_
  
- ▶ Work Practices
  - Work conducted under ventilation if airborne hazard
  - Housekeeping
  - Work instructions present and used



## Elements of a Chemical Management Program

### Inspection Checklist:

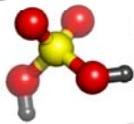
- ▶ General Facility Condition
  - Egress/aisles/passageways
  - Exit signs
  - Housekeeping
  - Access controls
    - Hazardous areas
    - Chemicals of concern
- ▶ Hazard Communication
  - Training documented
  - SDS available for all chemicals
  - All chemical containers/tanks/piping labeled
- ▶ Personal Protective Equipment (PPE)
  - Available for each exposure identified
  - Respirators and other PPE stored properly and appropriate for identified hazard



## Elements of a Chemical Management Program

### Inspection Checklist:

- ▶ Fire Safety
  - Evacuation maps
  - Fire pull stations & telephones appropriately placed and posted
  - Adequate number of fire detection and sprinkler equipment
  - Fire extinguishers tested, inspected, and appropriate type
  - Flammable chemical storage: quantities and containment
  
- ▶ Process Safety
  - Mechanical integrity program
  - Emergency shut-down equipment present and routinely tested
  - Emergency chemical release equipment available, maintained and posted
  - Management of change procedures

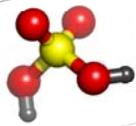


## Behavior Based Safety (BBS)



SAND No. 2011-0487C  
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,  
for the United States Department of Energy's National Nuclear Security Administration  
under contract DE-AC04-94AL85000.



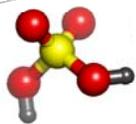


## What is Behavior Based Safety?

Behavior is “the manner of conducting oneself.”\*

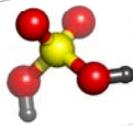
Therefore, behaviors are observable acts.

Behavior Based Safety focuses on behaviors that promote safety.



## Behavior Based Safety is NOT:

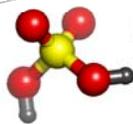
- ▶ A fully-developed safety program.
  - It is a process designed to eliminate behaviors that put workers at risk and enhance existing safety protocols.
- ▶ A process used to enforce safety rules, nor to correct hazardous conditions.
  - Safety rule violations and hazardous workplace conditions must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



## How does BBS differ from traditional safety?

### Traditional Safety...

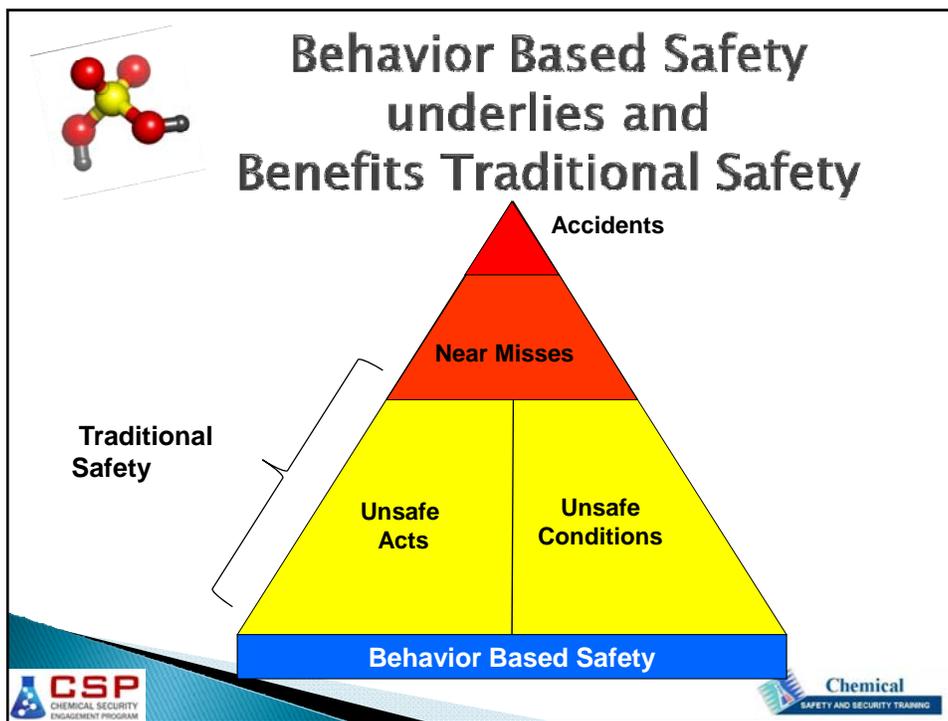
- Is *reactive* – focuses on correcting problems only after they have occurred.
- Searches for “root cause” of accidents
  - Using incident/accident data from investigations
    - e.g. Incident and Severity rate: TRCR/DART
- Focuses on making the working environment less hazardous.
- Sometimes assigns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



## How does BBS differ from traditional safety?

### Behavior Based Safety...

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



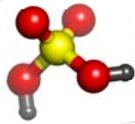
## Always Keep in Mind...

BBS is focused on two concepts:

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

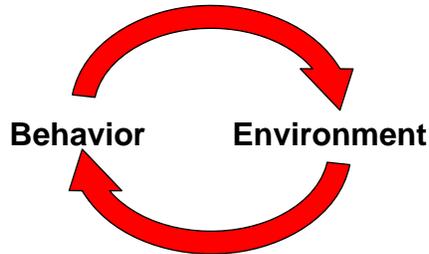
CSP CHEMICAL SECURITY ENGAGEMENT PROGRAM

Chemical SAFETY AND SECURITY TRAINING

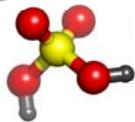


## Remember: Behavior is “the manner of conducting oneself”

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



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



## Risk = exposure x probability

Exposure - extent a person is involved in an activity.

Direct



Indirect



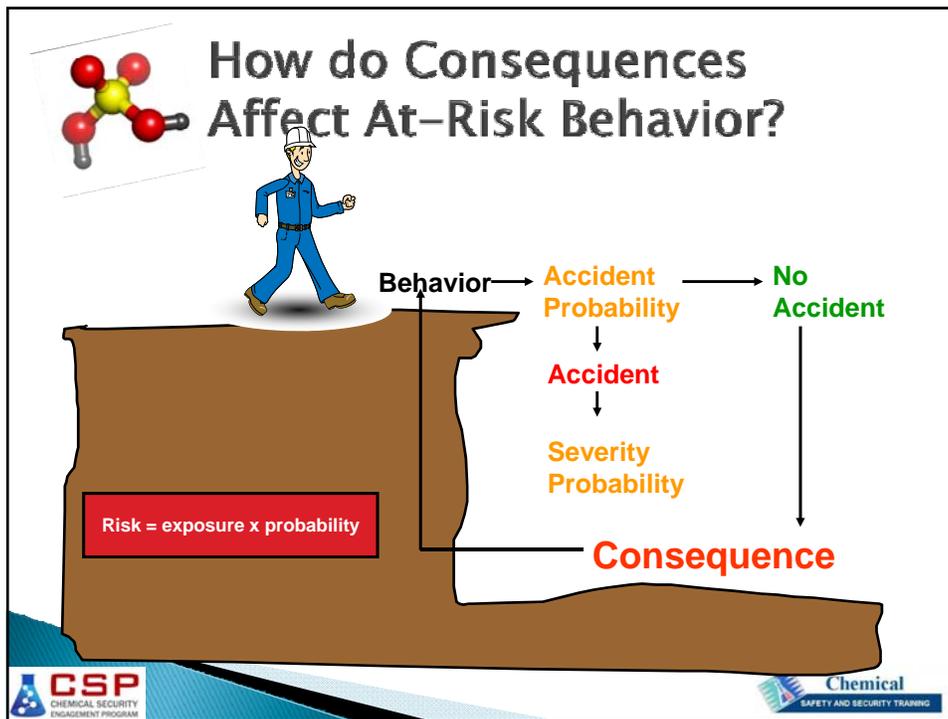
Probability - the chances of an accident occurring during activity.



1 in 6



1 in 52



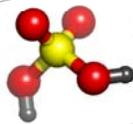
## Positive Consequences Influence At-Risk Behavior

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

How does cheaper/better/faster influence taking risks?

**CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

**Chemical**  
SAFETY AND SECURITY TRAINING



## Worker's reasons for taking a risk:

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

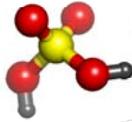
That's the way I always do it!  
I don't know.  
I didn't think about it.  
It's the way we always do it around here.



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



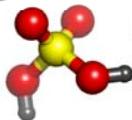
## Implementing Behavior Based Safety



## Prior to Implementation

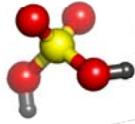
Important to develop a BBS Committee and working structure that persists after implementation:

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



## Responsibilities of Managers & Supervisors

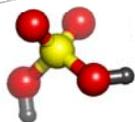
- Understand the process (receive training)
- Establish BBS as a part of the job
- Help identify and correct systems issues
- Remove barriers
- Support:
  - **Time for:**
    - Training
    - BBS Committee duties and meetings
    - Observations
- Encourage and provide positive reinforcement: workers,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



## 4 Steps of Implementation

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

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



## Step 1: Establish Feasible Goals

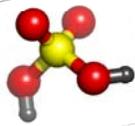
The overall purpose of BBS is to establish a culture of safety in the working environment. However, attainable goals need to exist in working toward this.

Make goals **SMART**:

**S**pecific - **M**otivational - **A**ttainable - **R**elevant - **T**rackable

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

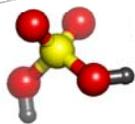
Goals should focus on outcomes, NOT behaviors.



## Step 1: Establish Feasible Goals

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

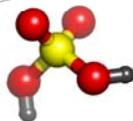
1. "Employee buy-in" – verbal and nonverbal support for change from those directly affected.
2. Interpersonal trust – trust among employees, and trust between employees and management.



## Step 2: Develop Observation Checklists

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

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



## Step 2: Develop Observation Checklists

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

**SHARP**  
BE SHARP  
STAY SHARP

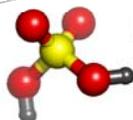
Sandia Hazard & Accident Reduction Program  
Division 2000 Behavior Based Safety—Electrical Lab Workers

Observer: \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_  
No. Observed: \_\_\_\_\_ Bldg: \_\_\_\_\_ Org: \_\_\_\_\_

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

Observer Comments: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Employee Comments: \_\_\_\_\_

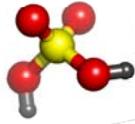


## Step 3: Observing

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

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

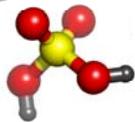




## Observers Have...

Three main responsibilities:

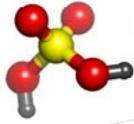
- Gather data
  - Observation data (Safe/Concern)
  - Discussion data (What/Why)
- Give feedback
  - Positive reinforcement for safe behaviors
  - Provide coaching on concerns
- To remain objective/unbiased



## Step 3: Observing

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

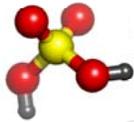
- Peer-to-peer
- Anonymous (No Names/No Blame)
- Announced
- 5 minutes or less
- Provide feedback:
  - Positive reinforcement for safe behaviors
  - Coaching for behaviors of concern
- Identify obstacles
- Foster safety communication



## An Observer's Job is

**NOT:**

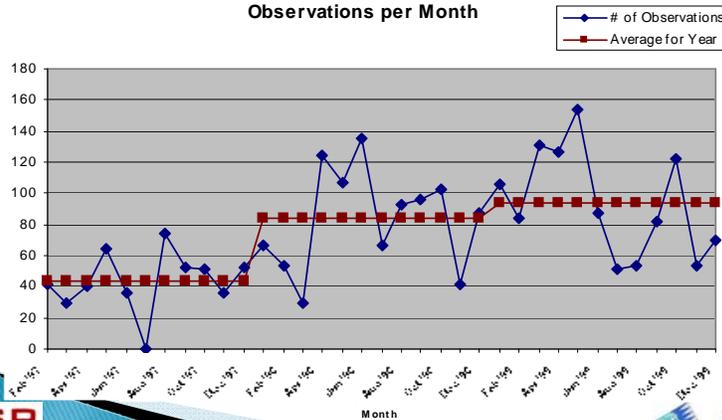
- Ambush or spy on workers
- “Catch” people doing activities unsafely
- Criticize worker performance
- “Safety cop” (risks vs. rules; right vs. wrong; safe vs. unsafe)
- Watch a whole task or job
- Force people to change
- Turn people in for discipline
- Identify conditions that don't directly impact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

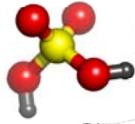


What happens with more observations?

## Feedback Changes Behaviors

Observations per Month

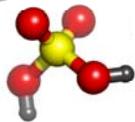
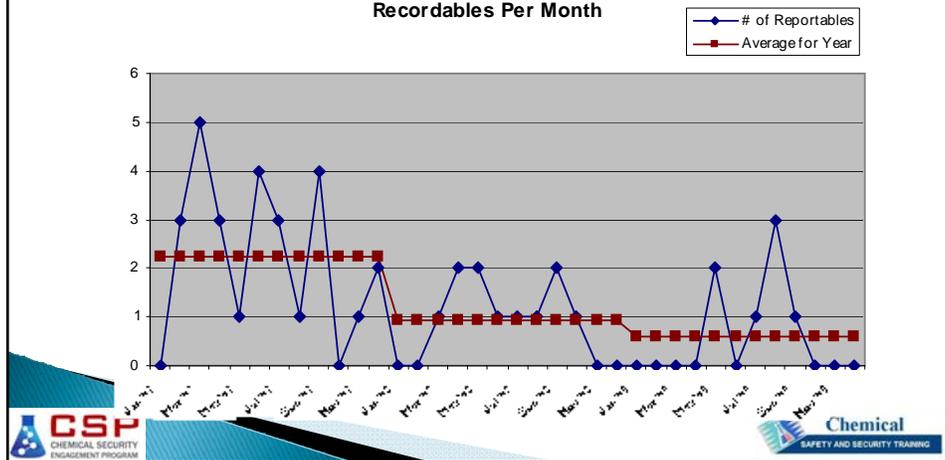




Fewer injuries!

## Changed Behaviors Reduce Accidents

Recordables Per Month

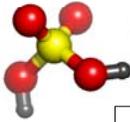


## Step 4: Providing Feedback

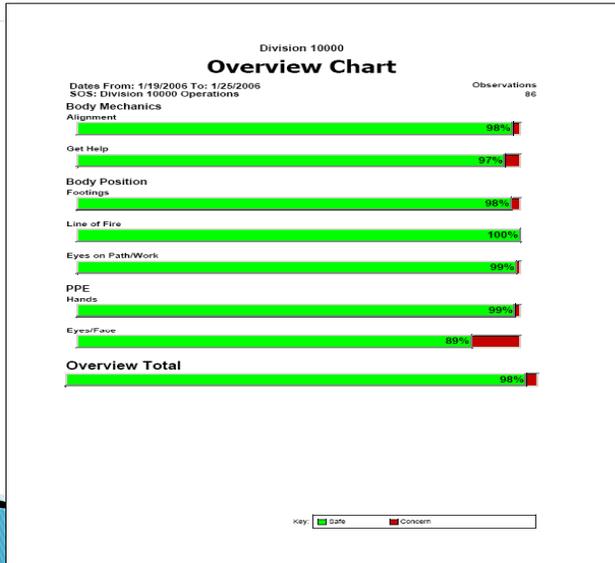
Providing feedback to workers in a timely manner is important. Using multiple methods has proven beneficial:

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

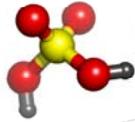
**NOTE:** It is important that workers are allowed time to adjust their performance before being observed again.



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



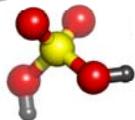
# Why Implement Behavior Based Safety?



## The BBS Process Closes the Gap to “Nobody Gets Hurt”

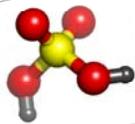
- Focuses on the critical few precautions that would prevent the most injuries
- Prioritizes actions to remove barriers
- Generates actionable data
- Provides positive reinforcement of safe behaviors
- Engages workers and management:

Worker driven/Management supported



## BBS is proven to reduce injuries

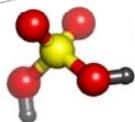
- ▶ At 850+ companies injuries were reduced by an average of:
  - 37% after 1 year
  - 66% after 2 years
  - 87% after 3 years
- ▶ Multisite Success – See case study of BP’s Fabrics and Fibers Business Unit (FFBU) included in your extra materials.



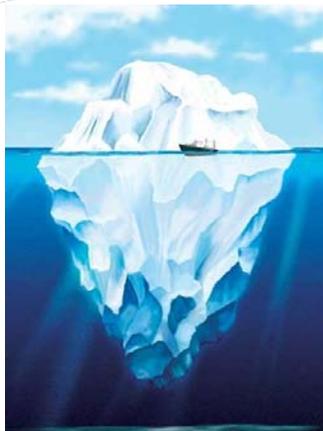
## The Benefits Outweigh the Costs

What is the Return on Investment for BBS?

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



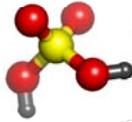
## Why Implement Behavior Based Safety?



*Remember:*

### The Iceberg Theory

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



## Sources

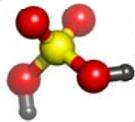
- ▶ M. Dominic Cooper. "Behavioral Safety Interventions: A review of process design factors." *Safety Management*. Feb 2009.
- ▶ Thomas E. Boyce and Horacio R. Roman. "Institutionalizing behavior-based safety: Theories, concepts, and practical suggestions." *The Behavior Analyst Today*. Vol 3, No 1.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



# Process Safety Overview

Bandung, Indonesia

March 2012

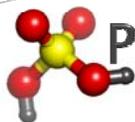


## Key acronyms

**PSM** = *process safety management*

**SDS** = *safety data sheet*

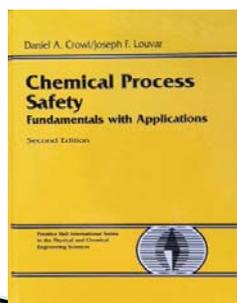
**RAGAGEPS** = *recognized  
and generally accepted good engineering  
practices*

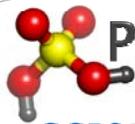


## Process safety resources

[D.A. Crowl and J.F. Louvar 2001.](#)

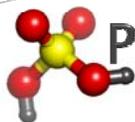
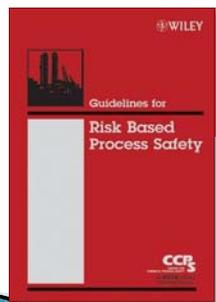
*Chemical Process Safety: Fundamentals  
with Applications, 2nd Edition*, Upper  
Saddle River, New Jersey: Prentice Hall.





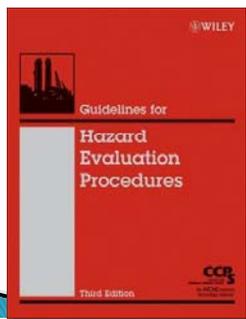
## Process safety resources

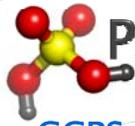
**CCPS 2007a.** Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*, New York (NY): American Institute of Chemical Engineers.



## Process safety resources

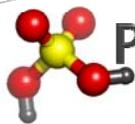
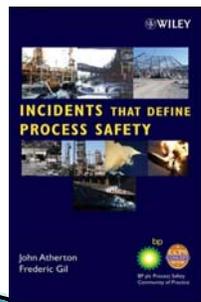
**CCPS 2008a.** Center for Chemical Process Safety, *Guidelines for Hazard Evaluation Procedures, Third Edition*, NY: American Institute of Chemical Engineers.





## Process safety resources

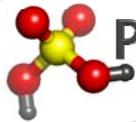
CCPS 2008b. Center for Chemical Process Safety, *Incidents that Define Process Safety*, NY: American Institute of Chemical Engineers.



## Process Safety Overview

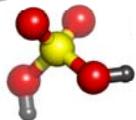
1. What is *process safety*?
2. Opposite of process safety: Major incidents
3. The anatomy of process safety incidents
4. Overview of process safety strategies
5. Taking advantage of past experience
6. Defense in depth / layers of protection
7. Elements of process safety management





# Process Safety Overview

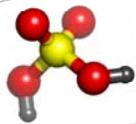
1. What is *process safety*?



## Process safety

= the absence of loss and harm resulting from fires, explosions and hazardous material releases at process facilities.

*(Event-focused definition)*

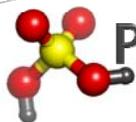


## Process safety

= the absence of loss and harm at process facilities by

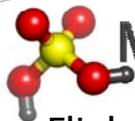
- identifying process hazards,
- containing and controlling them,
- countering abnormal situations with effective safeguards.

*(Activity-focused definition)*



## Process Safety Overview

1. What is *process safety*?
2. Opposite of process safety: Major incidents



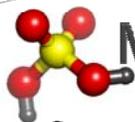
## Major process incidents

### ▶ Flixborough, UK (June 1974)

- Partial oxidation of cyclohexane
- Catastrophic failure of temporary piping
- 30 tonnes of hot cyclohexane released in 30 s
- Vapor cloud explosion
- 28 fatalities, 53 injuries; 1800+ houses damaged; plant destroyed
- 18 of those fatally injured were in control room
- Hastened passage of UK “Health and Safety at Work Act”



See CCPS 2008b for details of these incidents

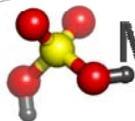


## Major process incidents

### ▶ Seveso, Italy (July 1976)

- Runaway reaction
- 2 kg of dioxin release from relief system
- Over 17 km<sup>2</sup> affected
- Locally grown food banned for several months
- Several inches of topsoil removed, incinerated
- 80,000 animals died or slaughtered
- Plant shut down and destroyed
- EU “Seveso Directive” prompted

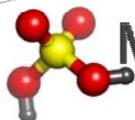




## Major process incidents

### ▶ Mexico City, Mexico (November 1984)

- Large LPG / fuels storage facility
- Fires, vessel ruptures, boiling-liquid-expanding-vapor explosions (BLEVEs)
- Initiating cause unknown
- 600 fatalities, 7000 injuries
- Horizontal tanks rocketed as far as 1200 m away
- Fixed fire protection destroyed by blasts
- Fuels terminal destroyed

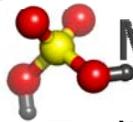


## Major process incidents

### ▶ Bhopal, India (December 1984)

- Pesticide production facility
- Water introduced into methyl isocyanate storage
- MIC toxic vapor release from vent system
- 2000 to 3000 early fatalities; ~200,000 injuries
- Plant shut down; Union Carbide eventually sold
- Seveso II, EPA Risk Management Program prompted

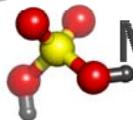




## Major process incidents

### ▶ Toulouse, France (September 2001)

- Ammonium nitrate storage at fertilizer plant
- Explosive decomposition initiated; cause unknown
- Equivalent blast energy 20–40 tons of TNT
- 30 fatalities; 2500+ injuries; US\$ 2 billion in losses



## Major process incidents

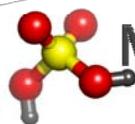
### ▶ Texas City, Texas (March 2005)

- Refinery isomerization unit
- One valve not opened during unit re-start
- Release of hot flammable material from blowdown
- Ignition and vapor cloud explosion
- 15 fatalities, 170+ injuries; BP losses and impacts





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



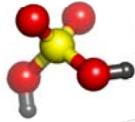
## Major process incidents

- ▶ Buncefield, UK (December 2005)
  - Petrol (gasoline) tank farm
  - Storage tank overflow
  - Ignition, vapor cloud explosion and fires
  - 40+ injuries; 20+ tanks destroyed
  - Consequences could have been much worse



See [www.buncefieldinvestigation.gov.uk/index.htm](http://www.buncefieldinvestigation.gov.uk/index.htm) for details

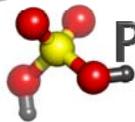




## DISCUSSION

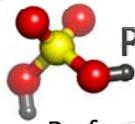
When “major chemical incidents” is mentioned, what come first to your mind?

- 
- 
- 
- 
- 



## Process Safety Overview

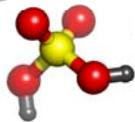
1. What is *process safety*?
2. Opposite of process safety: Major incidents
3. **The anatomy of process safety incidents**



## Process safety incident anatomy

### Preface

This presentation is adapted from course materials and from presentations used for several years for process safety lectures at the University of Cincinnati and The Ohio State University, with updates to reflect terminology used in the Third Edition of *Guidelines for Hazard Evaluation Procedures* (CCPS 2008a).

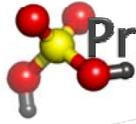


## Incident – Definition

### *Incident:*

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



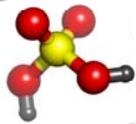


## Process industry incidents

- ▶ Fires
- ▶ Explosions
- ▶ Toxic Releases



- Fatalities
- Injuries
- Environ. Damage
- Property Damage
- Evacuations
- Business Losses
- Plant Closings
- Fines, Lawsuits

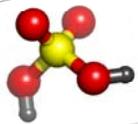


## Process industry incidents

*Loss  
Events*



- Fatalities
- Injuries
- Environ. Damage
- Property Damage
- Evacuations
- Business Losses
- Plant Closings
- Fines, Lawsuits

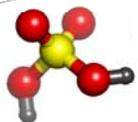


## Process industry incidents

*Loss  
Events*



*Impacts*

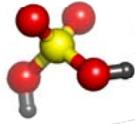


## Key definition

### Loss event:

*Point in time in an abnormal situation  
when an irreversible physical event  
occurs that has the potential for loss  
and harm impacts.*

- CCPS 2008a Glossary



## Key definition

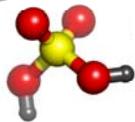
### Loss event:

*Point in time in an abnormal situation when an irreversible physical event occurs that has the potential for loss and harm impacts.*

- CCPS 2008a Glossary

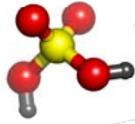
### Examples:

- ▶ Hazardous material release
- ▶ Flammable vapor or dust cloud ignition
- ▶ Tank or vessel overpressurization rupture



## Key questions

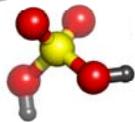
- ▶ Why do loss events happen?
- ▶ How do loss events happen?
- ▶ What must be done to avoid them?



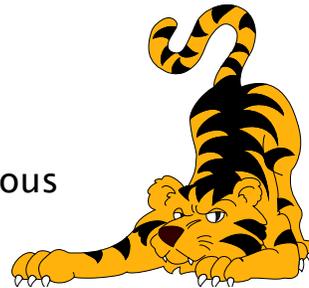
## WHY do loss events happen?



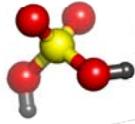
- ▶ We choose to handle dangerous process materials and energies
  - To make a living
  - To provide society with desirable products
- ▶ As long as we choose to handle them, a potential for loss events exists



## Analogy

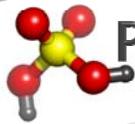


- ▶ We choose to handle dangerous animals at the Zoo
  - To make a living
  - To provide society with desirable experiences
- ▶ As long as we choose to handle them, a potential for loss events exists
  - Things can be done to reduce their likelihood and severity to negligible or tolerable levels



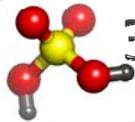
## Process safety

The absence of loss and harm at process facilities by  
(a) identifying process hazards,  
(b) containing and controlling them,  
(c) countering abnormal situations with effective safeguards.



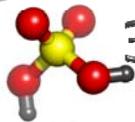
## Process hazard – Definition

*Presence of a  
stored or connected  
material or energy with  
inherent characteristics  
having the potential for  
causing loss or harm.*



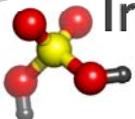
## 3 types of process hazards

- ▶ Material hazards
- ▶ Energy hazards
- ▶ Chemical interaction hazards

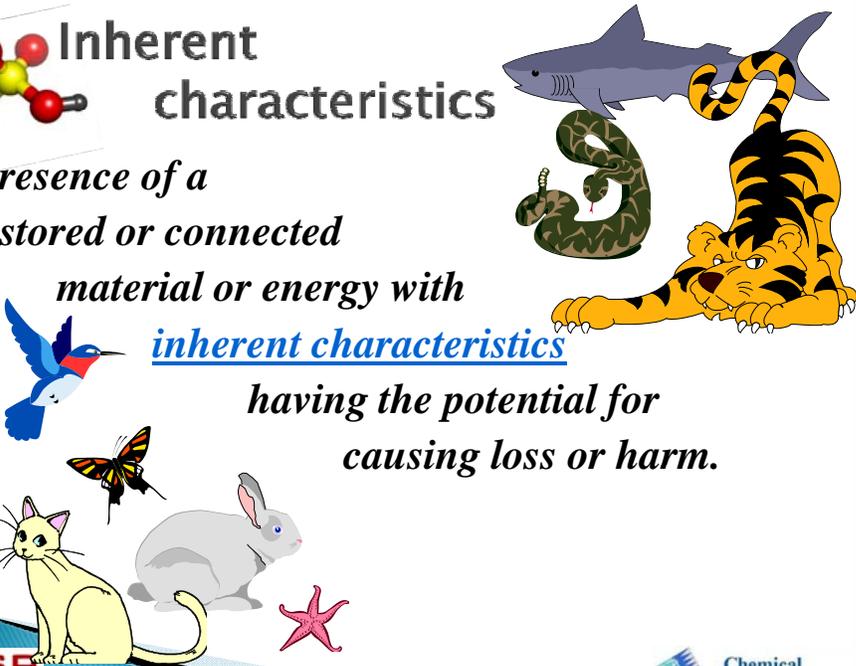


## 3 types of process hazards

- ▶ **Material hazard:** A contained or connected process material with one or more hazardous characteristics
- ▶ Energy hazard
- ▶ Chemical interaction hazard

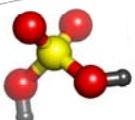
 **Inherent characteristics**

*Presence of a stored or connected material or energy with inherent characteristics having the potential for causing loss or harm.*



 **CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

 **Chemical**  
SAFETY AND SECURITY TRAINING

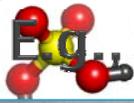
 **Material hazards**

*Inherently hazardous characteristics:*

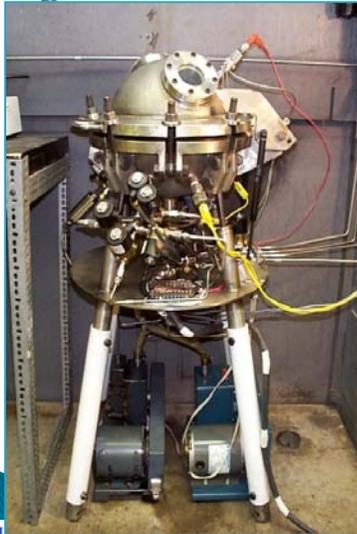
 Flammability	 Instability
 Toxicity	 Corrosivity

 **CSP**  
CHEMICAL SECURITY  
ENGAGEMENT PROGRAM

 **Chemical**  
SAFETY AND SECURITY TRAINING

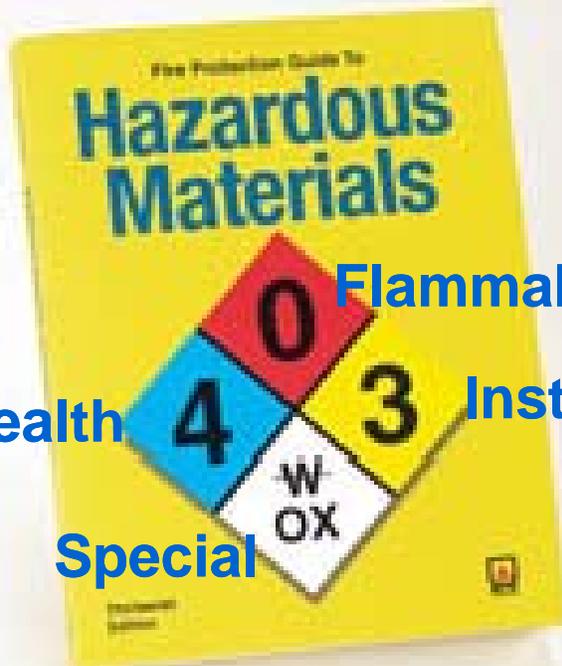


## Flammable materials



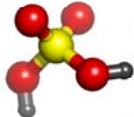
### *Inherent characteristics:*

- ▶ Flash point (volatility)
- ▶ Heat of combustion
- ▶ Ease of ignition
  - Flammability limits
  - Minimum ignition energy
  - Autoignition temperature



**NFPA 704**  
Summary  
of material  
hazards for  
emergency  
response

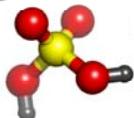
**Flammability**  
**Health**  
**Instability**  
**Special**



# Safety Data Sheets

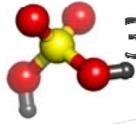
## “SDSs”

- ▶ More complete summary of hazards
- ▶ Required to be accessible in workplace
- ▶ All hazardous materials on-site
- ▶ Available from suppliers, internet sources
- ▶ Give only basic chemical reactivity info
- ▶ Often inconsistent from source to source



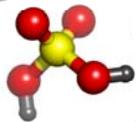
# Limitations

- ▶ NFPA 704 diamonds and SDSs only give properties of individual hazardous materials
  - Hazardous energies not identified
  - Some hazardous chemical interactions not identified
  - Connected hazards may not be identified



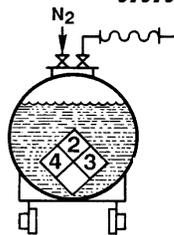
## 3 types of process hazards

- ▶ Material hazard
- ▶ Energy hazard: Some form of physical energy contained within or connected to the process with the potential for loss or harm
- ▶ Chemical interaction hazard



## Process hazard

*Presence of a stored or connected material or energy with inherent characteristics having the potential for causing loss or harm.*



Form of Energy with Injury Potential (examples)
Electrical (voltage, capacitance)
Mechanical (spring, machine parts)
Kinetic (moving or rotating mass)
Positional (elevated part or equipment)
Hydraulic (liquid under pressure)
Pneumatic (gas/vapor under pressure)
Chemical–Health Hazard (NFPA 2 to 4)
Chemical–Flammables (NFPA 3 or 4)
Chemical–Combustibles (NFPA 2)
Chemical–Reactive (NFPA 2 to 4)
Thermal–Hot Material (steam, hot oil)
Thermal–Cryogenic Fluid (liquid N <sub>2</sub> )

Page 1 of 1

**LOCKOUT/TAGOUT ENERGY CONTROL PROCEDURE**

**Drawing No.** X-100-101

**Equipment Name** Methanol Flowmeter

**Location** Bldg 1, Inside dike wall

Form of Energy with Injury Potential (examples)	Connected Energy Source and Magnitude	Residual and/or Stored Energy?
Electrical (voltage, capacitance)		
Mechanical (spring, machine parts)		
Kinetic (moving or rotating mass)		
Positional (elevated part or equipment)		
Hydraulic (liquid under pressure)	MeOH pump discharge, 3 bar g	
Pneumatic (gas/vapor under pressure)		
Chemical–Health Hazard (NFPA 2 to 4)	MeOH, up to 10,000 liters	Yes
Chemical–Flammables (NFPA 3 or 4)	MeOH, up to 10,000 liters	Yes
Chemical–Combustibles (NFPA 2)		
Chemical–Reactive (NFPA 2 to 4)		
Thermal–Hot Material (steam, hot oil)		
Thermal–Cryogenic Fluid (liquid N <sub>2</sub> )		

**ISOLATE CONNECTED ENERGY SOURCES**

**Energy Isolating Device #1** Ball Valve

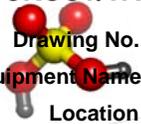
**Location** Between MeOH transfer pump and flowmeter

**Use of Device** Close valve

**LOTO** Lockout and tagout initials

## LOCKOUT/TAGOUT ENERGY CONTROL PROCEDURE

Page 1 of 1

  
**Drawing No.** X-100-101  
**Equipment Name** Methanol Flowmeter  
**Location** Bldg 1, Inside dike wall

...

### ISOLATE CONNECTED ENERGY SOURCES

**Energy Isolating Device #1** Ball Valve  
**Location** Between MeOH transfer pump and flowmeter  
**Use of Device** Close valve  
**LOTO** Lockout and tagout **Initials** \_\_\_\_\_

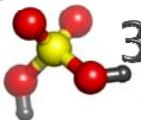
...

### BLEED OFF RESIDUAL OR STORED ENERGIES

**Bleed-Off Procedure:**  
Drain residual flammable liquid into grounded catch pan.  
**Initials** \_\_\_\_\_

### VERIFY ISOLATION AND DEENERGIZATION

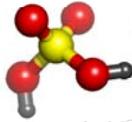
**Verification Procedure:**  
Visually check for pockets of flammable liquid while disassembling.  
**Initials** \_\_\_\_\_



## 3 types of process hazards

- ▶ Material hazard
- ▶ Energy hazard
- ▶ Chemical interaction hazard:  
Presence of materials with the potential for loss or harm upon their interaction in an unintentional or uncontrolled manner



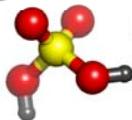


## Reactive interactions

Example Compatibility Chart for an Acetic Anhydride Handling Facility

<i>Will These Two Materials React?</i>	Acetic Acid	Acetic Anhydride	Cooling Water	Sulfuric Acid	50% Caustic	Lube Oil	Cleaning Solution
Acetic Acid							
Acetic Anhydride	<i>Reactive</i>						
Cooling Water	<i>Not reactive</i>	<i>Reactive</i>					
Concentrated Sulfuric Acid	<i>Reactive</i>	<i>Reactive</i>	<i>Reactive</i>				
50% Caustic	<i>Reactive</i>	<i>Reactive</i>	<i>Reactive</i>	<i>Reactive</i>			
Lube Oil	<i>Not reactive</i>	<i>Not reactive</i>	<i>Not reactive</i>	<i>Reactive</i>	<i>Reactive</i>		
Cleaning Solution	<i>Find out what the cleaning solution contains, then determine reactions</i>						

From CCPS 2001

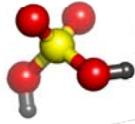


## Process hazard

*Presence of a  
stored or connected  
material or energy with  
inherent characteristics*

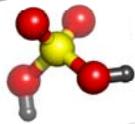
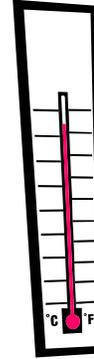
- having the potential for causing loss or harm.*





## Degree of hazard

- ▶ More hazardous material  
→ *greater degree of hazard*
- ▶ Farther from zero energy state  
→ *greater degree of hazard*



## EXERCISE

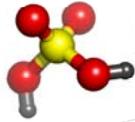
Which has more available energy?

1 t heptane at 98 °C

*or*

2 t heptane at 20 °C (ambient temperature)





## EXERCISE

### 1 t heptane, 98 °C

Chemical energy = 44,600 MJ

Thermal energy = 200 MJ

Total = 44,800 MJ

### 2 t heptane, ambient temperature

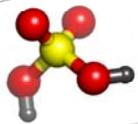
Chemical energy = 89,200 MJ

Thermal energy = 0 MJ

Total = 89,200 MJ

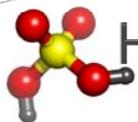


Form of Energy with Injury Potential (examples)	Zero Energy State
Electrical (voltage, capacitance)	0 volts
Mechanical (spring, machine parts)	Sprung
Kinetic (moving or rotating mass)	At rest
Positional (elevated part or equipment)	Ground level
Hydraulic (liquid under pressure)	0 bar gage
Pneumatic (gas/vapor under pressure)	0 barg, 0 m <sup>3</sup>
Chemical–Health Hazard (NFPA 2 to 4)	Nontoxic
Chemical–Flammables (NFPA 3 or 4)	Non-
Chemical–Combustibles (NFPA 2)	flammable
Chemical–Reactive (NFPA 2 to 4)	Nonreactive
Thermal–Hot Material (steam, hot oil)	Ambient
Thermal–Cryogenic Fluid (liquid N <sub>2</sub> )	Ambient



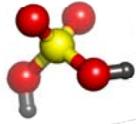
## Key questions

- ▶ Why do loss events happen?
- ▶ How do loss events happen?
- ▶ What must be done to avoid them?



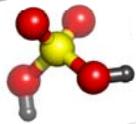
## HOW do loss events happen?

- ▶ Anatomy of an incident
- ▶ Unsafe act & condition precursors



## Incident sequence: *Hazard*

- ▶ *(Hazard)*
  - *Cause*
  - *Deviation*
  - *Loss event*
  - *Impacts*

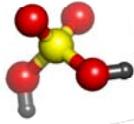


## Process hazard



*Presence* of a  
*stored or connected*  
*material or energy with*  
*inherent characteristics*  
*having the potential for*  
*causing loss or harm.*



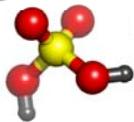


## Normal operation

### Hazards



During normal operation, all [hazards](#) are contained and controlled...

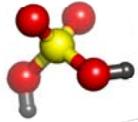


## Normal operation

### Hazards



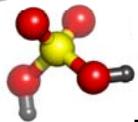
During normal operation, all [hazards](#) are contained and controlled, *but they are still present.*



## Incident sequence: *Cause*

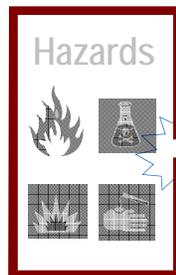
▶ (*Hazard*)

- **Cause**
  - *Deviation*
  - *Loss event*
  - *Impacts*



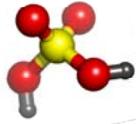
## Initiating cause

Every incident starts with an *initiating cause* (also called an *initiating event* or just a “*cause*”).



### *Example initiating causes:*

- Feed pump fails off
- Procedural step omitted
- Truck runs into process piping
- Wrong raw material is received
- Extreme low ambient temperature

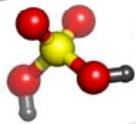


## Initiating cause

Once an *initiating cause* occurs, normal operation cannot continue without a process or operational response.



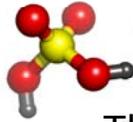
*Cause*



## Incident sequence: *Deviation*

- ▶ (*Hazard*)
  - *Cause*
  - ***Deviation***
  - *Loss event*
  - *Impacts*





## Deviation

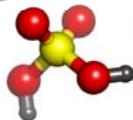
The immediate result of an initiating cause is a *deviation*.



Cause

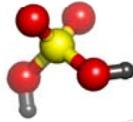
### Deviation

- No Flow
- Low Temperature
- High Pressure
- Less Material Added
- Excess Impurities
- Transfer to Wrong Tank
- Loss of Containment
- etc.



## Abnormal situations

- ▶ Most engineering focuses on designing a process to *work*:  
(normal situation)
- ▶ We must also consider how a process can *fail*, starting with an “abnormal situation”



## Deviation

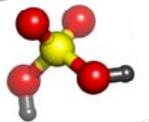
A *deviation* is an abnormal situation, outside defined design or operational parameters.



*Cause*

### Deviation

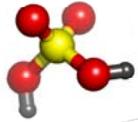
- No Flow
- Low Temperature
- **High Pressure** (*exceed upper limit of normal range*)
- Less Material Added
- Excess Impurities
- Transfer to Wrong Tank
- Loss of Containment
- etc.



## Incident sequence: *Loss event*

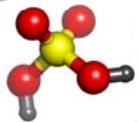
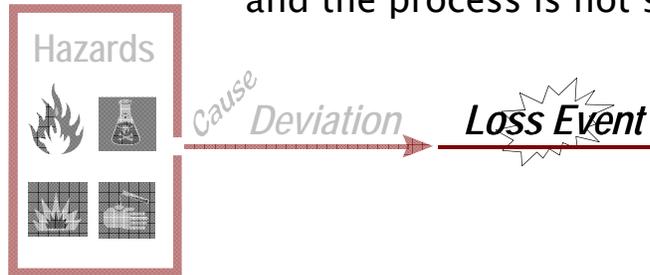
- ▶ (*Hazard*)
  - *Cause*
    - *Deviation*
      - **Loss event**
        - *Impacts*





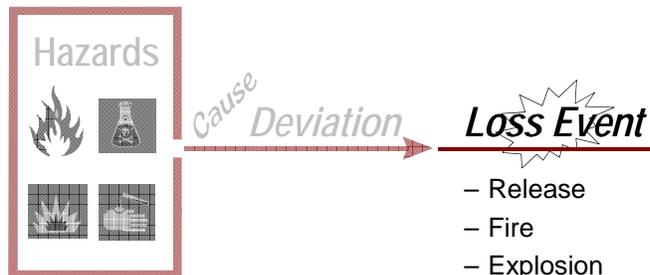
## Loss event

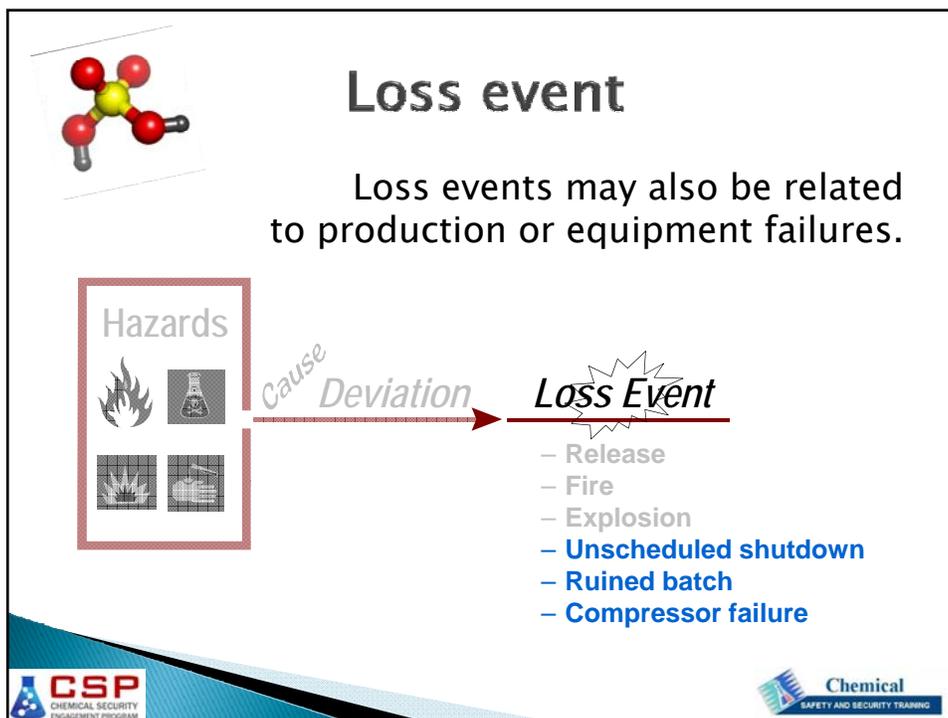
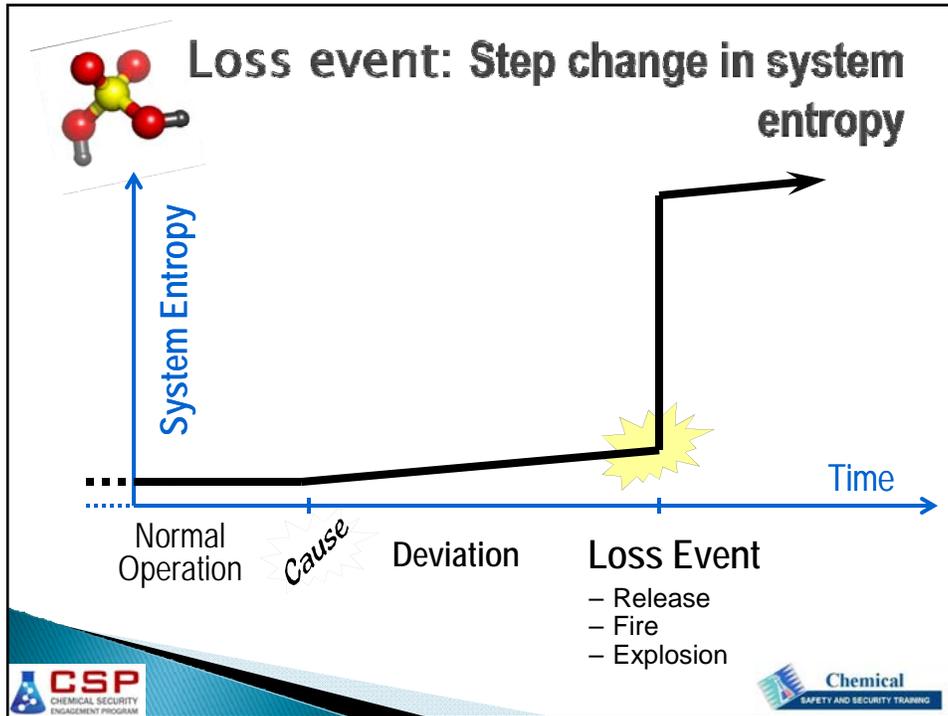
A *loss event* will result if a deviation continues uncorrected and the process is not shut down.

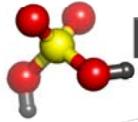


## Loss event

*Loss events* are generally irreversible process material/energy releases.



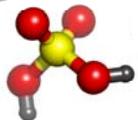




## Incident sequence: *Impacts*

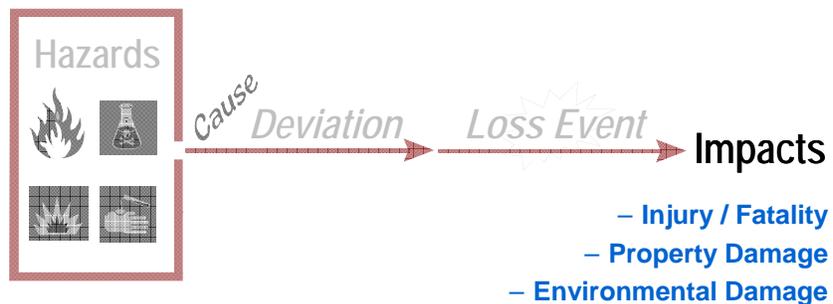
▶ (*Hazard*)

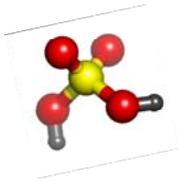
- *Cause*
- *Deviation*
- *Loss event*
- ***Impacts***



## Impacts

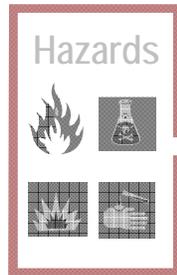
*Impacts* are the losses and injuries that can result from a loss event.





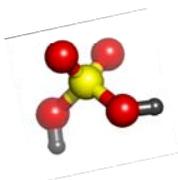
# Impacts

There are often other, less tangible impacts as well.



**Impacts**

- Injury / Fatality
- Property Damage
- Environmental Damage
- **Business Interruption**
- **Market Share Loss**
- **Reputation Damage**

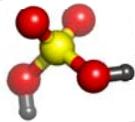


# Incident sequence without safeguards



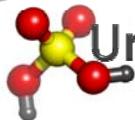
**Impacts**





## HOW do loss events occur?

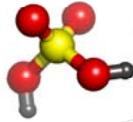
- ▶ Anatomy of an Incident
- ▶ Unsafe act & condition precursors



## Unsafe act & condition precursors

Major Catastrophe:  
Multiple Fatalities  
& Loss of Facility

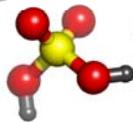
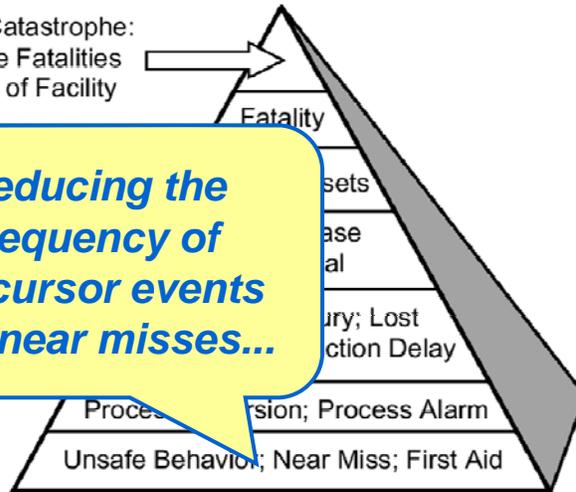




# Pyramid principle of safety

Major Catastrophe:  
Multiple Fatalities  
& Loss of Facility

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

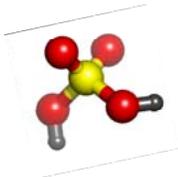


# Pyramid principle of safety

Major Catastrophe:  
Multiple Fatalities  
& Loss of Facility

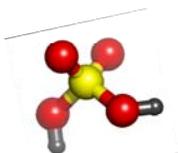
*... will reduce the likelihood of a major loss event*





## Key questions

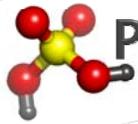
- ▶ Why do loss events happen?
- ▶ How do loss events happen?
- ▶ What must be done to avoid loss events?



## Process Safety Overview

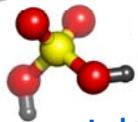
1. What is *process safety*?
2. Opposite of process safety: Major incidents
3. The anatomy of process safety incidents
4. Overview of process safety strategies
5. Taking advantage of past experience
6. Defense in depth / layers of protection
7. Elements of process safety management

*What  
must  
be  
done*



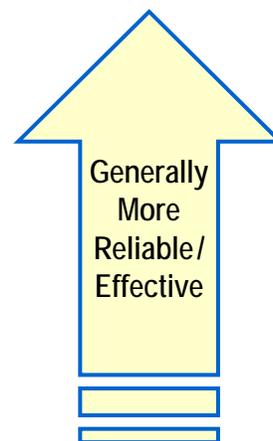
## Process Safety Overview

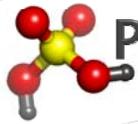
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## Process safety strategies

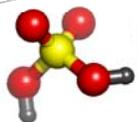
- ▶ **Inherent** – Hazard reduction
- ▶ **Passive** – Process or equipment design features that reduce risk without active functioning of any device
- ▶ **Active** – Engineering controls
- ▶ **Procedural** – Administrative controls





## Process Safety Overview

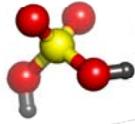
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## Using past experience

*“Those who cannot remember the past are condemned to repeat it.” - George Santayana*

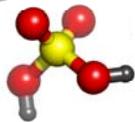
- ▶ Learnings from past (usually bad) experiences have been embodied in various forms:
    - Regulations
    - Codes
    - Industry standards
    - Company standards
    - “Best practices”
- **Handbooks**
  - **Guidelines**
  - **Procedures**
  - **Checklists**
  - **Supplier Recommendations**



## Using past experience

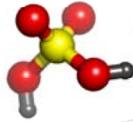
- ▶ One term commonly used for non-regulatory codes and standards is “**RAGAGEPs**”
- ▶ From U.S. OSHA’s Process Safety Management Standard (Process Safety Information element):

29 CFR 1910.119(d)(3)(ii) The employer shall document that equipment complies with **recognized and generally accepted good engineering practices**.



## Using past experience

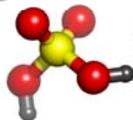
- ▶ One term commonly used for non-regulatory codes and standards is “**RAGAGEPs**”
- ▶ From U.S. OSHA’s Process Safety Management Standard (Process Safety Information element)
- ▶ Example: International consensus standard IEC 61511 [ANSI/ISA-84.00.01 (IEC 61511 Mod)], “Functional Safety: Safety Instrumented Systems for the Process Industry Sector”



## RAGAGEPs

### *Recognized and Generally Accepted Good Engineering Practices*

- Take advantage of wealth of experience
- Pass on accumulated knowledge
- Reduce recurrence of past incidents
- Enable uniformity of expectations
- Reduce liabilities when followed



## Example: Anhydrous ammonia

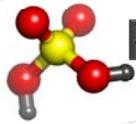
### ▶ Regulatory requirements:

E.g., U.S. OSHA Standard 29 CFR 1910.111,  
“Storage and Handling of Anhydrous Ammonia”

### ▶ Industry standards

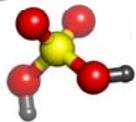
- CGA G-2, “Anhydrous Ammonia”
- ANSI/CGA K61.1, “American National Standard Safety Requirements for the Storage and Handling of Anhydrous Ammonia”

### ▶ Other standards apply to specific applications, e.g., EN 378 for ammonia refrigeration



## RAGAGEPs Alphabet Soup

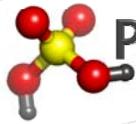
- ▶ IEC
- ▶ NFPA
- ▶ ASME
- ▶ ISA
- ▶ UL
- ▶ FM
- ▶ CGA
- ▶ BS
- ▶ DIN
- ▶ ASHRAE
- ▶ IIAR
- ▶ ASTM
- ▶ API
- ▶ AIChE/CCPS
- ▶ IRI
- ▶ Chlorine Institute
- ▶ SOCMA
- ▶ etc.



## DISCUSSION

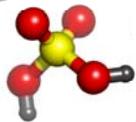
With what RAGAGEPs are you most familiar?

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- 
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-



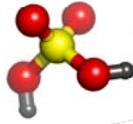
## Process Safety Overview

1. What is *process safety*?
2. Opposite of process safety: Major incidents
3. The anatomy of process safety incidents
4. Overview of process safety strategies
5. Taking advantage of past experience
6. **Defense in depth / layers of protection**

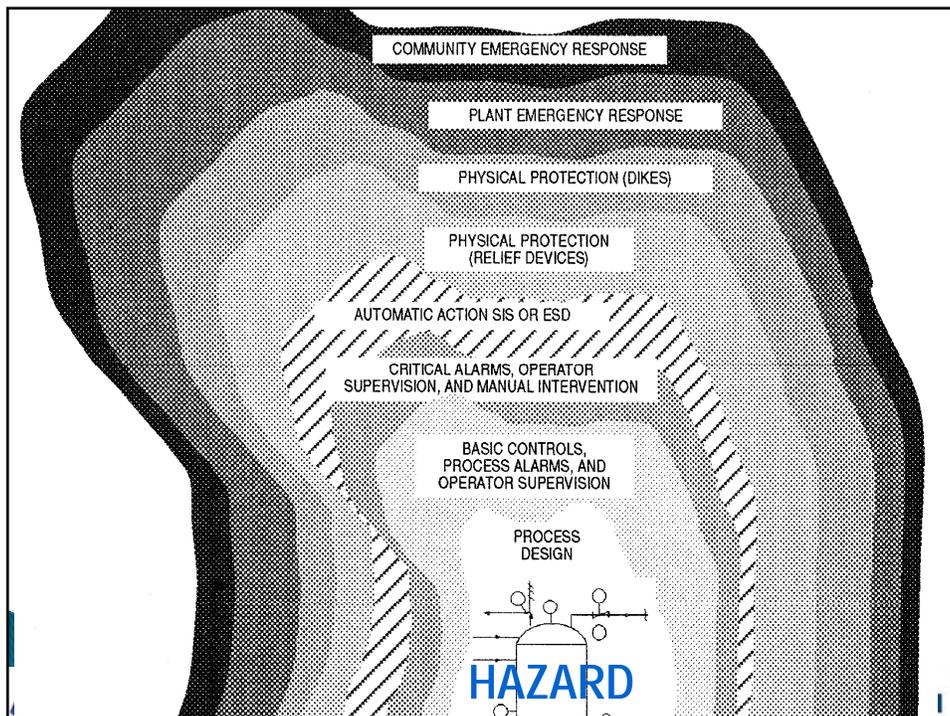
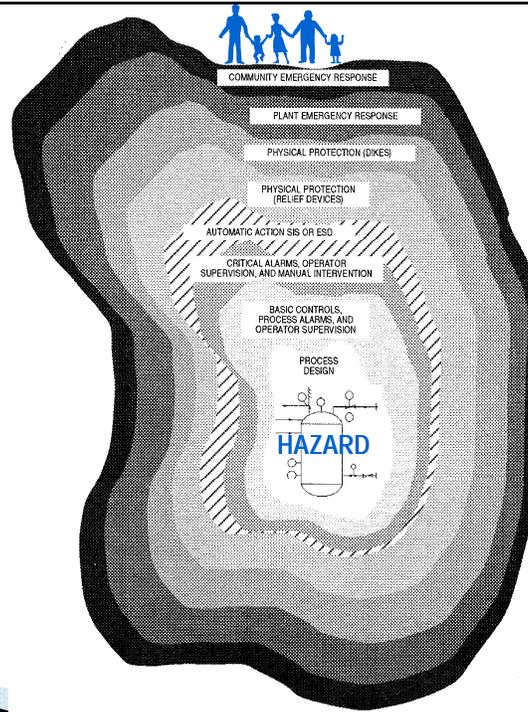


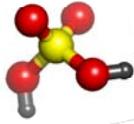
## Layers of protection

- ▶ Also called “Safety layers”
- ▶ Multiple layers may be needed, since no protection is 100% reliable
- ▶ Each layer must be designed to be effective
- ▶ Each layer must be maintained to be effective
- ▶ Some layers of protection are *contain and control measures*
- ▶ Other layers of protection are *safeguards*



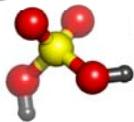
“Layers of protection”  
between  
hazards and  
receptors  
=  
“Defense  
in depth”





## Layers of protection

- ▶ Also called “Safety Layers”
- ▶ Multiple layers may be needed, since no protection is 100% reliable
- ▶ Each layer must be designed to be effective
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- ▶ Some layers of protection are *contain and control measures*
- ▶ Other layers of protection are *safeguards*



## Contain & control

### Contain & Control

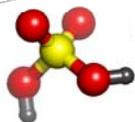
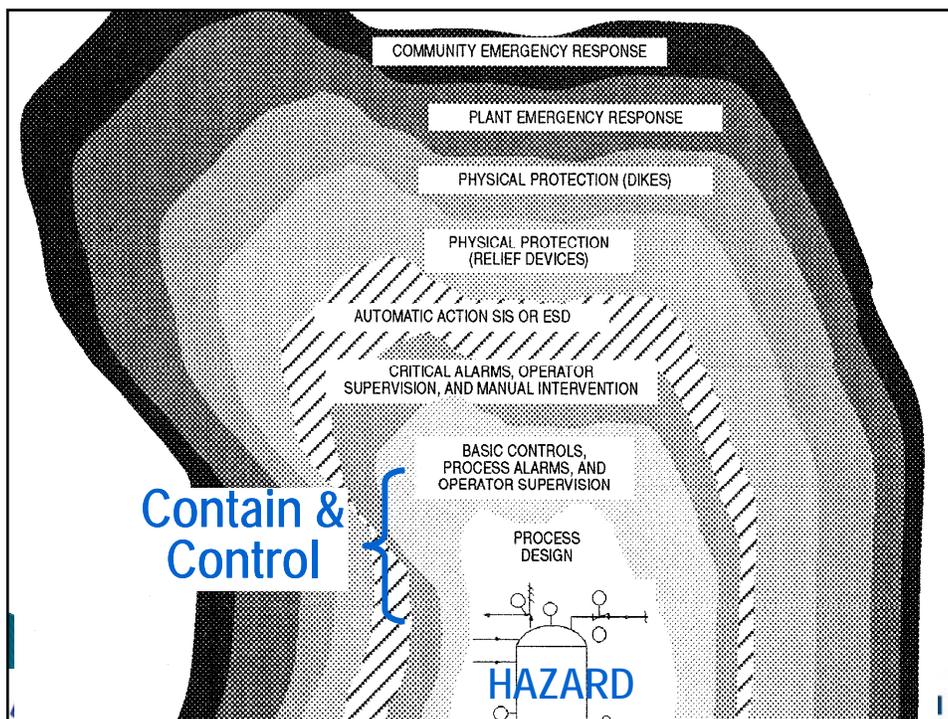


Operational Mode: Normal operation

Objective: Maintain normal operation;  
keep hazards contained and controlled

Examples of *contain & control* measures:

- Basic process control system
- Inspections, tests, maintenance
- Operator training
  - How to conduct a procedure or operate a process correctly and consistently
  - How to keep process within established limits
- Guards, barriers against external forces
- Management of change

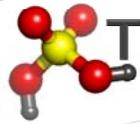


## Key definition

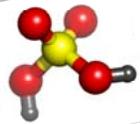
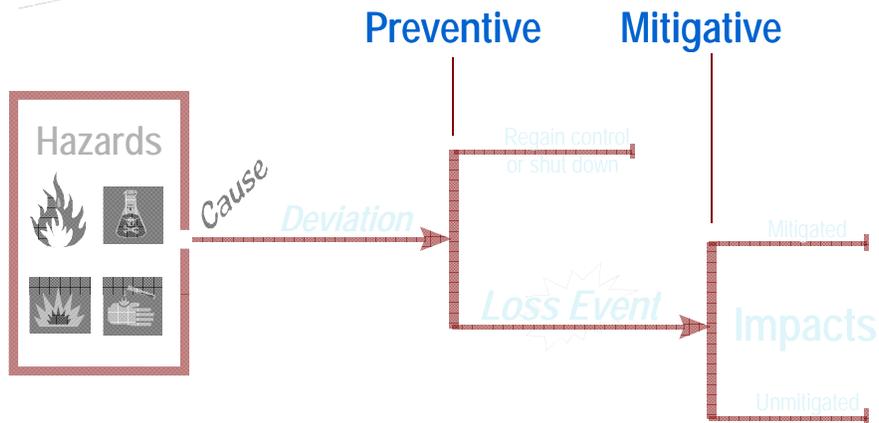
### Safeguard:

*Any device, system, or action that would likely interrupt the chain of events following an initiating cause or that would mitigate loss event impacts.*

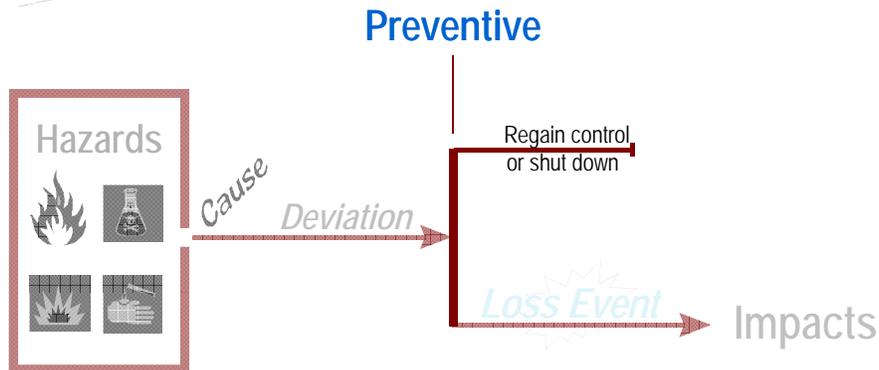
- CCPS 2008a Glossary

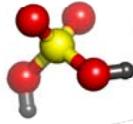


## Two types of safeguards



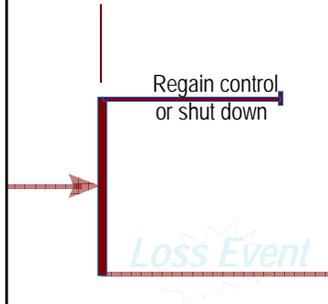
## Preventive safeguards





# Preventive safeguards

## Preventive

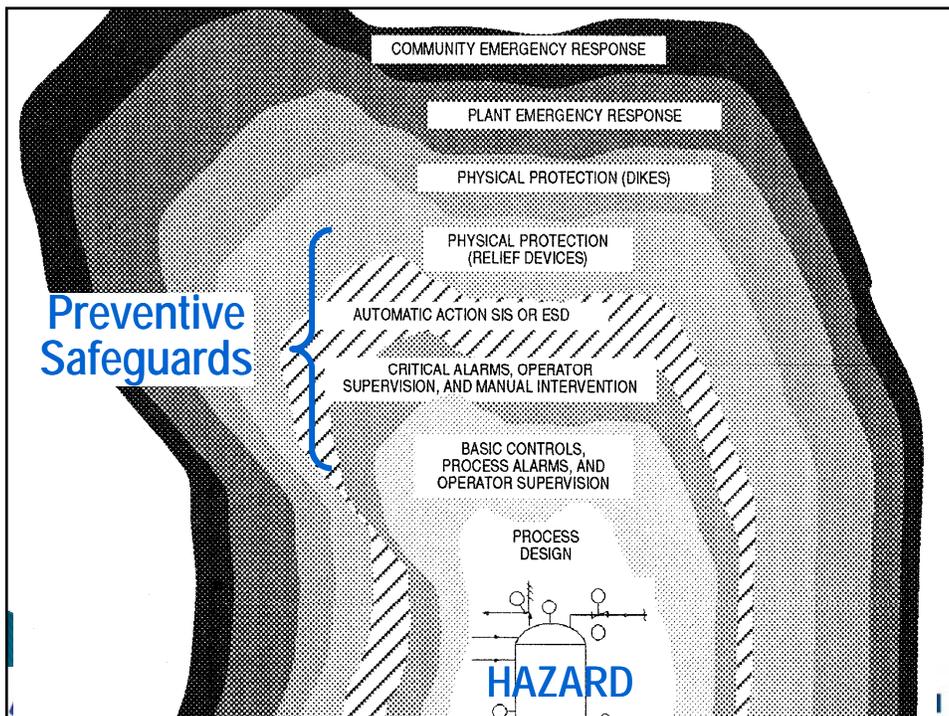


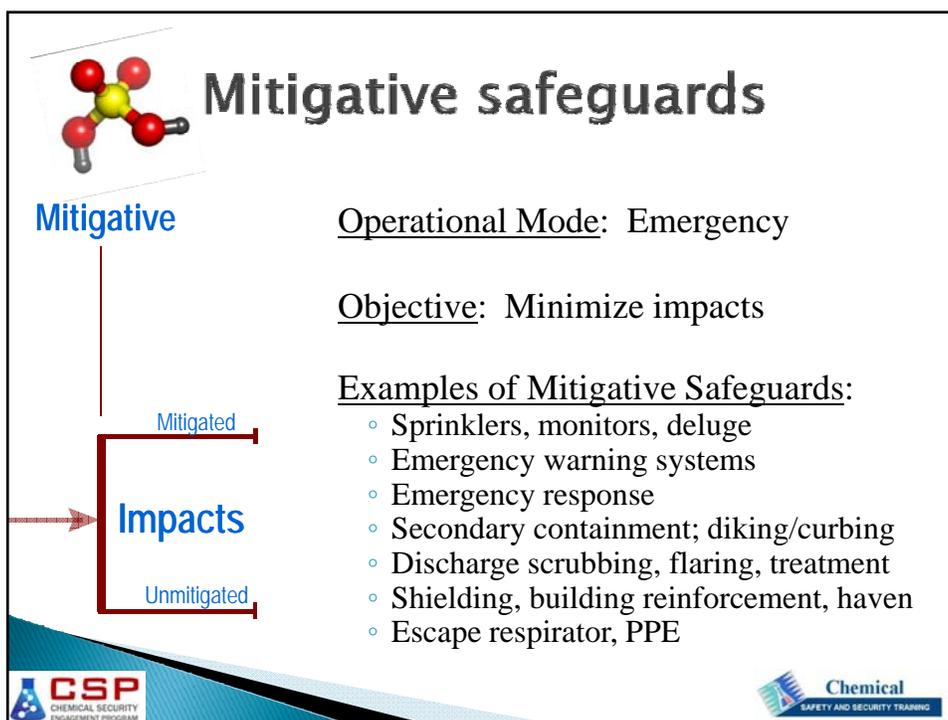
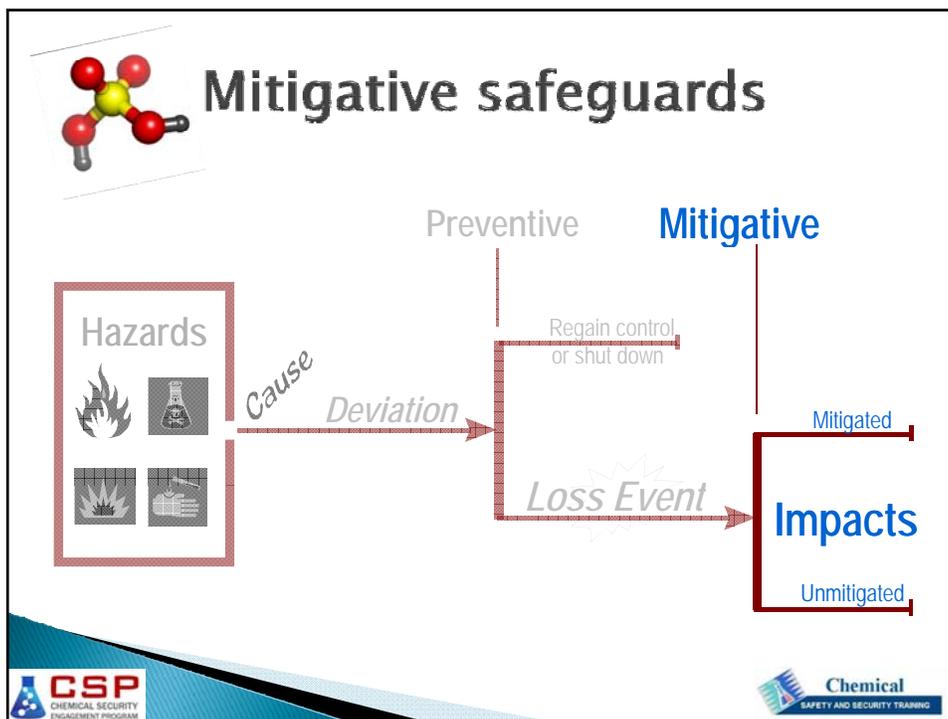
Operational Mode: Abnormal operation

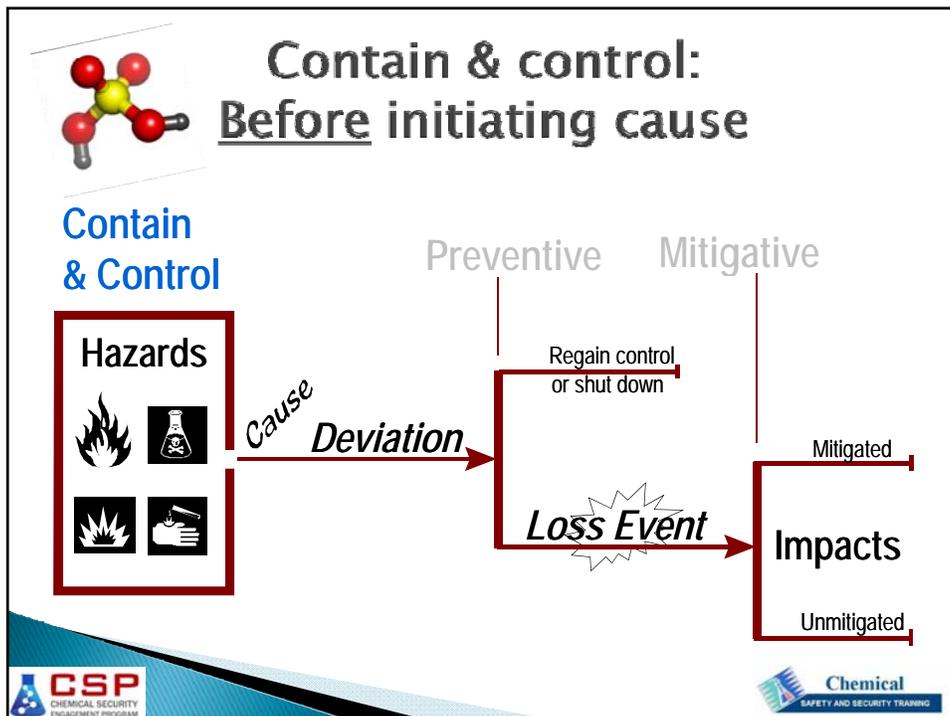
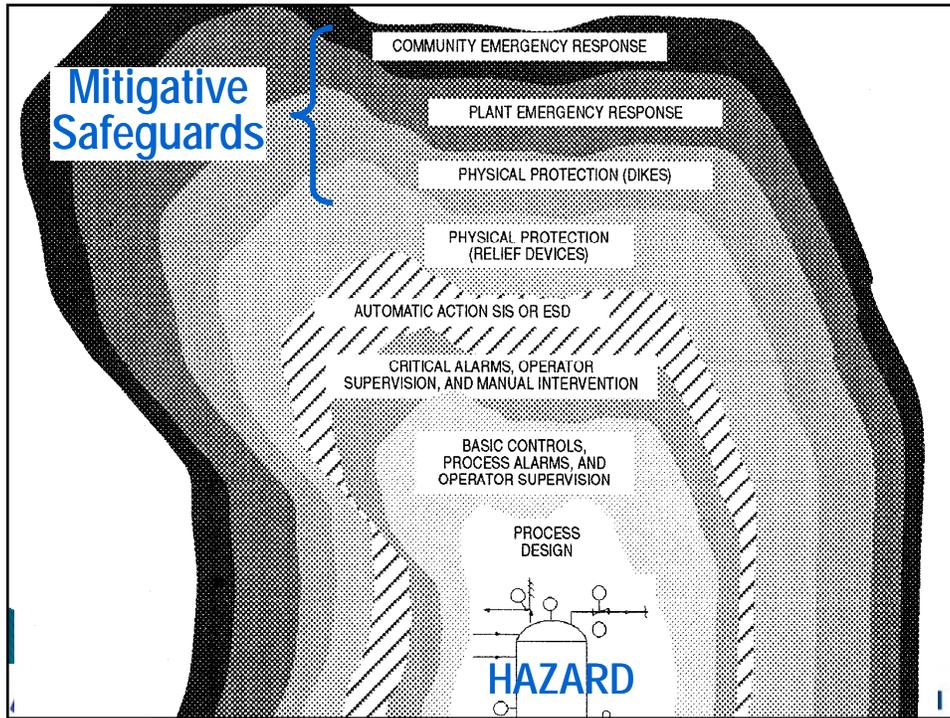
Objective: Regain control or shut down;  
keep loss events from happening

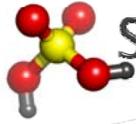
Examples of Preventive Safeguards:

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



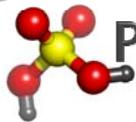
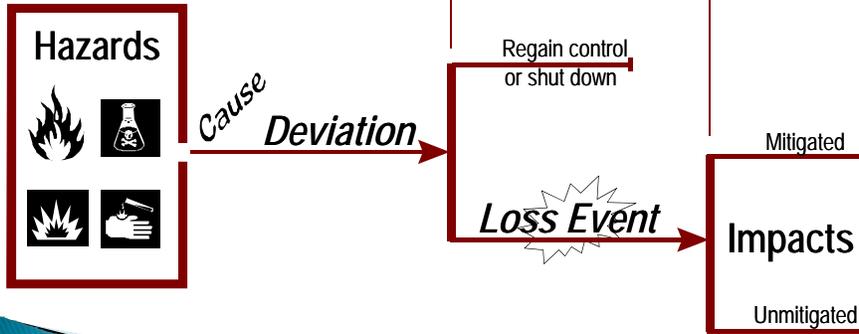






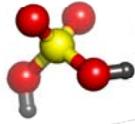
## Safeguards: After cause

Contain  
& Control



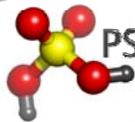
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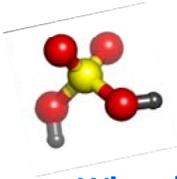
## Comprehensive PSM program elements

- ▶ Management systems
- ▶ Employee participation
- ▶ Process safety information
- ▶ Process hazard analysis
- ▶ Operating procedures
- ▶ Training
- ▶ Contractor safety
- Pre-startup safety reviews
- Mechanical integrity
- Safe work practices
- Management of change
- Emergency planning and response
- Incident investigation
- Compliance audits



## PSM elements covered in this course

- ▶ Management systems
- ▶ Employee participation
- ▶ Process safety information
- ▶ **Process hazard analysis**
- ▶ Operating procedures
- ▶ Training
- ▶ Contractor safety
- **Pre-startup safety reviews**
- **Mechanical integrity**
- **Safe work practices**
- **Management of change**
- **Emergency planning and response**
- **Incident investigation**
- Compliance audits



## DISCUSSION

What PSM elements do you think industrial facilities would find the most challenging to implement?

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