Chemical Security Engagement Program

Awareness Workshop: Basics of Chemical Safety and Security (CSS)

International Conference of Indonesian Chemical Society (ICICS 2012)
Malang, Indonesia
3 September 2012

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.

Sandia National Laboratories

Workshop Objectives

- Promote the safe and peaceful use of chemistry
- Appreciate the importance and benefits of Chemical Safety and Security (CSS)
  - To do top level work, you need top level CSS practices
- Encourage the creation of networks of people interested in CSS
  - Culture of Chemical Safety and Security

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Workshop Overview

- Orientation to Chemical Safety and Security (CSS)
- Fundamentals of CSS
- Laboratory Usage of Chemicals
- Emergency Equipment and Response
- Workshop Summary and Conclusions

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Introductions

- Introduce yourself to 2 or 3 people you do not know
  - What is your name?
  - Where are you from?
  - What is your background?
    - Professor or student?
    - Area of expertise?

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Orientation to Chemical Safety and Security

Overview: Orientation to Chemical Safety and Security

- Definitions of Chemical Safety and Security (CSS)
- Activity: Importance of CSS
- CSS Resources – Introduction to CSP
- Conclusions

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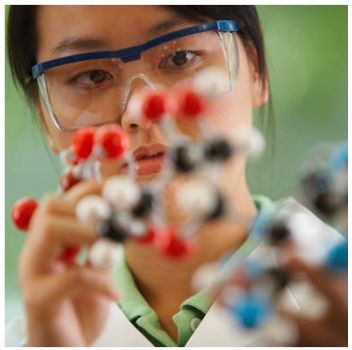
Chemical Safety and Security (CSS)

- Chemical Safety
  - Preventing and protecting against chemical laboratory **accidents**
- Chemical Security
  - Preventing and protecting against the **intentional misuse** of chemicals, people, or equipment for non-peaceful purposes

Our Goal: **Promote the Safe and Peaceful use of Chemistry**



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Activity: Importance of CSS

- Form groups of 4-5 people per group
- Discuss with your group to answer the questions:
  1. What are CSS hazards?
  2. Can you think of any well-known examples of CSS incidents?
  3. Who and what are potentially affected?
  4. What are the potential consequences?
  5. How common are CSS incidents?
  6. Have incidents ever happened at your institution or that of someone you know?
- Write down your answers and be prepared to share with the whole group

Take about 15-20 min

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Activity: Importance of CSS

1. What are CSS hazards?

- Hazard
  - Something that has the potential to do harm
    - Chemical
    - Physical
    - Biological
    - Radiological

Activity: Importance of CSS

2. Can you think of any well-known examples of CSS incidents?

- Sheharbano Sangji
- Los Angeles, USA 2008
  - Died from fire, *t*-BuLi
  - Inexperienced, proper training in question
  - UCLA Prof. Patrick Harran could face up to 4 ½ years in prison

www.chem-station.com
http://articles.latimes.com/2011/dec/28/local/la-me-1228-ucla-death-20111228

Activity: Importance of CSS

2. Can you think of any well-known examples of CSS incidents?

- Aum Shinrikyo
- Japan 1994-1995
  - Recruited young university scientists
  - Produced sarin and other chemical weapons
  - Killed ~20 and injured over 4000

Activity: Importance of CSS

3. Who and What are potentially affected?

- Laboratory personnel
- Research
- Faculty, Administrators, and Institutions
  - Careers
  - Reputations
  - Facilities
- Community
  - People
  - Relationships with institutions
- Economy
- Environment

Activity: Importance of CSS

4. What are the potential consequences?
5. How common are CSS incidents?
6. Have incidents ever happened at your institution or that of someone you know?

Activity: Importance of CSS

- Conclusions for Activity
  - Chemical laboratories have many types of hazards
  - There are many examples of notorious CSS incidents
  - CSS incidents happen too often and can cause severe harm
- Improving CSS will benefit
  - Laboratory personnel
  - Research
  - Faculty, Administrators, and Institutions
    - Careers, reputations, facilities
  - Community
  - Economy
  - Environment

CSS Resources

- Chemical Security Engagement Program (CSP)

www.csp-state.net

  - About CSP
  - Map of participating countries
  - Past and upcoming events
  - Photo galleries
  - Discussion board
  - Access resources
  - Contact us

Fill out name, email, and desired username
  - Will get an email to set your password

Conclusions: Orientation to Chemical Safety and Security

- Promote the safe and peaceful use of chemistry
- Benefits of improving Chemical Safety and Security (CSS) are far-reaching and significant
- After this workshop, you should be able to
  - Appreciate the importance and benefits of CSS
  - Help create networks of people interested in CSS

A culture of Chemical Safety and Security requires participation from everyone!

Workshop Overview

- ☑Orientation to Chemical Safety and Security (CSS)
- Fundamentals of CSS
  - Hazards
  - Controls
- Chemical Safety and Security Risk Assessment
- Laboratory Usage of Chemicals
- Emergency Equipment and Response
- Workshop Conclusions

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Fundamentals of Chemical Safety and Security

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Overview: Fundamentals of Chemical Safety and Security

- Laboratory Hazards
  - Chemical
  - Physical
  - Biological
  - Radiological
- Globally Harmonized System (GHS) Hazard Labels
- GHS Safety Data Sheets (SDS)
- Hierarchy of CSS Controls
- Conclusions

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Laboratory Hazards

- Chemical Hazards
  - Toxic
    - Principles of Toxicity
    - Acute Toxins
    - Irritants, Corrosives, and Allergens
    - Organ-targeting
    - Carcinogens
  - Flammable
  - Reactive
  - Explosive
  - Chemicals of Concern (COCs)
- Physical Hazards
- Biological Hazards
- Radiological Hazards

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Chemical Hazards: Principles of Toxicity

Toxicity Depends on Dose

Chemical	Beneficial Dose	Toxic Dose
Aspirin	300–1000 mg	1000–30,000 mg
Vitamin A	500 units/d	50,000 units/d
Oxygen	20% in air	50–100% in air
Water	~1-2 L/day	~13 L

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison from a remedy."

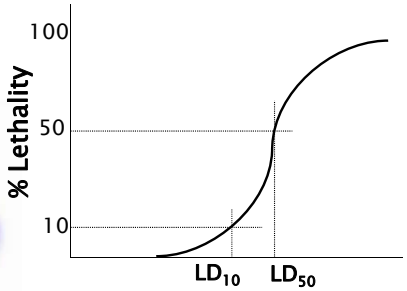
– Paracelsus (1493–1541)

Chemical Hazards: Principles of Toxicity

Toxicity is Measured by Lethality

- LD_{50} (mg/kg)
  - "Lethal Dose 50%"

Dose–Response Curve



Chemical Hazards: Principles of Toxicity

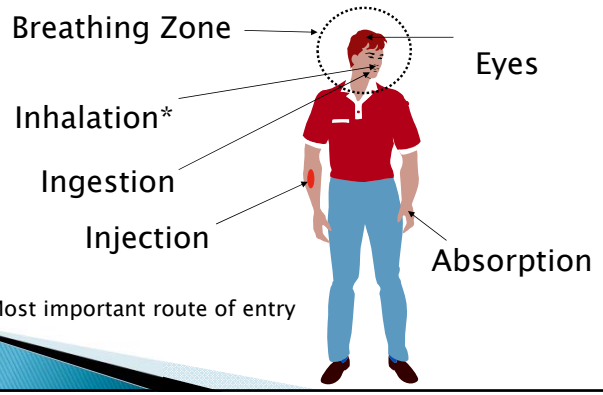
- Extremely wide range of toxicities between different substances

Agent	LD_{50} (mg/kg)
Ethanol	7060
NaCl	3000
Formaldehyde	800
Caffeine	192
Nicotine	1
Dioxin	0.0001

Toxicity depends on a variety of factors

Chemical Hazards: Principles of Toxicity

Routes of Exposure



*Most important route of entry

Chemical Hazards: Principles of Toxicity

- Acute
  - Cause harm right away
- Chronic
  - May only see effects after extended exposure, or later in life after repeated exposures

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Chemical Hazards: Acute Toxins

- Includes highly toxic chemicals/poisons
  - Phosgene
  - Strychnine
- Includes common lab chemicals
  - Cyanides
  - Cl_2

Need to ensure safety and security when using and storing acute toxins

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Chemical Hazards: Irritants, Allergens, and Corrosives

- Irritants
  - Effects are local and reversible
- Corrosives
  - Effects are local
  - Acids and bases
    - pH ≤ 2 or ≥ 12.5
  - React with and damage living tissue
- Allergens (and sensitizers)
  - Cause a reaction of the immune system

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Chemical Hazards: Organ-Targeting

- Neurotoxins
  - Ethanol, Hg, CS_2, xylene, *n*-hexane
- Reproductive and Developmental Toxins
  - Harm fertility or reproductive ability
  - Harm fetus
- Other Organs
  - Liver, kidneys, lungs, etc.
  - Chlorinated or aromatic hydrocarbons, some metals

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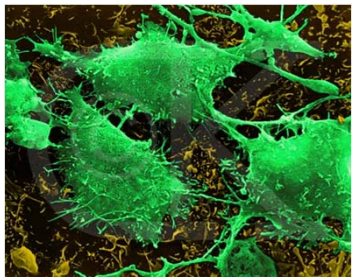
Chemical Hazards: Carcinogens

- Chronically Toxic
  - Vinyl chloride (liver cancer)
  - Asbestos (mesothelioma)
- Carcinogenicity of most chemicals is untested
  - Precautions taken may consider amount and frequency of use
- Treat known carcinogens as particularly hazardous



http://www.alternative-cancer.net/images/Cancer_cell,%20brain.jpg

Chemical Hazards: Flammable

- Fuel: Solids, Liquid, or Gases
  - Compressed or liquefied gases are especially hazardous
- Oxidant
  - Oxygen in air
  - Other oxidants
    - Cl_2, HNO_3
- Ignition
  - Spark
  - Heat

- University of California, Santa Cruz, 2002
  - Lab fire, cause not determined
  - Lost equipment, notes, samples, etc.
  - Labs took 2 years to reopen

Chemical Hazards: Reactive

- Water-reactive
- Pyrophoric materials
- Incompatible Chemicals
  - Combination leads to reactive or toxic hazards
    - Concentrated oxidizing or reducing agents

http://science.pixeladdiction.co.uk/?page_id=57

Chemical Hazards: Explosive

- Initiated by
  - Heat
  - Light
    - $H_2 + Cl_2$
  - Mechanical shock
    - Nitro, peroxo, chlorates
  - Certain catalysts
    - Acid/base catalyzed polymerization
- Dusts
- Peroxide-formers
  - Dialkyl ethers

- Texas Tech University Chemistry Lab, 2010
  - Synthesis of explosive compound
    - Scaled-up without precautions
    - One graduate student severely injured

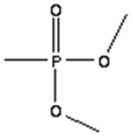
http://www.csb.gov/investigations/detail.aspx?SID=90&Type=2&pg=1&F_InvestigationId=90

Chemical Hazards: Chemicals of Concern (COCs)

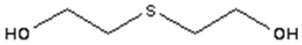
- Dual-Use
  - Peaceful
    - Research, production
  - Not peaceful
    - Diversion, sabotage

Examples:

1. Dimethyl methyl phosphonate (DMMP)
   - Flame retardant
   - Nerve agent precursor



2. Thiodiglycol
   - Dyes/inks, cosmetics, pharmaceuticals, polymers, coatings, etc.
   - Mustard gas precursor



Chemical Hazards: Chemicals of Concern

- Presence or suspected presence of COCs in your laboratory could make you and your institution a target
  - Outsider Threat
  - Insider Threat

Example: Outsider Threat

- Chicago, USA, 2002
  - Joseph Konopka arrested in tunnels under the University of Illinois
  - Had NaCN on him and a stockpile of stolen chemicals including NaCN and KCN in subway
  - Sentenced to 13 years in prison for "possessing a chemical weapon" and other charges

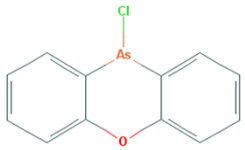
http://articles.cnn.com/2002-03-12/us/chicago.cyanide_1_cyanide-in-chicago-subway-sodium-cyanide-chicago-police?_s=PM:US

http://articles.chicagotribune.com/2004-01-04/features/0401040453_1_tunnels-urban-exploration-city-hall

Chemical Hazards: Chemicals of Concern

Example: Insider Threat

- Philadelphia, USA, 2007
  - Carol Anne Bond, microbiologist
  - Stole 10-chlorophenoxyarsine from work
  - Attempted to poison her husband's lover
  - Case is still in court



It is important to recognize the safety and security hazards posed by chemicals

http://articles.cnn.com/2011-06-16/justice/us.scotus.poisoned.paramour_1_potassium-dichromate-myrlinda-haynes-carol-anne-bond?_s=PM:CRIME

http://www.chemindustry.com/chemicals/0437452.html

Laboratory Hazards

- ☑ Chemical Hazards
  - ☑ Toxic
    - ☑ Principles of Toxicity
    - ☑ Acute Toxins
    - ☑ Irritants, Corrosives, and Allergens
    - ☑ Organ-targeting
    - ☑ Carcinogens
  - ☑ Flammable
  - ☑ Reactive
  - ☑ Explosive
  - ☑ Chemicals of Concern (COCs)
- Physical Hazards
  - Compressed gases
  - Cryogens, Pressure, and Temperature
  - Electrical
  - Mechanical and Other
- Biological Hazards
- Radiological Hazards

Physical Hazards: Compressed Gases

- Pressure
- Also chemical hazard depending on gas
  - Toxic
  - Reactive
  - Flammable
- Asphyxiation

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Physical Hazards: Cryogens, Pressure, and Temperature

- Cryogens
  - Dry ice
  - Liquid nitrogen
    - Contact
    - Oxygen condensation
    - Asphyxiation
    - Pressure
- Pressure
  - High, above ~1 atm
  - Vacuum work
- Temperature

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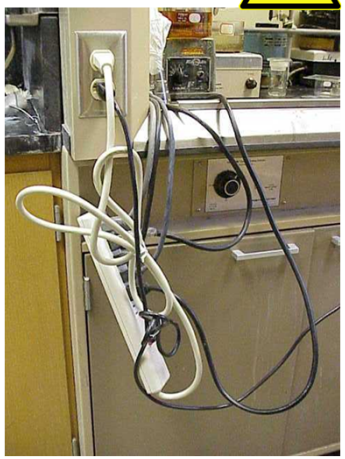
Physical Hazards: Electrical

- Power outages
- Shock
- Fire
- Frayed cords
- Overloaded circuits
  - Daisy chains
- Static electricity



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Physical Hazards: Mechanical and Other

- Mechanical
  - Noise
  - Moving parts
    - Yale University, 2011
      - Student dies after getting hair caught in lathe (machine shop of chemistry lab)
- Other
  - Sharps
  - Slips, trips, falls
  - Housekeeping
    - Fire
    - Blocked exits

http://www.waterfront-woods.com/Projects/Lathe/lathe1.JPG

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Laboratory Hazards

- ☑ Chemical Hazards
  - ☑ Toxic
    - ☑ Principles of Toxicity
    - ☑ Acute Toxins
    - ☑ Irritants, Corrosives, and Allergens
    - ☑ Organ-targeting
    - ☑ Carcinogens
  - ☑ Flammable
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  - ☑ Explosive
  - ☑ Chemicals of Concern (COCs)
- ☑ Physical Hazards
  - ☑ Compressed gases
  - ☑ Cryogens, Pressure, and Temperature
  - ☑ Electrical
  - ☑ Mechanical and Other
- Biological Hazards
- Radiological Hazards

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Laboratory Hazards: Biological

Pathogens

- Route of infection
  - Food or water borne
    - Salmonella
  - Blood borne
    - Hepatitis, HIV
  - Airborne
    - Tuberculosis
- Reason for exposure
  - Diagnostic work
  - Research work

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Laboratory Hazards: Radiological

- Ionizing Radiation
  - X-rays
  - Gamma rays
  - Alpha particles
  - Beta particles
  - Neutrons
- Ionizing Radiation Sources
  - Radioactive isotopes
    - ^{3}H, ^{14}C, ^{32}P, ^{35}S, ^{131}I
  - Instruments
    - Diffractometer
    - Electron microscope
- Nonionizing Radiation
  - Ultraviolet
  - Infrared

- Primarily an eye hazard

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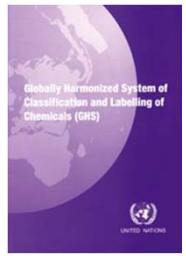
The Globally Harmonized System (GHS) of Classification and Labeling of Chemicals

- A system for standardizing and harmonizing the classification and labeling of chemicals
- Not a regulation or a standard.
  - establishes agreed hazard classification and communication provisions with explanatory information on how to apply the system
- GHS Labels and Safety Data Sheets (SDS)



http://www.osha.gov/dsg/hazcom/ghs.html

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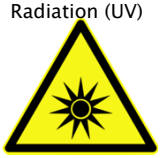
Globally Harmonized System (GHS) Hazard Labels

Corrosive	Irritant	Health Hazard	Acute Toxicity
			
Flammable	**Explosion**	**Oxidizer**	**Compressed Gas**
			

Globally Harmonized System (GHS) and Other Hazard Labels (ISO)

Environmental	Electricity	Hot Surface	Pinch Point
			
Biohazard	**Radioactive**	**Laser Beam**	**Optical Radiation (UV)**
			

GHS Safety Data Sheets (SDS)

- Comprehensive information for chemical management
- Use GHS hazard symbols
- Written and supplied by manufacturer
  - Online

16 sections, examples:

2. Hazards
   - Physical
   - Health
   - Environmental
   - Other
4. First aid measures
5. Firefighting
6. Handling and storage
7. Exposure controls/PPE

Drawbacks?

GHS Safety Data Sheets (SDS)

- Drawbacks
  - Not always current
  - Lack of toxicity information for most chemicals
  - Industry focus, not specific to laboratory scale
  - Sometimes inconsistent

SDS contains comprehensive information for chemical management in one place

Keep SDS for each chemical in your inventory

Module Overview: Fundamentals of Chemical Safety and Security

- ☑ Laboratory Hazards
  - ☑ Chemical
  - ☑ Physical
  - ☑ Biological
  - ☑ Radiological
- ☑ Globally Harmonized System (GHS) Hazard Labels
- ☑ GHS Safety Data Sheets (SDS)
- Hierarchy of CSS Controls
- Conclusions

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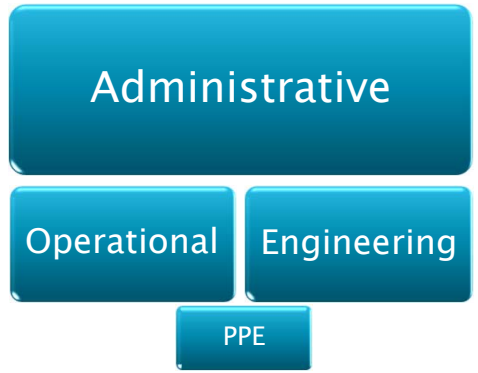
Hierarchy of CSS Controls

- Purpose
  - Safety
  - Security
- Administrative
- Operational
- Engineering
- PPE



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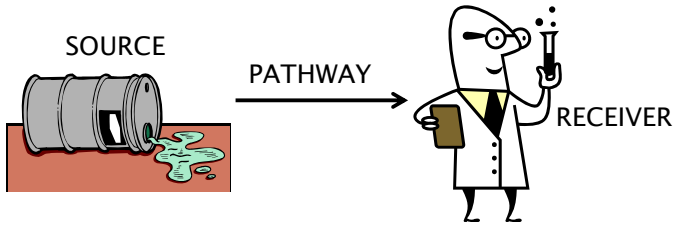
CSS Controls: Safety Purpose



1. Eliminate the source
2. Block the pathway
3. Protect the receiver

Chemical Safety Controls:
Protect People from Chemicals

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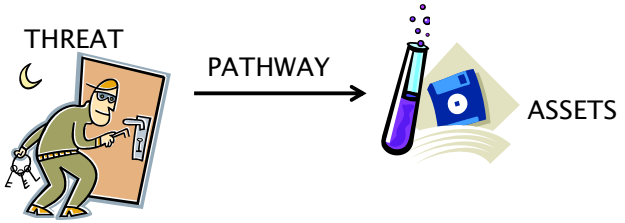
CSS Controls: Security Purpose



1. Eliminate the threat
2. Block the pathway
3. Protect the assets

Chemical Security Controls:
Protect Chemicals (assets) from People

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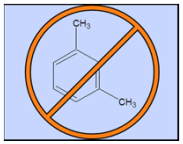
CSS Controls: Administrative

- Develop CSS policy
  - Communicate expectations regarding CSS
    - Prevent and mitigate CSS incidents
    - Build CSS into all operations
    - Comply with laws and regulations
    - Continually improve performance
- Implement CSS policy
  - Establish a CSS program
    - Assessments and reporting
    - Training
  - Appoint CSS personnel
    - Committee
    - CSS Officer
  - Provide resources and support
    - Incentives
    - Enforcement

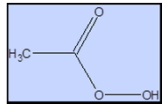
Administrative | Operational | Engineering | PPE

CSS Controls: Operational

- Standard Operating Procedure (SOP)
- Substitution
  - Use a less dangerous chemical
    - Alcohol thermometers instead of Hg
    - Citrus-based solvents instead of xylene



- Peracetic acid instead of formaldehyde



Administrative | Operational | Engineering | PPE

CSS Controls: Operational

- Scale Down
  - Procure and use a smaller amount of the dangerous chemical
    - Smaller cost
    - Smaller hazard
    - Easier to store
    - Easier to dispose

6th International Symposium on Microscale Chemistry, Kuwait, 2011
http://www.6ismc2011.com/images/welcome_img.jpg

Administrative | Operational | Engineering | PPE

CSS Controls: Engineering

- Isolate or enclose the process, hazardous material, or worker
  - Barrier (blast shield)
  - Ventilation (laboratory hood)
- Create barriers between threat and target
  - Control access to institution
    - Campus
    - Building
  - Lock laboratories and chemicals (especially COCs) when not in use

Blocks the pathway from source to receiver, or threat to target

Administrative | Operational | Engineering | PPE

CSS Controls: Personal Protective Equipment

- Last line of defense
- For emergency or spill response
  - Glasses or goggles
  - Gloves
  - Laboratory coats
  - Respirators
  - Footwear
  - Eyewash and emergency shower
- Must be appropriate for the specific hazards

- Hanover New Hampshire, USA, 1996
- Prof. Karen Wetterhahn, Dartmouth College
  - Spilled a few drops of dimethylmercury on latex glove
  - Died 6 months later

Administrative

Operational | Engineering

PPE

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Conclusions: Fundamentals of Chemical Safety and Security

- Recognizing laboratory hazards is an important first step in improving CSS
  - GHS hazard labels and SDSs are an important part of hazard recognition
- Appropriate controls are based on the hazards
  - Should address both safety and security concerns

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Chemical Safety and Security Risk Assessment

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Risk Basics Overview

- Hazard vs. Risk
- Definition of Risk
- Safety and Security
- Risk Characterization
- Risk Reduction

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Risk Basics: Hazard vs. Risk

- There is a difference between ***hazard*** and ***risk***
  - Hazard
    - Something that has the potential to do harm
- Is there a hazard in this picture? If so, what type?
- Is it a risk? If so, how much of a risk?
  - Depends on the situation
    - Probability that harm will result,
    - Consequence is a factor.

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Risk Basics: Hazard vs. Risk

- What is wrong?
  - Overloaded circuit

Hazard

- What are the possible scenarios?
  - Blown fuse
  - Electrical shock
  - Fire
- What is the likelihood?
  - Factors that lead to an event
    - Plugged in, broken/frayed cords, near oily rags
- What are the consequences?
  - Other factors and things that follow an event
    - Voltage, fire alarms, evacuation

Risk

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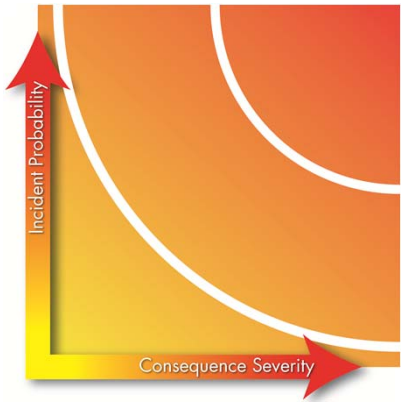
Risk Basics: Definition

- Risk is a function of
  - Probability that an incident will occur (**likelihood**)
  - Severity if the event occurs (**consequence**)



Risk = *f*(Likelihood, Consequence)

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Risk Basics: Definition

College Students

1. Nuclear Power
2. Smoking

4. Motor Vehicles

Experts

1. Motor Vehicles
2. Smoking

12. Nuclear Power

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Activity: Risk Perception

- What do you think may have influenced your risk assessment besides your best guesses regarding ***likelihood*** and ***consequence***?
- Emotional Risk Perception Factors (examples)
  - Involuntary vs. Voluntary
  - Immoral vs. Moral
  - Unfamiliar vs. Familiar

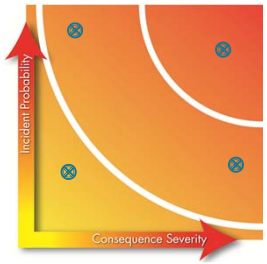
What ***should*** be the basis for your professional Risk Assessment of Chemical Safety and Security?

Risk Basics: Safety and Security

- Risk concept
  - Applies to both Chemical ***Safety*** and Chemical ***Security***
- Safety Incident
  - Spill
  - Accidental exposure
  - Uncontrolled reaction
- Security Incident
  - Theft or diversion of dual-use chemicals
  - Intentional release
  - Sabotage

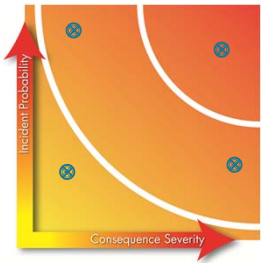
Safety Risk Characterization

1. Low
   - Laboratory procedures are routine; staff is trained and experienced; materials used are mostly benign and/or present in microscale amounts only
   - An incident would not likely be an emergency
2. Moderate
   - Procedures are not routine; staff may be partially trained or have limited experience; materials are reactive, flammable, toxic, and/or present in moderate quantity
   - An incident could constitute or develop into an emergency
3. High
   - Procedures are novel or extremely delicate; staff may be untrained or inexperienced; materials are highly reactive, toxic, explosive and/or present in large quantities
   - An incident would be a life and facility-threatening emergency



Security Risk Characterization

1. Low
   - Assets are possibly targets for theft or diversion
   - Consequences of loss or release are minimal
2. Moderate
   - Assets are attractive for theft or diversion due to monetary value or dual-use
   - Consequences could threaten the public; misuse could be harmful or even lethal to a small number of people, and would certainly damage the institution, its programs, and reputation
3. High
   - Assets are very valuable or hard to acquire dual-use materials
   - Consequences of misuse could result in harm or death to many people



Safety and Security Risk Characterization

- What are the benefits of characterizing risks?
- Can risks ever be reduced to zero?
- What does it take to reduce CSS risk?
  - Are resources for risk reduction limitless?

Characterizing CSS risks is a necessary step toward responsible and effective allocation of finite resources to reduce risk to acceptable levels

Risk reduction measures should always be applied in a graded manner

Large effort made to reduce high risks
Smaller effort made to reduce low risks

Risk Basics: Reduction

- Types of CSS Controls
  - Administrative
  - Operational
  - Engineering
  - PPE
- Decrease likelihood
- Decrease consequence

Risk = *f*(Likelihood, Consequence)

Workshop Overview

- ☑Orientation to Chemical Safety and Security (CSS)
- ☑Fundamentals of CSS
- ☑Chemical Safety and Security Risk Assessment
- Laboratory Usage of Chemicals
- Emergency Equipment and Response
- Workshop Summary and Conclusions

Laboratory Usage of Chemicals

Module Overview

- Labeling
- PPE
- Storage
- Transportation
- Inventory
- SOP
- Waste/Disposal

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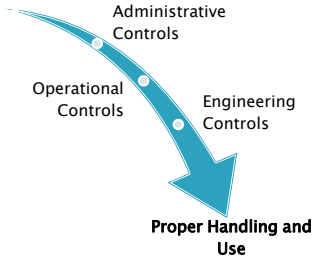
Key Principals of Chemical Usage

- Prevent Accidents/Harm
- Prevent Environmental Exposure

- Topics Discussed:
  - Labeling
  - Personal Protective Equipment (PPE)
  - Storage
  - Inventory
  - Standard Operating Procedure (SOP)
  - Waste/Disposal



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Labeling Basics

- Proper Labeling of Laboratory Hazards
  - Chemical
  - Physical
  - Biological
  - Radiological

Just ignore the label...
The worst stuff isn't listed anyway.

- Globally Harmonized System (GHS) Hazard Labels

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Recall: Globally Harmonized System (GHS) Hazard Labels

Corrosive	Irritant	Health Hazard	Acute Toxicity
			
Flammable	**Explosion**	**Oxidizer**	**Compressed Gas**
			

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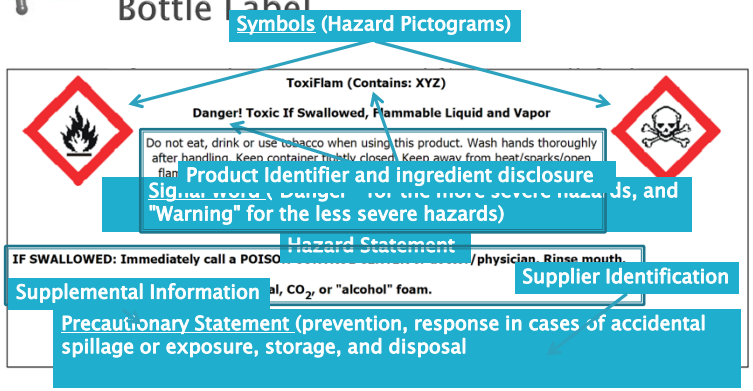
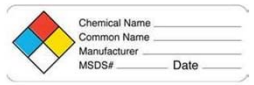
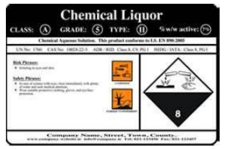
GHS Labels Elements: Example Bottle Label

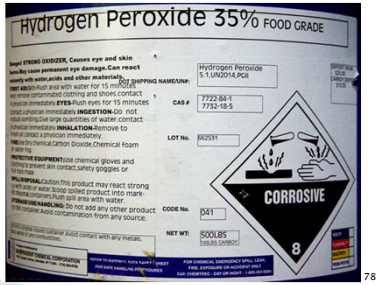


Example Labels

- Label Creation







Other Labeling Considerations

- Chemical Resistance
- Environmental Resistance
  - Heat, Fridge, Freezer
- Age
- Size
  - Label
  - Container
- Attachment to Bottle

Overview

- ☑Labeling
- PPE
- Storage
- Transportation
- Inventory
- SOP
- Waste/Disposal

General Considerations: PPE Proper Use and Training

Proper Use

- Demonstrated, by management and leaders
- Made an aspect of laboratory inspections
- Remove PPE when leaving the lab area
  - Gloves
  - Lab coats

PPE Training

- Initial training for new personnel
  - How to select PPE
  - How to use PPE
    - Don, doff, adjust, and wear
  - Limitations of PPE
  - Care for, store, maintain, and dispose of
- Retraining
  - Change in the process
  - Change in type of PPE used
  - Failed inspection
  - Periodically to reinforce understanding or skill

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PPE: Head and Face

- Helmets
- Eye Protection
  - Glasses
  - Goggles
  - Face Shields
- Breathing Zone
  - Dust, hospital masks
  - Air purifying respirators
  - Supplied air

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Head and Face: Helmets

- Rarely required in laboratory or research settings
- May be required in industrial or other settings
- Many different types
  - Know hazards and standards for protection
    - Impact
    - Penetration
    - Electric shock

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Head and Face: Eye Protection

- Laboratory eye hazards
  - Chemicals
    - Splash, vapor, mist
  - Impact
    - Sharp objects, flying debris
  - Light
    - Lasers, UV light, glare
  - Heat
  - Dust

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Head and Face: Eye Protection

- Safety glasses
  - Protect from impact, sharp or flying objects (notice side shields)
  - Certain types protect from light
- Splash goggles
  - Protect against liquids and objects
- Face shields
  - Should be combined with safety glasses or goggles
    - Do not protect from impact hazards alone
  - Certain types protect from light
- What are the barriers to proper use?

Head and Face: Breathing Zone

- Inhalation hazards
  - Dusts, particulate matter, aerosols
  - Chemical gases, fumes
- Dust masks and hospital masks
- Air purifying respirators (APR)
  - Many types and variations
  - Particulate filters
    - Effective for dusts and aerosols
    - High efficiency particulate air (HEPA) filter
    - Also not effective for chemicals
  - With chemical filters
    - Remove chemicals, gas, fumes from air breathed
      - Full or half face
    - Specific types are required depending on different chemicals

Head and Face: Breathing Zone

Other limits and requirements of air purifying respirators

- Can only handle limited chemical concentrations, have limited capacity
  - End of service life indicator
- Require proper maintenance and storage
  - Label with expiration date
  - Some types are disposable, dispose of cartridges based on expiration date, or end-of-service life indicator
  - Store in a clean, dry, container sealed air-tight
- Require proper fitting and training for use
  - No beards
  - Fit is specific for each person, requires fit testing
- Still need air with normal amount of O_2
  - Filtration for dusts and aerosols
  - Absorption, adsorption, or chemical reaction for chemicals and gases

Head and Face: Breathing Zone

- Supplied air
  - Air line
  - SCBA
  - Not common, very specialized
    - Extreme hazard environments
    - Expense
    - Training
    - Maintenance

PPE: Body

- Clothing
- Lab coats
- Specialized suits

Body: Clothing

- What is appropriate dress for the laboratory?
- Should cover all exposed skin from feet to neck
- Short sleeves may or may not be appropriate
- Should not be loose or dangling
  - Same goes for hair

Body: Lab Coats

- Protective value should not be underestimated
  - Corrosive chemicals
  - Fire
- Which materials are best?
- Who should wash them and how?
- Specialized types may be appropriate depending on hazards
- What are the barriers to proper use?

Body: Specialized Suits

- Many types depending on the specific hazards and risk level
- Not common in chemical research laboratories
- Used for special situations
  - Highly infectious biohazards
  - Emergency, or hazmat response

PPE: Hands

- Hazards
- General glove considerations
- Types of gloves
- Technique for removing gloves

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Hands: Hazards

- Hazards
  - Chemical exposures
  - Extreme temperatures
  - Abrasion, sharp objects

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General Glove Considerations

- Grip: oily, wet, dry
- Comfort, fit, size
- Type of glove
  - Disposable or reusable
- Always wash hands after removing gloves
- Exposure time
- Breakthrough time
- Permeation
  - Substances pass through intact material on a molecular level
- Penetration
  - Substances pass through seams, zippers, stitches, pinholes, or damaged material
- Degradation
  - Substance damages material making it less resistant or resulting in breakdown
- Contamination
  - Substances transferred to the inside of the glove
- Use a glove chart or glove selection guide

www.bestglove.com/site/chemrest/

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Hands: Types of Gloves

- Latex, natural rubber
- Polyethylene/Ethylene-vinyl Alcohol {"Silver Shield®"}
- Butyl Rubber
- Viton
- Nitrile (acrylonitrile-butadiene rubber)
- Neoprene
- Poly vinyl chloride (PVC)

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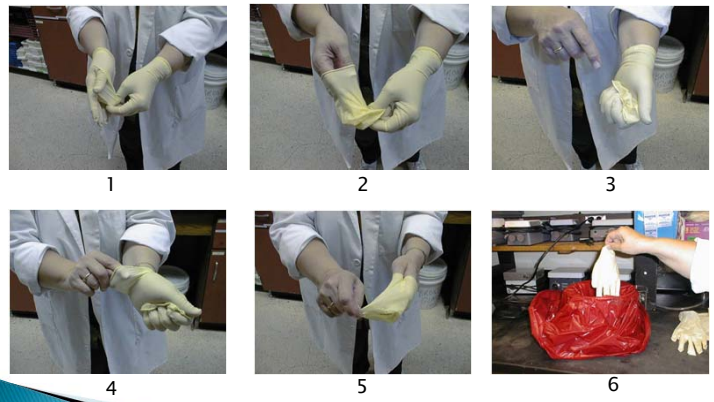
Technique for Removing Gloves



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General Glove Considerations

Should NOT wear gloves, lab coats or other PPE outside the lab.

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PPE: Feet

- Proper shoes
  - Cover all of foot from toe to heel
  - Provide some protection
    - Chemical spill or splash
    - Sharp objects
    - Non-skid, slip resistant

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PPE: Feet

- Special footwear required in certain circumstances
  - Chemical resistant
  - Steel toe
  - Temperature resistant
  - Anti-static
  - Electrical resistant, insulating

http://www.conney.com/wcsstore/Conney/images/fullsize/13678.gif

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Conclusions

- PPE is the last line of defense against laboratory hazards
- To be effective, PPE must be properly selected and individuals must be trained in its proper use
  - There are limitations and requirements for each type of PPE
  - Many resources exist to help you find the detailed information necessary

Overview

- ☑Labeling
- ☑PPE
- Storage
- Transportation
- Inventory
- SOP
- Waste/Disposal



Storage

- General Guidelines
- Compressed Gas Cylinders
- Examples
- Access Control

Storage: General Guidelines

- Separate incompatible chemicals
  - Organize by groups
  - Alphabetize only within groups
- Separate flammables and explosives from ignition sources
  - flammable storage cabinets
- Large containers on bottom shelves
- All containers properly labeled and closed

Storage: General Guidelines

- Wipe-off outside of container before returning to storage area
- Use secondary containment
  - Label with compatibility group
- Fasten storage shelves to wall or floor
- Shelves should have a lip and/or rod

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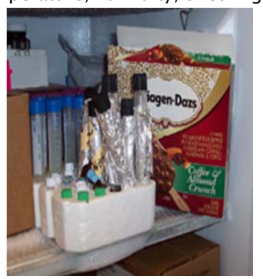
Storage: General Guidelines

- **Do Not Store Chemicals**
  - On top of cabinets
  - On the floor
  - In hoods
  - In hallways
  - With food
  - Where there are wide variations in temperature, humidity, or sunlight



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Storage: Reactive Chemicals

- Water reactive, pyrophoric, oxidizers
- Peroxide-forming
  - Ethers, butadiene, furans, others
  - Store in tightly closed original container
  - Avoid exposure to light, air, heat
  - Crystals or discoloration? Do not move or open container
  - Test for peroxides before using
    - Especially if distilling/concentrating
  - Know when to dispose
    - Mark when opened
    - Dispose even if unused

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Storage: Compressed Gas Cylinders

- Store in well-ventilated area away from direct sun
- Keep from being knocked over
- Screw down cylinder caps
- Separate incompatible gases

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Storage: Refrigeration

- Types
  - Ordinary, household refrigerator/freezers
    - NOT safe for flammables
  - Flammables-safe refrigerator/freezer
    - May contain flammables, but are NOT safe to be in areas with flammable vapors
  - Explosion-proof storage
- Proper refrigerator/freezer labeling
- Precautions
  - Stable power
  - Not all refrigerants are completely safe
    - Toxicity, flammability, and physical hazards
- Do not store peroxide formers in a refrigerator
- Defrost occasionally to prevent chemicals from becoming trapped in the ice formations

Storage: Access Control

- Access limitations depend on the material or information
  - More control of access if COCs are present
- Lock areas, rooms, cabinets
  - Control of keys
- Label areas "Authorized Personnel Only"
  - Means of identifying authorized personnel
    - Challenge unfamiliar people in restricted areas
- Authorized personnel
  - Trusted, background check
  - Trained
  - Legitimate need

Storage: Examples

Overview

- ☑Labeling
- ☑PPE
- ☑Storage
- Transportation
- Inventory
- SOP
- Waste/Disposal

Transportation

- Hazardous Shipments
- Modes of Transport
- Regulations
- Packaging
- Labels
- Documentation
- Emergencies and Security

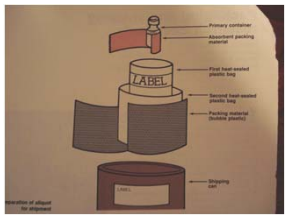
Transportation: Packaging Basics

- Protect sample integrity
  - Label (fragile, Etc.)
  - Bump, shock, drop
- Elements/Nature
  - Temperature
  - Moisture/Humidity
  - Sunlight

Transportation: Packaging

- Container within a container
- Specific requirements depend on material and other factors

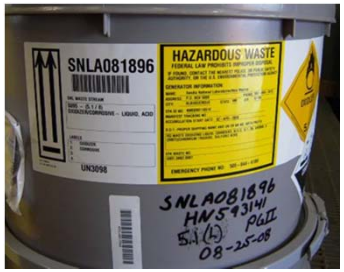
External/Shipping Packaging



Hand Carry Example

Transportation: Labels

- Identify material
  - Proper, full chemical name
  - ID codes (e.g., UN number)
  - Quantities, concentrations, number of containers
- Hazard class according to regulations
  - Transport symbols
- Emergency information
- Contact names and phone numbers
- Languages
- Proper universal symbols



Transportation Handling

- Where, how, who opens shipment?
- Should package be opened in a hood?
- Is material radioactive, flammable, reactive, explosive, etc.?
- Is monitoring equipment needed?
- Is special storage needed on receipt?

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Internal Transportation

- Many different types to choose from
  - Plan ahead
- Secondary Containment
  - Hand carry
- Carts
  - PPE
  - Spill kit

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Transport of Gas Cylinders

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Overview

- ☑Labeling
- ☑PPE
- ☑Storage
- ☑Transportation
- Inventory
- SOP
- Waste/Disposal

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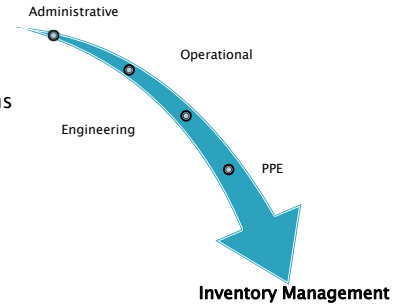
Inventory

- Creation
- Database
- Access Control
- Inspection
- Reporting and Conclusions

Inventory

- "Living" database of chemicals
  - Updated with procurement, transport, use, and disposal
- Requires training and maintenance with inspections
- Control access to database
- Ensure control and accountability
  - Designated owner
  - No orphan chemicals
- May be required for regulatory compliance



Inventory Management Best Practices

Inventory: Creation

- Database of chemicals in possession
  - Simple system
    - Appropriate for small inventories
  - Computer/web-based
    - Barcodes
    - More useful with larger inventories

- Each chemical is accounted for
  - Designated owner
  - No orphan chemicals
  - For synthesis labs
    - Enter synthesis products into inventory or just label properly

Inventory: Database

- Name
  - IUPAC, common, trade
- CAS number
- Formula
- Ingredient
- Location
  - Facility, building, room, cabinet, shelf
- Owner
  - Organization
  - Individual
- Requester
- Purchaser
- Barcode
- Supplier or producer
- Physical state
- Hazards
  - Compatibility/storage info
  - COC flag
  - Biosafety/biosecurity level
- Safety Data Sheet (SDS)
- Certificate of analysis
- Quantity
- Date purchased or received
- Expiration date
- Status (open or not)
- Use and transfer history

It is possible to keep track of a lot of useful information with a computer/web-based Chemical Inventory Management System

Inventory: Access Control

- Different levels of access to inventory system and database
  - Students
  - Faculty, staff researchers
  - Department heads, system administrators
  - Chemical safety and security officers, centralized procurement

- Insider threat
  - Personnel management
  - Procurement
  - Inventory
    - Chemical owner
- Outsider Threat
  - Restrict access to information about COC locations and physical security

Inventory: Physical Inspection

- Assures accuracy of inventory database
- Provides visual assessment of chemical condition
- Should be done once or twice a year
  - More often for COCs

Inventory: Reporting

- May be required by law or by institution policy
  - Comprehensive inventory
  - Based on location
  - Consumption
    - Quantities of chemicals used in a given time
  - Expiration
  - Transport
  - Price
  - COCs
- Use of a computer/web-based CIMS makes reporting easier

[1] Santos et al. "Developing a chemical and hazardous waste inventory system" *Journal of Chemical Health and Safety* **2011,** *18,* 15-18.

Inventory: Conclusions

- One of the main challenges is maintenance
- Benefits of a Chemical Inventory Management System
  - Saves time
  - Improves research
  - Improves safety
  - Improves security
  - Saves money
  - Regulation compliance
  - Earn recognition
- Published articles about CIMS
  - Ateneo de Manila University[1]
  - Stanford University
  - Temple University
  - Los Alamos National Laboratory
  - West Virginia University

Inventory: Example

Barcode	Location	Date In	Name	Cas #	State	Quantity	Units	Container	Hazards/Alerts
AQ879816	124/2	2/12/2011	Sulfuric Acid	7664-93-9	Liquid	500	mL	Glass	acid
AQ879817	122/1	5/24/2003	Ferric Chloride	7705-08-0	Solid	500	gram	Metal Can	toxic, corrosive
AQ879818	124/3	1/1/2001	Oxygen	7782-44-7	Gas	5	m^3	Gas Cylinder	flammable
AQ879819	121/A	6/24/2005	Acetone	67-64-1	Liquid	1	L	Plastic	flammable
AQ879820	122/2	2/7/1998	Diethyl Ether	60-29-7	Liquid	1	L	Plastic	peroxide former
AQ879821	124/1	5/8/1996	Magnesium	7439-95-4	Solid	100	gram	Metal Can	flammable
AQ879823	121/B	5/30/2005	Pinacolyl Alcohol	464-07-3	Liquid	26	kg	Glass	CWC sch 2
AQ879824	121/A	10/24/2002	Sodium Cyanide	143-33-9	Solid	5	gram	Glass	toxic

- What information is missing?
  - Depends on what you need!
    - Compatibility groups?
    - Expiration dates?
    - Owner?
    - Waste Inventory too?

Overview

- ☑Labeling
- ☑PPE
- ☑Storage
- ☑Transportation
- ☑Inventory
- SOP
- Waste/Disposal

Standard Operating Procedures (SOPs)

- Describes how your lab will carry out a certain procedure
- A lab may have SOPs for
  - Security clearance and visitor access
  - Employee training
  - Respiratory protection and equipment fitting
  - Eye protection
  - Housekeeping
  - Ventilation system maintenance
  - Storage, receipt, and transport of hazardous materials
  - Accident and emergency response including natural disasters
  - Hazardous material handling or special equipment operation
    - Toxic chemicals, radiation, lasers, infectious agents, flammable chemicals
  - Spill cleanup
  - Waste management

- No specific format exists for SOPs

Standard Operating Procedures (SOPs)

- SOPs for work with hazardous chemicals can be written into a set of steps for an experiment or procedure
- Should include
  - Date
    - Issued
    - Reviewed
    - Revised
  - Subject, title and identification code
  - Amounts and/or concentrations used
  - Special handling procedures, engineering controls, and personal protective equipment
  - Official review by management, signed
  - Review by all responsible parties, signed
- Should be written in a consistent and official format
  - Example SOP templates
    http://www.safety.duke.edu/OHS/chemsopsTemplates.htm

Standard Operating Procedures (SOPs)

Consider written SOPs on:

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

SOP Activity

Document SAND Number: 2012-6076 P
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

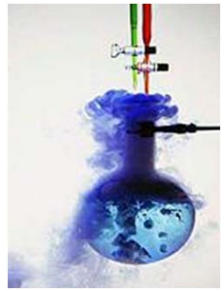
Activity: Standard Operating Procedures (SOPs)

- SOP: A set of steps for carrying out a laboratory task
- Scenario: You are a chemist in a Quality Control (QC) lab
- Goal: Develop an SOP for preparing a standard acid solution for titration
- Get in groups of 4-5 people per group

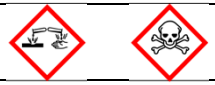
Buret photograph courtesy of Indigo® Instruments

Activity: Standard Operating Procedures (SOPs)

- Refer to the SDS for H_2SO_4, and the partially completed SOP
- In your groups, discuss
  - Hazards
    - Chemicals, reactions, and products
    - Equipment
    - Storage
    - Disposal
    - Security
  - Controls
    - Operational
    - Engineering
    - PPE
- Fill in the blanks to complete the SOP
  - Be prepared to discuss with the whole class



Activity: Standard Operating Procedures (SOPs)

Hazards in this SOP	
Preparation of solutions	
Equipment	
Waste/disposal	
Security	

Activity: Standard Operating Procedures (SOPs)

Controls?

- Operational
  - SOP
  - Substitution
  - Scale down
- Engineering
- PPE
  - Quantity dependent

Activity: Standard Operating Procedures (SOPs)

Conclusions

- SOP is a set of steps for carrying out a laboratory task safely and securely
- Should be part of a formal training procedure
  - Update regularly
- Protects students/workers, faculty, administrators, chemicals/info

http://offthewallchemistry.blogspot.com/2011/01/chemistry-cartoons.html

Overview

- ☑Labeling
- ☑PPE
- ☑Storage
- ☑Transportation
- ☑Inventory
- ☑SOP
- Waste/Disposal

Waste: Overview

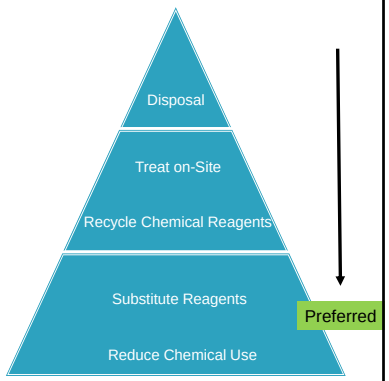
- Basics
- Waste management
- Collection
- Minimization
- Recycling
- Waste Treatment
- Orphans and Unknowns
- Disposal

Waste: Basics

- Plan ahead
  - Minimize amount and hazards
- Separate during collection and storage
- Recycling and/or disposal
- Prevent orphans and unknowns
- Secure Storage and Collection

Waste Management

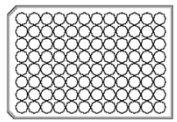
- Key Elements
  - Source reduction
  - Recycling of chemicals, containers, and packages
  - disposal
- *Chemical management is intrinsic to waste management*



Waste Management: Chemical Substitution and Reduction

- Replace a hazardous solvent with a non-hazardous one
- When purchasing automated equipment think of chemical waste

- Source Reduction
  - Procure and use less
  - Scale down experiments



Waste: Collection

- Avoid creating mixed waste during collection
- Use separate containers for incompatible wastes (e.g., organic solvents and oxidizers)
- Container must be compatible with waste (e.g., no hydrofluoric acid in glass)
- Label containers
  - Warning
  - Contents
  - Date
  - Owner
- Keep containers closed
- Use secondary containment
- Avoid using containers that will easily break

Waste: Minimization

Minimize volume

- Evaporation
- Adsorption
  - Activated carbon
  - Ion exchange resin
  - Activated alumina
- Precipitation
- Extraction

Minimize Hazard

- Requires chemical expertise
  - May not be allowed by regulations, specific to each chemical
- Acid base neutralization
- Dilution

Minimization of the volume and hazards of waste is best accomplished when?

Handbook of Laboratory Waste Disposal, Martin Pitt and Eva Pitt, 1986. ISBN 0-85312-634-8

Chemical recycling

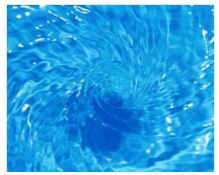
- Reuse by others in the organization or community
- An active chemical exchange program
- Beware of accepting unusable chemicals
- Reuse in experiments in the laboratory
- Exchange for credit with suppliers by agreement

Donated chemicals are not always "free"

Waste treatment: Down the drain?

If legally allowed:

- Deactivate & neutralize some liquid wastes yourself
  - e.g., acids & bases
  - Don't corrode drain pipes
- Dilute with lots of water while pouring down the drain
  - Be sure that you do not form more hazardous substances
  - Check reference books, scientific literature, internet



Waste: Orphans and Unknowns

Orphan Chemicals and Waste

- Have a checkout procedure for those leaving the laboratory
- For chemicals and samples being kept
  - Label all carefully
  - Document in lab notebook and elsewhere
- Dispose of all unneeded or excess chemicals
  - Put into chemical exchange program
  - Dispose of as hazardous waste

Good Policy:
Everything left behind has a new owner

Waste: Orphans and Unknowns

- Avoid
  - expensive and hazardous
- Not necessary to know exact identity
  - Need hazard information for disposal
- Consider more serious hazards first
  - Radioactive, explosive, bio-waste
- Look for hints from container, physical characteristics, location found, talk to other people
- Before handling, prepare for the worst
- Test
  - pH
  - Reactivity
    - Air, water, flammability, redox
  - Solubility
  - Qualitative analysis for presence of heavy metals, cyanide, etc.

Waste: Disposal

- If legal, deactivate/ neutralize some liquid wastes yourself
  - acids & bases
- Dilute with lots of water while pouring down the drain
- Be sure that you do not form more hazardous substances
- Check reference books, scientific literature, internet
- If using a disposal service:
  - Licensed?
  - How will waste be packaged?
  - How will waste be transported?
  - Where and how will waste be disposed?
  - Dispose by incineration if possible
    - NOT the same as open burning
  - Maintain records

When is the best time to figure out how to dispose of waste?

Waste management: References

- "Less is Better," American Chemical Society, Washington DC, 2003, available online:
  - http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_SUPERARTICLE&node_id=2230&use_sec=false&sec_url_var=region1&__uuid=ef91c89e-8b83-43e6-bcd0-ff5b9ca0ca33
- "School Chemistry Laboratory Safety Guide," US NIOSH Publication 2007-107, Cincinnati, OH, 2006, available on-line:
  - http://www.cpsc.gov/CPSCPUB/PUBS/NIOSH2007107.pdf
- "Prudent Practices in the Laboratory: Handling and Disposal of Chemicals," National Academy Press, 2011, available online:
  - http://dels.nas.edu/Report/Prudent-Practices-Laboratory-Handling/12654

Conclusions

- Chemical Management
- Key to chemical safety and security
- Involves all CSS controls
  - Administrative
  - Operational
  - Engineering
  - PPE
- Many issues addressed by planning ahead
- Best practices in chemical management and high quality research are positively correlated
- Opportunities for those willing to pioneer improvements

Workshop Overview

- ☑Orientation to Chemical Safety and Security (CSS)
- ☑Fundamentals of CSS
- ☑Laboratory Usage of Chemicals
- Emergency Equipment and Response
- Workshop Summary and Conclusions

Emergency Equipment and Response

Laboratory Safety Equipment

- Not only your PPE
- Internal and external communication
  - Telephone (Label all phones with emergency numbers)
  - Alarms
- Eyewash
- Safety Shower
- Spill Kit
- Fire Extinguisher
- First Aid Kits

Always know their location!

Are there are maintenance or inspection requirements?

Eyewash and Showers

- US regulations
  - 29 CFR 1910.151(c)
  - ANSI Z358.1-2004
- Types
  - eyewash
  - shower
  - drench hose
- Concerns
  - drainage
  - freezing
  - contaminated water



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Eyewash Standards

- Eye wash stations
  - Minimum 0.4 to 3.5 gal/min (1.4 – 13.2 l/min.)
  - Flush for 15 minutes
- Provide flow for both eyes
  - Hold eyes open
  - Tepid, pH match eye (preferred)
- Easily accessible locations
  - 33 to 45 in. (84-114 cm) from floor
  - 6 in. (15cm) from wall
- Test weekly
  - Portable: clean/refill (6 mo – 2 yrs)
- Various types


ANSI Z358.1 NC DOL Guide:
www.nclabor.com/osha/etta/indguide/ig28.pdf

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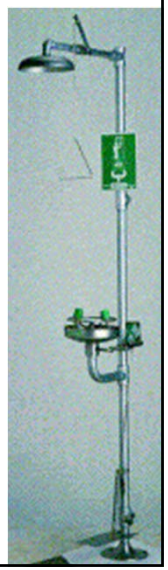
Safety Shower Standards

- Within 55 ft. (17 m) or 10 seconds
  - Normal walking = 3.8 mph (6.1 km/hr)
- Test monthly
- Pull within reach (highly visible)
  - 82 to 96 in. high (208 – 244 cm)
  - Deliver 20 in (51 cm) column
  - Height: 60" (152 cm) above floor
- 20-30 gal/min (76-114 L/min)
- Tepid: 60 to 100 °F (16 – 38°C)
- Consider
  - Drains
  - Blankets/modesty curtains
- Avoid or protect electrical outlets



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Fire Basics: Science of Fires

- What are common sources of fuel in chemical labs?
  - Flammable liquids
  - Flammable gases
  - Wood, paper, cardboard
  - Oil soaked rags
  - Clothing
- What are common sources of heat/ignition in chemical labs?
  - Electricity
  - Heating devices
    - Hotplates, heating mantles
    - Coffee makers
  - Welding
  - Smoking
  - Open flames
  - Static electricity
  - Damaged wiring

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Fire Basics

- Many chemical laboratories are at HIGH RISK for fire
- Steps can be taken to decrease both the **likelihood** and **consequences** of a laboratory fire
- Laboratory personnel should be trained in the causes of fire, the basic science of fires, and best practices for prevention and protection

Fire Prevention

- Train employees to notice, report, and correct fire hazards
- Separate flammable chemicals from ignition sources
  - Ventilation
  - Storage
  - Use
- Periodic inspections of work areas and ***work practices***

- A worker attempted to check the fuel level using a lit match for light

Fire Prevention: Storage

- Limit quantities
- Use secondary containment
- Flammable storage containers, cabinets, rooms or areas
  - Example, container for oily rags

Fire Protection

- Detectors
- Alarms
- Response
  - Training
  - Evacuation
  - Sprinklers
  - Fire Extinguishers
  - Other

Fire Extinguishers

- Several types exist
  - Water
  - Foam
  - CO_2
  - Dry chemical powder (monoammonium phosphate)
- Correct type depends on classification of fire
  - Depends on fuel
- Annual & Monthly inspections

http://www.southerncare.co.uk/fire-extinguishers/
http://www.maumellefire.com/photos/extinguisher03.jpg

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Blocked Safety Equipment

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Dirty Eyewash Station

Spills

- Hazard Assessment
- Preparation
- Prevention
- Cleanup
- Reporting

http://0.tqn.com/d/chemistry/1/7/Q/q/testtubespill.jpg

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Spills: Hazard Assessment

- Plan ahead – know the worst case scenario for a spill
  - Hazards of the spilled material
    - Toxic, flammable, etc.
  - Size of spill
    - Smaller or greater than 4 L
  - Location of spill
    - Ventilation
- Know if spill is an emergency situation or not
  - Emergency
    - Isolate
    - Communicate
    - Evacuate
  - Not an emergency
    - Know the appropriate cleanup and decontamination procedures
    - Have the necessary equipment

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Spills: Preparation

- Spill Kits
  - Absorbent material
  - Neutralizing agents
    - $NaHCO_3$, citric acid powder, activated carbon (for organic solvents)
  - Plastic bucket with lid
  - Plastic dust pan
  - Broom or brush
  - Plastic bags
  - Tape
  - pH paper
  - Signs: Keep Out, Danger Chemical Spill
  - PPE for at least 2 people
    - Goggles
    - Gloves
    - Disposable aprons or jump suits
    - Disposable shoe covers
    - Respirators

- Emergency Equipment
  - Phones with emergency numbers
  - Alarms
  - Fire extinguishers
  - Emergency eyewash and showers
  - First Aid
  - Safety Data Sheets

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Spill Cleanup Preparation

- Additional equipment?
- Respirators
  - Air purifying (APR)
    - Disposable
    - Half Face
    - Full Face
    - PAPR
  - Air supply
    - Air line
    - SCBA

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Spills: Prevention

- Have only the amount of chemical required
- Understand work practices and procedures
  - SOP
- Eliminate clutter
- Use secondary containers
  - Storage
  - Transport
  - Work
- Dispose of waste and excess chemicals properly and timely

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Spills: Cleanup Steps

- Assess the hazard
- Get someone to help
- Wear appropriate PPE
- Alert people in immediate area
- Confine spill
- Absorb excess, surround area with absorbent material
  - Do not dry sweep
- Neutralize and test as necessary
- Gather contaminated absorbent material from outer edge toward center
- Collect contaminated absorbent, residues, and disposable PPE
- Clean and dry the spill area
- Restock emergency and spill kits

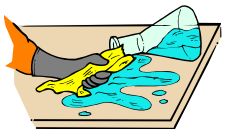
http://www.dawginc.com/media/catalog/category/275X275/Spill-Kits-ba.jpg

Cleanup Responsibilities

- Laboratory Staff:
  - Ensuring timely spill reporting and cleaned up
  - Cleaning up nuisance spills in their area, even if someone else spills them (janitors, service people)
  - Knowing the properties of what they work with
  - Taking reasonable steps to prevent spills
- Specially trained Safety Cleanup Team:
  - Assist researchers not comfortable cleaning up spills (including nuisance spills)
  - Clean-up serious/major spills

If unsure or need assistance with PPE selection or cleanup, call the Safety Cleanup team.

Potentially Hazardous Spills



- Spills of > 4L or
- Smaller spills of:
  - Low LD_{50} (high acute toxicity)
  - Carcinogens, repro-toxins, etc.
  - Flammable liquids or metals
  - Chemicals of unknown toxicity or hazards

Spills: Reporting

- Maintain accurate records of near misses, incidents, and response
  - All involved personnel
  - Exposure measurements
  - Medical treatment
- Examine records for patterns
  - Use to improve safety and security program
- Encourage reporting and discourage hiding of incidents
  - Maintain confidentiality

Conclusions

- Centrally locate, inspect, and maintain
  - First aid kits
  - Chemical Spill kits
  - Special chemical antidotes, if necessary
  - Respirators
  - Fire extinguishers
- Post inspection dates on equipment, including hoods
- Specially Train emergency personnel, if necessary
- Encourage reporting and discourage hiding of incidents



Workshop Overview

- ☑Orientation to Chemical Safety and Security (CSS)
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- ☑Emergency Equipment and Response
- Workshop Summary and Conclusions

Workshop Summary

- What we have showed you today are some best practices that you should be able to use in your laboratories
- Connection between Safety and Security

Workshop Conclusions

- Promote the safe and peaceful use of chemistry
- Appreciate the importance and benefits of Chemical Safety and Security (CSS)
  - To do top level work, you need top level CSS practices
- Encourage the creation of networks of people interested in CSS
  - Culture of Chemical Safety and Security

Closing Remarks

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Evaluations

- Please find and fill out the evaluations for this workshop

Thank you for your participation!

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Thank You!!

Drs. Joe, Christine, and Morgan