



Chemical
SAFETY AND SECURITY TRAINING

Chemical Safety and Security Officer Training

Bangkok, Thailand
June 2011



International Year of
CHEMISTRY
2011



Sandia No. 2009-8395 P
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.




**Fire Extinguisher Demonstration
and Practice**



Two photographs showing fire extinguisher practice. The left photo shows a person in a dark jacket using a fire extinguisher on a large fire. The right photo shows a person in a light blue jacket and red helmet using a fire extinguisher on a fire.



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Lunch



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**Laboratory Emergency
Planning, Response,
and Management**

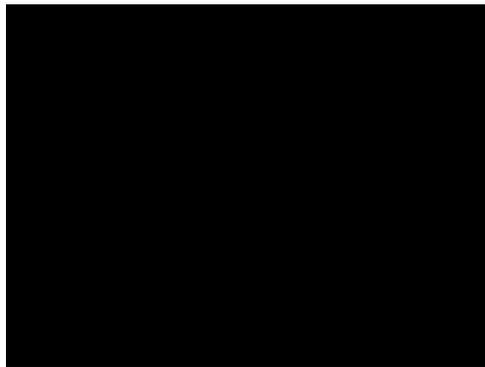


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Video – Explosion and Fire at T2 Lab



Emergency Planning and Response is based on principles of:

- Anticipation
- Recognition
- Evaluation
- Control



Preparing For Emergencies

- **Emergencies**
 - potentially life threatening
 - occur suddenly without warning
- **Quick response will:**
 - make difference between life and death
 - minimize damage
 - prevent panic, timely control
- **Emergency responders**
 - organize, stabilize, administer
- **Adequate preparation requires**
 - planning, practice, evaluation, adjustment



Emergency Management

- **Mitigate**
 - eliminate / reduce occurrence or effects of an emergency
- **Preparedness**
 - plan how to respond; resources
- **Response**
 - assist victims, reduce damage
- **Recovery**
 - return to normal and assess





Planning & Preparation

Anticipate types of emergencies:

- Step-by-step procedures
- Assess resources available
- Coordinate with all responding agencies
- Chain of command
- Roles & assignments
 - Clearly spelled out and understood
- Accident prevention strategies
- First aid – inspect, date, replacements
- Site maps – update
- Train & practice
- Evaluate & improve



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Emergency Response Plan

Include all situations and conditions:

- Weather emergencies:
 - Flood
 - Tidal waves
 - Cyclones
 - Heavy rains
 - High winds
- Fire
- Earthquakes
- Security breaches
- Distraught employees
- Medical Emergencies
- Student unrest
- Political unrest
- Explosion
- Evacuation
- Terrorism

Prepare for and expect the unexpected



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Dr. Walters home, Raleigh NC, USA After Hurricane Fran 1996



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Emergency Action Plan

- Have a written plan and distribute it to all employees, especially new employees:
 - Emergency escape/evacuation procedures & routes
 - Critical process emergency shutdown procedures
 - Procedures to account for evacuated employees
 - Rescue or medical duties if employees required to perform them
 - Procedure for reporting emergencies
 - Contact information for Q&A
- Alarm systems
- Training



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Emergency Response Plan

- Comprehensive employee training
 - General employee training
 - Specialized & emergency responders
 - Annual refresher training or drills
 - Untrained personnel should not participate
- Spill & emergency response plans
- Contingency plans
- Medical response/first aid
- Personal Protective Equipment
- Safety Data Sheet's
- Site maps
- Clean up procedures
- Decontamination techniques



Fire Safety

Is covered in a separate presentation



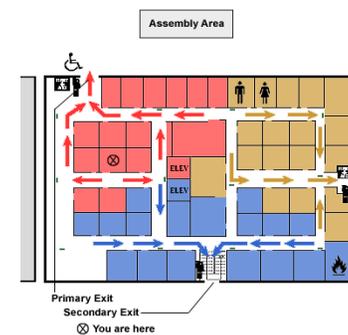
Include: Fire Prevention Plan

- Written plan
 - List major fire hazards
 - Proper handling and storage procedures
 - Potential ignition sources & controls
 - Type of fire prevention systems
 - Contact information for those responsible for system maintenance
 - Contact information for Q&A
- Housekeeping requirements
- Training
- Maintenance requirements



Egress – Exit Route

- Continuous and unobstructed path from any point within a workplace
- Consists of three parts:
 - Exit access
 - Exit
 - Exit discharge





Emergency Planning & Response

Don't use hallways for storage

Dangerous!!

Blocks passage and emergency exit path



Egress – Exit Route

• Exit Doors:

- Must *not* be Blocked or Locked
- Can use a panic bar
- Must be well marked
- *Open in direction of travel*



Emergency Planning & Response

- Have routine, unannounced evacuation drills.
- Test and maintain alarms.
- Designate person for each area to ensure bathrooms, etc. are evacuated.



- Locate outside staging areas sufficient distance from building.
- Designate person to meet/direct emergency vehicles.



Emergency Planning & Response

Alarm systems need to be properly located, maintained, and serviced regularly.





Emergency Planning & Response

Backup power

Does switch-over automatically?

How long will it run?

How much fuel do you have?

What areas will it support?

How often is it tested and maintained?



Emergency Planning & Response

Post each room with:

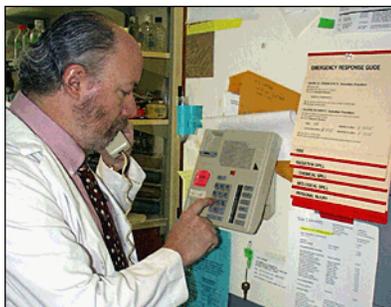
- Emergency phone numbers
- After hours phone numbers
- Person(s) to be contacted
- Alternate person(s)
- Unique procedures to be followed

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



Emergency Phone Numbers

Clearly post emergency numbers
Do people know what to do?



Emergency Planning & Response

Hoods should have low flow alarms.



Chemical specific toxicity alarms may be needed in certain areas.



Emergency Planning & Response

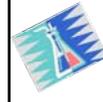
Centrally locate safety showers and eyewashes.



Schedule routine, periodic maintenance of all safety equipment.



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Teach employees to properly use the Safety Shower

Time can make a difference...



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Chemical Spills

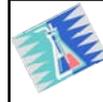
Centrally locate spill clean-up kits

Clean up spill only if you know the chemical hazards, have appropriate equipment and are trained to do so!

- Alert colleagues and secure area
- Assess ability to clean-up spill
- Find spill kit
- Use appropriate PPE and sorbent material
- Protect sinks and floor drains
- Clean-up spill, collect/label waste for disposal
- Report all *spills*



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Centrally locate, inspect and maintain:

- First aid kits
- Special chemical antidotes, if necessary
- Respirators
- Specially train emergency personnel, if necessary
- Post inspection dates on equipment, including hoods



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Always Expect the Unexpected



Shown at Funny-games.biz



Safe/Secure Transport of Chemicals



Transport References

UNECE, "Globally Harmonized System Of Classification and Labeling of Chemicals (GHS)," 1st edition, 2003, online,

http://www.unece.org/trans/danger/publi/ghs/ghs_rev00/00files_e.html

International Airlines Transportation Association, Dangerous Goods Regulations(DGR), 2008, not online,

<http://www.iata.org/ps/publications/9065.htm>

UN International Maritime Organization (IMO),

<http://www.imo.org/>

European Union (EU) Transport Activities

<http://europa.eu/>

US Department of Transportation (DOT)

<http://www.dot.gov>



International Shipping Fines

- For international shipments fines are severe
 - up \$250,000 fine + 5 years prison in US
- Apply to scientists improperly transporting
 - samples
 - test material
 - specimens
- Dangerous Goods Regulations are set by:
 - IATA: International Air Transport Association





Modes of transport



- Air
- Ship
- Rail
- Road



- Vehicle (car/truck)
- Cart, Bicycle
- Hand carry

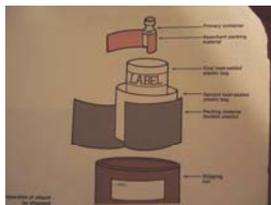


Always expect the unexpected



Universal Safety/Security Concept

Container within a Container



What is a hazardous chemical shipment?

- Corrosives
- Dry ice
- Explosives
- Flammables
- Gases
- Flammable liquids
- Flammable solids
- Genetically modified organisms
- Infectious substances
- Magnetized material
- Oxidizing substances
- Radioactive substances
- Toxic substances
- Aerosols



Are there special shipping requirements?

What are the physical and chemical properties?



dry ice, refrigeration?

Are specific containers required?
size, strength, composition



Specific transport concerns

- Quantities, exclusions, limitations
- Restricted routes:
tunnels
bridges
populated areas



Sender/Shipper Should Know

- Who transports the material?
- How is it transported?
- How is it packaged?
- Are transporters knowledgeable and prepared?
- Is there safety documentation?
- When did it leave, arrival time?
- Did all material depart and arrive as scheduled?



Labels continued



properly and fully identify material

use proper, full chemical name
no abbreviations
ID codes, e.g., UN Numbers



specify
quantities, concentrations,
number of containers





Labels continued



indicate specific hazard class
according to regulations

include
emergency information
contact names
24/7 phone numbers



language(s)
proper universal symbols



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Documentation



shipping order
bill of lading
manifest
full shipper, receiver addresses
packing & labeling certification
verification of receipt



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Documentation continued



Safety Data Sheets

follow up documentation
require incident/accident
reports



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Handling

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



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Who requires training?

- Managers
- Packers
- Handlers
- Loaders
- Drivers
- All shipping and receiving personnel
- Mailroom personnel



Emergency Preparation

- Transportation accidents/incidents:
 - Organization reports
 - Police reports
 - Emergency contacts
- Spill and leakage control:
 - prevention
 - minimization
 - spill clean up kits
 - PPE
- Emergency contacts
 - Regulation requirements
 - local, national, international



Emergency preparation continued

- Emergency contacts
 - Regulation requirements
 - local, national, international
- Public relations
 - Designate spokesperson beforehand
 - Be responsive to public concerns



Plan ahead

- Have a plan
- Remember:
 - Anticipation
 - Recognition
 - Evaluation
 - Control





Unsafe Transport of Gas Cylinders



Acknowledgement

International Labour Organization (ILO)

International Occupational Safety and Health Centre (CIS)

Programme on Safety and Health at Work and the Environment (SafeWork)

<http://www.ilo.org/public/english/protection/safework/cis/index.htm>



Any Questions?



GHS/REACH

REACH and the Global Harmonized System for the Labeling of Chemicals





REACH



Registration, Evaluation, Authorisation of Chemicals

2007 EU regulation; replaces 40 existing acts to create a single system for all chemicals

- requires authorization to use, manufacture and import
- to track and manage chemical risks and provide safety information
- proposes to integrate REACH with GHS
- creates European Chemical Agency (ECHA, Helsinki, Finland)



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REACH

Life of the chemical from Cradle-to-the-Grave



Manufacturing
 Importing
 Marketing
 Use
 Waste stream



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REACH



- **Comprehensive legislation to ensure European authorities know and condone what chemicals are used as they enter the EU supply train**
- **Objective is to protect human health and the environment by recognizing and classifying hazardous chemicals so they are handled safely**
- **REACH & GHS are not equivalent or optional but separate legislation with parallel requirements**



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REACH



- **The responsibility for proving whether a chemical is hazardous or non-hazardous is on the manufacturer and supplier not the government**
- **The responsibility also includes documentation, tests, classification, risk exposure, labeling, safety data sheets**
- **ECHA will store the information in the International Uniform Chemical information Database (IUCLID)**



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REACH

Four Steps

1. Registration
2. Evaluation
3. Authorization
4. Restriction



ECHA maintains database



REACH: Registration

Importers and manufacturers of substances in quantities over 1 ton/yr must register their substance with ECHA

Registration began June 2007

December 1, 2010

≥ 1000 tons per year

- carcinogenic, mutagenic, or reproductive toxin ≥ 1 ton per year
- substances classified as dangerous for aquatic environment ≥ 100 tons per year

June 1, 2013

- manufactured or imported at 100-1000 tons per year

June 1, 2018

- manufactured or imported at 1-100 tons per year



REACH: Evaluation

Authorities will review registration and request further information or testing to determine the impact of the substance on human health and the environment

Decides next steps:

- action for authorization
- align classification & label
- other action



REACH: Authorization

Decisions on what substances require an authorization or restriction are carried out for substances that pose the most concern, such as carcinogens and mutagens

Three steps:

- **SVHC (Substances of Very High Concern)**
 - carcinogenic, mutagenic and reprotoxic substances, persistent, bio-accumulative and toxic
- **Prioritize**
- **Authorization provided**



REACH: Restriction

- **Limit uses**
 - Where no viable alternative exists, a research and development plan to derive a suitable alternative is developed
- **Ban substance**
 - where there is an unacceptable risk to human health and the environment.



REACH: Concern

A potential concern may be creating country specific safety data sheets and labels that are compatible with the GHS proposal



REACH: Resources

About REACH: <http://guidance.echa.europa.eu/>

http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

REACH Help:

http://echa.europa.eu/help_en.asp#helpdesks

About ECHA: <http://ec.europa.eu/echa>



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

International UN standardization for classification, safety data sheet format, and labeling of chemicals using pictograms, signal words, and hazard warnings

US OSHA is reviewing GHS for adoption



GHS

- United Nations proposed system to internationally standardize chemical communication
- Countries will adopt on their own timeframe
- 2008 - UN goal for world-wide implementation



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GHS Implementation

- Intergovernmental Forum on Chemical Safety (IFCS)** - adopted GHS implementation goal of 2008. The US participates and agreed to work toward this goal
- Japan, Korea, New Zealand** – various stages of adopting & implemented GHS
- European Union** – 2010 deadline for GHS substance classification
- Canada** – Analyzing how to implement GHS
- United States** – OSHA proposed rulemaking at end of 2009. DOT has adopted some parts, still working on others. EPA thinking about it.



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GHS Benefits



- Uniform Communication
- Better Safety
- Improved International Trade
- Lower cost



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GHS Changes

MSDS now named: “SDS” (Safety Data Sheet)

Labels will be standardized with:



- signal words
- hazard statements
- precautionary statements
- pictograms
- elimination of US, Canadian and EU labels



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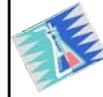




GHS Labeling

Information required on a GHS label:

- Pictograms
- Signal words
- Hazard statements
- Precautionary statements and pictograms
- Product identifier
- Supplier information



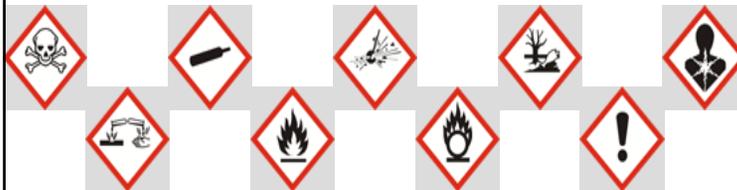
Changes to (M)SDS

GHS name: Safety Data Sheet (SDS)

- Format:
 - 16 sections required in specified order (as per ANSI MSDS format in US Regulations presentation)
- Reclassification:
 - (MSDS) Health & Physical Hazards
 - (SDS) Environmental Hazards
- Building Block Approach
 - each country can select portions of GHS to adopt
 - Not every country will require all categories or all hazards



Examples of GHS Pictograms



Differences between REACH and GHS

- REACH and GHS have different scopes but there are many links between the two regulations
- REACH aims to produce information on hazards, risks, and risk management
- GHS aims to harmonize classification and labeling of materials
- GHS is a UN recommendation which applies across countries, including the EU





Differences between REACH and GHS

- REACH intends to replace current EU classification criteria with GHS. REACH has provisions for safety data sheets based on GHS.
- GHS intends to apply classification and labeling beginning December 1, 2010, when the new GHS regulation will be available.
- Substances will be phased in the first 3.5 years. Mixtures will be given an additional 4.5 years for reclassification.



Globally Harmonized System



Resources



http://www.unece.org/trans/danger/publi/ghs/ghs_rev02/02files_e.html

http://www.unece.org/trans/danger/publi/ghs/presentation_e.html

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



BREAK



Other Hazards in a Chemical Laboratory



Physical Hazards

Conditions, besides chemical, biological or radiological conditions or circumstances, that can cause injury, illness and death:

Fire / Asbestos	Noise
Centrifuges	Heat/cold
Cryogenics	Sunlight
Ergonomic	Non-ionizing radiation
Office	Mechanical
Physical stress/strain	Electrical
Construction	Housekeeping
	Spills/trips



Asbestos-Containing Materials

- Gloves
- Lab hoods
- Lab benches





Centrifuge Equipment

- Uses
- Hazards
- Control of hazards
 - Only authorized users can use equipment
 - Users must be trained
 - Assign responsibility to lab tech
 - Include in periodic lab inspections





- Rotor
- Drive Shaft
- Motor
- Cabinet provides varying degrees of protection

Centrifuge Safety

Don't overload ...

Check rotor for cracks

Keep rotor and centrifuge clean ...

Set it up right...

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Chemical storage: Cryogenics

- Store cryogenics separately from other chemicals
- Store cryogenics (liquid nitrogen) & dry ice in well ventilated areas
- Use proper PPE (including eye protection) when handling & moving cryogenics
- Do not use cryogenics in closed areas



Cryogenics

- What are they?
- Uses
- Hazards
- Control
 - training
 - inspection





Cyrogen Storage

Exploding liquid nitrogen cylinder ruins lab.

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Dry Ice

- What is dry ice?
- Uses
- Hazards
- Control measures

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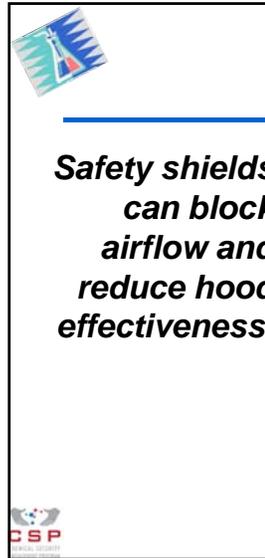






***Don't block hood
air flow.***

***Place large
equipment in a
hood on 5 cm
blocks to allow air
flow around and
under equipment.***



***Safety shields
can block
airflow and
reduce hood
effectiveness.***



***Don't block hallways
and exits!***



***Access to
emergency
equipment is
essential.***

***Always check
that equipment
is not blocked.***





Food is never allowed in laboratories.



What's Wrong With This Picture?



Open-toed shoes should not be allowed in laboratories.



Employees should not wear gloves, lab coats or other PPE outside the lab.



Working Alone/Unattended Operations

- **Working Alone**
 - *Avoid!*
 - Murphy's Law will get you!
(Anything that can go wrong, will go wrong!)
 - Use the "Buddy System"
- **Unattended Operations/Reactions**
 - **Caution!** Prime sources of fires, spills and explosions
 - Check periodically!
 - Fail-safe provisions
 - Leave the lights on to indicate the presence of an unattended activity
 - Post appropriate signs and emergency phone #'s
 - **Notify those potentially impacted by malfunction**



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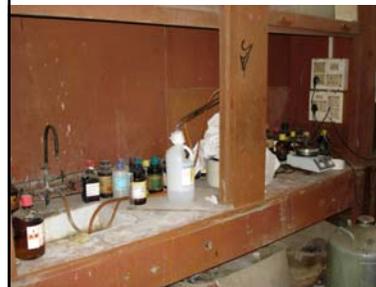


Electrical Hazards

- Can be a significant problem
 - Frayed cords, no UL-listing, overloaded circuits
 - Static electricity
- Hazards
 - Fires, electrical shock, power outages
- Control
 - Inspect, act immediately, education



Check to see that all outlets are grounded and that the polarity is correct.



Storage should be at least 1 m from electrical panels, mechanical rooms, air ducts, heaters, light fixtures.

Don't store combustibles in mechanical rooms or electrical closets.

In emergencies it may be necessary to access these panels quickly.

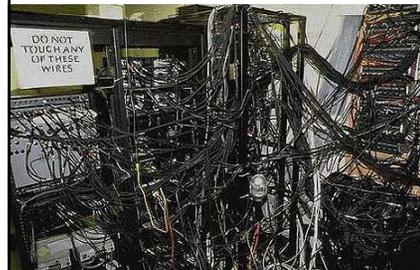




Multi-outlet strips must be approved and not used for high-amp equipment. (e.g., ovens, refrigerators)



Don't Do This...



Heating Mantles

- Uses
- Hazards
- Unshielded rheostats
- Control measures



Ergonomics

- Types of hazards



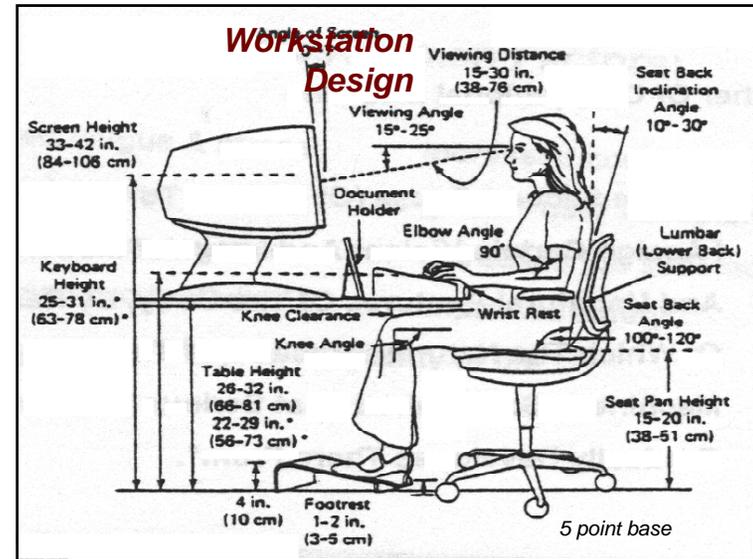
- Why be concerned with Ergonomics?

Awkward Posture

Too low **Too far away** **Too high**

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Repetitive Motion Disorders

About 15 to 20% of workers in jobs requiring highly repetitive motion of shoulders, arms, wrists or hands develop repetitive motion disorders.

<u>Disorder</u>	<u>Affected Site</u>
Carpal Tunnel Syndrome	Wrist
Tendonitis	Elbow, wrist, hand
Tenosynovitis	Elbow, wrist, hand
Epicondylitis	Tennis elbow
Reynaud's phenomenon	"White finger"
Ulnar neuropathy	Fingers

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Freezers

- Ultra low temperatures
 - -20°C, -80°C
 - Upright vs. walk-in
- Emergency power
- Labels

• *Precautions*

- No dry ice in freezers!
- Improper storage

• PPE

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Glassware Handling

- Potential Hazards
 - Ergonomics
 - High temperature
 - Broken glassware
 - Improper use
- Control
 - Inspection
 - Training



Beware of contaminated Glassware, especially if broken!



Autoclave Explosion



High Pressure Reactions

- Experiments carried out at pressures above 1 atmosphere (~1bar, 760 Torr, ~100,000 Pa).
 - Use of supercritical fluids (CO₂)
- Hazards
 - Explosions, equipment failure
- Control Measures
 - SOPs, training, engineering controls, inspection
 - Dry runs





Vacuum Work

- **Uses**
 - Aspiration
- **Hazards**
 - Injury due to glass breakage
 - Toxicity of chemical contained in vacuum
 - Fire following flask breakage
 - Contaminated pump oil
- **Control Measures**
 - SOPs, inspection, education



Mechanical hazards like open drive belts with pinch points must have shields and guards.

Oil pumps need drip pans to contain oil.



Noise

- Elevated noise levels can be a problem.
- **Potential Hazards**
 - Examples: bone-cutting saws, mechanical water aspirators, sonicators, pumps.
- **Control Measures**
 - Inspections, PPE, warning labels, training.



Magnetic Fields

- **Uses** – NMR, MRI
- **Hazards**
 - Magnetic field
 - High voltage
 - Cryogenic liquids
 - e.g., nitrogen, helium
 - Other hazardous materials in lab
- **Control Measures**
 - Control access to area
 - Training
 - Warning signs





Ionizing vs. Non-ionizing Radiation

❖ **IONIZING RADIATION**

- Particulate or electromagnetic
- Charged (α , β) or uncharged (γ , X, n)
- Causes **ionization** of atoms or molecules

❖ **NON-IONIZING RADIATION**

- Electromagnetic (UV, IR, MW, RF)
- Can not ionize atoms or molecules

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Common Uses of Ionizing Radiation

Research & Development

$^{14}_6\text{C}$ $^{35}_{16}\text{S}$ ^3_1H

$^{125}_{53}\text{I}$ $^{32}_{15}\text{P}$

X-Rays

Medical

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Protect yourself by:

| **TIME** – Limit time near source

| **DISTANCE** – Stay away

$$I_2 = I_1 \left(\frac{d_1}{d_2} \right)^2$$

| **SHIELDING** – Absorb energy

| **CONTAMINATION CONTROL**

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Shielding Materials

The diagram illustrates the penetration of four types of radiation through different shielding materials:

- Alpha (${}^4_2\alpha^{++}$):** Stopped by Paper.
- Beta (${}^0_{-1}\beta^-$):** Stopped by Plastic.
- Gamma & X-Rays (${}^0_0\gamma$):** Stopped by Lead or concrete.
- Neutron (1_0n):** Stopped by Water.

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Electron Microscopes

- Types
 - SEM, TEM
- Hazards
 - X-rays
- Control of hazard
 - Periodic maintenance
 - Conduct radiation survey
 - Include in personnel radiation safety program

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Non-Ionizing Radiation

- UV, Visible, IR, Lasers
- Hazards
 - Skin erythema
 - Eye injuries
- Control Measures
 - Training, PPE, warning signs and labels, interlocks

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Radio-frequency & Microwaves

- **Uses**
 - RF ovens and furnaces
- **Hazards**
 - Cataracts, sterility
 - Arcing – use of metal in microwave
 - Superheating of liquids
 - Explosion of capped vials
- **Control Measures**
 - SOPs, education, inspection



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CSP Chemical SAFETY AND SECURITY TRAINING

Robotics

- **Free-moving parts**
 - “Struck by” injuries
- **Noise**
- **Lasers**
- **Aerosol Generation**



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CSP Chemical SAFETY AND SECURITY TRAINING

Robotics



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CSP Chemical SAFETY AND SECURITY TRAINING



Sharps, Needles, Blades

Hazards

- Needlesticks
- Cuts
- Contamination



Sharps, Needles, Blades

Control Measures

- SOPs
- Training
- Modify work practices
- Engineering Controls



Slips, Trips, Falls

- Most common injuries
- Causes
 - Chemical spills and leaks
 - Improper work practices
- Control Measures
 - SOPs, proper equipment, effective communication, engineering controls



Control of Hazards

- Think!
- Develop SOPs, safety manual, policies
 - reviewed and approved by management
- Research protocol review
- Install engineering controls
- Provide PPE
- Provide training
- Conduct inspections, routine & unannounced with lab supervisor
- Document and *follow-up*
- Take action



**Small Group Discussions:
Prioritize Safety/Security Issues**

Any Questions?

