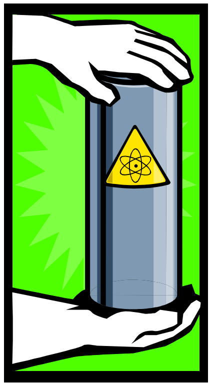
Lab Safety



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Phys 3313

University of Houston

Electrical Safety

Introduction

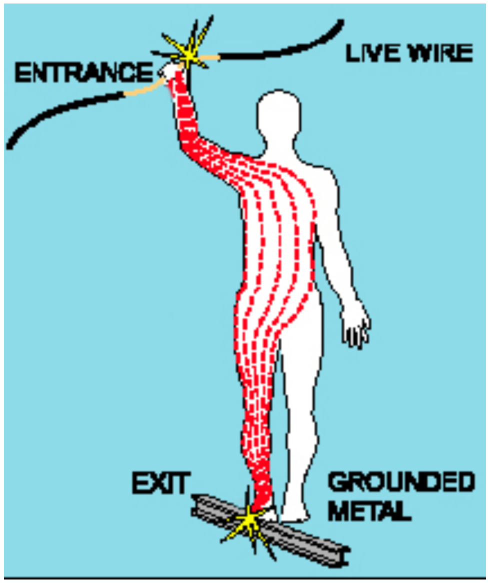
- There are three main types of electrical injuries:
  - Electrical shock
  - Burns
  - Falls

Electrical Terminology

- **Current** – the movement of electrical charge
- **Resistance** – opposition to current flow
- **Voltage** – a measure of electrical force
- **Conductors** – substances, such as metals, that have little resistance to electricity
- **Insulators** – substances, such as wood, rubber, glass, and bakelite, that have high resistance to electricity
- **Grounding** – a conductive connection to the earth which acts as a protective measure

Electrical Shock

- Received when current passes through the body
- Severity of the shock depends on:
  - Path of current through the body
  - Amount of current flowing through the body
  - Length of time the body is in the circuit
- The maximum safe shock duration at 110 V is 1 second (IEEE Std. 80)
- LOW VOLTAGE DOES NOT MEAN LOW HAZARD – time matters



How Electrical Current Affects the Body

Current (Amps)	Human Reaction
0.001	Perception level. Just a faint tingle.
0.005	Slight shock felt; not painful but disturbing. Average individual can let go.
0.006-0.025 (Women)	Painful shock, muscular control is lost. This is called the freezing current or "let-go" range.
0.009-0.030 (Men)	
0.050-0.150	Extreme pain, respiratory arrest, severe muscular contractions, ventricular fibrillation is possible.
1 - 4.3	Ventricular fibrillation.
10	Cardiac arrest, severe burns and probable death.

Note: some smaller microwave ovens use 10.0 Amps (10,000 milliamps) and common florescent lights use 1 Amp (1,000 milliamps)

Source: GE Safety

How is an electrical shock received?

- When two wires are at different potentials (voltages), current will flow if they are connected by a conductor
  - In most household wiring, the black wires are at 110 volts relative to ground
  - The white wires are at zero volts because they are connected to ground
- If you come into contact with an energized (live) black wire, and you are also in contact with the white grounded wire, current will pass through your body and YOU WILL RECEIVE A SHOCK

How is an electrical shock received? (cont'd)

- If you are in contact with an energized wire or any energized electrical component, and also with any grounded object, YOU WILL RECEIVE A SHOCK
- You can even receive a shock when you are not in contact with a ground
  - If you contact both wires of a 240-volt cable, YOU WILL RECEIVE A SHOCK and possibly be electrocuted

Electrical Burns

- **Electrical Burns** cause tissue damage, and are the result of heat generated by the flow of electric current through the body.
- Most common shock-related, nonfatal injury
- Occurs when you touch electrical wiring or equipment that is improperly used or maintained
- Typically occurs on the hands
- *Electrical burns are serious injuries and need to receive immediate medical attention.*

Involuntary Muscle Contraction

6 - 9 mA

- Muscles violently contract when stimulated by excessive amounts of electricity
- These involuntary contractions can damage muscles, tendons, and ligaments, and may even cause broken bones.
- If the victim is holding an electrocuting object, hand muscles may contract, making it impossible to drop the object.

Note: injury or death may result from a fall due to muscle contractions.

LOW VOLTAGE DOES NOT IMPLY LOW HAZARD!

- Muscular contraction caused by stimulation does not allow a victim to free himself from a circuit
- The degree of injury increases with the **length of time** the body is in the circuit.
- Thus even relatively low voltages can be extremely dangerous.

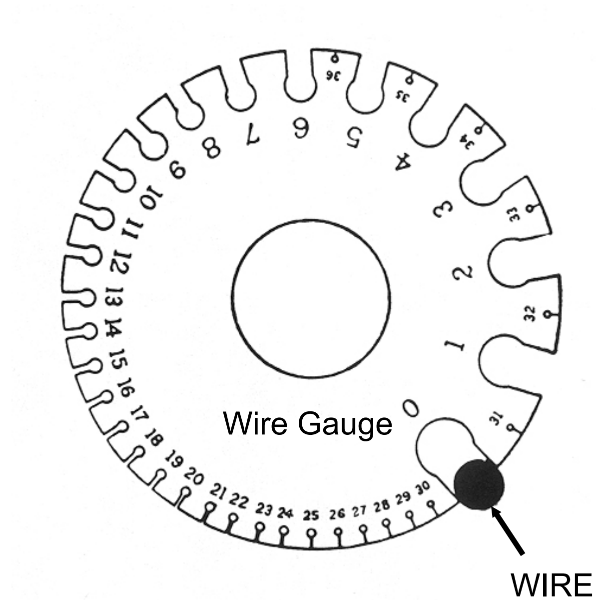
- **An exposure of 100mA for 3 seconds can cause the same amount of damage as an exposure of 900mA for 0.03 seconds**

Inadequate Wiring Hazards

- A hazard exists when a conductor is too small to safely carry the current
- *Example:* using a portable tool with an extension cord that has a wire too small for the tool
  - The tool will draw more current than the cord can handle, causing overheating and a possible fire without tripping the circuit breaker
  - The circuit breaker could be the right size for the circuit but not for the smaller-wire extension cord

Inadequate Wiring Hazards

- Most of our wires in Phys 3313/3214 are 20 AWG, rated at 5 Amps.



Overload Hazards

- If too many devices are plugged into a circuit, the current will heat the wires to a very high temperature, which may cause a fire
- If the wire insulation melts, arcing may occur and cause a fire in the area where the overload exists, even inside a wall

ICC Compliance Center Blog, http://www.thecompliancecenter.com/blog/tag/electrical-hazards/, accessed 8/20/13.

Electrical Protective Devices

- These devices shut off electricity flow in the event of an overload or ground-fault in the circuit
- Include fuses, circuit breakers, and ground-fault circuit-interrupters (GFCI's)
- Fuses and circuit breakers are <u>overcurrent</u> devices
  - When there is too much current:
    - Fuses melt
    - Circuit breakers trip open

Grounding Hazards

- Some of the most frequently violated OSHA standards
- Metal parts of an electrical wiring system that we touch (switch plates, ceiling light fixtures, conduit, etc.) should be at zero volts relative to ground
- Housings of motors, appliances or tools that are plugged into improperly grounded circuits may become energized
- Hand held tools especially must be grounded
- If you come into contact with an improperly grounded electrical device, YOU WILL BE SHOCKED

Don’t Ignore Clues that Electrical Hazards Exist

- Tripped circuit breakers or blown fuses
- Warm tools, wires, cords, connections, or junction boxes
- GFCI that shuts off a circuit
- Worn or frayed insulation around wire or connection

In Case of Emergency

- Call 911
- Fire Extinguisher in hallway

References

www.osha.gov/SLTC/etools/construction/electrical_incidents/mainpage.html

Cryogen Safety

Main Physiological Hazards

- Contact Burns/Frostbite
- Asphyxiation/Toxicity

Contact Burns/Frost Bite: What are they?

Contact Burns/Frost Bite: What are they?

- Contact Burn – exposure of the skin to low temperatures.
  - Similar to heat burns; can locally freeze and tear or remove skin.
- Frost Bite – freezing of skin and body parts due to exposure to low temperatures.
  - Can lead to permanent damage, discoloration, up to loss of limb
  - Prolonged exposure of cold vapor or gas can damage lungs and the eyes.
  - Exposure time on the order of seconds, not minutes!!

R. Bell, "Short Course on Cryogenic Safety",
http://www.slac.stanford.edu/econf/C0605091/present/BELL1.PDF, accessed 8/20/2013.

Contact Burns/Frost Bite: How to avoid them

- Wear proper protective clothing
- Non-absorbent loose fitting gloves; eye protection, closed-toe-footwear

R. Bell, "Short Course on Cryogenic Safety", http://www.slac.stanford.edu/econf/C0605091/present/BELL1.PDF, accessed 8/20/2013.

Contact Burns/Frost Bite: What to do if they happen

- Immediate first aid
  - Remove person from area, if required
  - Flush area with copious amounts of tepid water – Do not apply direct heat to area
- Get into medical facility as soon as possible.
- While awaiting transport
  - Loosen restrictive clothing
  - Continue flushing with water
  - Protect frozen/burned parts with sterile dry bondages
  - Do not smoke or drink, affects blood flow

Asphyxiation/Toxicity: What is it?

- Displacement of oxygen in the air that you breathe by the cryogenic fluid vapor/gas release or venting could be an asphyxiation risk
  - Confined or minimal ventilation areas are biggest risk
  - However, all vapor clouds should be treated very carefully

R. Bell, “Short Course on Cryogenic Safety”, http://www.slac.stanford.edu/econf/C0605091/present/BELL1.PDF, accessed 8/20/2013.

Asphyxiation/Toxicity: How to avoid them

- Only use a cryogen in a large, well ventilated room.
- Don’t transport open dewars in elevators

R. Bell, “Short Course on Cryogenic Safety”,
http://www.slac.stanford.edu/econf/C0605091/present/BELL1.PDF, accessed 8/20/2013.

Asphyxiation/Toxicity: What to do if they happen

- Remove any victim as quickly as practical to a normal atmosphere
  - If not breathing, start artificial respiration immediately
  - Time is the killer here!
- Get into medical facility as soon as possible.

R. Bell, "Short Course on Cryogenic Safety", http://www.slac.stanford.edu/econf/C0605091/present/BELL1.PDF, accessed 8/20/2013.

Personal Protective Equipment (PPE)

- Safety glasses
- Cryo gloves (inside sleeves), Lab coat and/or apron
- Long sleeves, pants, no cuffs
- Proper shoes (no open toes; no mesh fabrics; no loafers)

http://www.gassafeconsultants.co.uk/cryogenic-gases-liquids

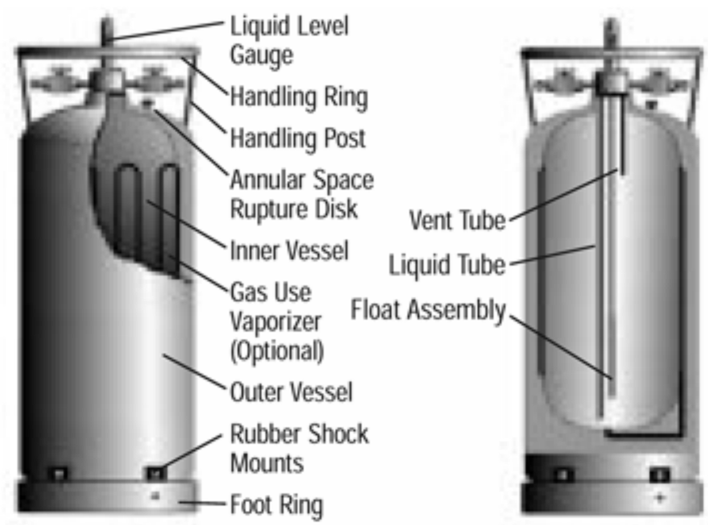
Dewars

LN_2

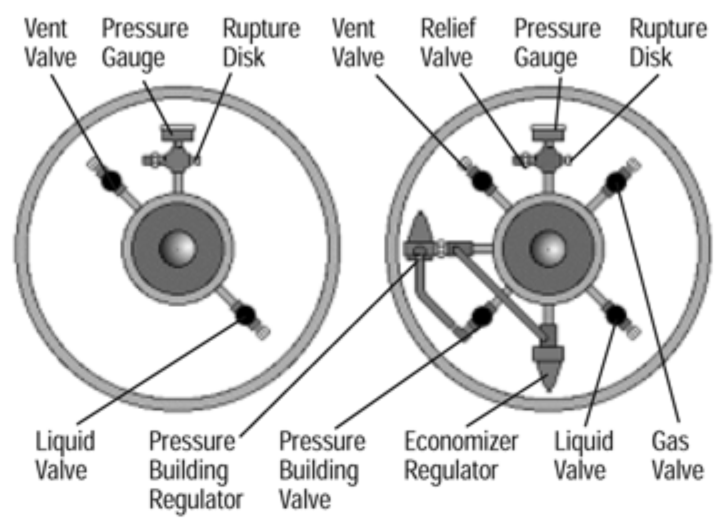
He

Pressurized Nitrogen dewars

- A hissing sound is normal if the dewar has been refilled
- External ice, sweating, or hissing of an undisturbed dewar indicates poor vacuum
- Operator is exposed to liquid and vapor
- Use gloves, identify the proper valve, turn it the proper direction



Side View



Top Views

Non-Pressurized Nitrogen dewars

- Metal are safer than glass
- Lid is NOT sealed, allows vapor to escape
- Releases nitrogen vapor

SPI Liquid Nitrogen Dewars & Accessories From Taylor Wharton, http://www.2spi.com/catalog/instruments/liquid-nitrogen-dewars.php, accessed 8/20/13.

What's safe? What's unsafe?

Gloves are mandatory

Safety Information for Sealed Source Users

Sealed source

Sealed source

Radioactive materials sealed inside metal/plastic.

Most sealed sources can be handled without concern that the radioactive material will be dispersed onto hands or clothing.

Sealed source

Sealed sources are used

- in many laboratory devices, such as Radiation counters, gas chromatographs, and portable gauges.

- as check sources, calibration sources for the detectors

Types of radiation

Alpha (α) : Highly Energetic Helium Nucleus ($^{4}_{2}He$)

Beta (β): Electrons

Gamma (γ), X-ray (X) :
Electromagnetic Wave

Neutron(n) : Neutrons

Sealed sources in 3313 & 3214

Sr-90, Tl-204
Beta Source
Used as irradiation sources.

Units

Ci (Curie) Original Unit of radioactivity

1 Ci = Activity of 1 g Ra

= 3.7×10^{10} dps (disintegration or decay per second)

1 mCi = 10^{-3} Ci, 1 μ Ci = 10^{-6} Ci

Bq (Becquerel) International Unit (SI)

1 Bq= 1 decay per second

1 Ci = 3.7×10^{10} Bq

R (Roentgen)

amount of radiation required to create 1 esu (one ionization) in 1 cm^3 of dry air.

rad (Radiation Absorbed Dose)

1 rad = 0.01 J/kg

rem (Roentgen Equivalent Man)

rem = rad x Relative Biological Effectiveness = 0.01 Seivert

RBE for β's is 1.0 – 1.7

Exponential Decay

Decay calculation

$A_t = A_0 e^{-\lambda t}$

A_t:Activity at time t = t (in Bq)

A_0:Initial activity, Activity at time t=0

λ: decay constant (= ln2/Half life)

User responsibilities

Authorized user

- Supervising activity using sealed source
- Assisting Leak test, Notify the RSO of any leak/damage
- Ensuring Security
- Ensuring that all workers received appropriate training
- Notifying the RSO of any staff changes

Radiation Workers

- Follow the instructions of authorized users
- Take required training

Survey & Monitoring

- **Be sure to monitor the work area while handling sealed sources.**

- **Select appropriate meters for monitoring.**

Alpha, low-energy Beta sources
→ Scintillation survey meters (ZnS, CsI) Gas-flow counters, Silicon diodes

High-energy Beta sources
→ Geiger Mueller (GM) counters

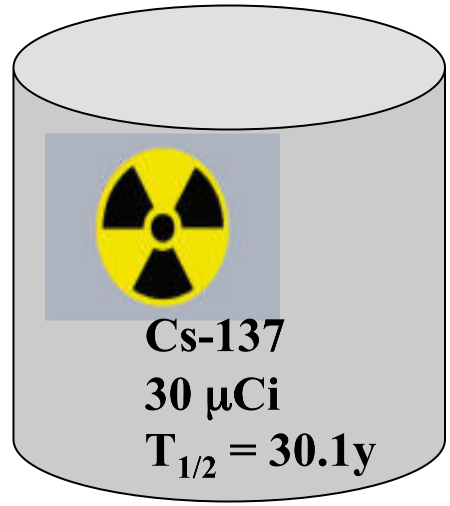
Gamma sources
→ Scintillation survey meters (NaI)

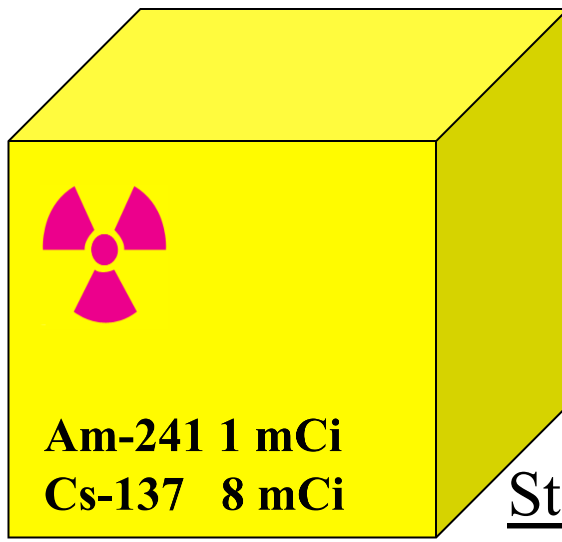
Neutron sources
→ Neutron detectors (BF_3), Proportional counters

Posting/Labeling

Area

sources





Storage/case

ALARA

ALARA = As low as <u>reasonably</u> achievable

- Radiation protection philosophy
- Should be applied to maintain any dose
  at levels as low as are practicable

Protection

Time : Shorter usage → Less exposure
Have a plan to minimize time.

Distance : Keep distance (Inverse square law)
Double the distance, the exposure rate is decreased by four

Shielding : Shielding material selection
- Bremsstrahlung…

Shielding

Select proper shielding material

Gamma, X-ray – Thick/dense material
(*e.g.* lead, concrete, steel)

Neutron – Neutron absorber (*e.g.* Paraffin)

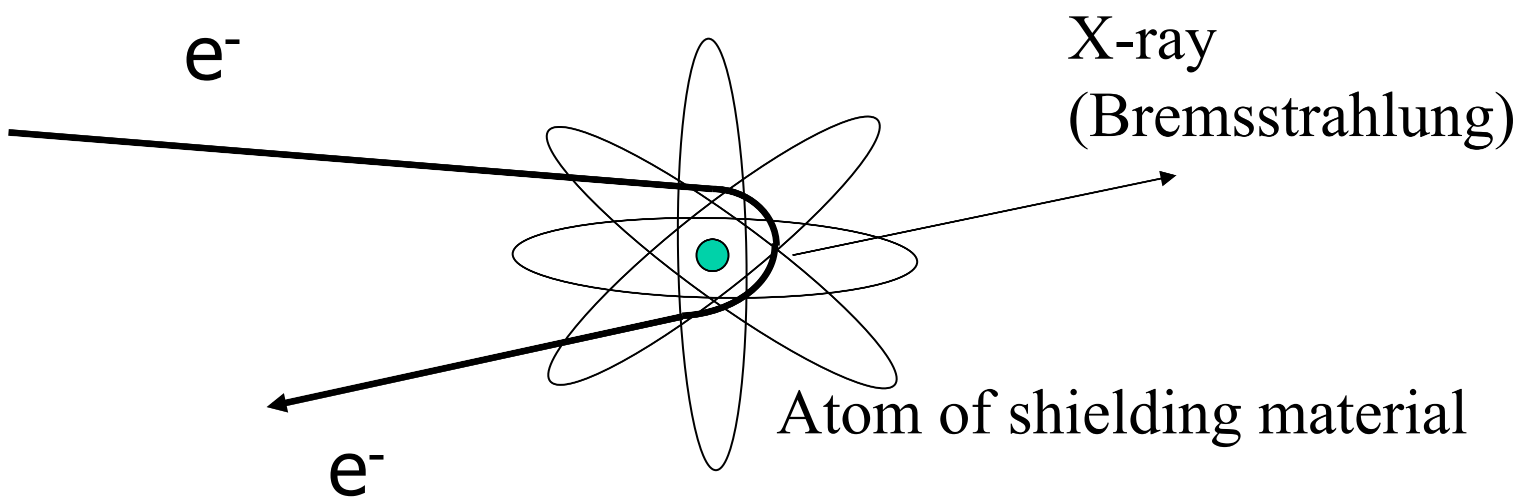
Beta – Low Z material (*e.g.* Plastic, wood, glass)

Alpha – No shielding required
(dead layer of skin cells is shielding!)

Why not lead??
* See next slide

Shielding - Bremsstrahlung

High Z materials (dense materials like lead, steel) promote bremsstrahlung production
(white radiation emitted during braking of a charged particle, like β.)



Radiation Doses

- Typical “Natural” dose ~0.24 rem/year
  - Solar, radon, medical, etc.
- Medical x-ray – 0.07 rem/year
- Maximum permissible occupational dose – US NRC (radiation worker)
  - Whole body 5 rem/year
  - Pregnant worker 0.5 rem total during gestation
    0.05 rem/month
- UH regulations - Shield radioactive sources to less than 2 mR/hour at one foot. (ALARA)
  - For β, ~ 2 mrem/hour = 0.002 rem/hour

Our beta sources

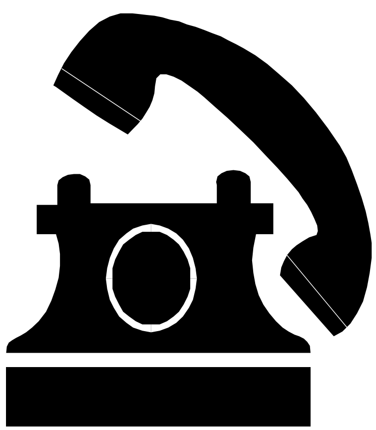
- Outside big plexiglass box ~ 0.01 mR/hr
  ~ 0.01 mrem/hr (background level) << 2 mrem/hr
  - For a 6 hour lab, ~ 0.06 mrem.
- At top surface of sealed source
  ~ 1mR/hr ~ 1 mrem/hr.
  Hold it for 1 minute, ~ 0.02 mrem.
- At bottom (active) surface
  ~ 15 mR/hr > 2 mrem/hr.
  Hold it for 1 minute, ~ 0.25 mrem.
- ***Keep bottom pointed away from people***

Contact information

- **In an emergency: 911**

- **University of Houston Police Department (UHPD)**
  (713) 743-3333

- **Office of Environmental Health & Risk Management (EHRM)**
  (713) 743-5858
  (M-F, 7:30am – 4:00pm)
  (After hours & holidays, UHPD)



- **Radiation Safety Officer**
  (713) 743-5858