

E_001 - Electrical Safety Training



LLE Plasma Electrode Pockels Cell Driver

Electrical Safety Officers

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If it is 50 Volts or Greater -



It is High Voltage

Safety is Everyone's Business and Compliance with Safety Procedures is MANDATORY



Summary

- Electricity is a serious safety hazard when handled improperly
- 50 Volts or higher is considered **HIGH VOLTAGE** at LLE
- Training - only perform activities for which you are qualified
- If an activity seems unsafe, “Stop Work” and address concerns
- Promptly report safety deficiencies or events
- Never defeat engineering safeguards
- Always verify voltage is not present before beginning work
- Lockout/Tagout (LOTO) & Safety Inspection Policy

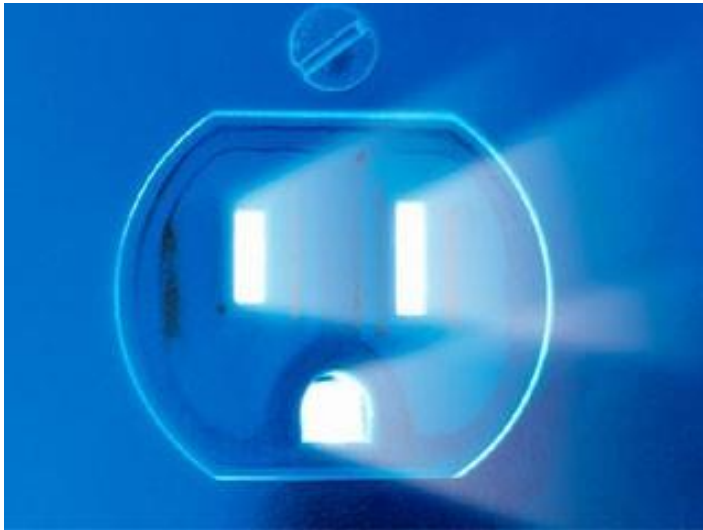
Ensuring a safe working environment at LLE is a responsibility shared by all personnel

Safety is a Culture at LLE



- Everyone receives training to ensure they understand and adhere to LLE Safety Policies
- Safety is emphasized in all aspects of training
 - i.e. Takes about 1 year to be trained to work in OMEGA or EP Laser Facility
- Safety discussion begin at the conceptual design level
- If there are ever questions or concerns 'raise your hand and ask'
- Safety Office relies on communication from all of you
 - 16 members of the LLE Safety Team
 - 500+ people at LLE

Electrical Safety = Awareness + Prevention



- Shocks > 50mA can kill
- Fire – can be caused by overloaded circuits, defective equipment, and inadequate ventilation
- Explosion – can result if sparks occur near a flammable gas, as a result of an arc-flash event, or rapid overheating

- ✓ Avoid Complacent Behavior
- ✓ Maintain Mental Alertness

The Shocking Facts: How Electricity Affects Your Body



- **Shock is the nerve sensation caused by electric current flowing through the body**
- **A shock occurs when your body becomes part of a circuit**
- **The severity of shock is determined by three factors:**
 - **The current flowing through your body**
 - **The path the current takes**
 - **The total time current flows**

What Factors Influence the Severity of a Shock?



- **Your skin's electrical resistance**
 - **Work in a dry environment**
 - **Below 600 volts, dry skin is 100× more resistive**
 - **Minimize contact area**
 - **A finger contact is higher resistance than a whole hand.**
 - **Minimize contact pressure**
 - **Pressure decreases resistance, increases the risk of a burn.**
- **Duration of contact**
 - **The longer the contact, the more likely the burn.**

Use proper tools and appropriate Personal Protective Equipment

Shock is Not the Only Threat from Electricity...



The Dangers of High-Voltage Electricity include:

- **Hearing loss**
- **Eye injury (projectiles, burns, intense light)**
- **Burns (internal and external)**
- **Broken bones (reflex reaction causing fall or impact injury)**
- **Cardiac arrest**
- **Death**

Physiological Effects of an Electric Shock

Effects of Electrical Current* on the Body³

Current	Reaction
1 milliamp	Just a faint tingle.
5 milliamps	Slight shock felt. Disturbing, but not painful. Most people can "let go." However, strong involuntary movements can cause injuries.
6–25 milliamps (women)† 9–30 milliamps (men)	Painful shock. Muscular control is lost. This is the range where "freezing currents" start. It may not be possible to "let go."
50–150 milliamps	Extremely painful shock, respiratory arrest (breathing stops), severe muscle contractions. Flexor muscles may cause holding on; extensor muscles may cause intense pushing away. Death is possible.
1,000–4,300 milliamps (1–4.3 amps)	Ventricular fibrillation (heart pumping action not rhythmic) occurs. Muscles contract; nerve damage occurs. Death is likely.
10,000 milliamps (10 amps)	Cardiac arrest and severe burns occur. Death is probable.
15,000 milliamps (15 amps)	Lowest overcurrent at which a typical fuse or circuit breaker opens a circuit!

*Effects are for voltages less than about 600 volts. Higher voltages also cause severe burns.

†Differences in muscle and fat content affect the severity of shock.

Electric shock victims suffering from ventricular fibrillation will die if they do not receive prompt, emergency medical attention

Responding to an Electric Shock Event



- When you witness someone being shocked, don't panic or rush into action.
 - Assess the situation to avoid being electrocuted yourself
- Do not touch the person! If the victim is contacting an energized object - contacting them will also shock you
 - If possible, shut off the power
 - If not, separate the person from the circuit using an insulator (e.g. dry wooden broom handle, a shepherds hook or a piece of PVC pipe)
- Once the victim is free,
 - Immediately call 911 for emergency medical assistance
 - Try to keep the person calm and still until help arrives
 - Provide first aid assistance if you are trained

Electric shocks can cause significant internal injuries, and have delayed onset of symptoms. Advise shock victims to seek medical attention.

What to do if an Electrical Shock Event Occurs



- **STOPWORK**
 - **Secure the area. De-energize affected equipment unless doing so introduces known hazards**
 - **Assess the victim's status. Call for emergency medical assistance if injuries are suspected, or if the victim is acting abnormally.**
 - **Talk with the victims. Investigate. Learn exactly what happened.**
- **The Electrical Safety Officer (ESO) or his designee must ensure that ALL necessary actions have been completed to establish safe operating conditions before resuming operation**
- **Report all electrical shock events that occur at LLE (except those from static electricity) to your supervisor and the ESO or Chief Safety Officer**

An employer may not retaliate or take unfavorable personnel action for reporting a workplace safety deficiency when the complaint is made in good faith

LLEs Approach to Training



- No Employee is expected OR PERMITTED to undertake a job until he or she has received appropriate instructions on the performance of that task.
- This may include any or all of:
 - Safety Training
 - Technical Training
 - Equipment Training

OSHA 29 CFR 1910 Section 399: A qualified person is “one who has received training in and has demonstrated skills and knowledge in the construction and operation of [electrical] equipment and installations and the hazards involved.”

LLE Electrical Safety Training



- **Basic Electrical Safety Training (this module)**
 - **Fundamentals and awareness**
- **HV Worker Training (E_004 module + equipment specific)**
 - **Completion of Basic Electrical Safety Training**
 - **Area and task specific training**

High Voltage Worker Qualification



ONLY those who NEED to perform work on high voltage systems will be qualified

- **Review the E-004 HV Basics Safety Overview & quiz**
- **Complete G_011 Lockout Tagout Training**
- **May also need to complete E_003 Arc Flash Training**
- **Understand how to safely perform 0-volt verification**
- **Receive area/equipment specific training and qualification**

HV workers are expected to verify equipment is fully discharged, and install LOTO as needed, before any work is performed

Performing Electrically Energized Work – Shall be Avoided Whenever Possible



Electrically energized work will only be performed when there is no other alternative

- **Must be trained as a high voltage worker**
- **Must have a safety buddy and proper PPE available**
- **Complete a Energized Work Permit which includes approval by the Chief Safety Officer**
- **Permit requires approval by:**
 - **Individuals group leader,**
 - **Chief Safety Officer (CSO)**
 - **Electrical Safety Officer**

Individuals must work within the scope of their training and qualification

Electrical Safety Common Sense Practices



- Allow proper ventilation for power dissipating equipment
- Investigate “hot” or unusual smells around equipment
- Ask for help if you have questions
- Turn off unused equipment (except computers)
- Verify area is clear and secure prior to activation of remote (OUT OF SIGHT) equipment
- Never leave a potentially hazardous situation unattended for ANY REASON
- Recognize and mitigate hazards
- Use **simple** warning signs to communicate danger or possible risks
- Insist on proper lighting for your work area
- Be vigilant in checking for overhead conductors when using ladders, elevated work platforms or other conductive objects
- Use a non-conductive ladder when performing elevated electrical work

Safe Work Practices – Making 0-volt Checks



Implement safeguards prior to starting work until 0-volt verification is completed:

- **Employ the buddy system**
- **Maintain safe working boundaries for HV equipment**
 - **As indicated on Arc Flash/Shock Boundary labels**
 - **Use barriers to restrict access**
- **Use insulating materials, tools and wear rubber soled shoes where possible**
- **Remove conductive jewelry, buttons and (metal) zippered clothing**
- **Wear arc flash hazard suit if hands or arms will cross the restricted boundary**
- **Wear electrical insulated and rated footwear**
- **Use right hand for work, keep other behind or in pocket**
- **Insist on proper lighting**
- **Control your environment to avoid distractions and unsafe activities**

Test for presence of voltage once all steps are addressed

Engineering Controls – Electrical Safety is Addressed During the Design Phase of Every Project



- **Include equipment interlocks for hazardous voltages existing behind closed doors or panels**
 - **Ex. External disconnect that allows for Lock install**
- **Preclude access to non-insulated electrical terminals or wiring**
- **Ground all conductive frames, enclosures and accessible metallic components including optical benches and tables:**
 - **Ground conductors must be permanent and continuous**
 - **Ground conductor size must provide sufficient impedance for all frequencies and anticipated fault currents**
- **Affix appropriate warning labels to all high-voltage equipment**

Safety features such as interlocks, alarms, detectors may only be bypassed on a case by case basis following Safety Officer review

Personnel Protective Equipment (PPE) for Electrical Work



- PPE is your *last line of defense* when all else fails to prevent an accident
- PPE doesn't prevent accidents, but may reduce the severity of injuries
- These factors are critical to working safely:
 - Robust equipment engineering design
 - Proper equipment maintenance
 - Proper training
 - Good work practices
- What PPE is required/recommended? It depends on the job!
 - Impact resistant eyewear (Always!)
 - Electrical hazard (EH) safety-toe shoes protect the wearers' feet from completing an electrical circuit at up to 600 volts. Protection may be compromised when wet, soles are worn, or metal particles are embedded in the sole or heel.
 - Electrically insulating gloves
 - Arc-flash garments (tight-weave cotton preferred over synthetics)
 - Nomex or similar is required for cleanroom work
 - Hearing protection

Consult with the Electrical Safety Officer to discuss task-specific PPE requirements

LLE Policy for Facility Modifications of the Electrical Distribution System

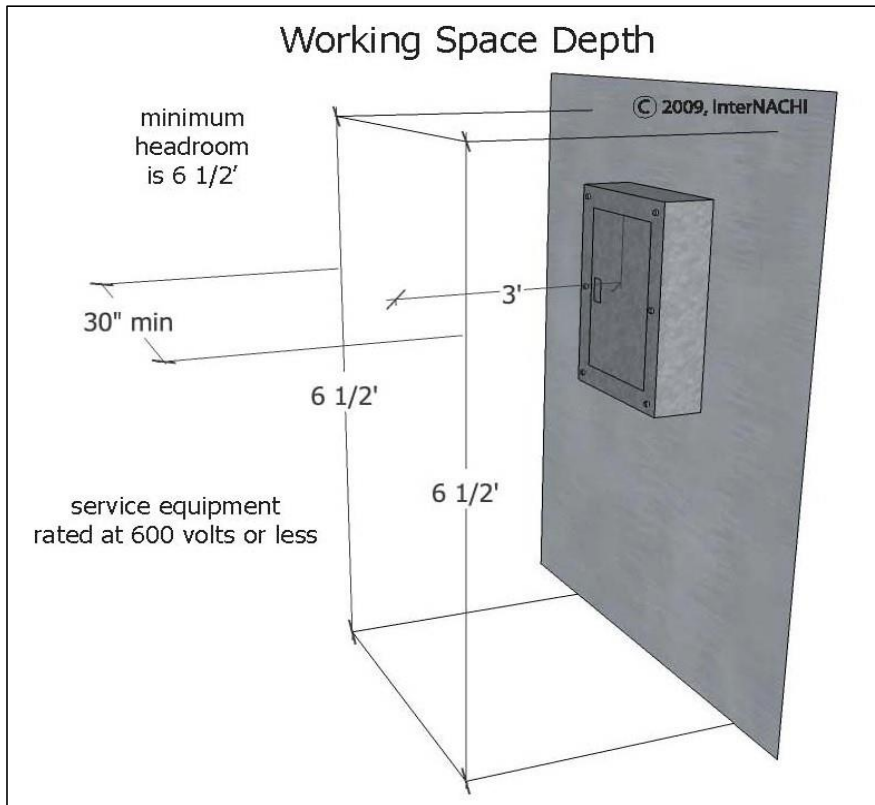


ONLY electricians reporting to the Facilities Group Supervisor may service or modify Building Power Distribution equipment. This includes:

- 120 / 208 / 240 / 480 VAC
- Wall switches and outlets
- Circuit breakers
- Panel boxes
- Transformers
- Conduit
- Uninterruptable power supplies (UPS) > 1500 VA rating

General LLE Staff may operate circuit breakers only when following written procedures approved by the Electrical Safety Officer

Maintain 36" Clearance Around ALL Breaker Panels



Electrical Safety Protection Devices



- Fuses and circuit breakers are switches that “open” when the flow of electric current exceeds safe levels for the circuit or equipment involved
 - *Fuses and circuit breakers (those without ground-fault interrupt, below) are designed to protect building wiring, and do not reduce the risk of a shock injury*
 - Tripped breakers and blown fuses indicate an overloaded circuit which may be a fire hazard and can damage equipment
 - Do not reset a tripped circuit breaker
 - Replacement fuses must meet the manufacturer’s specifications

Electrical Safety Protection Devices



- Ground fault circuit interrupters (GFCIs, or GFI), provide shock and overload protection, and are mandatory outdoors, near sinks, and in damp/wet locations
 - *GFI's are designed to protect people*
 - The GFI compares the current flowing in the “hot” and neutral conductors
 - When a 5 milliamp difference is detected (typical threshold for a person to feel an electrical shock), the GFCI will quickly trip
- Transient surge suppressors protect sensitive electronics from voltage spikes, but do not eliminate shock hazards

Test Ground Fault Circuit Interrupters (GFI's) in your work area regularly

LLE Electrical Equipment Policy



- **DO:**
 - Use only UL Listed 3-wire appliances
 - Limit the load according to the manufacturer's device label
 - Investigate abnormal operation, smells, etc.
 - Discard or tag out damaged equipment
 - Have qualified & authorized personnel repair devices

- **DO NOT:**
 - Daisy Chain (connect in series) devices
 - Use damaged equipment
 - Take damaged equipment home



When Specifying or Purchasing Equipment, Understand the Markings that Indicate Safety Agency Qualification



These example markings are used by the Underwriters Lab (**UL**) for equipment and component safety qualification. The reverse “**UR**” symbol means the item is a **UL Recognized component** intended for integration into a product.

For more info: <http://ul.com/marks/ul-listing-and-classification-marks/appearance-and-significance/marks-for-north-america/>



These are example **CSA** marks that indicate that a sample of the product has been certified to applicable standards written or administered by the American National Standards Institute (ANSI), Underwriters Laboratories (UL), CSA Group (CSA), NSF International, and other North American organizations.

For more info:

<http://www.csagroup.org/global/en/about-csa-group/certification-marks-labels/csa-marks>



Batteries Present Electrical, Chemical, Fire and Physical Hazards



Battery-operated uninterruptible power supplies are commonly used with sensitive electronics (e.g., computers). **When de-energizing equipment, look for and secure ALL power sources**

During battery maintenance (e.g., charging, replacing), consider electrical, physical, chemical and explosion hazards including:

- Electric shock
- Burns and shrapnel-related injuries from a short circuit
- Chemical burns from electrolyte spills or surface contamination
- Fire or explosion due to hydrogen
- Physical injury from lifting or handling the cells
- Fire from overheated electrical components

Immediately remove a battery from service if it shows abnormal signs of distortion, overheating, or chemical discharge. Properly dispose of batteries.

LLE Policy for Lockout / Tagout



- POLICY:** Refer to LLEINST6300
Supplemental Within the Laser Facility: INST3000
- LOCKOUT:** Installation of a physical barrier, or removal of a connecting link, to isolate hazardous energy before starting maintenance
- TAGOUT:** Placement of tag on breaker, switch, control device or valve stating “DANGER DO NOT OPERATE”

A Tagout will only be used when the installation of a Lockout is not possible

Examples of Acceptable Electrical Lockout / Tagout



Lockout / Tagout Guidelines



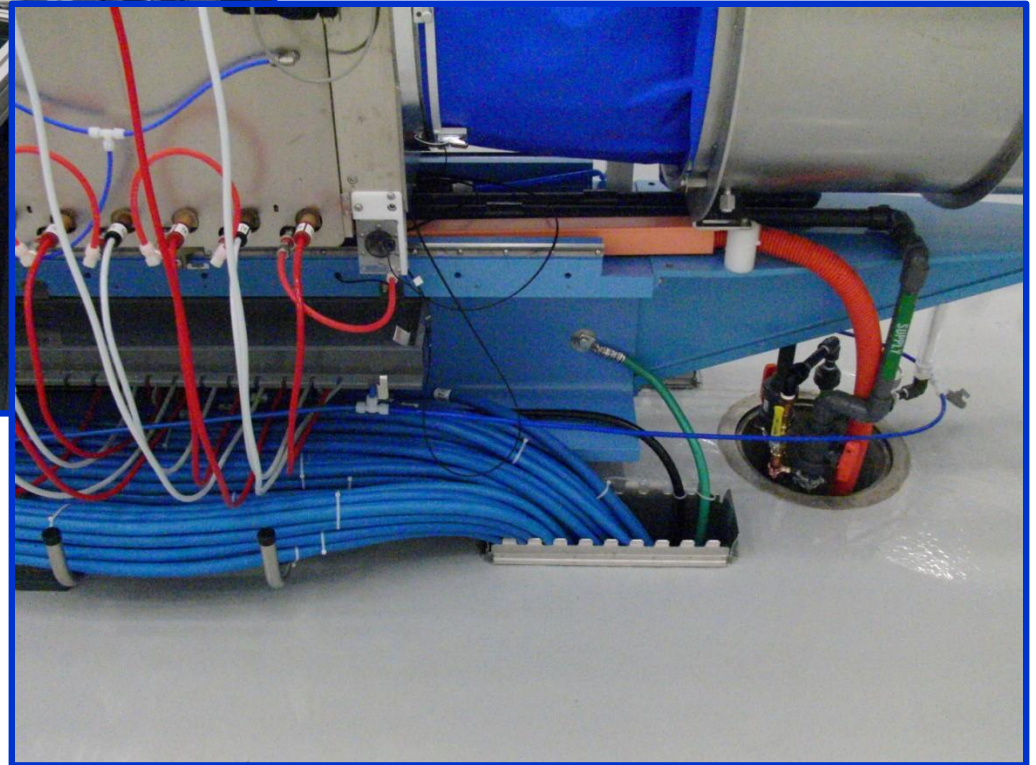
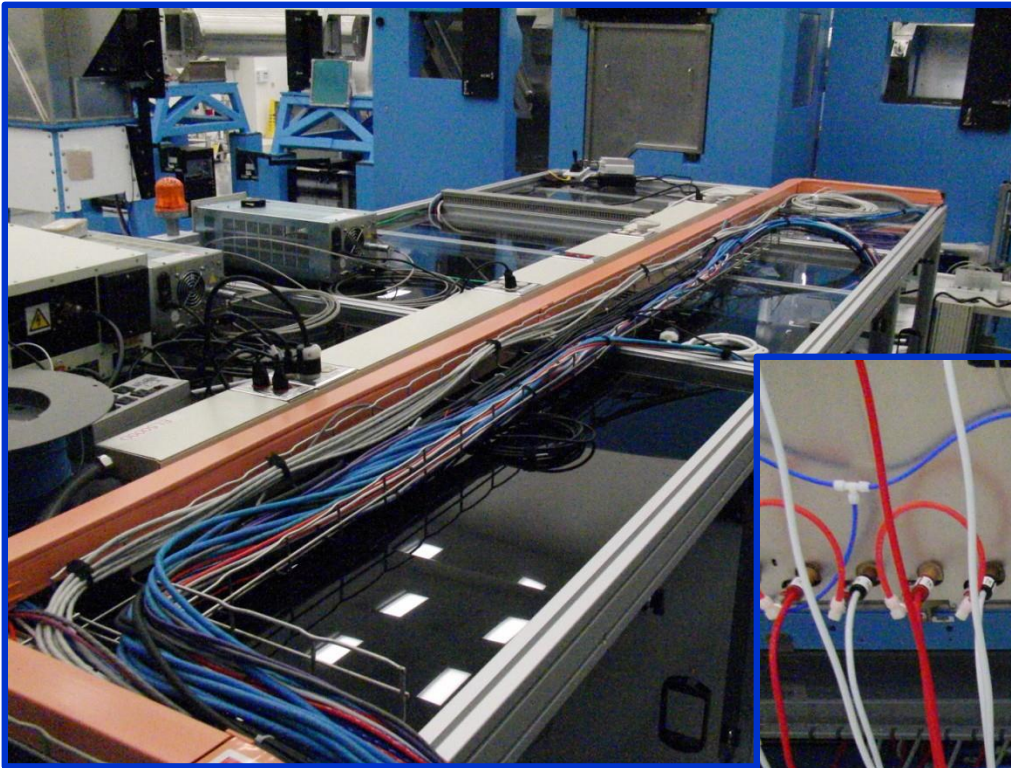
- **Lockout/Tagout (LOTO) equipment suspected of presenting a hazard to personnel or other equipment if operated.**
- **Install a LOTO prior to beginning maintenance**
- **Verify potential hazardous energy is discharged, dissipated**
- **Tags must be legible, and indicate: initiator, reason, time & date**
 - **Tags must be respected as if they are a physical barrier preventing operation of equipment**
- **NEVER operate locked or tagged-out equipment.**

Cable Installations Must be Planned, Engineered, Documented, and Properly Executed to be Safe and Reliable



Cable installations must comply with LLE Documents

- M-TM-M-002 and
- E-CB-G-001



Cables must not inhibit access, or cause trip or overhead hazards. Cables must be rated for the environment.

General Housekeeping - Do Not use Electrical Raceways as Shelves



Equipment will be De-energized to the Greatest Extent Possible Before Work May Proceed



- Guidelines for De-energizing Electrical Equipment
- Identify and isolate equipment from energy source(s)
- Verify power is off
 - Attempt to operate
 - Measure voltage * - when possible use a non-contact voltage tester
- Release stored energy
 - Electrical *
 - Mechanical, hydraulic, pneumatic, gravity, chemical
- Ground chassis with clip leads or ground cables to ensure zero-volt safe state *
- Lockout and tagout to prevent unexpected activation



*** These operations must be done by a properly trained individual**

Obtain assistance from a qualified electrical worker when necessary or unsure

Laboratory Safety Inspection are Performed Semiannually



Semiannual inspection of all lab spaces is mandated by LLE Instruction 6550

- **Electrical Safety Guidelines**
 - **Compliance with the NFPA National Electric Code**
 - **Undamaged Cables, Leads, and Plugs**
 - **Guarding for Electrical Terminals**
 - **Electrical Interlocks Installed and Operational**
 - **Equipment De-energized Prior to Maintenance**
 - **Appropriate Labels on High Voltage Equipment**
 - **Optical Tables and Benches Properly Grounded**
 - **GFI Outlets Utilized Near Sinks**
 - **Non-UL Approved Equipment Not In Use**

Electrical Safety Inspections are Required on a Case by Case Basis when Modifications Occur



- **New Construction**
- **New System Installations**
- **Modifications of Existing Equipment**

Electrical Safety Awareness is a Mindset at LLE



- **Plan jobs thoroughly; review procedures with your supervisor**
- **Include safety plans and actions in Design Reviews**
- **Maintain safe working distance from exposed circuitry**
 - **As per Arc Flash / Shock Hazard labels**
 - **Use barricades and warning signs**
- **Maximize use of insulating materials**
- **Always perform a 0-volt verification check**
- **Employ Good Housekeeping**
- **Immediately report deficiencies**

Electrical Safety Conclusions



- Understand and follow all LLE safety policies
- Seek further training / use Safety Officers when required
- It's your experiment, it's your lab, take responsibility
- Clearly communicate with co-workers
- Plan jobs and discuss with your supervisor
- Always verify voltage is not present before beginning work
- Follow Lock out / Tag out procedures
- Clearly label all recognized and potential hazards
- Have an emergency response plan
- Clearly post emergency phone numbers
 - Daytime hours, 8 to 5, dial **55101** – front desk
 - After Hours dial **9-911**

Safety is Everyone's Business and Compliance with Safety Procedures is MANDATORY



Summary

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- 50 Volts or higher is considered **HIGH VOLTAGE** at LLE
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