Stanford | Environmental Health & Safety

STANDARD OPERATING PROCEDURE FOR ELECTRICAL, ENGINEERING & ROBOTICS RESEARCH WORK

[INSTRUCTIONS: Template Guidance text is provided in [GREEN TEXT inside brackets]. When completing your SOP, please delete these "Instructions" and the [GREEN TEXT inside brackets] and replace it with your project information where relevant, or indicate N/A.]

I. CONTACT INFORMATION

Procedure Title	[Specify]
Procedure Author	[Specify]
Creation/Revision Date(s)	[Specify]
Responsible Person	[Name of PI, Lab Supervisor, or Autonomous Researcher, as appropriate]
Location of Procedure	[Building and room number]

II. PRIOR APPROVALS

Consult your PI and/or lab supervisor if experiments involve high-risk operations that can potentially result in serious injury or illness, to ensure safety precautions are taken. Retain a record of their prior approval for at least one year.

- High-risk operations may involve working with exposed electrical conductors carrying 50 Volts and 15 milli-Amps or more, confined space entry, custom-made pressure vessels, Cobot interaction(s), high-speed/large payload robotics studies, Robotic Control Software or Firmware Studies, etc. as may be determined by the PI.
- Consultation can include discussion of special hazards and safety precautions and review of applicable standard operating procedures.
- Your PI or lab supervisor's prior approval may be documented by their signature in the Approval Signature field at the end of this Section.
- For granting prior approval to individuals other than the procedure author, use one of the following forms of documentation:
  - Complete the Documenting SOP Review and PI Approval
  - Have the PI or lab supervisor sign and date the staff member's notebook and indicate approval for the process, procedure, or activity
  - Use another form of written approval, such as an e-mail or memo.

Approval Signature, if applicable	[Obtain prior approval from the PI or lab supervisor, as appropriate with a signature on this line]

III. THIS STANDARD OPERATING PROCEDURE (SOP) IS FOR A:

☐ **Specific laboratory/research/maintenance procedure or experiment**
[Examples: Maintenance and cleaning of research work cell; End Effects Design / Payload Coupling study; Li-ion battery cell harvesting study; Plasma deposition study; Cobot/Human Interaction study; etc.]

☐ **Generic laboratory/research/maintenance procedure for similar materials or equipment**
[Examples: Designing and Installing a Robotic Work Cell; Vibration Study Equipment Operation and Maintenance; Shock Wave Study Equipment Operation and Maintenance; Automation Control Firmware Study Protocols used by the Lab; etc.]

IV. PROCESS OR EXPERIMENT DESCRIPTION

[Provide a brief description of your process or experiment, including its purpose. Include type of equipment or machinery to be used and whether modifications will be made to the hardware, software, or firmware. Do not provide a detailed sequence of steps, as this will be covered by Section VII of this template. Indicate the frequency and duration of experiments below.]	
Frequency	☐ One time ☐ Daily ☐ Weekly ☐ Monthly ☐ Other (Describe): _____
Duration per Experiment	_____ minutes; _____ hours; and/or _____days

V. HAZARD SUMMARY & SAFETY REVIEW

Conduct a hazard assessment using this checklist below. Check any hazards that may be part of your intended research. Then, provide details in Section VI regarding the hazards.

A. Physical Hazards (Check all that apply)

1. ☐ Exposed electrical conductors carrying 50 Volts or more, and 15 milli-Amps or more (Electric Shock / Physical Contact hazard)
2. ☐ Capacitors and/or Capacitor Banks that are not self-grounding with a total stored capacitance of 5 joules or more (Electric Shock / Physical Contact / Explosion / Arc Flash hazard)

3. ☐ High pressures or vacuum that can result in equipment structural failure or potential safety risk.
4. ☐ Extreme surface temperatures below 0°C or in excess of 50°C (Contact / Radiant Heat / Cold)
5. ☐ Cryogens and extremely cold fluids / gas(es) (BLEVE, material embrittlement, contact frost bite hazards)
6. ☐ Open Flame / Combustion Processes (Fire or explosion hazard)
7. ☐ Noise in excess of 85dB (Noise hazard)
8. ☐ Vibration (Ergonomics and/or Structural Failure)
9. ☐ Shockwave / Explosion (Body Impact / Fire / Equipment Damage Hazard)
10. ☐ Lifting / Carrying / Manual Material Handling 20 lbs. or greater repetitively (Ergonomics)
11. ☐ Lifting / Carrying / Manual Material Handling 50 lbs. or greater infrequently (Ergonomics)
12. ☐ Repetitive motion with arms/hands for >30 minutes continuously (Ergonomics)
13. ☐ Gripping or other forceful exertion applied by wrists/hands (Ergonomics)
14. ☐ [List other physical hazards not noted above, and their associated health and safety concern. Examples of potential hazards include physical-impact, projectiles, ballistics, etc.]

B. Environmental / Location Hazards (Check all that apply)

1. ☐ Ambient / environmental or surface temperature below 0°C/32°F or greater than 26°C/80°F
2. ☐ Humidity level below 20% or greater than 60%
3. ☐ Work location with an unguarded edge having a 30" or more drop
4. ☐ Confined workspace (e.g., a pit, vault, tank, or other space that can be bodily entered, is not designed for continuous occupancy, and has limited access/egress)
5. Field Research – Select: ☐ Outdoor, ☐ wilderness, ☐ urban, ☐ rural, ☐ international
6. ☐ Wet or underwater location
7. ☐ Dry or desert location
8. ☐ Use of marine equipment / marine operations at the Surface or Underwater
9. ☐ Location has limited or no access controls that restrict non-lab personnel's access to the research site (e.g. shared lab space, doors are not locked, non-lab personnel may gain access, student access of space, etc.)
10. External factors – Select:
    ☐ Access by the public, or ☐ Existing hazard(s) in workspace unrelated to SOP
11. ☐ [List other environmental / location hazards not noted above.]

C. Hazardous Operations / Equipment (Check all that apply)

1. ☐ Manually testing for presence of voltages above 50 volts and/or amperages above 15mA.
2. ☐ Designing/ constructing/ modifying devices that store electrical charges (i.e., Batteries, Capacitors, Chemical Batteries, Fly-Wheel Storage, etc.)
3. ☐ Building homemade or modifying manufacturer-made research equipment
4. ☐ Alternative Energy Sources (PV Arrays, Wind-powered Turbines, Wave Motion, Geothermal, etc.)
5. ☐ Plasma Generating Equipment and/or creating Electrically-charged Atmospheres
6. ☐ Class 3b or 4 LASER
7. ☐ Magnets (superconducting or otherwise) or Super-conducting Magnets (Cryogens / High magnetic fields)
8. ☐ Non-ionizing Radiation Generation / Use / Study
9. ☐ Ionizing Radiation Sources / Generation / Use / Study
10. ☐ Hot Work (Welding, Soldering, Metal Printing, etc.)
11. ☐ Lifting/ moving objects using powered equipment (e.g., Crane, hoist, winch, forklift)
12. ☐ Mechanical Systems and/or Automation with exposed / unguarded moving parts
13. ☐ Mechanical Systems and/or Automation with motion controlled by computer / PLCs
14. Vehicles or Mobile Equipment – Select:
    ☐ Human-driven, ☐ Automated, or ☐ Computer Controlled
15. Flying Equipment – Select:
    ☐ Human-driven, ☐ Automated, or ☐ Remotely Controlled
16. ☐ [List other equipment / operational hazards not noted above, and their associated health and safety concern. Examples of potential hazards include impact, projectiles, struck-by robot, damage to robot, lifting, craning, materials movement, data collection / storage challenges, etc.]

D. Chemical Hazards (Check all that apply)

1. ☐ Flammable gas(es) and their transfer between storage container(s) and their use
2. ☐ Flammable Liquid(s) and their transfer between storage container(s) and their use
3. ☐ Pyrophorics
4. ☐ Oxidizers
5. ☐ Acids
6. ☐ Corrosives
7. ☐ Bases

8. ☐ Heavy Metals
9. ☐ Reactants
10. ☐ Depositions
11. ☐ Solvents
12. ☐ [List other chemical hazards not noted above, and their associated health and safety concern.]

E. Other Hazards

[List other hazards not noted above.]

F. References (List all references / sources)

[List all references you are using for the safe and effective design of your process or experiment, including user manuals, safety literature, and peer-reviewed journal articles.]

VI. HAZARD CONTROLS

List in the table below:

- the hazard number by referring to the Hazard Summary checklist in *Section V above* (e.g., A3, C1, D2, etc.);
- followed by the description, magnitude, and/or quantity of the hazard; and,
- the control measures and methods intended to control the hazard to an acceptable level.

SPECIAL CONSIDERATIONS:

- For "**Chemical Hazards**" checked off in *Section V. D* above, include planned waste management and/or disposal methods as part of control measures noted below, but provide details on quantities and EH&S Hazard Waste Management requirements in *Section IX* below.
- For "**Field Research**" B5 checked above, complete a Field Safety Plan to assess field hazards and determine controls. (https://ehs.stanford.edu/forms-tools/field-safety-plan) Include the completed "Field Safety Plan" as part of this SOP.

Hazard #	Description and Magnitude	Control Measure(s)

VII. STEP-BY-STEP OPERATING PROCEDURE

[Provide or attach a drawing with the layout, work-cell, or plan-view of the lab with key apparatus and safety systems noted. Include:

- where the researchers will stand when conducting research relative to the set up or equipment;
- the Designated Work Areas;
- nearest fire extinguisher, first aid kit, eye wash, emergency shower as may be appropriate;
- locations of safety equipment such as Emergency Stops, Interlocks, etc.;
- the Emergency Exit route from the Designated Work Area to the nearest exit doorway. Note any potential obstructions along the emergency exit route as may be appropriate.]

A. Describe the location, accessibility, and/or certification status of the safety equipment that serves your lab:

ITEM	LOCATION & STATUS
Eyewash/Safety Shower	Location: _____ ☐ Ensure that it is accessible, not blocked. ☐ Check tag that it has been tested within last month.
First Aid Kit	Location: _____
Other: _____ _____ (*e.g., Battery Containment Kit)*	Location: _____
Fire Extinguisher	Type: _____ Location: _____
Telephone	Location: _____
Fire Alarm Manual Pull Station	Location: _____

B. Detail the hazard controls used while conducting this research

1. **Engineering and Administrative Controls –** Review safety literature and peer-reviewed journal articles to determine appropriate engineering and ventilation controls for your

process or experiment. Are interlocks, equipment guards, machine control logic, emergency stops, etc. used as part of research apparatus' safety systems? How are these engineering controls tested to confirm safety before research begins? Are procedures used and followed by researchers? How are these Administrative / Procedure Controls assured by researchers?

i. [Describe the engineering hazard control methods used for your research. Describe how safety systems are tested to confirm correct operation prior to commencing research. ii. Describe what administrative hazard controls and/or procedures are used to ensure safety of research? Who implements these controls and how are they trained?]

2. **Personal Protective Equipment -** To assist with your PPE selection, refer: https://ehs.stanford.edu/wp-content/uploads/General-Hazard-Assessment-Tool.pdf. Respiratory protection is generally not required for lab research, provided the appropriate engineering controls are employed. For additional guidance PPE selection, consult with EH&S, (650)723-0448.

Prior to starting research, put on the following PPE (check and complete as may be appropriate): ☐ Lab-appropriate street clothing (long pants, closed-toed shoes) ☐ Only Natural Fabric street clothing (cotton / wool / rayon / blends) (Required for electrical hazards) ☐ Gloves; indicate type: _____ ☐ Safety goggles ☐ safety glasses ☐ face shield ☐ Lab coat ☐ Flame-resistant lab coat ☐ Hair control net or other hair-control method ☐ Footwear; indicate type (i.e. safety-toe, closed-toe): _____ ☐ Other: (i.e. approved use of respiratory protection masks for COVID prevention)	[Note Potential Risks if Step is Not Done or Done Incorrectly (if any)]
The following are prohibited during research activities for the safety of researchers and must be removed for this SOP as they pose a snag, burn, or magnet hazard(s) (check as may be appropriate):	[Note Potential Risks if Step is Not Done or Done Incorrectly (if any)]

☐ Jewelry on hands ☐ Jewelry around neck ☐ Dangling jewelry ☐ Loose-fitting head or neckwear ☐ Loose-fitting clothing ☐ Other: _____	

3. **Designated Work Area(s) (DWAs)** are required whenever carcinogens, highly acutely toxic materials, reproductive toxins, non-ionizing and ionizing radiation sources, or other hazardous processes or equipment (e.g., robots, lasers) are used. The intent of a DWA is to limit and minimize people's possible exposure to hazardous materials, equipment, and operations. The entire laboratory, a portion of the laboratory, or a laboratory fume hood or bench may be considered a DWA. DWAs should have access control / restrictions such that only authorized and trained lab personnel have access to the DWA where research will take place. Below, please describe the DWA planned for your research:

[Describe the Designated Work Area and Access Control Methods for Authorized Personnel that are used for your research.]

4. **"AT REST CONDITION" –** The "At Rest Condition" of your research apparatus is the condition of the equipment or research process BEFORE you start to use the equipment to conduct research and gather data. It may include:
    - What switches and valves controlling utilities are turned "off" and what are turned "on".
    - Bonding and Grounding straps are in place.
    - What electrical, vacuum and pressure meter-readings should be.
    - What ancillary equipment is off and what is on.

The "At Rest Condition" is the starting place from which to write your step-by-step procedure. And, when research is done, please include the step-by-step process to return your research apparatus to its "At Rest Condition".

[Describe the research apparatus and its "AT REST CONDITION"]

C. Description of Process or Experiment

Step-by-Step Description of Your Process or Experiment	Potential Risks if Step is Not Done or Done Incorrectly (if any)
1) Ensure **Access to the Designated Work Area (DWA) is restricted** to Authorized Personnel only. [Describe how this will be done.]	
2) Conduct a pre-experiment safety inspection of the research apparatus before energizing the equipment and starting experiments. Confirm the research equipment is in an "**At Rest Condition**" as noted above, and safe to energize to conduct research work.	
3) [Describe the step-by-step procedure to energize your research apparatus and conduct experimental data-collecting work. Insert as many steps as needed to fully document your procedure process, including the steps to de-energize.]	
4) **Return to "At Rest Condition" -** Once research has been completed, return the research apparatus to the "At Rest Condition". [Describe the steps to be taken to return the research equipment to the "At Rest Condition". How is the research equipment confirmed to be in the "At Rest Condition" prior to leaving the Designated Work Area?]	
5) **Emergency Shut Down –** [Describe the steps to be taken to quickly shut down and/or put the research equipment into a safe condition in the event of an emergency. Is this different from the "At Rest Condition"? Note any differences, as well as example situations that might require the apparatus to be put into a safe condition in an emergency versus returning it to "At Rest Condition" before exiting the lab in an emergency. Never delay in responding to an emergency, and always default on the side of saving your life and that of others over property and research equipment.]	

6) **Dispose of hazardous waste -** Solvents, solutions, mixtures, and reaction residues must be considered hazardous waste until classified as otherwise. See detailed Waste Disposal instructions in Section IX below.	
7) Clean up work area and lab equipment. [Describe specific cleanup procedures for work areas and lab equipment that must be performed after completion of your process or experiment. For controlled substances, carcinogens, reproductive toxins, ionizing sources, other hazardous materials, the Designated Work Area must be immediately wiped down following each use.]	
8) Remove and dispose of PPE and remember to wash your hands.	
9) **Remove Access Control Restrictions**, if appropriate.	

VIII. EMERGENCY PROCEDURES

A. Fire, Explosion, Health-Threatening Hazardous Material Spill or Release, Compressed Gas Leak, Valve Failure, Electrical Fire, etc.

1. Call 911.
2. Alert people in the vicinity and activate the local alarm systems.
3. If it is safe to do so, complete Emergency Shut Down Procedures on research equipment.
    i. For compressed gas leaks, liquid leaks, electrical malfunctions, etc. shut off supply valves and switches only if this can be done safely, without risk to personnel. Never delay in vacating the lab to complete an emergency shut down of research equipment if your or other's life/lives is threatened by taking time to complete an Emergency Shut-down Procedure, or shutting off utilities.
4. Evacuate the area and go to your Emergency Assembly Point (EAP):
    i. This Lab's EAP location is: _____
5. Remain at the EAP to advise emergency responders of conditions in your Lab.
6. Once personal safety is established, call EH&S at (650)725-9999.
7. Provide local notifications (local notifications are listed at the end of this section).

B. Injuries and Chemical Exposures

Health-threatening

1. Remove the injured/exposed individual from the area unless it is unsafe to do so because of the medical condition of the victim or the potential hazard to rescuers.
2. Call 911 if immediate medical attention is required.
3. Call (650)725-9999 to report the exposure to EH&S.
4. Administer first aid as appropriate.
5. Flush contamination from eyes/skin using the nearest emergency eyewash/shower for a minimum of 15 minutes. Remove any contaminated clothing.
6. Bring to the hospital copies of SDSs for all chemicals the victim was exposed to.

Non-health-threatening

For injuries and exposures that are not considered serious or a medical emergency, call the Occupational Health Center (OHC) at (650)725-5308 between 8:00 am-5:00 pm Monday through Friday at (650)725-5308 for immediate phone triage and to schedule an appointment. For urgent conditions when OHC is closed, go to the Stanford University Medical Center Emergency Department.

C. Spills with Environmental Impact

For hazardous material spills or releases which have impacted the environment (via the storm drain, soil, or air outside the building) or for a spill or release that cannot be cleaned up by local personnel:

1. Notify Stanford University responders by calling (650)725-9999. These services are available 24 hours a day, 7 days a week.
2. Provide local notifications (local notifications are listed at the end of this section).

D. Local Cleanup of Small Spills

In the event of a minor spill or release that can be safely cleaned up by local personnel using readily available equipment (absorbent available from EH&S in Small Spill Kit) and laboratory PPE:

1. Notify personnel in the area and restrict access. Eliminate all sources of ignition.
2. Review the SDS for the spilled material or use your knowledge of the hazards of the material to determine the appropriate level of protection (do not clean up spills requiring respiratory protection locally).
3. Wearing appropriate personal protective equipment, clean up spill. Collect spill cleanup materials in a tightly closed container. Manage spill cleanup debris as hazardous waste.
4. Submit online waste pickup request to EH&S.
5. Reporting Requirements: All spills cleaned up locally must be reported if they occur outside of secondary containment. A spill that occurs within secondary containment (a

laboratory hood is considered secondary containment) must be reported if it is greater than 30 ml or if it takes longer than 15 minutes to clean up. To report a spill, call EH&S at (650)725-9999 as soon as possible.

E. Lab-Specific Procedures

[This section is for any emergency procedures different from standard responses, or for additional emergency information due to the nature of materials or task. Include information on gas leaks, chemical spills, and personal exposure/medical emergency as appropriate.]

F. Building Maintenance Emergencies

Call Facilities Operations at (650)723-2281 (or (650)721-2146 in the School of Medicine) for building maintenance emergencies (e.g., power outages, plumbing leaks).

G. Local Notifications

[Identify the Lab's management staff that must be contacted in the event of an Emergency and include their work and after-hours numbers. This must include the principal investigator and may include the lab safety coordinator, facilities manager, and/or building manager.]

IX. WASTE DISPOSAL

[Describe the quantities and volume of waste products you anticipate generating and appropriate waste disposal procedures. Include any special handling or storage requirements for your waste. Contact EH&S at (650)723-0448 for questions and additional guidance.]

X. TRAINING REQUIREMENTS

General Training *(check all that apply):*

☒ General Safety & Emergency Preparedness (EHS-4200)
☒ Electrical Safety Awareness (EHS-2800)
☐ Electrical Safety for STEM and Physics Researchers
☐ Electrical Safety for LASER Users
☐ Electrical Safety Authority "Cardinal"

☐ Shop Safety / Maker Space Safety Orientation
☐ Lock out / Tag out – Energy Isolation Safety
☐ Confined Space Awareness / Safety
☐ Fall Protection Equipment
☐ Forklift / Industrial Lift Truck Use
☐ Aerial Lifts / Elevating Platform Use
☐ Craning / Hoisting / Rigging / Material Handling
☐ Chemical Safety for Laboratories (EHS-1900)
☐ Compressed Gas Safety (EHS-2200)
☐ Biosafety (EHS-1500)
☐ Other: _____

[Include links to relevant training documents, websites, or videos. Depending on the hazardous materials and processes you will be working with as detailed in this SOP, additional safety training may be required by the University. To evaluate if additional safety training is required, go to: https://stanford.box.com/lsg-training-needs-assessment.]

Location Where Training Records Are Kept:	[Describe if different from STARS/Axess]

Laboratory-specific training *(check all that apply):*
☒ Review of user manual or safety information involved in process/experiment
☒ Review of this SOP
☐ Other: _____

Location Where Training Records Are Kept:	[Describe if different from STARS/Axess]