Stanford University Environmental Health & Safety

Electrical Safety Management Plan for Research

September 19th, 2023

Contents

Purpose

The purpose of the Stanford University Electrical Safety Management Plan for Research (ESMPR) is to support the safety of researchers while conducting research activities involving routine and specified higher levels of electrical hazard. The intent is to mitigate the risk of electric shock and arc flash injuries, and fires and explosions, while providing a means for regulatory compliance and conformance with recognized standards and established work practices, including:

- NFPA 70E
- NFPA 70 (National Electric Code)
- Cal/OSHA Electrical Safety Orders
- California Electric Code
- International Electric Equipment Engineering (IEEE) Codes

The guiding principle of the ESMPR is to ensure that an electrically safe work condition is established whenever there is potential for exposure to electrical hazards. The ESMPR incorporates key components of NFPA 70E Article 350, "Safety-Related Work Requirements: Research and Development Laboratories," and the Department of Energy Handbook for Electrical Safety, particularly the sections on electrical safety in laboratories.

Scope

The ESMPR generally applies to research activities conducted by Stanford University faculty and researchers involving electricity up to 250 volts AC single phase, in accordance with the hazard categories and thresholds described below. Any researcher or research group working with equipment or systems that may have exposed conductors carrying 50 volts AC/DC or more, and/or triggers the thresholds shown below shall implement the ESMPR. Some research groups working with Class IIIb or IV lasers also conduct research activities involving high hazard electrical work. Custom-built equipment and systems should be designed, operated, and maintained in accordance with additional standards and requirements. Contact EH&S Research Safety for more information and assistance with custom equipment and installations.

Permissible and Prohibited Activities

The ESMPR sets forth the requirements for researchers to conduct activities with routine electrical hazards (i.e., generally not to exceed 50 volts AC) and for qualified persons, involving a high level of electrical hazard (i.e., generally not to exceed 250 volts AC). Researchers are not permitted to conduct activities above the thresholds shown below. Three phase, low- and high-voltage work above 250 volts, and other extremely hazardous electrical work (including energized work that requires an Energized Electrical Work Permit per Cal/OSHA standards) may not be conducted by researchers or Qualified Person(s) (QP(s)), and instead must be

done and overseen by Qualified Electrical Workers (QEWs) as defined by the Cal/OSHA electrical safety orders, or licensed electricians. Researchers are not permitted to conduct work on energized equipment or systems on a regular basis. Researchers are not permitted to open electrical panels unless authorized to do so. Exceptions may be granted by the Electrical Safety Authority (ESA) in particular cases and unique conditions.

Roles and Responsibilities

Principal Investigator

- Ensure that electrical hazards are identified, assessed, and controlled
- Ensure that the required templates for risk assessment, standard operating procedures (SOPs), and QP designation are completed for high hazard electrical work; approve risk assessments and SOPs
- Ensure that the ESMPR is implemented as necessary for all research activities that trigger hazard control thresholds
- Designate QP(s) for high hazard electrical work; ensure that the QP(s) is/are appropriately qualified for the specific research activities under the PI's purview
- Complete required training; includes training beyond awareness course if routine or high hazard electrical work is conducted by the research group
- Ensure that researchers complete required training
- Ensure that the appropriate engineering and other hazard controls are installed and maintained properly, including any necessary emergency response equipment
- Ensure that researchers conduct research activities in accordance with hazard controls specific to the risks
- Ensure that custom built equipment and systems conform to best practices guidance and standards
- Ensure that electrical safety inspections are conducted routinely for equipment used regularly, and periodically for overall electrical safety hazards, conditions, and work practices
- Ensure that documentation of plan implementation, including completed procedure templates, training records, equipment diagrams, etc. are maintained and accessible to researchers, EH&S and the ESA
- Prohibit work above the permissible thresholds
- Engage the Electrical Safety Authority for policy decisions and guidance

Researcher Conducting Activities Involving Routine Electrical Hazards

- Complete required training
- Obtain permission from the PI or QP to conduct research activities involving routine electrical hazards
- Conduct research activities in accordance with the ESMPR and the specific hazard controls identified for research tasks

- May test for the presence of voltage up to 120 volts on de-energized conductors, by using a non-contact voltage testing instrument
- May reset a circuit breaker once if the cause had been found and corrected
- Do not conduct research activities involving electrical hazards exceeding 50 volts and other specified threshold limits

Qualified Person

One who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved

At Stanford, this may be a PI, researcher, staff, or other experienced person

- Maintain appropriate training and demonstrable skills and knowledge specific to the research activities directed by the PI
- Oversee PI-identified high hazard electrical activities
- Ensure that the design, installation, wiring and use of electrical equipment meets relevant standards
- Ensure that custom built equipment meets relevant standards
- May design, construct, wire and test research equipment up to 250 volts (or other applicable threshold)
- Prohibit work above the permissible thresholds
- Deliver specialized information and on-the-job training to researchers conducting routine and high hazard electrical activities

Environmental Health & Safety (EH&S)

- Establish the ESMPR and infrastructure needed for plan design, implementation, and continuous improvement
- Review risk assessments, SOPs, and hazard control designs and configurations upon request
- Develop training programs and assist research groups with the development of specific training content
- Coordinate with stakeholders and subject matter experts to evaluate and address needs for electrical safety in research
- Communicate with research leadership about challenges and situations in which PIs and research groups may struggle to meet minimum expectations
- Periodically evaluate the effectiveness of the ESMPR and update accordingly
- Continuously improve the ESMPR through participant feedback and plan adjustment

Electrical Safety Authority (ESA)

Per NFPA 70E (350.4): The Electrical Safety Authority functions to "ensure the use of appropriate electrical safety-related work practices and controls; competent in electrical system requirements applicable to R&D laboratories."

At Stanford, this role is carried out by a committee administered by EH&S

- Ensure the ESMPR is optimally effective to mitigate risks
- Provide guidance to PIs, researchers, QPs, and EH&S on the implementation of the ESMPR
- Set policies regarding permissible / prohibited thresholds and activities

Electrical Hazards and Risks

Hazardous levels of electricity are present in many research settings. However, electrical hazards are usually mitigated by proper equipment design and guarding of energized, exposed conductors. The ESMPR helps research groups to self-identify electrical hazards and implement appropriate hazard controls, particularly for activities that carry the potential of exposure to energized conductors and other energized components of electrical equipment and systems. Technical details of hazards and control measures are outlined in ESMPR supporting documents. The ESMPR addresses hazards and risks including:

- Serious Injury and Fatality
    - Electric Shock
    - Electrocution
    - Skin Burns
    - Internal Burns and Organ Damage
- Ignition Source and Static Discharge
- Arc Flash and Arc Blast
- Fire, Explosion and Property Loss

Electrical Hazard Thresholds and Categories

The table below shows the thresholds for electrical hazards at which only qualified persons or qualified electrical workers are permitted to work. [Thresholds derived from University of California Riverside program.]

Source	**Includes**	**Thresholds**
AC	50-60 Hz nominal	=>50 V and => 5 mA
DC	All	=>100 V and => 40 mA
Capacitors	All	=>100 V and => 10 J
Batteries	All	=>100 V
Sub-RF	1 Hz to 3 kHZ	=>50V and =>5 mA

Source	Includes	Thresholds
RF	3 kHz to 100 MHz	Function of frequency

The table below summarizes the electrical hazard categories that form the basis of the ESMPR.

Category	Research Routine	Research High Hazard	Research Prohibited
Range	Not to exceed AC: 50 volts and 5 milliamperes DC: 100 volts and 40 milliamperes	AC: 50 to 250 volts, single phase Other sources: use-specific	AC: > 250 volts, single phase Any 3-phase
Role	Researchers	Research Electrical Qualified Person (QP)	Qualified Electrical Worker (QEW)

The Risk Assessment Template (Appendix 1) outlines additional details on thresholds for each category.

Electrical Hazard Controls

The overriding goal when selecting and implementing electrical hazard controls is to establish an electrically safe work condition by applying the hierarchy of controls summarized below. When this cannot be reasonably achieved, QPs may employ other means authorized by the PI for high hazard electrical work (and permissible as described in NFPA 70E 350.10).

Eliminate / Reduce

The best hazard control is to eliminate the hazard. If research can be done below 50 volts AC, for example, the level of hazard can be lowered.

Engineering Controls

Engineering controls such as insulation and enclosures integrate safer design features into equipment. Engineering controls are permanently built into equipment (e.g., interlocks), or incorporated into a system (e.g., access gate) intended to control hazards for the life of the equipment or system, if used and maintained properly. Many electrical hazard controls are

regulated by NFPA 70, NFPA 70E (safe methods for working on or near energized equipment), and IEEE which sets forth design standards for manufactured and custom-built equipment.

The PI (and QP, if applicable), ensures that appropriate engineering controls for electrical hazards are implemented.

Administrative Controls

In cases where engineering controls are not sufficient to eliminate electrical safety hazards during research activities, administrative policies and procedures must be developed and followed by personnel to ensure personal safety. Use of Lock-out / Tag-out (LOTO), development of Standard Operating Procedures (SOPs), and consistent training for researchers on electrical safety requirements contribute to ensuring electrical hazards are adequately controlled. The following are administrative controls implemented by adoption of this ESMPR.

Training

All researchers must complete the online course *Electrical Safety Awareness*.

Researchers conducting activities involving routine electrical hazards may also complete additional basic training. Researchers may opt for certification in first aid, CPR, and AED use.

To supplement basic training, QPs must complete additional training tailored to the specific activities and electrical hazards in their research setting. This may include formal courses offered by OSHA training partners. Other training methods for QPs may include shadowing, one-to-one or group coaching and mentoring, self-study, and apprenticeships. QPs are also required to be certified in first aid, CPR, and AED use.

All research group members who conduct activities involving routine and/or high electrical hazards must also complete task-specific training customized to the particular research. This necessarily includes training on relevant group-specific SOPs, hands-on training with equipment that incorporates manufacturers' use instructions, local emergency response procedures for electrical incidents, and other targeted training deemed necessary by the PI, QP, EH&S and/or ESA.

Electrical Safe Work Practices

Researchers must employ sound work practices to establish and maintain electrically-safe work conditions. To apply standard electrical safe work practices for research:

- Always de-energize equipment before inspection, repair, or altering wiring
- Confirm that equipment is de-energized before working on it, if there is a chance that energized, exposed conductors or other electrical sources are present
- Keep electrical tools in good working condition
- Use insulated tools as appropriate

- Remove jewelry, belts, keys, and other conductive materials before working around electrical systems

See the Appendix for additional guidance, including researcher work practice requirements.

Lockout/Tagout
Troubleshooting, servicing, or maintenance of equipment and systems that may create the potential for unexpected release of hazardous energy, including electrical energy, may require hazardous energy control (lockout/tagout (LOTO)) per Cal/OSHA regulations. Researchers conducting routine activities shall not operate equipment that has had LOTO applied. Some QPs may develop and/or implement specific LOTO procedures for their research activities, in conjunction with other qualified personnel. Contact EH&S for further information.

Personal Protective Equipment (PPE)
PPE represents the last line of defense in the hierarchy of hazard controls. It must be consistently and properly used in conjunction with other appropriate hazard controls to be effective. Minimum PPE requirements are shown below.

Routine

- Safety glasses
- Enclosed-toed shoes
- 100% natural fabrics (cotton, wool, rayon, linen, etc.)

High Hazard

- Routine PPE and supplemental PPE
- Heavy 100% cotton or leather work-gloves if switching circuit breakers or testing for presence of 50-250 volts in potentially energized circuits
- Flame resistant clothing (FRC) may be recommended for some activities, per NFPA 70E (e.g., lab coat or a combination of under-garment and coverall with 8 cal/cm2 FR rating)

Electrical Safety Management Plan Implementation
Each PI responsible for research activities involving routine and/or high hazard electrical work shall ensure that the templates shown in the Appendices section are completed for the following implementation processes.

Risk Assessment (Appendix 1)
Conduct a high-level electrical safety risk assessment of planned research activities to determine the category of electrical hazard (i.e., routine, high hazard, prohibited); evaluate risks; and select hazard controls. Implement the risk assessment hazard controls by installing

or improving engineering controls; establishing SOPs (see below); training researchers; providing PPE; and completing any other tasks necessary to enable researchers to establish electrically safe working conditions for their research activities.

Standard Operating Procedure (Appendix 2)

Use the risk assessment to inform and establish SOP(s) for research activities involving electrical hazards. SOP content may be combined with consideration of other, non-electrical hazards. Each SOP must incorporate emergency response guidance, customized for local research conditions. Consult with EH&S Research Safety for additional SOP development and implementation resources.

Qualified Person Designation (Appendix 3)

Each PI whose research group conducts high hazard electrical work must formally designate appropriate qualified person(s). Complete the Qualified Person Designation template for each qualified person, and ensure that both qualifications and persons designated remain up-to-date.

Appendix: Fundamental Electrical Safety Measures for Research Activities

Safeguards

PIs and researchers conducting routine and high-hazard electrical work should ensure that the appropriate combinations of the following safeguards are in place and operating properly wherever electrical hazards are present:

- Ground-fault circuit interrupters (GFCIs)
- Circuit breakers and fuses
- Strain relief for wires to protect from chafing, abrasion, and other damage
- Grounding
- Appropriate wire sizing and selection based on intended amperage
- Insulation, conduits, enclosures, and guards for conductors and potentially exposed, energized conductors carrying 50 volts or greater
- Interlocks and emergency stops
- Insulation for equipment and tools
- Warning signs and labels
- Insulating floor mats and work surfaces

Contact EH&S Research Safety for further guidance.

Standard Electrical Safe Work Practices

Researchers shall adhere to these work practices when electrical hazards are present:

- Apply the principles and work practices illustrated in electrical safety training
- Adjust streetwear to remove conductive materials
- Don appropriate clothing and required PPE
- Create limited-approach boundary work areas in research areas as appropriate.
    - Demarcate electrical hazard areas using signs, bollards and/or stanchions as “Off Limits” to people not involved in the electrical work.
- Follow customized and general SOPs applicable to specific research activities.
- Ensure that electrical systems and research equipment are disconnected, grounded and/or locked/tagged out before working
    - Only QPs shall allow equipment guards to be removed or conductors to be exposed if deemed necessary for specified high hazard electrical research activities
- Test for the presence of up to 120 volts after de-energization under the direct supervision of the QP.

    - Only QPs shall test for the presence of up to 250 volts; another trained researcher must be present during high hazard testing and zero voltage verification.
- Pause work as needed to establish electrically safe work conditions

Researchers are not permitted to:

- Enter work areas that have restricted access due to high hazard electrical or other safety risks
- Operate equipment that has been locked out or otherwise designated as highly hazardous (e.g., contains an arc flash warning label); inoperable; or defective
- Work alone when conducting high-hazard electrical research activities
- Deliberately carry out research activities on energized systems and exposed conductors without prior PI / QP approval and authorized safeguards in place

Appendices: Implementation Templates

1 Risk Assessment

ESMPR Appendix 1 Risk Assessment

NO answers = Research Routine Hazard Category

YES answers within thresholds = Research High Hazard Category: Complete SOP(s) (Appendix 2) and Qualified Person Designation (Appendix 3)

YES answers above thresholds = Research Prohibited

Risk Identification Questions	Risk Magnitude Assessment	High Hazard Work Registration Guideline Thresholds
Do researchers have the potential to contact a conductor energized at 50 volts or greater? **OR, to test exposed conductors for the presence of electricity of 50 volts or greater?** **OR, to do work at less than 50 volts but at levels 1000 amps and greater in a circuit?**	List: ● Maximum voltage ● Maximum amperage ● AC/DC ● Hertz Upper Thresholds: Research Prohibited ❑ AC: more than 250 volts ❑ All 3-phase work ❑ Others may be use-specific	❑ AC: 50 to 250 volts, single phase ❑ DC and other sources: use-specific ❑ All circuits carrying 1000 amps or greater regardless of voltage or whether AC or DC
Does the researchers use and/or store capacitors greater than 5 joules?	● How many capacitors? ● Largest capacitor? ● Are capacitors arranged in banks? ● Total capacitance? Risk Mitigation Best Practices	❑ Capacitors 5 joules or greater in size that are exposed, allowing potential physical contact as part of research work ❑ Stored capacitors of 5 joules or larger that do

	❑ Automated capacitor grounding systems ❑ Hand-held grounding wands to ensure zero charge in capacitor circuits ❑ Faraday cages, interlocks and other guarding devices near large capacitors / capacitor banks	not have bonding and grounding straps installed on them ❑ =>100 V and => 10 J
Do researchers build or modify equipment powered by 50 volts or greater?	● What activities are done? ● Is equipment listed by NRTL? o If not, are proprietary equipment components listed by NRTL? ● What kinds of equipment are modified? ● To what extent is the equipment modified? ● Does the manufacturer approve of the equipment modifications? ● What is the purpose of the modifications? ● Who does this work and where? ● Do the modifications void warrantees or cause the equipment to operate in a way not intended by the manufacturer? ● Is equipment returned to a non-modified state, or destroyed, once research is complete? <u>Risk Mitigation Best Practices</u> ❑ Use of NRTL or other standardized components ❑ Systems safety review	❑ Permanent removal of manufacturer-supplied equipment guard(s) that exposes conductors or other physical hazards ❑ Modifications that remove or negate an NRTL rating ❑ Modifications that void equipment manufacturer's warrantees ❑ Proprietary equipment built from non-NRTL approved components ❑ Equipment built outside of code compliance with NFPA70, the CEC, and/or IEEE electrical equipment standards ❑ Modified equipment that is re-purposed for another use after original research is complete

	❑ Specialized equipment inspections	
Do researchers build or modify electrical storage devices or batteries?	• What activities are done? • What is the storage capacity?	❑ 50 to 100 V

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. Environmental / Location Hazards (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 Error! Reference source not found.* (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 Error! Reference source not found.. 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 Error! Reference source not found.*.

- 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): ☐ Jewelry on hands ☐ Jewelry around neck ☐ Dangling jewelry ☐ Loose-fitting head or neckwear ☐ Loose-fitting clothing ☐ Other:	[Note Potential Risks if Step is Not Done or Done Incorrectly (if any)]

_____ _____	

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 of 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.
    a. 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):
    a. 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.

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]

3 Qualified Person Designation

ESMPR Appendix 3
Qualified Person Designation

Qualified Person Name:_____ Date:

_____

Research Location (s) (building / room):_____

Department:_____

PI Name: _____

A Qualified Person is one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk.

For research activities at Stanford, a qualified person at the research group level is designated by the PI to oversee and assess the risks of high hazard electrical work (defined by the thresholds shown in the Stanford Electrical Safety Management Plan.)

Research equipment description:

Demonstrated skills and knowledge related to electrical hazards of specific research equipment:

Completed Training

Electrical Safety Awareness, EH&S 2800 online (required)

Additional training in energized electrical safety / NFPA 70E:

Other relevant electrical training, including on-the-job:

Licenses, certificates, and/or credentials related to electrical work and equipment operation used in the research activities:

By signing this you acknowledge that the person designated is a Qualified Person who meets the criteria to be so classified.

Principal Investigator's Name & Signature: **Date:**

Qualified Person's Name & Signature: **Date:**