Guidelines on University Designed/Built Equipment Safety

Introduction

Cutting edge research can sometimes involve the need to make the specialized equipment or modify existing equipment. Safety must be considered when equipment is designed by a research group and either built under the direction of University members, built in the lab, or built in a University machine shop. One of the safety challenges is that the nature of research may mean that all the hazards presented by the equipment may not be easily predicted or anticipated. Since it is difficult for any individual to have the expertise to assess equipment safety in a very broad area, a consultative approach is required and sometimes this may include seeking outside expertise. The best practice would be to have a professional engineer involved in the design of the equipment and any safety features needed from the outset.

Scope

All equipment built or significantly repurposed, modified or altered that is for use in the lab where the equipment design or modification is directed by UofT staff or students whether or not the equipment is built at UofT. For equipment being built in University maker spaces please also consult the document Health and Safety Considerations for the Management of Makerspaces

Responsibilities

Chairs, Directors, Principals shall:

1. Consider the project relevant knowledge, training and experience of the PI when assessing the lab-built equipment proposal.
2. Develop a process of review of newly built or significantly modified equipment. The process should include consultation with any management responsible for departmental safety.
3. Review and sign the completed Risk Assessment Tool confirming that hazards have been appropriately identified.

Principal Investigators (PIs) shall:

1. Define the scope and limitations of the equipment.
2. Ensure that all aspects of safety involving the design and installation of built equipment are considered through involving appropriately knowledgeable parties. Note that sometimes the expertise will reside in the lab while other times EHS, regulators, or consultants would need to be involved.
3. Take any steps required to mitigate hazards presented by the equipment. For example, apply the hierarchy of controls approach, refer to ***Appendix B.***
4. Complete the Risk Assessment Tool in Appendix A and maintain a copy until the equipment is decommissioned. Consider using the hazard management tool at this link: Hazard Management Tool – Environmental Health & Safety to recognize, access, control and evaluate (RACE) existing or potential hazards.

5. Review the Risk Assessment Tool for UofT Designed Equipment in this guideline in consultation with parties outlined in the departmental process.
6. Develop Standard Operating Procedures (SOPs) including safe operation of any equipment that is designed or built by the University.
7. Establish appropriate training and record keeping for use of the equipment.

Lab Staff and students shall:

1. Follow all safety instructions around operation of equipment and wear appropriate protective gear.
2. Communicate any questions or concerns around the safe operation of the equipment to the PI.
3. Consult with the PI before making any changes to the materials, process or equipment.

The Office of Environmental Health and Safety (EHS) shall:

1. Provide advice and guidance on safety where the topic is within their expertise or suggest additional consultation where applicable.
2. Provide assessment of the appropriate containment level and any needed EHS permits for the proposed activity.
3. Maintain and update this guideline as needed.

Table 1 – Hazard Identification and Possible Mitigation

The below are examples of hazards that can be presented by equipment. It is NOT an exhaustive list, and the PI is responsible for adding any unaddressed issues in the blank portions of the table.

Please note that many risks may require the involvement of a professional engineer to sign off on any potential danger to the public. U of T maintains a website of Institutional Core Facilities across the campuses offering specialized research services or equipment to the U of T community. EHS also has a list of University faculty and machine shop managers who may be able to assist with risk assessment. For consultation on hazards and mitigation contact ehs.office@utoronto.ca.

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
Physical Hazard	Closed vessel that could be pressurized.	Overpressure explosion – flying material.	Always provide pressure release for closed vessels. TSSA consultation/approval obtained if required.	Pressure vessels are approved by the Technical Standards and Safety Authority (TSSA). Some closed vessels not intended for pressure could be accidentally pressurized – e.g. vacuum chambers or ambient pressure closed vessels.	
	Accidental vessel pressurization	An open vessel that was not designed for pressure is clogged, and pressure is building up, and components fail	Review the design from the position of failure, secondary containment, needed control systems, shut-offs, etc.	Add a monitoring/alarm system that would indicate abnormal operating parameters and inform the users.	

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
	Vessel material and manufacturing	Vessel corrosion, cracking, or failure due to material or manufacturing issues is not appropriate	Select appropriate to the task materials for the vessel enclosure or any supporting components. Review the lifecycle and required administrative controls for maintenance.	Review vessel purpose, longevity, and maintenance, including individual components vessel's shell, valves, seals, O-rings, etc. If welding/soldering is used, review the quality of the seams, materials, etc.	
	Use of chemicals outside of a fume hood.	Exposure of students or staff to inhalation of hazardous chemicals. Large volume, accidental release to the environment.	Evaluate the hazard of the chemicals and ensure ventilation, room infrastructure are adequate.	EHS is available for consultation. Equipment and outlets/switches may need to be spark free.	
Physical Hazard	Vessels containing hazardous biological materials.	Release of biologicals to the local or outside environment. Harm from the released biological material could occur.	Evaluate the infrastructure, volume of materials, risk group of the material to see if it is covered by the current biosafety permit.	Every reasonable attempt to prevent release should be taken. Spills need to be captured by secondary containment. People in the area need to wear appropriate PPE.	
	Accidental external impact, cracks, failure	Evaluate safeguarding, procedures, location	Secondary containment, protective enclosure and administrative controls	Glass Vessels, panels. Consider potential for accidental external impacts, cracks, failure	

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
	Potential to produce a flammable atmosphere in the equipment.	Fire	Evaluate materials, motors, wiring, etc. Evaluate volumes and ignition/spark sources.	Equipment where flammable or combustible materials could become airborne must be spark free. In some cases, ventilation can mitigate this requirement.	
	Reaction vessels containing hazardous chemicals.	Release of chemicals to the local or outside environment. Burns, fire or other chemical exposure could occur.		Every reasonable attempt to prevent release should be taken. Spills need to be captured by secondary containment. People in the area need to wear appropriate PPE.	
Electrical Hazards	Electrical equipment above 24V.	Shock, electrocution, fire	If required, obtain approval from the ESA. For more information see the course Electrical Safety Awareness EHS564.	Any equipment not approved for use in Canada must be certified by the Electrical Safety Authority (ESA) prior to being plugged in.	

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
	Electrical Equipment and water.	Electrical shock or electrocution	Evaluate how electrical system are insulated; Prioritize engineering controls vs administrative controls; Isolate and separate water sources when possible.	Make reasonable efforts to ensure that water is contained, and electrical equipment is in areas where water will not reach in the event of a leak.	
Mechanical Hazards	Human body hazards.	Equipment that is sharp, or that may fall or that create ergonomic hazards including force, fixed or awkward postures and repetition on users.	Evaluate equipment ergonomics, prioritize user-friendly design, assess duration of use by the operator.	Look at potential sources of injury and make every reasonable attempt to remove them at source.	
	Robotic equipment.	Powerful robotic equipment that may cause physical injury	Space for the free moving parts should be adequate with proper shielding of users/operators/by standards Powerful equipment requires kill switch (motors, drone blades, multi-directional plotters and printers, etc.)	Provide a safety cut-off for excessive force or an interlocked enclosure	

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
	Potential for falls.	Injuries from falls		Where a work area is elevated, a railing must be provided to prevent falls	
	Falling equipment from weight not being distributed properly.	Injuries from falling equipment, and damage to equipment.	Improve weight distribution & stability. Falling equipment occurs when the weight is not distributed properly.	Check at full load, half load, when: changing parts; servicing the equipment; loading/unloading; partially dismantling, etc. Review the design to prevent accidental imbalance in weight distribution, locking wheels, etc.	
	Powerful moving equipment – rotating, cutting, punching etc.	Crushing or breaking of body parts. Burning of motors when obstructions interrupt rotation/movements – potential fire.	Look at the power of the motor and any safeguarding. Monitoring and alarm systems should be evaluated and incorporated when applicable.	Guarding must be provided around equipment that could injure someone. Emergency shut- off must be provided. Lock out/Tag out procedures must be developed for work on the equipment.	
	Moving parts, heavy parts/doors, rotation	Injury due to crushing of body part between/under objects.	Safeguards might be required. Consider maintenance activities when evaluating.	Review the ability to fix moving parts in a locked position for maintenance (accidental energizing, falling by weight, moved by wind, vibration, etc.)	

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
	Equipment capable of producing X-rays	Exposure to radiation. Regulatory implications.	Use lower voltage if possible or add adequate shielding	Must consult with EHS. X-ray machines have mandatory Ontario registration.	
	Equipment capable of producing strong electromagnetic fields (EMFs)	Interaction of medical devices with EMFs. Potential for health effects.	Add shielding/insulators or implement floor markings	EHS is available for consultation and surveying of EMFs	
	Use of lasers or UV/other energetic light (e.g.IR or intense blue light)	Eye damage, unexpected airborne materials from laser contact with a target.	Enclosure and safety interlocks are common solutions.	Must consult with EHS Laser Safety Officer.	
	Ionizing radiation	Exposure to radiation. Regulatory implications.	Covered by the Canadian Nuclear Safety Act.	Must consult with EHS Radiation Safety Officer.	
	Failure of remote alarm, monitoring and control and systems	Out of control situation going unnoticed. E.g. floods, chemical or biological releases etc. (the specific consequences are dependant on system being monitored).	Backup power for all critical monitoring systems.	Remote alarms are required for fully or partially unattended operations. Local alarms are also required for hazardous systems where people are present.	
	Other hazard				

Hazard Group	Hazard	Consequences	Proposed Mitigation and/or Approvals*	Notes	Safety Mitigations Implemented by Lab as Applicable
	Other hazard				
	Other hazard				

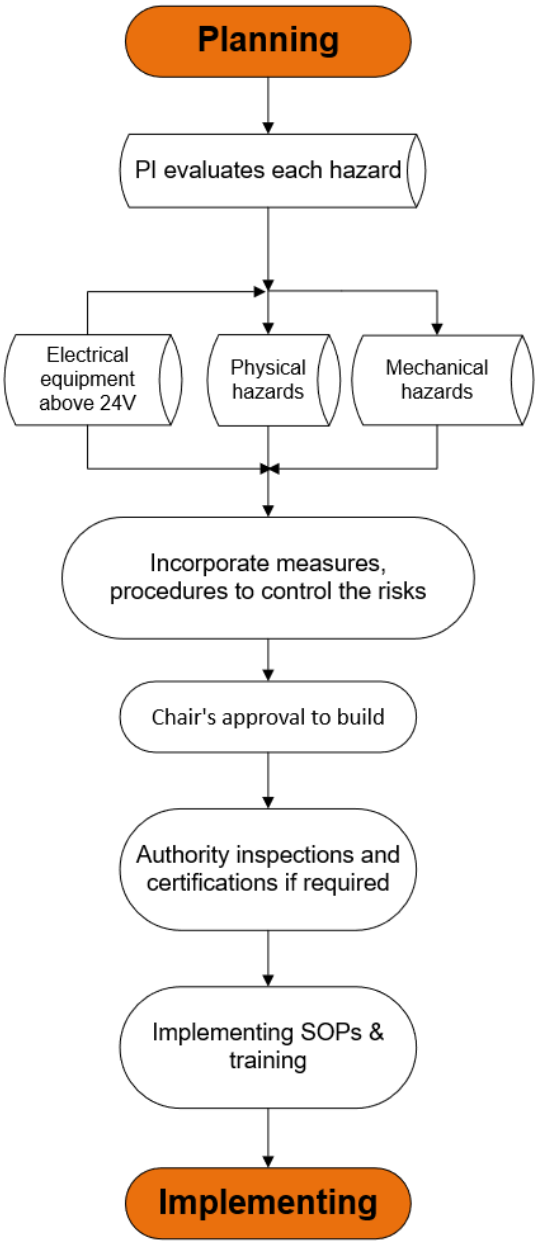
*Refer to ***Appendix B*** *Hierarchy of Controls*

Signature of PI _____ Date_____

Signature of Chair_____Date_____

Appendix A - Risk Assessment Tool for UofT Designed Equipment

Recommended assessment and approval process:



Hazard Groups

Hazards can be grouped into Electrical, Physical and Mechanical hazard assessments.

For more detail see Table 1

1. **Electrical Safety:**
    - Electrical equipment above 24V
    - Electrical equipment and water
    - Electrical equipment is ESA certified
    - Electrical equipment is grounded
2. **Physical Hazards:**
    a. Closed vessel that could be pressurized
    b. Potential to produce a flammable or toxic atmosphere
    c. **Chemical Hazards**
    - Reaction vessels containing hazardous chemicals
    - Use of chemicals outside of a fume hood
    d. **Biological Hazards:**
    - Vessels containing hazardous biological materials
    e. Radiation Hazards:
    - Equipment capable of generating X-ray radiation
    - Equipment capable of generating strong electromagnetic fields
3. **Mechanical Hazards:**
    - Sharp equipment
    - Falling hazards, equipment weight distribution, etc.
    - Robotic equipment
    - Powerful moving equipment (rotating, cutting, punching)
    - Moving parts, heavy parts/doors, rotation
    - Safe maintenance access for repairs
    - Potential for falls
    a. **Ergonomics:**
    - Equipment creating ergonomic hazards (force, fixed and awkward postures and repetition) for users

Appendix B: Hierarchy of Controls,

- CCOHS: Hazard and Risk - Hierarchy of Controls , taken from Fact sheet last revised: 2022-06-03, on March 8, 2024