

College of Engineering, Architecture and Technology

Oklahoma State University



ENDEAVOR

College of Engineering, Architecture and Technology

ENDEAVOR Safety Manual

July 2019

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1. Approvals and Revisions

TITLE: ENDEAVOR Safety Manual	DATE:	<hr/> Original Approval Date		
The ENDEAVOR Safety Manual is for use within the ENDEAVOR. It is compliant with the OSU Laboratory Safety Manual, as well as OSHA regulations and ANSI recommendations.	REV.NO:	2	DATE:	16 July 2018

2. Preface

Procedures and information given in the ENDEAVOR Safety Manual are intended to supplement the OSU Laboratory Safety Manual by providing laboratory specific guidance. Guidance includes specific requirements for PPE, locations of safety equipment, operations that are not addressed in the OSU Laboratory safety manual, and ENDEAVOR specific training requirements. Any procedures not addressed in this manual or the OSU safety manual will be documented by laboratory specific Standard Operating Procedures (SOP).

Remember, the most important key to safety is YOU deciding to work safety and expect others to do the same. Approximately 80% of accidents are caused by unsafe behaviors and acts, and only 20% are due to unsafe conditions. Significant planning and thought went into building ENDEAVOR to provide the safest possible laboratories. In addition, procedures and instruction given in this manual are based on industrial best practices, experience, and guidance from other Universities. However, safe workplaces and instructions cannot prevent accidents without students and employees working in a safe manner. If there are any questions regarding safety, do not hesitate to ask.

3. General Program Requirements

3.1 Roles and Responsibilities

3.1.1 Dean and Associate Deans

The Dean and Associate Deans are responsible for ensuring that departments are aware of their responsibilities under the Laboratory Safety Manual.

3.1.2 ENDEAVOR Safety Manager

The ENDEAVOR Safety Manager is responsible for implementing a laboratory safety program, which includes documentation and training. The Safety Manager provides oversight for procurement, use, and storage of laboratory chemicals. The ENDEAVOR Safety Manager will approve all Standard Operating Procedures (SOP) and notify CEAT Associate Dean for Academics regarding all approved SOPs.

3.1.3 CEAT and ENDEAVOR Faculty and Staff

ENDEAVOR and college faculty and staff are responsible for the overall laboratory safety that includes:

- Develop and implement Standard Operating Procedures (SOPs) for specific laboratory procedures.
- Ensure that students know and follow the laboratory safety guidelines.
- Ensure that protective apparel and equipment are available and appropriate for the potential exposure.
- Ensure that appropriate training has been provided and documented.
- Conduct regular internal laboratory safety inspections.
- Ensure that facilities and training are adequate for the use of any material that is present in the laboratory.
- Implement and enforce the use of safety procedures.
- Ensure the availability of the chemical inventory list and Safety Data Sheets (SDS).
- Consult with Environmental Health and Safety (EHS) for safety matters as they pertain to specific laboratory waste.
- Submit all necessary and appropriate documents to EHS.
- Provide the initial response for any laboratory incidents.
- Keep the laboratory clean after experiments are completed.

Note: No “acutely” hazardous experiments will be conducted in the ENDEAVOR. All experiments should have an SOP that the laboratory Safety Manager reviews before the experiment is conducted.

3.1.4 TA Responsibilities

Students have the following responsibility:

- Implement Standard Operating Procedures (SOPs) for specific laboratory experiments and operations.
- Ensure that students know and follow the laboratory safety guidelines.
- Ensure that protective apparel and equipment are available for the potential exposure.
- Ensure that appropriate training has been provided and documented.
- Report all hazardous conditions to the ENDEAVOR staff or supervisor.
- Report any incidents, injuries, or illnesses to ENDEAVOR faculty or staff immediately.
- Provide the initial response for any laboratory incidents.
- Implement and enforce the use of safety procedures.
- Keep the laboratory clean after experiments are completed.

3.1.5 Student Responsibilities

Students have the following responsibility:

- Conduct each experiment and operation according to approved procedures and safety guidance.
- Comply with all aspects of the laboratory safety program.
- Participate in training programs concerning the requirements of the laboratory safety program and other applicable environmental, safety and health regulations.
- Request information or training when unsure how to work with a hazardous chemical.
- Wear or use prescribed personal protective equipment.
- Report all hazardous conditions to TA or Instructor.
- Report any incidents, injuries, or illnesses to ENDEAVOR faculty or staff immediately.
- Keep the laboratory clean after experiments or every day after working on design projects.

3.2 Training

3.2.1 General Training Requirements

ENDEAVOR faculty and staff are responsible for ensuring that all persons working in the ENDEAVOR have the following minimal training:

- Laboratory Safety
- Hazardous Waste
- Hazard Communications
- Personal Protective Equipment in Laboratory
- When required, specific training such as Laser or Nanomaterials

3.2.2 CEAT Faculty, Staff, and TAs

PIs and laboratory managers are responsible for ensuring that TAs, faculty, and staff have the following laboratory specific training:

- General ENDEAVOR training requirement courses (Section 3.2.1)
- Specialized ENDEAVOR TA training
- Operation found in relevant SOPs
- Laboratory specific hazards
- Laboratory specific waste disposal
- Emergency and evacuation procedures

3.2.3 Students

Students will have the following training:

- General training requirement courses (Section 3.2.1) provided by ENDEAVOR personnel
- Laboratory and/or experiment specific training that is provided by TAs or Instructor.

3.2.4 Documentation

Proof of training is required to ensure regulatory compliance. Faculty and staff in charge of specific laboratories are required to document student training given. This can be done using BrightSpace or paper-training documentation for each experiment. Safety training records will be kept for one year – except for persons where injuries are recorded.

3.3 Visitors/Minors in Lab

The ENDEAVOR is a showcase of modern technologies and recruitment tool for CEAT, and should be toured whenever possible. However, before entering a workspace, it is the responsibility of the host to contact the laboratory Safety Manager or responsible faculty member to coordinate the visit. The host must ensure that those entering any of workspaces are adequately protected from hazards and are informed about the safety and emergency procedures relevant to their activities.

Minors (children under the age of 18) are not permitted in hazardous work areas with the exception of University or Department sanctioned tours and visits as defined by University policies. In these instances, the tour leader or other knowledgeable personnel must exercise careful supervision. This policy does not apply to minors who are enrolled OSU students.

If visitors will be performing laboratory work or working within a laboratory space, they must receive required ENDEAVOR safety training prior to starting.

3.4 Working Alone Policy

No person will work alone in the ENDEAVOR while performing experiments, design projects, or any other tasks where injury is possible. During off-hours (9 pm to 8 am and weekends), two persons must work in close proximity in the laboratory. All persons working in a laboratory must utilize the buddy system and schedule overlapping laboratory hours. Studying in sticky spaces and other non-laboratory spaces are exempt from the working alone policy.

If the room requires safety glasses, never work alone. See maps in Appendix A.2.

3.5 Service Dogs and Therapy Pets

Service dogs and therapy pets are ban from ENDEAVOR teaching laboratories, mechanical rooms, custodial closet, areas that require personal protective equipment (PPE) and any location that poses a danger to the animal. On a case-by-case basis, the ENDEAVOR Safety Manager may allow exceptions based on the animal's training and laboratory hazards.

Service dogs and therapy pets are allowed in ENDEAVOR's common areas (sticky spaces), pre-laboratory instruction areas and seminar room.

3.6 Basic Rules

3.6.1 ENDEAVOR Basic PPE and Cell Phone Rules

ENDEAVOR has basic rules for what PPE is worn in specific laboratories.

- Closed toe shoes and pants are required in **all** laboratories and maker spaces.
- Safety glasses are required in laboratories that have snorkel, hood, or machinery that may pose an eye hazard. Locations that require safety glasses will be marked.
- Cell phones are not permitted in certain laboratories and maker spaces (unless with limited permission by instructor). These laboratory/spaces are identified in the safety maps given in Appendix A.2.

3.6.2 ENDEAVOR Hours of Operation and Security

Please consult the ENDEAVOR Safety Maps in Appendix 2, and the Table below. Specific ENDEAVOR hours of operation and expected personal protective equipment (PPE) are -

- Appropriate faculty and staff will control access to RF/COM/Energy laboratory (350), facility spaces, and specific equipment storerooms.
- During the fall and spring semesters, all laboratories, design laboratories, and maker spaces will be open from 8 am to 9 pm.
- After 9 pm, only the design laboratories and common areas will be accessible to students – unless access is approved by ENDEAVOR faculty or Safety Manager.
- Card reader identification is required for building access during off hours.
- The ENDEAVOR will be open from 8 am to 5 pm during the summer semester.
- Locks on laboratory door will not be altered unless authorized by CEAT Facility Manager.
- Doors will not be blocked open, unless temporarily to move equipment.
- Doors will not be blocked closed.

Safety Requirements per Laboratory					
Pants and Closed Toe Shoes	Safety Glasses	Conditional (eye protection)	NO Cell Phone	Special	Closed at 9 pm
Room Numbers 1 st Floor					
105, 108, 110, 115, 120, 130, 140, 150, 170	110, 115	105, 130, 140, 150, 170	110	130 and 140 – laser usage	110, 115, 120, 130, 140
Room Numbers 2 nd Floor					
230, 240, 260, 270	230, 240, 260, 270		230, 240, 260, 270	240 – X-ray	230, 240, 260
Room Numbers 3 rd Floor					
305, 310, 320, 325, 330, 340, 350, 360, 370	330	305, 320, 325, 340, 360, 370	330		305, 310, 320, 330, 350, 360

3.6.3 General Laboratory Safety Rules

Basic safety rules for laboratory conduct should be observed whenever working in a laboratory. Many of common safety rules are listed below.

- Know locations of laboratory safety showers, eyewash stations, and fire extinguishers. The safety equipment may be located in the hallway near the laboratory entrance.
- Know emergency exit routes.
- Avoid skin and eye contact with all chemicals.
- Minimize all chemical exposures.
- No horseplay will be tolerated.
- Assume that all chemicals of unknown toxicity are highly toxic.
- Post warning signs when unusual hazards, hazardous materials, hazardous equipment, or other special conditions are present.
- Avoid distracting or startling persons working in the laboratory.
- Use equipment only for its designated purpose.
- Combine reagents in their appropriate order, such as adding acid to water.
- Avoid adding solids to hot liquids.
- All laboratory personnel should place emphasis on safety and chemical hygiene at all times.
- Never leave containers of chemicals open.
- All containers must have appropriate labels. Unlabeled chemicals should never be used.
- Do not taste or intentionally sniff chemicals.
- Never consume and/or store food or beverages or apply cosmetics in laboratories or design areas.
- Do not use mouth suction for pipetting or starting a siphon.
- Wash exposed areas of the skin prior to leaving the laboratory.
- Long hair and loose clothing must be pulled back and secured from entanglement or potential capture.
- No contact lenses should be worn around hazardous chemicals – even when wearing safety glasses.
- Laboratory safety glasses or goggles should be worn in any area where chemicals are used or stored. They should also be worn any time there is a chance of splashes or particulates entering the eye. Closed toe shoes will be worn at all times in the laboratory. Perforated shoes or sandals are not appropriate.
- Determine the potential hazards and appropriate safety precautions before beginning work.
- Formation and dispersion of aerosols will be minimized.
- If an unknown chemical is produced in the laboratory, the material should be considered hazardous.
- Do not pour chemicals down drains. Do NOT utilize the sewer for chemical waste disposal.
- Do not utilize fume hoods for evaporations and disposal of volatile solvents.
- Perform work with hazardous chemicals in a properly working fume hood to reduce potential exposures.
- Avoid working alone in a building. Do not work alone in a laboratory.
- The Permissible Exposure Limit (PEL) and the Threshold Limit Values (TLV) will be observed in all areas. If exposure above a PEL/TLV is suspected for an ongoing process, please contact EHS immediately.
- Laboratory employees should have access to a chemical inventory list, applicable SDSs, Laboratory Safety Manuals, and relevant SOPs.

- Access to laboratories and support areas such as stockrooms, specialized laboratories, etc. should be limited to approved personnel only.
- All equipment should be regularly inspected for operability, wear and deterioration.
- Equipment should be maintained according to the manufacturer's requirements and records of maintenance or repairs should be maintained for the life of the equipment. ENDEAVOR equipment will remain calibrated and accurate, but not industrially certified for commercial use.
- Designated and well-marked waste storage locations are necessary.
- No cell phone or ear phone usage in the active portion of the laboratories, or during experimental operations.
- Clothing made of synthetic fibers should not be worn while working with flammable liquids or when a fire hazard is present as these materials tend to melt and stick to exposed skin.
- Laboratory coats should not be stored in offices or break rooms as this spreads contaminants to other areas.
- Computers and instrumentation should be labeled to indicate whether gloves should be worn or not. Inconsistent glove use around keyboards/keypads is a source of potential contamination.
- Avoid wearing loose jewelry in the lab as this can pose multiple safety hazards.
- Avoid placing extension cables, air hoses, or other cables across walkways as this can create a trip hazard.

3.6.4 Design/Experiment Specific Safety Rules

Safety rules for laboratory specific operations will be provided in appropriate SOPs.

3.6.5 Safety Enforcement

The ENDEAVOR uses a three-strike rule over a semester. Application of this policy will be at the instructor's discretion and backed by the Safety Manager.

- First Strike is a written warning.
- Second Strike may facilitate removal of access to the laboratory for a week. Upon the second strike, the student will have a face-to-face meeting with the Safety Manager.
- Third Strike will initiate a process through the Associate Dean of Academic Affairs and OSU Student Conduct and could result in the loss of ENDEAVOR access and/or other disciplinary action through the OSU Student Conduct process.

The TA or Instructor may deny laboratory access to any student not wearing proper laboratory attire, such as pants, shoes, and safety glasses.

Willful, neglectful, and/or otherwise serious unsafety behavior will likely result in immediate and potentially permanent removal from ENDEAVOR. These cases will be referred immediately to the Associate Dean for Academics and through the OSU Student Conduct process.

3.7 General Emergency and Evacuation Response

General first aid training can be provided by Oklahoma State University EHS. Laboratory responsible instructors will provide laboratory specific response training. In addition, ENDEAVOR will have at least two evacuation drills per year.

Emergency Phone Numbers

- Campus Police – 911 using landline phones to reach OSU police.
- Campus Police – 405-744-6523 non-emergency campus police
- Poison Control – 800-222-1222

Students General Evacuation Procedures

- If evacuation is necessary, stop all work and secure immediate hazards
- Extinguish all experiment related flames and heat sources.
- Proceed to the nearest exit using the posted evacuation routes, or by following the instructor.
- Do not use elevators.
- Stay at a safe distance away from the laboratory, or at predesignated locations.
- Do not re-enter until instructed by authorized personnel.

Laboratory Employee General Evacuation Procedures

- Know the ENDEAVOR's Emergency Action Plan.
- Be aware of the location of all laboratory safety equipment and evacuation routes.
- Understand the procedures as given in the laboratory's SOP.
- Understand the hazards and emergency response associated with laboratory procedures and/or chemicals used.
- Ensure your personal safety first.
- Ensure safety of others.
- Mitigate immediate danger if it can be done safely.
- Notify proper authorities.
- Provide initial response according to the type of incident and personal threat.
- Evacuate area until response personnel arrive and provide response personnel with incident related information.

Documentation

All chemical spills or potential exposures will be reported on the Employee Exposure Form to the department and EHS regardless of size. If injury occurs, the incident is also documented on the Employee Injury Form. Both Forms can be found at <http://ehs.okstate.edu/forms/index.htm>.

4. Laboratory Design and Safety Features

4.1 Ventilation

4.1.1 Fume Hood

The primary purpose of a laboratory hood is to keep toxic or irritating vapors and fumes out of the general laboratory working area. Hoods are the primary engineering controls where most work with chemicals should occur. Usage includes etching, diluting concentrated chemicals, and sample preparation that use hazardous chemicals. However, the ENDEAVOR Laboratory hoods do have intended limitations, which are:

- No highly corrosive chemicals/procedures will be used in the ENDEAVOR hoods due to ventilation material incompatibility.
- Hoods are designed for common chemical usage, such that, the chemical use that requires special construction (e.g. perchloric acid and radiation) are prohibited.

Fume hoods will be tested and certified annually by EHS.

4.1.2 Snorkels

Snorkels are available for capturing exhaust, dust, soldering, and general vapor discharge from approved chemical processes outside of the hood. Snorkel use for combustion exhaust and chemical processes will be determined on a case-by-case use. In the case of combustion exhaust, a CO monitor may be required.

4.2 Fire Safety

Flammable and combustible materials are ubiquitous in laboratories. Many laboratories store and use highly flammable organic solvents. Simple precautions and preparation can significantly reduce the risk of a laboratory fire.

- Fire extinguishers will be located in the hallways, and their locations will be part of the laboratory training.
- The use of open flames in the ENDEAVOR will be rare. However, the users will make sure there are not flammable vapors in the area. In addition, gas burner tubing will be examined periodically for wear.
- When transferring flammable liquids from one metal container to another, containers will be bonded and grounded. Many solvents are also toxic, and should be transferred in the hood.

4.3 Emergency Safety Equipment

All laboratory students, staff, and faculty will have access to emergency eyewash and safety shower equipment, fire alarm, fire extinguishers, and telephone for use in an emergency. All staff faculty and TAs are expected to know where the fire alarm pulls, safety showers, eyewashes, spill clean-up kits, fire extinguishers, and emergency exits are located.

- Approved eyewash stations or drench hoses will be available at-or-near each laboratory that utilizes hazardous chemicals or materials.
- Safety shower and eyewash stations are located in all laboratories that have hoods and use corrosive chemicals.

- Fire extinguishers will be available, charged, and hung in locations that are immediately accessible (generally in a hallway). If discharged, contact EHS to get the extinguisher serviced and returned.
- EHS will annually inspect laboratory safety equipment, such as hoods, showers, eyewashes, and drench hoses.
- ***The ENDEAVOR personnel will test eyewash stations, drench hoses, and safety showers weekly.***

4.4 Signage

Proper signage at a laboratory entrance provides important information about the hazards located inside, as well as required PPE. Properly posted signage provides valuable information for responders and visitors and reminds employees of the hazards they encounter upon entering a laboratory. The below guidance provides easy identification of hazards and location of safety equipment.

- All signs will be conspicuously posted in each area where hazardous chemicals are used or stored. These signs must be written in English.
- Current laboratory emergency POC information must be posted, which includes POC(s) name and 24-hour contact number.
- Signage at laboratory entrances will represent the current laboratory hazards.
- Laboratory safety equipment clearly marked and easy to locate.
- Chemical and hazardous waste storage locations inside the laboratory will be clearly marked with lettering at least 1 inch in height.

4.5 Laser Signage

Lasers will be occasionally used in the Flow Laboratory, which will be in a well-marked and beam blocked exclusion area in the laboratory. At the laboratory entrances, the entrance will clearly be marked regarding potential laser usage, and a laser in use light will be required at each entrance. Specific laser operation procedures must be written and approved by University Research Compliance (URC).

4.6 X-ray Signage

X-ray equipment will be used in the ENDEAVOR building. Proper signage will be posted at the laboratory entrance and instrument locations according to URC guidance. Exclusion areas will also be marked by tape on the floor for persons who are not approved for the instrument usage.

5. General Lab Practices

5.1 Housekeeping

Keeping working areas clean is the responsibility of the faculty, TA, and students. For design courses, the students are responsible for leaving their work areas clean. There will be consequences for leaving laboratories messy that includes loss of laboratory privileges in repeated cases. As with safety, a three-strike rule will be used to address frequent offenders.

The following list of good housekeeping practices provides common sense activities that prevent incidents.

- Work areas will be kept clean and free of obstructions. Avoid clutter, excessive storage, and excessive combustible materials.
- Laboratory students will be responsible for maintaining the cleanliness of their work areas.
- Reagents and equipment should be returned to their proper place immediately after use. Contaminated or dirty glassware should be cleaned immediately after use.
- Counter tops should be kept neat and clean. Bench tops and fume hoods will not be used for chemical storage. All work done in fume hoods will be performed in the "Safety Zone" (6" minimum from the sash).
- Stored items, equipment, and glass tubing will not extend beyond the front of a shelf or counter limits.
- Access to exits, emergency equipment, utility controls and other safety equipment must never be blocked, such that a three-foot clearance for access must be maintained.
- Materials stored near aisles will be restrained to prevent their falling.
- Mats and carpeting will be kept in good condition.
- All working surfaces and floors should be cleaned regularly.
- All containers must be labeled with the identity of the contents and with associated hazards.
- Waste will be stored in appropriate receptacles. All employees and students must be instructed about the different kinds of waste generated and appropriate methods for disposal.
- Sharps such as needles, scalpels, broken glass will be placed in approved sharps containers prior to disposal.
- Hallways and stairways must not be used as storage areas.
- Chemicals, especially liquids, should never be stored on the floor – unless secondary containment is provided. Large bottles (2.5L or larger) or heavy items (greater than 25 lbs) should never be stored above the bench top.
- Reagents, solutions, glassware, or other materials will not be stored in hoods.

5.2 Personal Protective Equipment (PPE)

As listed in 3.6.1, closed toe shoes and long pants will be worn in all laboratories, maker spaces, and design laboratories. Safety glasses will be worn in all areas that have snorkels, hoods, thermal laboratory, and digital maker space. Additional PPE guidance in the ENDEAVOR Laboratory includes:

- PPE will be readily available for use at all times, and location is known to laboratory employees. Students will provide their own approved safety glasses.

- No tasks requiring respirators will be conducted in the ENDEAVOR.
- “Comfort Mask” may be used, but only after signing an EHS waiver for use.
- Eye protection will be worn at all times by employees and students in laboratories
 - Where hazardous chemicals are used or stored.
 - Where a significant potential for eye injury exists.

5.3 Safety Data Sheet

The SDS will be located in each laboratory that stores and/or uses non-consumer chemicals. An ENDEAVOR repository of SDS will be located in the Safety Manager’s office.

5.4 Glassware

See OSU Laboratory Safety Manual.

5.5 Unattended Experiments

All unattended experiments and processes must be approved by the Safety Manager and comply with guidance found in the OSU Laboratory Safety Manual.

5.6 Spill Policy

ENDEAVOR faculty, staff, and TAs will be trained on cleaning chemical spills, based on EHS and the OSU Laboratory Safety Manual.

6. Chemical Management

6.1 Chemical Procurement and Storage

6.1.1 Procurement of Chemicals

ENDEAVOR faculty (or laboratory designee) will be responsible for purchasing chemicals, and ensuring that the laboratory can safely use, store, and dispose of the chemical. The faculty member or designee will also check inventories to ensure adequate quantities do not already exist.

6.1.2 General Chemical Storage

Many laboratories in ENDEAVOR will have capacity to store chemicals, in accordance with the OSU Safety Manual requirements. As a general rule, laboratories with hoods will have chemical storage. However, the primary location for storage of large volumes of chemicals is the Process and Transport Support Laboratory. The below rules provide guidance for storage of chemicals.

- Corrosive chemicals, such as acids, are stored in the cabinets under the fume hoods.
- Organic chemicals are stored in flame cabinets located in various laboratories. Storage guidelines are as follows -
 - Laboratories with Hoods
 - Lab Fire Haz Class: C
 - Storage in Flame Cabinet: 24 gallons in three separate flame cabinets (8 gallons per cabinet)
 - Amount (pure chemical) used at an open system experiment station: 0.4 gallons
 - Total amount in lab that can be used for multiple open systems: 8.4 gal
 - Max use in the Hood or appropriated engineering controlled system: 4 gallons
 - Process and Transport Support Laboratory
 - Lab Fire Haz Class: B
 - Storage in Flame Cabinet: 60 gallons in three flame cabinets (20 gallons per cabinet)
 - Max use in the Hood: 8 gallons
- Every chemical in the laboratory should have a specific storage location, and returned to that location after each use.
- Storage must conform to compatibility restrictions.
- Adequate containment for spills and releases will be available.
- Hazardous chemicals should never be stored on the floor. Containers should be kept on low shelves or in cabinets. The shelves should have a lip on the forward edge to prevent bottles from slipping off. Shelving units should be securely fastened to the wall or floors, and not be overloaded.
- Utilize compatible/suitable containers for experiments, storage, and collected wastes. See the SDS for specific compatibility information.
- Containers storing chemical waste must be inspected weekly for any sign of chemical leakage. Containers of all types should be free of rust and deformation.
- Caps and covers for containers will be secured whenever the container is not in immediate use.

- All containers used for storage (even short term) will be labeled in accordance with OSU labeling policy.
 - Metal drums used for storage and dispensing of flammable chemicals will be properly grounded or bonded. Ground cables will be available and utilized in any laboratory using metal storage containers for flammable liquid storage.
 - Out-of-date chemicals will be disposed of on a periodic basis to reduce overall hazard potential and minimize inventory tracking and updating.
 - No chemical may be stored in ENDEAVOR for more than 36 months.
 - Secondary containment (spill tray) will be used (when reasonable) for chemical storage or transfer.
- Storage of compressed gases
 - Always clearly mark empty cylinders and store them separately.
 - Only compatible gases should be stored together in a gas cylinder cabinet.
 - Do not store compressed gas cylinders in areas where the temperature exceeds 125F.

6.2 *General Handling and Transporting Chemicals*

Many laboratory incidents occur through the simple operation of carrying chemicals from one place to another or transferring them from one container to another. The chemicals used in laboratories are often corrosive, toxic, or flammable. Any incident has the potential for personal injury.

- Incompatible chemicals should not be transported on the same cart.
- Individuals transporting chemicals must ensure that containers are properly labeled, and know what to do in the event of a release or spill.
- Wear appropriate PPE. Minimum PPE includes safety glasses, closed toed shoes, and other appropriate laboratory attire. Hazardous chemicals must be attended at all times while being transported.
- If possible, freight-only elevators should be used to avoid exposure to other passengers on the elevators. If freight elevators are not available, use unoccupied passenger elevators.
- Special padded or rubber bottle carriers, pails, or carts should be used to prevent breakage by accidental striking against walls or floor, and to contain the material if breakage does occur.
- Bottles of concentrated acids must be carried using bottle carrier.
- Organic solvents will also be carried from storage areas in bottle carriers.
- When large bottles of acids, solvents, or other liquids are transported within the laboratory, only one bottle should be carried at a time. Never carry or attempt to pick up a bottle by the cap. Using a bottle carrier is the safest method for transporting chemicals within a laboratory.
- When transporting bottles within the laboratory facility, a wheeled cart may be used. Carts should be stable under load and have wheels large enough to negotiate uneven surfaces (such as expansion joints and floor drain depressions) without tipping or stopping suddenly. Bottles should not be placed near the edge of the cart, nor should they be touching each other or other glassware during transport. Be cautious rolling the cart over doorsills or other possible obstructions.
- When transporting chemicals using a cart outside on sidewalks and other paved surfaces, two people are required to prevent cart tipping over uneven terrain and changes in

elevation.

- Transportation of compressed gases
 - Complete the handling of compressed gas cylinder training on the EHS website.
 - To transport a cylinder, put on the safety cap and strap the cylinder to a hand truck in an upright position. Never roll a cylinder.
 - Be careful while handling compressed gas cylinders and never drop or strike a cylinder against anything.

6.3 Chemical Inventory

Chemical inventory will be tracked using the OSU Chemical Safety Assistant online program (<http://ehs.okstate.edu/hazcom/OnSite.htm>). Departments will reconcile the inventory information annually. During the year, it is the responsibility of PIs and/or departments to keep the inventory data current, such as significant/permanent changes in inventory volumes or additions of new hazardous materials.

ENDEAVOR faculty and staff will enter chemical inventories into the OSU Chemical Safety Assistant. The faculty and staff will audit the inventory on an annual basis and update the Chemical Safety Assistant and SDS.

6.4 Chemical Labeling

Labeling of chemical containers is fundamental to effective hazard communication. The manufacturers provide compliant labeling for chemicals they sell. However, OSU labeling standards are needed for labeling secondary containers and expiration of sensitive chemicals such as peroxide formers. OSU labeling standards are listed below.

- Manufacturers' chemical labeling will remain intact and not defaced.
- All chemicals must be prominently and accurately labeled as to content. The full chemical name must be in legible English. Formulas and abbreviations are not acceptable.
- Unlabeled chemicals must not be stored or used.
- Make sure all labels are legible and intact. Periodically check inventory for labels that may have degraded or fallen off. Labels must be on containers that are designated for chemical pick up.
- Date all peroxidizable and other chemicals that may become unstable over time. They should display the arrival date, date opened, and latest date tested. Expiration dates may be extended based on testing.
- All secondary containers must be labeled with common name, chemical name, and NFPA diamond (Figure 6.4). Dilutions should be labeled with common name, chemical name, concentration, and NFPA diamond (if hazardous).



Figure 6.4. Example Labels for Secondary (a) and Dilute (b) Chemicals

6.5 Incompatibles

Refer to guidance given in the OSU Laboratory Safety Manual.

6.6 Chemical Disposal

Disposal will be part of any new experiment being developed; such that, ENDEAVOR faculty and staff will coordinate hazardous and regulated waste disposal with EHS. Storage of waste will also be coordinated with EHS and will be located in a well-marked designated area. Labeling and disposal procedures will follow guidance given in the OSU Laboratory Safety Manual.

6.7 Inspections

ENDEAVOR faculty and staff will perform weekly inspections of eyewash stations, drench hoses, and safety showers. Periodically, ENDEAVOR staff will inspect laboratories using the latest EHS Inspection Checklist

7. Procedures for Common Categories of Hazards in ENDEAVOR

This section offers specific guidelines for mitigating hazards in potentially hazardous areas of the ENDEAVOR.

7.1 Chemical Hazards

Refer to guidance given in the OSU Laboratory Safety Manual.

7.2 Mechanical Hazards

Hand held and other power equipment will be used in the ENDEAVOR by staff and students.

- Students must be trained and approved to use specific power equipment.
- Moving components must have appropriate guard to prevent contact with dangerous moving parts.
- Never reach your hand toward the point of operation of a machine.
- Allow time for the machine to stop moving once turned off.
- Use equipment as specified by the manufacturer.
- Maintain blades and bits in good condition. Replace them when they are damaged.
- Identify and avoid pinch points and wear appropriate gloves for tasks where the potential for pinch, puncture, or cut are possible.

7.3 Laser Hazards

A class IV laser will be used in specific areas of the Flow Laboratory. When lasers are in use, the beam will be completely contained by appropriate attenuating curtains such that, the laboratory may be occupied by students not using lasers. General laser operation guidance is given below -

- Laser Operators

- Operators will receive appropriate training for laser operation and training.
- Operators are responsible for installing beam protection, marking off exclusion area(s), and providing notification of laser usage. Appropriate laser attenuating curtains will be installed and surround laser work area.
- Perform laser-based experiments during times when the laboratory has low usage.
- Laser beams should never be at eye level. Open beam areas should be clearly marked so that all lab personnel are made aware of these locations.
- Jewelry and other reflective material should not be worn near the laser system.
- Beam stops should be around the edges of the laser table if applicable.
- Proper eye protection must be worn. Only eyewear approved for laser protection must be used. All approved eyewear will have the range(s) of wavelengths they will attenuate, as well as the optical density (OD) for each indicated range. The wavelength of the laser being used must be included in the range of wavelengths listed on the eyewear. Eyewear must be in good condition and properly stored.
- Non-Operators
 - Notice when laser is in use.
 - Do not enter marked exclusion areas.

7.4 Radiation Safety

X-ray equipment will be used in the ENDEAVOR. Laboratories and locations using this equipment will be clearly marked with signage and marked exclusion-areas that are observed when the sources are active. General X-Ray operation guidance is given below -

- Machine Operators
 - Operators will receive radiation training through the radiation safety program.
 - Operators will receive and wear a radiation badge during instrument operation.
 - Operators will receive appropriate training for the specific X-ray equipment.
 - Operators are responsible for following security and safety instructions to ensure no X-ray exposures occur. This includes locking the software and/or removing source keys to insure non-trained personnel cannot activate the X-ray source.
- Non-Operators
 - Be aware when X-ray equipment is in use.
 - Do not enter marked exclusion areas when the source is active. A trained operator will provide on-site guidance.

Note. No radioactive sources or chemicals will be used in the ENDEAVOR.

7.5 Pressure Vessel Safety

Pressure vessels are used to contain pressures above one atmosphere. Pressurized vessels are common, such as shop air compressor, and are used in courses such as Thermodynamics. General guidance regarding pressure vessels include:

- Pressure vessels should meet AMSE standards and be labeled to indicate the maximum allowable working pressure and temperature.
- If a vessel is not AMSE stamped, a hydrostatic pressure test is required following hydrostatic test SOP.
- Custom pressure vessels used by students in classes must be hydrostatically tested annually.

- Service lines shall not be not connected to any closed apparatus incapable of withstanding the maximum pressure of the service line (air, water, etc.).
- All pressure systems must be protected with appropriate pressure-relief devices that are set at least 25% below the maximum operating pressure (or lower). Two devices, such as pressure relief valve and/or rupture disk are preferred.
- The pressure-relief device should be installed so that the discharge is directed away from the area where a person could be affected.
- Pressure-relief devices will be periodically tested by lab staff. Orifices on both sides of the pressure-relief device should be checked for obstruction.
- Pressure gauges with pressure ranges about twice the working pressure of the system will be used.
- Containers, fittings, and other equipment to be used when working with pressure vessels will be chosen to be able to withstand the stresses imposed by the given pressures and temperatures.
- The pressure levels of high-pressure devices shall be monitored periodically as heating proceeds.

7.6 Metal and Plastic Printers

Additive manufacturing printers will have specific safety requirements and instruction that are equipment and task specific. The below is general guidance given for printer safety that may not be relevant for specific printers or tasks.

- Fully enclose or cover 3D printers to limit exposure to VOCs and UFPs. Once a printing job is started, do not open the cover or override the interlock switch. Maintain a safe distance from the printer to limit inhalation of particles.
- Use 3D printers in well-ventilated areas.
- Avoid contact with heated surfaces to prevent burns.
- Uncured material may be hazardous. Wear suitable gloves and safety goggles if the material poses a splash risk.
- Use of printers is limited to only personal that have been trained and authorized.

7.7 Design Projects

Design project instructors and/or staff will provide appropriate safety instruction and documentation for students and employees. This includes appropriate SOPs and training. Safety concerns related to their project should be fully addressed in these SOPs, and include any special safety aspect regarding project location as assigned by CEAT.

7.8 Electrical Hazards

Significant use of electrical power is common throughout every laboratory in ENDEAVOR. Providing power both at the walls and overhead is intended to reduce hazards caused by electrical

power usage. However, attention must be given to avoid common hazards that will occur during daily usage. Please follow the general guidance given below.

- Cords should not have signs of wear or bare wires exposed.
- Extension cords should only be used temporarily with adequate gauge to handle current. Extension cords should not replace permanent wiring or be plugged into a power strip. Extension cords should be three-prong if they are used with grounded equipment.
- GFCI receptacles should be located within 6 feet from water sources.
- Water cooled in/by electrical outlets can pose a shock hazard. Similarly, organic liquids that pool near outlets could pose a fire hazard.
- Power strips must be UL certified and have overcurrent protection. In addition, a power strip should not be plugged into another power strip (daisy chaining).
- Use overhead trays or other similar means of running cables throughout the laboratory. Cable routing should not pose a tripping, shock, or clothes-line hazard.
- Proper training is required to perform maintenance on any electrical equipment over 50 V. Refer training needs to the EHS Occupational Safety Program Manager.
- No halogen light bulbs should be used in the laboratory.
- No missing or damaged cover plates on outlets, junction boxes, etc., are allowed.
- Hand tools must be double insulated or grounded.
- Only authorized personal are allowed to access breaker boxes and reset breakers.

7.9 Compressed Gas

Follow guidance given in the OSU Laboratory Safety Manual. ENDEAVOR specifics include:

- Oxygen should be stored in an area that is at least 20 feet away from any flammable or combustible materials (including gasses) or separated from combustibles by a non-combustible barrier at least 5 feet high and having a fire-resistance rating of at least ½ hour. Exceptions are granted for operational commercial cutting torches and brazing equipment.
- Highly toxic, corrosive, or reactive compressed gases (NFPA = 4) will not be used in the ENDEAVOR without special permission provided by the laboratory Safety Manager. Request will require a full SOP, hazard analysis, and experiment design. Approval will require at least a month.

7.10 Cryogenics

Follow guidance given in the OSU Laboratory Safety Manual

7.11 High Voltage

The following guidelines for high voltage work should be followed in ENDEAVOR:

- De-energize the equipment at least twice prior to beginning work. Make sure that the controls applied will prevent operation of the equipment and that all hazardous energy is

blocked, discharged, or relieved prior to starting work. This includes residual or stored energy.

- After everything has been discharged, touch the circuit with the back of your hand first, to allow you to let go if necessary.
- Only use the test instruments and insulated tools rated for the voltage and current specified.
- Wear rubber bottom shoes.
- Know your equipment. Always follow SOPs.
- Perform as many tests as possible with power off and the equipment unplugged.
- If you need to probe, solder, or otherwise touch circuits with power off, discharge across large power supply filter capacitors at least two times. Monitor while discharging and verify that there is no residual charge with a suitable voltmeter.
- If you must probe live, put electrical tape over all but the last 1/16" of the test probes to avoid the possibility of an accidental short. Clip the reference end of the meter or scope to the appropriate ground return so that you only need to probe with one hand.
- Ensure that all supplies are switched off before you leave the laboratory.

7.12 Soldering

When soldering in the ENDEAVOR, the following guidelines should be followed:

- Work in a well-ventilated area. Use a snorkel whenever possible.
- Make sure you know what is in your solder. When in doubt, ask.
- Never touch the element of the soldering iron
- Hold wires to be heated with tweezers or clamps
- Keep the cleaning brass sponge or wet sponge available during use. The brass sponge is preferred.
- Always return the soldering iron to its stand when not in use. Never put it down on the workbench. Turn the unit off and unplug when not in use.
- Always wear eye protection.
- When using a snorkel or hood, any standard solder may be used. Otherwise, use rosin-free and lead-free solders.
- Keep cleaning solvents in dispensing bottles to reduce inhalation hazards.
- Wash your hands with soap and water after soldering.
- Read and understand the SDS for all materials before beginning work
- Work on a fireproof or fire-resistant surface and wear fire resistant clothing (100% cotton or FRC).
- Use a grounded outlet and grounding prong.
- Do not use soldering irons that have obvious damage to body, cable, or plug.

8. ENDEAVOR Documentation

8.1 *Standard Operating Procedures*

This Laboratory Safety Manual is focused on ENDEAVOR procedures and policies. However, SOPs are necessary to address specific hazardous operations in a laboratory.

- The faculty and appropriate staff are responsible for developing written standard operating procedures for routinely performed tasks or any work with hazardous chemicals that is not addressed by this manual or the OSU Laboratory Safety Manual.
- SOP training must be provided to affected employees and lab personnel.
- SOPs should be reviewed and approved by knowledgeable persons within CEAT.
- The laboratory Safety Manager must approve all ENDEAVOR SOPs before implementation.
- Please update SOPs to capture and review incremental changes in procedures to avoid procedure creep.
- The EHS SOP format will be used for new or significantly revised SOPs. Legacy SOPs and instruction may keep the former format.

8.2 *Incident and Near Miss Reports*

Incident and near miss reports provide key metrics to improve safety. These reports provide quantitative data that identify recurring safety incidents and used to perform root-cause analysis that are necessary to change related safety processes. Exposure and injury reports will follow guidance given by EHS and the OSU Laboratory Safety Manual. Near misses will be reported to ENDEAVOR faculty or staff, where the miss will be discussed by faculty and staff during the weekly staff meeting. Once discussed, action will be reviewed, implemented and documented.

8.3 *Documentation Control*

ENDEAVOR will be in charge of production and upkeep of SOPs and other safety related documentation. SOPs will be reviewed and updated during the summer semester. Student training records will be kept for a one-year period.

EHS is responsible for the version control and annual review of the LSM and support SOPs, such as inspection related SOPs.

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Appendix 1: Terms and Definitions

Term	Definition
Acute	Single short-term exposure that may produce immediate reversible symptoms
BSO	Biological Safety Officer
Chronic	Repeated exposure with delayed effects that is usually irreversible.
EHS	Environmental Health & Safety
ft/min	Feet per minute
Fire Hazard	
Class I*	Flash point < 38 C
Class II	Flash point between 39 - 60 C
Class III	Flash point > 68 C
Hazardous Chemical	Chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Chemicals covered by this definition include carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes. Operationally: Any neat chemical with an NFPA label number greater than 2.
HEPA	High Efficiency Particulate Air
HR	Human Resources
Lab Supervisor	Person officially designated as being in charge of a laboratory in place of the Principal Investigator.
DLSM	Department Laboratory Safety Manual
LSM	Laboratory Safety Manual
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Agency
NIOSH	National Institute of Occupational Health & Safety
OSHA	Occupational Health & Safety Administration
OSU	Oklahoma State University
PEL	Permissible Exposure Limit
PI	Principal Investigator
PPE	Personal Protective Equipment
RSO	Radiation Safety Officer
SDS	Safety Data Sheet – previously Material Safety Data Sheet
STEL	Short Term Exposure Limits
SOP	Standard Operating Procedure
TLV	Threshold Limit Values
UHS	University Health Services
URC	University Research Compliance

Appendix 2: ENDEAVOR Safety Maps

Safety maps in Appendix 2 correspond to the Table in Section 3.6.2. In the safety maps for each floor, safety equipment and requirements for each lab are given. Asterisk indicates that the requirement is conditional and may be determined by laboratory responsible person.

A.2.3 Third Floor Safety Map

