The Cooper Union for the Advancement of Science and Art

Health and Safety Manual

Third Edition

September 2023

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Table of Contents

Introduction

The Health and Safety Committee is committed to establishing and maintaining a healthy and safe work environment for Cooper Union's faculty, students and staff. We strive to minimize individual risks and the environmental impact of our actions. We hope to accomplish this by identifying, evaluating and controlling personal and environmental hazards, as well as by personnel training.

This manual has been created to give practical guidance to faculty, students and staff at Cooper Union who are working with hazardous materials, and to provide information on important environmental health and safety practices, policies, procedures and regulations. While there has been effort for this manual to be comprehensive, this manual cannot cover all aspects of proper safety and hazardous materials usage. For purposes of this manual, the words "lab", "shop" and "studio" will be used to describe a space where members of the Cooper Union community may work with tools, equipment, instrumentation, biological materials and/or chemicals. Please consult with the director of a particular laboratory or research space for specific information that may be relevant to working safely in that area. Furthermore, please be advised that changes in policies and regulations may be necessary due to new government regulations. Current information will be updated regularly, and communicated at Health and Safety meetings.

Occupational Safety and Health Administration (OSHA)

OSHA was created in 1970 to ensure safe and healthful working conditions by setting and enforcing standards and by providing training, outreach, education and assistance. OSHA is part of the U. S. Department of Labor. Although a number of states have OSHA-approved state plans covering all employees, New York's state plan covers only state and local government employees. Private sector employers, such as Cooper Union, and their employes (including faculty and staff) are covered by federal OSHA standards and regulations.

OSHA has established occupational exposure limits for a number of chemicals and physical hazards. OSHA's occupational exposure limits are known as Permissible Exposure Limits (PELs) and describe the maximum allowable exposure for a range of hazards. Exposures exceeding the established PELs are generally considered harmful and constitute a violation of OSHA regulations. PELs are usually calculated as 8-hour time-weighted average (TWA) exposures to indicate the approximate exposure to harmful agents over a regular daily shift of workers in the United States. However, OSHA has also established Short Term Exposure Limits (STELs) for a number of agents. STELs are expressed as the maximum allowable average exposures over a 15-minute work period. Some agents have OSHA-mandated ceiling values, which are the maximum allowable exposure limits that cannot be exceeded at any point and are usually relevant to particularly toxic chemicals.

It is not uncommon for materials with established OSHA PELs to be stored, used or generated in laboratory spaces. Additional information on OSHA mandated exposure limits can be found on the OSHA website. It is important to note that the majority of chemicals that are available in the U. S. market do not have an established OSHA PEL. There are many hazardous chemicals that can have adverse health effects in the event of exposure, for which the federal government has not established mandatory exposure limits. Furthermore, available information regarding the toxicology and potential harmful effects of these chemicals can be updated regularly and the consensus of the scientific community relating to what constitutes a safe exposure level may change. Consequently, many of the OSHA PELs are now largely considered outdated, and in some cases inadequate, for the protection of employee health and wellbeing. In addition, for many agents that can increase the risk of certain health outcomes upon prolonged or chronic exposure, no accepted safe exposure levels have been identified and any exposure can potentially contribute to an increased risk of disease or injury.

For all of the above reasons, the legally mandated OSHA exposure limits, although still enforceable, are not considered adequate for ensuring health and safety, and the Health and Safety Committee may recommend or require that exposure to certain hazardous agents be maintained at levels lower than the OSHA standards, or even be minimized to approach zero exposure levels.

OSHA requires that PPE for the eyes, face, extremities and body be made available to employees, maintained in good condition and used safely in accordance with relevant guidelines. 29 CFR Part 1910 includes a number of hazard-specific requirements intended to ensure safety and health in the workplace. Specific guidelines for categories of chemicals (e.g. toxic or reactive chemicals), or even specific compounds (e.g. formaldehyde and mixtures that contain it, nitrous oxide, etc) describe OSHA's requirements when these hazards are present. OSHA regulations and guidelines are drafted for the purpose of protecting employees, and OSHA's standards do not apply to members of the Cooper Union community that are not employees. The EPA establishes legally binding limits for the general population, but these guidelines may not always be relevant to research environments or workplace settings as they generally aim at preventing environmental contamination of the air, water, soil and natural resources. As a result, the Health and Safety committee may require that regulations and standards intended for the protection of employees also be adhered to in the case of students engaged in research activities.

The National Institute for Occupational Safety and Health (NIOSH) is a research agency focused on the study of worker safety and health, and empowering employers and workers to create safe and healthy workplaces. NIOSH is part of the CDC, tasked with conducting research and providing recommendations relating to occupational health and safety in the United States. NIOSH establishes, reviews and updates occupational exposure limits (OELs) for a number of hazardous agents. NIOSH recommended exposure limits (RELs) are not mandatory standards and in many cases are more stringent that OSHA's corresponding PELs. Information on RELs for specific hazardous materials or workplace conditions can be obtained through the NIOSH Pocket Guide to Chemical Hazards. In many cases legislators and regulatory agencies have not established mandatory guidelines for the safe use of certain hazardous materials. The American Conference of Governmental Industrial Hygienists (ACGIH) is a non-governmental scientific organization that publishes standards similar to OELs called threshold limit values (TLVs) that often differ significantly from the mandatory OSHA limits and are generally considered more protective of employees. Cooper Union generally requires that exposure levels are maintained below TLVs where applicable, although these standards are not mandated by federal or state laws. In the absence of government guidelines, or when government guidelines are considered inadequate for protecting health and safety, consensus or industry standards or guidelines from non-governmental organizations may be adopted or referred to by the Health and Safety Committee.

General Safety and Precautions

Working safely in a laboratory, studio or shop begins with general attire. Any person in a laboratory containing hazardous materials must cover the full length of their legs and feet. This applies to everyone, whether they are working with any hazards or not. It is strongly recommended that laboratory personnel keep a second set of clothes and shoes at their desk to change into as needed. Shorts, cropped pants or short skirts are prohibited in a laboratory. Likewise, sandals, open-toed shoes and shoes exposing the top of the foot such as a flat or pump must not be worn in a laboratory.

Good laboratory practices require personal clothing or a lab coat to cover exposed skin. It is important to pull back loose hair and avoid dangling jewelry, which may get caught in equipment or make accidental contact with hazardous materials.

The habits and work practices of the laboratory and shop personnel, as well as the managing of the space itself, are very important for the safe operation of an area. Laboratory- and shop-specific SOPs should be developed by knowledgeable workers and reviewed with all laboratory and shop personnel to ensure that the procedures are understood. The safety rules and policies set forth in The National Academies of Sciences, Engineering and Medicine handbook, *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*, and those listed below can help minimize exposure to hazardous chemicals and should be employed in conjunction with laboratory-specific standard operating procedures (SOPs):

- Never eat, drink, chew gum, smoke or apply cosmetics in the laboratory
- Select, use and maintain appropriate PPE
- Store and segregate hazardous materials according to hazard class
- Report unsafe conditions to a laboratory or shop supervisor, or the campus wide safety officer
- Keep all work areas clean and uncluttered
- Keep all aisles, doorways and emergency exits free from obstruction
- Keep all emergency equipment, including fire extinguishers, fire blankets, overhead emergency showers, eye washes and chemical spill kits free from obstructions
- Scale the size of the experiment or work and use the smallest amount of material necessary for the work to be done
- Remove gloves and wash hands and arms with soap and water after removing gloves and before leaving the work area or handling common items like phones, instruments and door handles
- Properly manage and dispose of all hazardous substances

Protect your back muscles when lifting heavy or awkward sized/shaped objects – have someone help you! Lift with your arm and leg muscles. Secure help with long boards, even if they are not heavy.

Personal Protective Equipment (PPE)

The appropriate use of PPE is critical in reducing dermal and mucosal exposure to laboratory and shop hazards, and represents the last line of defense against potential exposure. Departments are responsible for purchasing and distributing PPE. PPE must be provided at no cost to personnel and used whenever the potential for occupational exposure exists. In most instances, the minimum level of PPE for laboratory personnel consists of a laboratory coat, gloves and eye protection.

A laboratory coat is required to be worn by all personnel in a laboratory whenever there is the potential for dermal exposure to hazardous materials. Laboratory coats must be selected to fit the individual, and new laboratory members should not inherit an unwashed laboratory coat, or a laboratory coat that is too big or too small. Laboratory coats must be changed immediately if they become contaminated and must not be worn outside of the laboratory. Liquid resistant aprons (vinyl or rubber, depending on the compound in use) are a good supplement to laboratory coats for activities with an elevated chemical splash potential. Fire-resistant laboratory coats made from materials such as Nomex or Kevlar are recommended for applications carrying a high risk of ignition or fire, such as those involving large amounts of flammable materials.

Gloves are made in a variety of materials, and there is no one glove for all chemical hazards. For most laboratory work, a nitrile glove is enough to create a thin skin barrier that allows the soiled glove to be removed and replaced before skin contact occurs. The use of latex gloves should be discouraged, due to skin sensitization and latex allergies. Gloves are often disposable, and not intended to be impermeable. Common glove manufacturers, such as Ansell, Marigold and VWR, publish glove guides for chemical compatibility and breakthrough times with their product lines. Common examples of reusable gloves include cryogenic gloves and heat resistant gloves. Cryogenic gloves (for use when handling dry ice or cryogenic liquids) are insulated to prevent burns from extreme cold temperatures. They have different properties from gloves designed for hot temperatures. Cryogenic gloves with mid-arm or longer protection are recommended for transferring cryogenic liquids. Heat resistant gloves are made of absorbent fabric and should never be used to handle cryogens.

Eye protection is always required when handling hazardous materials. Eye exposure and eye injury can occur even with small volumes. A good rule of thumb is that if the material can burn or damage your eyes, eye protection is required when handling the material. This includes laboratory use of ultraviolet and other harmful radiation, in addition to solid, liquid and gaseous materials. Eye protection must fit the individual properly. Safety glasses provide the minimum protection against chemical hazards. When working with large amounts of hazardous materials, or when there is a significant splash risk, tight-sealing safety goggles with a face shield are recommended. Eyeglasses and contact lenses do not offer an appropriate level of splash or impact protection. The American National Standards Institute (ANSI) has criteria and testing for eye protection under Standard Z87.1-2003, *Occupational and Educational Personal Eye and Face Protection Devices*. All eyewear meeting this standard are marked with “Z87+” on the eyewear.

Respirators are a special category of PPE designed to filter out airborne contaminants, purify the air, or provide fresh air. There are different types of respirators that are only effective against the types of hazards for which they are designed. In cases where respiratory protection is needed, adequate protection is only possible if the requirements below are met: the right type of respirator is selected; the respirator is in good condition and properly maintained; the respirator works properly; and the user is medically cleared to use the specific type of respiratory protection.

The use of respiratory protection is generally not necessary in most spaces at Cooper Union. The implementation of proper engineering and administrative controls is usually sufficient to reduce the risk of exposure to airborne contaminants. In the case when respiratory protection is needed, users must comply with OSHA’s respiratory protection standard. This standard outlines the requirements for medical clearance, annual fit testing, training, recordkeeping, maintenance and proper use. Whenever a respiratory is deemed necessary, it is essential that the campus wide safety officer lead the process for selecting the proper respirator for the user since not all respirators will protect against all potential airborne hazards. As such, the purchase and/or use of any NIOSH-approved respirator, including N-95 respirators, must not occur until a work practice and exposure assessment is performed. When respiratory protection is deemed necessary, a user must obtain medical clearance from a personal healthcare provider, as necessary; receive annual fit-testing, as applicable; receive training on the proper use, handling, storage, inspection and maintenance of the respirator; inspect the respiratory monthly and keep records of the inspection; wear the respirator only for its intended use; notify his/her supervisor and the campus wide safety officer when the scope of work that required respiratory protection changes; and communicate to a health care provider if a significant health event occurs. Improper use of respirators can be harmful to the user and can result in significant adverse health effects or injury. When a risk assessment concludes that respiratory protection is not necessary, investigators who wish to conduct work with respiratory protection must follow the requirements outlined in the OSHA respiratory protection standard. OSHA requires adherence to guidelines relating to the voluntary use of respiratory protection.

Crystalline Silica

Crystalline silica is a common mineral found in naturally occurring and manufactured materials like stone or artificial stone countertops and sand. Employees can be exposed to respirable crystalline silica – very small particles typically at least 100 times smaller than ordinary sand found on beaches or playgrounds – during the manufacturing of products like glass, pottery, ceramics, brick, concrete, and artificial stone.

Exposure to crystalline silica can result in serious health effects. This includes the following:

- Silicosis, an incurable lung disease that can lead to disability and death;
- Lung cancer;
- Chronic obstructive pulmonary disease (COPD); and
- Kidney disease.

Employees at The Cooper Union may have potential exposure to crystalline silica when using the product Satin Cast #20. Specifically, employees working in the Art and Architecture Shop during lecture activities and while assisting students with projects. There is also a potential for exposure to crystalline silica during cleanup activities. All work activities involving the Satin Cast #20 should be performed in the High Vent room, or with localized exhaust ventilation when possible. Sweeping compound must also be used when cleaning up Satin Cast #20. A copy of the Safety Data Sheet for Satin Cast #20 can be found here, as well as in the SDS binder in the room(s) where it is being used.

While there is no indication that employees are exposed to crystalline silica at levels exceeding OSHA's permissible exposure limits, we ask that all Cooper Union employees who use this product to exercise caution while handling the Satin Cast #20. Cooper Union employees are permitted to use N-95 Respirators voluntarily during the use of Satin Cast #20. Please refer to the section on PPE of the Health and Safety Manual for additional information on voluntary use respirators and the information contained in OSHA's Appendix D of the Respiratory Protection Standard.

For additional information on the OSHA's Crystalline Silica Standard, including exposure limits, and the medical surveillance portion of the standard (see 1910.1053(i)), please visit the OSHA website or contact the Cooper Union Health and Safety Coordinator.

Roles and Responsibilities

Cooper Union faculty and staff who supervise laboratory spaces, studios and workshops are responsible for ensuring that all personnel attend requisite trainings. They must also provide task-specific training for activities that can create hazardous conditions in the laboratory, provide appropriate PPE, and notify the campus wide safety officer when there is an intent to use OSHA regulated chemicals.

The Health and Safety Committee provides guidance to ensure compliance with OSHA regulations in laboratory spaces, creates and provides specialized and general safety training relating to chemical and physical hazards, conducts exposure assessments and generates formal reports with interpretation of the results and recommended actions for supervisors and their staff, provides consultations and conducts hazard and risk assessments for member of the Cooper Union community, is responsible for oversight of the respiratory protection program of the university, remains updated on changes in OSHA regulations to ensure the compliance by the university, and remains updated on emergency occupational safety hazards in order to update the university's policies.

Common Equipment and Laboratory Equipment

Mixers, blenders and sonicators may be used in laboratories and shops to mix materials or extract compounds. A sonicator applies sound energy to agitate particles in a sample. Sonicators mix solutions, dissolve solids into liquids and remove dissolved gas from liquids. Mixers, blenders and sonicators produce large quantities of aerosols. Sonication may be safely performed by placing a tightly capped tube or vial in a beaker of water and putting the probe in the water rather than in the tube or vial.

A lyophilizer, or freeze dryer, executes a water removal process, typically used to preserve perishable materials. Lyophilization is a process in which water is removed from a product after it has been frozen and placed under a vacuum, allowing the ice to change directly from a solid to a vapor without passing through the liquid phase. Lyophilizers produce a dry solid that is very easily dispersed. They should be fitted with a HEPA filter or vented to a biological safety cabinet when used for drying suspensions of biological material. Ampules of lyophilized solids should be opened only in a biological safety cabinet.

Sharps are defined as any object that can penetrate a person's skin, such as needles, scalpels, broken glass, razor blades, broke glass, and capillary tubes. Sharps such as needles and syringes should be used only when there is no plastic alternative available. The following work practices are recommended:

- Use blunt needles, pipettes or cannulas to aspirate fluids instead of hypodermic needles; substitute plastic for glass when possible
- Use only needle-locking units or units in which the needle is an integral part of the syringe
- Dispose of all needles properly in a sharps container immediately after use
- Dispose of unused needles in sharps containers
- Never recap, shear, break or bend needles under any circumstances. Expel air and bubbles into a disinfectant-moistened pad or Kimwipe.

Autoclaves provide the most efficient and reliable method of sterilization for most biological applications. Sterilization refers to the destruction of all microbial life. The critical process factors are temperature, exposure time, and ensuring that packaging materials allow the steam to penetrate throughout the load. Sterilization time will vary in relation to the size of the load and the packing density of the chamber. Typically laboratory autoclaves operate at 121 ^{o}C and 15 psi. All users must review the operating manual periodically. Autoclave instructions should be prominently posted. Users should use heat-resistant gloves and face protection, particularly when removing processed material from the autoclave. For dry loads, researchers should add 250-500 mL of water to the load pan to aid in steam generation. Autoclave bags should be closed loosely to allow steam to penetrate; users must not tightly cap bottles and/or test tubes. Autoclave tape is not a fail-safe indicator of sterilization. Tape blackens only after a brief exposure to a temperature of 121 ^{o}C and does not indicate sustained temperature.

Ventilation

The primary building control in the laboratories and shops is a chemical fume hood. These are connected to the building's HVAC system to ensure that any carcinogenic and reactive vapors are drawn to the fume hood and exhausted away from the user's breathing zone. All of this air is vented to the outside using dedicated exhaust fans. Chemical fume hoods should be used only for handling chemicals with significant inhalation hazards, such as those that produce toxic gases or vapors, volatile substances, and respirable toxic powders. Facilities Management personnel certify each fume hood at least once annually.

Prior to using a fume hood in any room, workers in a space should become familiar with the locations of the nearest exit, emergency shower, eye-wash station and fire extinguisher. Emergency equipment such as the eye-wash and the shower must always remain unobstructed and ready to use. Experimental apparati and chemical materials should be handled at a distance of at least six inches behind the sash opening to avoid disruption of airflow. The air inside a fume hood can change when a window or door is opened, and even by a change of position of the person at the hood. When working at a chemical fume hood, keep the sash open only to the minimum height necessary.

The vertical sliding sash is also intended to serve as a physical barrier in the event of chemical splashes within the hood. For this reason, the sash should be kept below eye level and breathing zone height to protect the user if hazardous materials escape the fume hood. Everyone in the laboratory or shop should remain alert to changes in airflow and report any exhaust failure to Facilities Management for repair.

When hazardous chemicals cannot be used in a fume hood, extractor arms and ventilation trunks may be needed to minimize exposure. Extractor arms allow for capture and exhaust of hazardous substances close to the source of use, before their release into the environment.

Safety in Labs, Centers and Research Spaces

The NYC Department of Environmental Protection (NYC DEP) enforces the NYC Community Right-To-Know Law, which regulates the use and storage of hazardous chemicals. This legislation sets thresholds for the quantities of hazardous materials that may pose a health risk and therefore must be reported by an institution. Laboratory chemical inventories are used to prepare these reports.

The campus wide safety officer is responsible for recognizing, evaluating and controlling the hazards and risks associated with storing, handling and using chemical materials and/or equipment, including, but not limited to, flammable, corrosive, toxic or reactive materials, and heat- or pressure-generating equipment used in work conducted at the university. Through the application of suitable materials substitution, engineering controls, administrative controls and the use of Personal Protective Equipment (PPE), we aim to minimize the incidence of laboratory-related injuries and to ensure a safe and productive working environment for everyone in the Cooper Union community. The campus wide safety officer will work closely with researchers, technicians and other staff members to ensure that each space is safe and that appropriate protocols and policies are put in place. Some examples of this work would be as follows:

- Developing standard operating procedures (SOPs) to address hazards or operations in the laboratory
- Making sure that current and new laboratory personnel receive adequate laboratory and/or equipment-specific safety training
- Marking equipment with appropriate hazard symbols
- Providing and documenting hands-on training that is protocol specific
- Maintaining easy-to-access copies of SDSs for materials used in their procedures and stored in their areas
- Ensuring that all workers have adequate PPE
- Regularly flushing eyewash stations
- Having clear access to emergency equipment such as fire extinguishers, eye washes and safety showers
- Keeping an up-to-date laboratory door sign, including emergency contact information
- Reporting any injuries, accidents or incidents in the laboratory.

The Occupational Safety and Health Administration (OSHA) Occupational Exposure to Hazardous Chemicals in Laboratories Standard (1910.1450 - Occupational exposure to hazardous chemicals in laboratories. | Occupational Safety and Health Administration (osha.gov)) establishes general requirements for the laboratory use of hazardous chemicals. The OSHA Hazard Communication Standard (1910.1200 - Hazard Communication. | Occupational Safety and Health Administration (osha.gov)) establishes requirements for manufacturers of hazardous chemicals to provide Safety Data Sheets (SDSs) to users following the UN Globally Harmonized System (GHS) of Classification and Labeling of Chemicals. All manufacturers are legally required to include a copy of an up-to-date SDS with any sale of chemicals. SDSs provide useful information about emergency aid/response measures and a chemical's constituents, hazards, exposure and controls. A hazardous chemical's SDS will identify likely routes of exposure (i.e. inhalation, skin or eye absorption, ingestion or injection). In addition, other important information about the chemical manufacturer, fire-fighting procedures, PPE requirements, and spill clean-up procedures is provided. Cooper Union will maintain SDSs for all hazardous chemicals in their laboratories, shops and studios. Effective hazard communication includes maintenance of current chemical inventories, ready access to SDSs for hazardous chemicals, proper labeling of chemical containers, posting of hazard signs and training of laboratory personnel.

OSHA broadly defines a hazardous chemical as any substance that is classified as a health hazard or simple asphyxiant in accordance with the OSHA Laboratory Standard. A chemical classified as a health hazard poses one or more of the following hazardous effects:

- Acute toxicity
- Skin corrosion or irritation
- Serious eye damage or eye irritation
- Respiratory or skin sensitization

- Germ cell mutagenicity
- Carcinogenicity
- Reproductive toxicity
- Specific target organ toxicity
- Aspiration hazard

The criteria for determining whether a chemical is classified as a health hazard are detailed in Appendix A of the OSHA Hazard Communication Manual.

Working Alone or During Off-Hours

Working with chemicals alone, at night, or otherwise in isolation places individuals at special risk and should be avoided whenever possible. The faculty or staff member responsible for a space must ensure that employees and students perform only those tasks for which they are qualified by training and experience, especially during off-hours when they may be unsupervised or unaccompanied. They must also define for the people using their laboratory or shop any prohibited activities when personnel work alone or during off-hours, based on the hazards of the materials used or the activity performed. All personnel working alone in the laboratory must hold an applicable FDNY Certificate of Fitness.

Signs and Labels

Each laboratory or shop must have on its entrance door a sign identifying the room number, name and phone number of the person overseeing the space, the appropriate hazard symbols describing the activities inside, and emergency contact information. If there is a personnel change, the emergency contact information must be updated. All emergency contact numbers must be 24-hour accessible, such as a cell phone number, and cannot be a daytime only or office line. It is recommended that the primary emergency contact be the faculty or staff member responsible for a particular space. The emergency contact should be knowledgeable about the materials and equipment inside the space, and ideally live close to campus. Emergency contacts can differ from room to room depending on the type of work that is conducted inside.

By adopting the GHS, OSHA now requires that hazard communication labels contain the following features: product identifier, supplier information, precautionary statements, hazard pictograms, signal word, hazard statements and supplemental information. A comprehensive list of label components and descriptions can be found here: https://www.osha.gov/sites/default/files/publications/OSHA3636.pdf

Commercial suppliers of chemicals must label chemical containers with the chemical name, hazard information and safe storage conditions. These labels must never be defaced or obstructed unless an emptied and rinsed container is to be used for another purpose. Chemicals produced within laboratories must be labeled in English to meet these requirements.

When chemicals are transferred from primary, labeled containers to portable, secondary containers, the NYC Fire Code requires labeling of such containers with a chemical name. OSHA may also require labeling in certain instances. It is good practice to label all laboratory containers with a chemical name.

Chemical Storage and Segregation

Proper storage of chemicals in laboratories is a critical safety concern. Chemicals that have been stored improperly could react, forming hazardous products or resulting in a fire. Good storage practices should be followed, irrespective of where the chemicals are stored. It is very important to read the SDS and container label before storing a chemical, as these will indicate any special storage requirements, as well as incompatibilities.

Good storage practices include the following:

- Chemicals should be segregated in accordance with their compatibilities and classifications
- Chemicals should be stored in approved, compatible containers
- Chemicals should be stored below eye level, with heavy objects stored on lower shelves
- Corrosives should not be stored on bare metal shelves; rather, they should be stored in plastic storage bins or shelves, or on metal shelves that have been covered with protective, plastic-backed paper (e.g. Bench-Kote)
- When practical, chemicals in the same hazard class should be stored in corrosion-resistant secondary containers

Transportation of Hazardous Materials

The U. S. Department of Transportation (US DOT) and the International Air Transport Association (IATA) regulations cover the movement of hazardous materials between locations by ground and air transportation, respectively. According to US DOT regulations, a "hazardous material" is any substance that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety and property when transported in commerce. This includes hazardous substances and hazardous wastes. When materials are being moved from site to site, whether domestically or internationally, it is mandatory to use a certified shipper, which is often FedEx or another commercial carrier. It is also strictly required that packages of most chemical material be prepared by certified personnel. According to US DOT regulations, a "hazardous material" is any substance that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety and property when transported in commerce. This term is used for domestic shipment by motor vehicle or rail. For air, water or international transport by motor vehicle or rail, the term "dangerous good" is used instead.

A DOT hazard class is the category assigned to a material under the DOT Hazardous Material Regulations. There are nine DOT Hazard Classes, only some of which are applicable to laboratory materials. A material is assigned to only one DOT Hazard class.

Transport of hazardous materials within a laboratory/shop or between locations on campus must be accomplished using secondary containers and/or utility carts. Secondary containers can be made of rubber, metal or plastic, should be large enough to hold the contents of the primary container, and must not be made of a material that would react with the hazardous material being transported. These containers are available commercially through laboratory equipment suppliers. Before moving any compressed gas cylinder, ensure that the valve is protected by securing the cap to the cylinder and securely strapping the cylinder to a cylinder cart.

The following items and hazardous substances should be transported via freight elevators and not via passenger elevators:

- Hazardous chemicals and samples
- Chemicals in open containers
- Compressed gas cyliners and cryogenic liquids
- Laboratory items requiring the use of a cart or hand truck

Glassware and Chemical Containers

Glassware is a common waste product in laboratories, shops and studios. If uncontaminated, glassware may be recycled in collection containers found throughout the campus. Empty chemical bottles may be used as hazardous waste collection containers, but lab workers must make sure that the waste stream being collected is compatible with the container. To dispose of unwanted empty chemical containers, rinse the container with tap water (if necessary) and place it in a designated “glass waste” box. Glassware and containers must be completely empty of chemicals and residue. Once the box is full, the box must be closed and picked up for recycling.

Containers that held acutely toxic materials Chemicals Listed Under EPCRA Section 313 (epa.gov) must be treated as hazardous waste and may not be reused for waste collection.

Biological Safety

The campus wide safety officer is responsible for anticipating, assessing and controlling risks posed by the handling and use of biological materials. These include bacteria, viruses and recombinant DNA. Research with biological materials is subject to a number of laws, regulations and guidelines. The following is a brief outline of the most relevant federal agencies, regulations and guidance.

The National Institutes of Health Office of Science Policy (NIH OSP) administers the NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules. These guidelines detail safety practices and containment procedures for basic research involving recombinant or synthetic nucleic acid molecules, including the creation and use of organisms and viruses containing such molecules. The guidelines also describe the requirements for getting approval for various types of research. The NIH guidelines provide biosafety practices for constructing and handling recombinant and synthetic nucleic acids, which are defined as: molecules (a) that are constructed by joining nucleic acid molecules and (b) that can replicate in a living cell, i.e. recombinant nucleic acids; nucleic acid molecules that are chemically or by other means synthesized or amplified, including those that are chemically or otherwise modified but can base pair with naturally occurring nucleic acid molecules, i.e. synthetic nucleic acids; and molecules that result from the replication of recombinant nucleic acids or synthetic nucleic acids. Recombinant DNA also includes viral vectors, which is a viral genome that has been genetically modified to deliver foreign material into a cell. Viral genome modifications generally include deletions in some or all essential genes. The viral vector may be contained in and/or expressed by another vector, such as a bacterial plasmid or other virus.

The two most important principles of biological safety are risk assessment and containment. Risk assessment is the process used to identify the hazardous characteristics of a known infectious or potentially infectious agent or material that enables the appropriate selection of microbiological practices, safety equipment and facility safeguards that can prevent laboratory-acquired infections. The fundamentals of containment of potentially harmful biological agents include the microbiological practices, safety equipment and facility safeguards that protect laboratory workers, the environment and the public from exposure to infectious microorganisms that are handled and stored in the laboratory.

The principal hazardous characteristics of an agent are: its capacity to infect and cause disease in a susceptible human or animal host, its virulence as measured by the severity of disease and the availability of preventive measures and effective treatments for the disease. The NIH guidelines assign agents to risk groups to assist in risk assessment. Agents are classified into four risk groups according to their relative pathogenicity for healthy adult humans. Once the risk group of the agent is identified, a thorough consideration of how the agent will be manipulated must be undertaken. Factors to be considered in a risk assessment include:

- Pathogenicity (the ability of the organism to cause disease)
- Virulence (severity of the disease)
- Transmission route
- Agent stability (the survival of the agent in a particular environment)
- Infectious dose (the dose required to cause infection in humans or animals)
- Antibiotic resistance

The use of recombinant DNA may alter any of the above risk factors and students, faculty and staff should take these modifications into consideration when working with recombinant microorganisms.

All of the above factors are inherent in a particular microbe. External factors to be considered in a risk assessment include:

- The titer or volume of material used
- Availability of effective treatment or vaccine
- Nature of activities, including the potential for splashes, volume used, complexity of manipulations, skills and training of investigators
- Health status of the investigator

The Center for Disease Control (CDC) describes four biosafety levels assigned to biological materials in order to characterize their risk. For each level, there is a unique set of safety equipment, facility design features and practices. These are described in more detail here. The NIH guidelines also provide additional information and guidance for risk assessment of microorganisms and materials containing recombinant DNA.

- Biosafety Level 1 (BSL-1) is the appropriate containment level for Risk Group 1 microorganisms that are not known to consistently cause disease in healthy adults. Examples include *B. subtilis*, *S. cereversiae*, *Lactobacillus spp*., and non-pathogenic *E. coli*. Recombinant DNA activities at this level use non-pathogenic organisms as hosts for the expression of genes incorporated into bacterial plasmids or low risk viral vectors such as baculovirus or adeno-associated virus. For all BSL-1 work, standard microbiological practices and aseptic techniques hold; gloves, laboratory coats and eye protection are recommended.

Cooper Union only permits research at the first level of biosafety. One new recombinant DNA technology that is not specifically covered by the NIH guidelines is the Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-Cas system. These systems give researchers the ability to change an organism's DNA easily, rapidly and cheaply with higher throughput and broader applications, including alterations to the human genome. Cooper Union does not require Institutional Review Board (IRB) approval for any gene editing experiment that is exempt from the NIH guidelines. This includes *in vitro* experiments with prokaryotes and eukaryotic cell lines. Also exempt are experiments with invertebrates such as *D. melanogaster* or *C. elegans* (but excluding gene-drive experiments).

The following are considered to be basic precautions for all laboratories working with biohazardous materials:

- Food or beverages should never be stored in refrigerators or freezers used for research materials
- Cover work surfaces with Benchkote Asborbent liner or another absorbent material
- Decontaminate work surfaces at the end of procedures and immediately after a spill. Limit bench-top items to those in immediate use; cluttered areas are more likely than well-maintained spaces to be the sites of accidents that are harder to clean and disinfect
- When pipetting, expel liquids against the sidewall of the tube rather than against the tube bottom
- Whenever possible, personnel should replace glassware with plastic. Glass Pasteur pipettes are prone to breakage, which may lead to injury
- Never pipette by mouth. Use only mechanical pipetting devices and cotton-plugged pipettes.

Biological safety cabinets are the primary engineering control for the minimization of exposure to potentially infectious materials. These safety cabinets combine directional airflow with high efficiency particulate air (HEPA) filters to protect workers and the environment from aerosolized microorganisms. Most biological safety cabinets also protect the materials used within the cabinet from contamination. The most commonly purchased and utilized type of biological safety cabinet is a Class II, type A2 cabinet. Air enters the cabinet through the front, recirculates in the cabinet and is discharged from the cabinet into the laboratory through a HEPA filter that removes 99.97% of particles with an aerodynamic diameter of 0.3 microns. HEPA-filtered air is also supplied to the work area, and air stream meets incoming (ambient) air to create an "air curtain" that provides protection against environmental contamination. Clean air benches and laminar flow hoods are for handling sterile materials, or when a dust-free environment is needed for the protection of the material, rather than the researcher. Therefore, these should never be used for handling infectious materials. Biological safety cabinets should be located in low traffic areas within the laboratory, away from air-supply grilles and doorways as drafts may disrupt protective air flow. In addition, do not block the front air intake or the rear exhaust grille.

When using a biological safety cabinet, the following are recommended practices:

- Work 4-6 inches from the front of the cabinet, over the tray and not over the grille
- Avoid rapid arm movements that can disrupt airflow
- In order to minimize arm movements in and out of the safety cabinet, place all needed materials in the cabinet at the start of the experiment, arranging them so that "dirty" items do not pass over "clean" ones
- To prevent backflow of contaminated fluids into the HVAC system, use a vacuum line HEPA filter between the vacuum line and the aspiration flasks

- Allow the biological safety cabinet fan to run for five minutes prior to and at the completion of work; wipe the interior with 70% ethanol before and after work
- Remember to clean the work surface and the removed work surface to clean the area beneath. A schedule for regular removal of the tray and disinfection of the space beneath with 10% bleach followed by 70% ethanol is recommended.

Faculty, staff and students doing biological work must not use volatile or toxic chemicals inside a biological safety cabinet. The HEPA filters do not capture gases or vapors. Additionally the recirculating air will cause fumes to accumulate, which may cause lung injury or a fire hazard. Researchers must not use a Bunsen burner inside a biological safety cabinet. Open flames are not required to keep a microbe-free environment; rather, an open flame creates turbulence that disrupts the pattern of HEPA-filtered air being supplied to the work surface and may damage the cabinet, or cause a fire inside it.

If there is a spill inside a biological safety cabinet, please follow the procedure below:

- Keep the cabinet running
- Make sure you have the appropriate PPE: gloves, a laboratory coat and eye protection, at a minimum
- Cover the area twice the size of the spill with disinfectant-soaked paper towels or other absorbent material. Alternatively, surround the spill with dry disinfectant according to the label directions
- Allow a 20-minute contact period. If material has spilled into the catch basin beneath the work surface, add a volume of disinfectant equal to the quantity in the basin, wait 20 minutes, and absorb with paper towels or other absorbent material
- Wipe down the back and side walls of the cabinet with disinfectant
- After completion, allow the cabinet to run for an additional 10 minutes before resuming work.

For spills inside a centrifuge:

- Shut centrifuge off and do not open the lid for 20 minutes to allow aerosols to settle
- Make sure you have the appropriate PPE: gloves, a laboratory coat and eye protection, at a minimum
- Use a squeeze bottle to apply disinfectant to all contaminated surfaces within the chamber, taking care to minimize splashing
- Allow a 20-minute contact period and then complete the clean-up of the chamber
- Remove buckets and rotors to the nearest biological safety cabinet, and disinfect and clean as per the manufacturer’s instructions.

Fire Safety

The risk of fire is among the most common safety concerns in a workspace. Fire safety at Cooper Union encompasses best practices and safe behaviors in the conduct of research, design principles, emergency preparedness and compliance with applicable regulations.

Everyone at Cooper Union is expected to participate fully in applicable fire safety programs, including training, fire drills and other workspace-specific education. The campus wide safety office and the fire safety director are available to assist laboratories, shops and studios with managing their fire safety-related responsibilities.

The International Fire Code is designed to meet the need for uniform international standards of fire safety in buildings and dwellings. It has been adopted at the national and/or state level by 41 states, including New York. The OSHA General Industry Standards establish requirements for a variety of fire safety-related topics, including extinguishing systems, exit and egress routes, and other broad areas. These requirements are general in nature, with more specific rules being found under local regulations. The New York State Uniform Fire Prevention and Building Code prescribes minimum standards for both fire prevention and building construction. It is applicable to every municipality in the state, except New York City, which is permitted to retain its own Code. The New York City Fire Code is the final standard regulating all matters of fire safety applicable to laboratories in NYC. The NYC Fire Code also incorporates, by reference, partial requirements of more than 17 different compilations of industry standards and the rules of various states and federal agencies.

The Fire Department of the City of New York (FDNY) is the "authority having jurisdiction" over fire safety on New York City campuses. Under the NYC Fire Code, Cooper Union laboratories are considered "non-production chemical laboratories" and laboratory spaces must meet a set of minimum requirements to use and store chemicals. The NYC Fire Code requires laboratories to meet a variety of construction standards relating to ventilation, fire suppression and containment and the availability of emergency equipment such as fire extinguishers, eyewashes and overhead showers. The construction and operation of any non-production chemical laboratory in NYC requires a permit from the FDNY. A permit is issued by the Fire Commissioner after the laboratory has been inspected and approved as acceptable for handling, storing and using flammable or combustible liquids and/or flammable gases. Laboratories built or substantially renovated after July 2008 (for example in 41 Cooper Square) have limits assigned according to the square footage of the space. Please note that waste material is counted toward the laboratory's permitted flammable material limit, and laboratories should manage their inventories accordingly. Permits are valid for 12 months and the laboratory must be inspected by the FDNY prior to permit renewal. Permits are non-transferable.

This section of the manual will provide guidance on training, certification and instruction for safe practices to prevent fires.

The FDNY requires and issues Certificates of Fitness for different types of potentially hazardous occupations or activities. Cooper Union laboratories must be operated under the supervision of a holder of a C-14 Certificate of Fitness for Supervising Non-Production Chemical Laboratories (a C-14 Holder). The FDNY has delegated to C-14 holders the responsibility for overseeing all fire safety in a university laboratory. As a result, the C-14 holder is responsible for keeping up to date with regulatory mandates and, most importantly, at least one C-14 holder must be present in a laboratory **at all times when the laboratory is in operation**, including evenings, weekends and holidays. A C-14 holder is responsible for the safe storage, handling and use of all hazardous materials in the laboratory where the C-14 holder works, and must be trained in aspects of the laboratory's emergency plan, including:

- Procedures for activating a fire alarm
- Procedures for notifying and coordinating with all emergency response agencies

- Procedures for evacuating and accounting for personnel, including primary and secondary evacuation routes, as applicable
- Procedures for establishing requirements for rescue and medical duties for those personnel requiring or performing such duties
- Procedures and schedules for conducting regular emergency drills
- Procedures for shutting down and isolating equipment under emergency conditions, including the assignment of personnel responsible for maintaining critical functions or for shutting down processes
- Appointment and training of personnel to carry out assigned duties, including steps to be taken at the time of initial assignment, as responsibilities or response actions change, and at the time anticipated duties change
- Clearance of aisles designated as necessary for movements of personnel and emergency responders
- Maintenance of fire protection equipment
- Safe procedures for startup to be taken following the abatement of an emergency

Please note that if a laboratory has more than one C-14 holder, all holders must understand all the foregoing responsibilities. Graduate students, faculty or stuff who want to apply to be a C-14 holder should familiarize themselves with the FDNY Study Materials prior to taking the examination. Depending on level of education and experience, it is possible to be exempt from the written exam and still obtain a C-14 license through their Alternat Issuance Program (AIP). Microsoft Word - C-14 AIP Information 6-2014.doc (nyc.gov) Participation in the AIP requires a minimum of a bachelor's degree in a science-related discipline, plus two years of post-baccalaureate laboratory experience. Any experience gained prior to the receipt of a degree will not be accepted toward meeting the requirements of the AIP. Holders of M.D., Ph.D., M.S., M.A. and M.P.H. degrees automatically qualify without the need for prior laboratory experience. An individual who does not meet these requirements is required to have at least 60 college credits, of which 21 must be in science related coursework, to qualify to be a C-14 holder. Personnel who do not meet the minimum requirements are still eligible to obtain a C-14 Certificate of Fitness, but must complete the exam at FDNY headquarters at Metrotech Center in Brooklyn.

In accordance with FDNY requirements, any applicant for a C-14 Certificate of Fitness using the AIP must furnish the following documents:

- Photocopy of his/her diploma or transcript stating the degree earned and date conferred. Any diploma or transcript issued by a non-U.S. school or university must be translated into English, if applicable
- Completed FDNY C-14 Application (A-20)
- Completed Employee Affirmation and Employee Statement (not required for applicants holding a M.D., Ph.D., M.S., M.A. and M.P.H. degrees)
- Employer recommendation
- Student or employee visa (for applicants without a U.S. Social Security number)

A C-14 Certificate of Fitness is valid for three years. C-14 holders are entered into a database managed by the campus wide safety officer. Prior to expiration of a C-14 Certificate of Fitness, each C-14 holder will be contacted by email with a request to verify whether he/she wishes to renew or discontinue their certification. If a C-14 holder's certification has lapsed for more than a year, a new application must be submitted. In addition, individuals who obtained a C-14 Certificate of Fitness at another New York City institution must apply for new certification through Cooper Union. Certification is transferable, however, for individuals whose laboratory has relocated within the university.

Facilities Management and the campus wide safety coordinator serve as the primary liaison with the FDNY on all matters of laboratory fire safety. The FDNY carries out regular inspections of laboratories, and visits annually to renew permits. The FDNY inspector is escorted at all times by a Facilities Management staff member or the campus wide safety coordinator. Upon arrival at a laboratory during an inspection, the escort will engage with laboratory staff, announce the presence of the FDNY and explain the intention of the visit. As the inspection proceeds, input may be sought from the laboratory staff, and in general, the escort will serve as an intermediary between the inspector and laboratory personnel. In addition, if a non-compliant condition is observed, Facilities Management and the campus wide safety coordinator will work with the laboratory to enact corrective measures, whenever possible, ideally preventing a formal violation from being issued. If a FDNY laboratory inspection results in a violation, Facilities Management and the campus wide safety coordinator will support the laboratory in identifying and affecting the necessary corrective actions to remedy the non-compliant condition. The Fire Safety Director remains abreast of relevant code updates and changes, as well as trends, developments and best practices relating to fire safety in the laboratory. This information is then communicated to the rest of the facilities management team.

The FDNY inspections carry the weight of the law, and compliance with findings is mandatory. Failure to correct a finding may result in the issuance of a Summons, based on the severity of the noncompliance, and may ultimately require payment of monetary penalties or appearance at a New York City Environmental Control Board (ECB) hearing. In the event that a noncompliant condition is observed by the FDNY during an inspection, the FDNY inspector may issue a violation order (VO) to the university upon the first instance of the condition. Facilities Management and the campus wide safety office will visit the laboratory within two weeks of the issuance of the VO to verify correction of the violation. Once they confirm that the violation has been corrected, the FDNY Certificate of Correction portion of the VO will be completed and returned to the FDNY. If the same citation is identified during a follow-up inspection, the FDNY will issue a Summons which will necessitate an in-person visit to the ECB. The campus wide safety officer will accompany a laboratory representative to the hearing. The university will pay any fine resulting from the ECB decision. Lab managers, technicians or faculty who have recurrent violations in their laboratory will be contacted by the campus wide safety officer. If it is determined that this person has been grossly negligent or in willful violation of FDNY rules, the university will take appropriate action.

The following section describes some of the most common fire hazards in a laboratory setting. The presence of any of these hazards will most likely result in the finding of a violation by the FDNY. This section is not meant to be an all-inclusive discussion of laboratory fire safety. For more comprehensive guidance on laboratory fire safety, please review the C-14 Study Materials.

- Chemical Management – missing or illegible labels; untested or expired peroxide forming materials; the presence of expired chemicals; refrigerated storage of flammable materials; improper chemical segregation; storage of glass bottles on floors; permanent storage in chemical fume hoods; improper acid storage, including the use of incompatible cabinets and improper segregation

- Chemical Storage – FDNY regulations mandate the segregation of incompatible chemical materials based on general chemistry and the potential for incompatible combinations to react and increase fire risk. Materials deemed incompatible must be stored separately from one another at either 20 feet of distance, or by means of a non-combustible partition at least 18 inches above and to the sides of the stored materials. Steel cabinets and laboratory casework generally meet this requirement, but wood shelving and storage areas do not. Chemicals of the same hazard class may be stored in the same storage cabinet, but should be further divided by compatibility, as follows:
    - Acids and bases – materials with a low pH (acids) and those with a high pH (bases) must be physically segregated
    - Inorganic acids must be separated by secondary containment from organic acid (e.g. hydrochloric acid must be segregated from acetic acid)
    - Oxidizing acids (e.g. nitric acid) must be separated by secondary containment from all combustibles (e.g. acetic acid, organic solvents)
    - Oxidizers – materials that can accelerate combustion must be physically segregated from flammable materials. Examples of oxidizers include peroxides, perchlorates and permanganates, which must be segregated from solvents and other ignitable materials.
    - Toxic materials – chemical storage areas should be arranged as to avoid hazardous conditions such as moisture, excessive heat and light, where applicable. Examples of toxic materials include certain heavy metals, organophosphorus compounds, and other compounds with low LD50 values.
    - General storage considerations – chemicals should be managed to minimize the risk of breakage and spillage. Do not store chemicals on the edges of shelving. Do not store hazardous materials about “eye level” to minimize the risk of bodily contamination while retrieving and storing items. Check storage areas periodically for leaking, damaged or expired materials. Do not store full chemical containers on the floor, unless adequate secondary containment is utilized to prevent breakage.
- Cylinder Storage – unsecured cylinders; failure to label empty tanks; storage of flammable gas within 10 feet of laboratory exits; failure to utilize protective caps on cylinders that are not in use; storage of cylinders in corridors
- Facilities Management – the following hazards are subject to violation: the presence of excess clutter and fire load materials such as paper, cardboard and rubbish; hazardous material storage above eye level and within close proximity to ceilings and sprinklers; inadequate aisle and egress path width; inoperable self-closing doors; blocked emergency equipment; missing, discharged or damaged fire extinguishers
- Refrigerators and Freezers – the interior space of refrigerators and freezers does not provide air circulation and is therefore prone to the buildup and concentration of flammable vapors. Accordingly, the storage of flammable materials in “household” refrigerators (i.e. those without intrinsically safe internal electrical components) is strictly prohibited. Laboratories that require refrigerated storage space for flammable chemicals must use a specifically equipped flammable materials storage refrigerator designed to prevent the accidental ignition of chemical vapors inside the refrigerator. All “household” refrigerators must be labeled to indicate that storage of flammable materials is prohibited.

- Electrical Equipment – misuse of electrical equipment may pose a fire hazard under a variety of conditions, including:
    - Improper use of extension cords – only small, benchtop equipment may be connected to an extension cord when necessary to reach an electrical receptacle. Extension cords must be properly rated for the amperage of the equipment to which they are connected, and cords must never be "daisy chained" together; only one extension cord may be used for any piece of equipment. "Permanent" equipment such as refrigerators and freezers, incubators, centrifuges and other standalone items must be connected directly to a wall outlet. Regular cords, as well as extension cords, must never be run under carpets, floor mats or other combustible materials. Stretching cords across trafficked areas should be avoided, and where necessary, cords should be covered by protective conduit to reduce the hazard of slips, trips and falls.
    - Electrical outlets/receptacles – Facilities Management should be consulted to verify that a high-powered equipment with heavy voltage or amperage loads will not short or trip a laboratory's standard wall outlets. The need for specialized outlets, breakers, switches and other equipment to support high voltage electrical devices must be evaluated via Facilities Management or a qualified electrician.
    - Maintenance and certification – electrical cords and equipment should be inspected regularly for signs of wear, fatigue or other damage and should be taken out of service if compromised. All electrical equipment should be "rated" or certified by a recognized third-party testing service and should bear a mark or stamp from Underwriters Laboratories, FM Global, MET Laboratories or a similar organization.
- Curtains – the use of curtains for light control, lase beam management, acoustical dampening or any other purpose in any occupational setting is strictly regulated by the FDNY. All curtains installed in laboratories, studios and shops must be made of a material that is either inherently flame resistant, or that is chemically treated to achieve flame proofing. Curtains must be permanently tagged (i.e. sewn into the fabric) with a label to indicate compliance with the flame resistance or flame proofing standards of the National Fire Protection Association Code (NFPA Standard 701). In addition, the curtains must be certified by holder of a Certificate of Fitness for Supervision of Flame Retardant Treatment (C-15) issued by the FDNY.
- The use of torches for cutting, welding, brazing, grinding, soldering or similar operation in a laboratory, shop or studio requires specialized permission, including advanced Certificate of Fitness qualifications. Torch use is generally referred to as "hot work" and must not be performed without prior approval from Facilities Management. Hot work permits are issued by Facilities Management in accordance with applicable policies, and generally require up to 48 hours advance notice, as well as a fire safety director to be posted at the work site.

There are three common classes of fire extinguishers, categorized by the types of fires they are intended to fight:

- Class A – ordinary combustibles such as wood, paper and fabrics
- Class B – flammable liquids and gases, including solvents, paints and oils
- Class C – live electrical equipment
- Class D – sodium, potassium, magnesium, titanium, zirconium and other reactive metals. If any of these flammable metal powders are to be used in a laboratory, an appropriate dry powder

extinguishing agent such as graphite, limestone or sodium carbonate must be made available before work is started. DO NOT USE pressurized water, carbon dioxide, dry chemical or halon extinguishers on metal or organometallic fires. The use of these extinguishers may introduce substances that are very reactive with the burning metal that may either make the fire grow or trigger an explosion.

To simplify firefighting, laboratories studios and shops are equipped with multipurpose (ABC) dry chemical or CO_2 extinguishers that can be used on all types of fires other than those resulting from reactive flammable metals (which require specialized extinguishers). All fire extinguishers are inspected monthly and tested annually by a third-party vendor and are tagged to reflect their test dates. Extinguishers must be available within 50 feet of any point in the space; large rooms may therefore require additional units. Extinguishers must be readily available, must never be used as a door stop or coat hanger, and must be elevated from the floor, typically by a hook or integrated cabinet or casework fixture. C-14 holders or personnel who have received other equivalent instruction are qualified to use an extinguisher in the event of a fire. However, no individual is obligated to attempt to fight a fire with an extinguisher. The primary obligation of all individuals in the event of a fire is personal safety. Before attempting to extinguish a fire that breaks out in a laboratory, the fire must be judged as being controllable by the faculty or staff member. This depends on the judgment of the person making the decision and the factors involved (the size and intensity of the fire, the nature of the burning material, the proximity of other flammable or explosive materials, the availability of escape routes and proper fire-fighting equipment, and the safety of personnel in the area). Activation of a fire extinguisher for any reason must be immediately reported to Facilities Management so that it can be replaced. Should the nature and size of the fire make it controllable, use the appropriate available extinguisher and proceed with the methods described below. Should the fire be judged “uncontrollable”, follow the evacuation procedures described below.

The mnemonic devices RACE and PASS can help when there is a fire and how to use a fire extinguisher, respectively.

R – RESCUE/REMOVE anyone in immediate danger

A – Activate the Manual Fire ALARM or pull station

C – CONFINE the fire (close the door)

E – EXTINGUISH small controllable fires or EVACUATE

P – PULL the pin

A – AIM the nozzle at the base or leading edge of the fire

S – SQUEEZE the handle

S – SWEEP from side to side

FDNY, OSHA and other appliable standards require that all areas where corrosive materials are stored or used, or where solvents with the potential for injurious contamination to the eyes are used, to be equipped with an overhead emergency shower.

All members of the Cooper Union community, including any guests or visitors on campus, are required to participate in any and all fire drills that may take place. Fire drills are conducted twice each semester (in each building) in conjunction with the Fire Safety Director and the office of Facilities Management. Generally, drills include a signal to assemble at a designated point outside of the building, a brief review of the building's fire alarm system, egress and escape route(s), fire extinguishing techniques, and related topics. Alarms are tested regularly for maintenance and during unplanned repair scenarios. Unless otherwise communicated, all alarms should be treated as real, and personnel should evacuate as instructed during drills.

The following procedures should be used if a person is engulfed in flames:

- If a person's clothing is on fire, they must not be allowed to run, as this will fan the flames and cause a more serious burn. Remember: STOP, DROP and ROLL! Clothing fires must be extinguished immediately, before anything else is done, in order to minimize skin burns. Try not to use your hands as this may result in additional burns
- Roll the person on the floor if necessary
- Wrap them in a fire blanket, coat or whatever is available to smother the flames. Put the person under a shower or use an extinguisher
- After calling the appropriate emergency number(s), place clean, wet, ice-packed cloths on small burned areas. Wrap the person warmly to avoid shock, and secure medical assistance
- Never attempt to remove any clothing that has been burned. Soak any burned fabric with tepid water while awaiting emergency crews.

The following procedures should be followed in the event of a controllable fire:

- For all fires, the fire alarm must be transmitted immediately to ensure FDNY response
- The decision of whether to fight the fire oneself or to wait for fire-fighting help must be made according to the type and size of the fire, its location and the circumstances of the fire. A small fire in a container may be easily snuffed out by the placement of a nonflammable cover across the container opening. A small fire in an area free of other fuels can be extinguished with an appropriate available extinguisher after calling for help
- To extinguish a minor fire with an extinguisher, remember PASS!
- When extinguishing a burning solid, direct the extinguisher discharge at the base of the flame; in the case of burning liquids, direct it at the leading edge. Larger or rapidly growing fires are best left to the FDNY
- No personnel are required to attempt to extinguish a fire. One should only attempt this action if they are comfortable and confident in their ability to use a fire extinguisher
- Only one fire extinguisher may be used. If the extinguisher does not quench the flames, then all personnel are to leave the space immediately and report the attempt to the firefighters on scene.

In the case of an uncontrollable fire, please remember RACE:

- Leave the area of danger. DO NOT stay to fight a large fire

- Rescue anyone in immediate danger. On your way out, if it can be done safely, turn off equipment and move any explosive or flammable materials away from possible contact with hot surfaces or other sources of ignition. YOUR SAFE EXIT MUST BE GIVEN THE HIGHEST PRIORITY
- Where available, using the space's circuit breaker or Emergency Power Off switch (EPO) is often the quickest and most effective way to turn off all laboratory electrical equipment simultaneously. For this reason, the circuit breaker or EPO must always be readily accessible
- Transmit the fire alarm by pulling the alarm box near any point of egress (stairwell doors and exits) and notify personnel on the floor
- Leave by means of one of the predetermined evacuation routes for your area. For the Cooper Union community, this is most likely Peter Cooper Park (4th Avenue and 7th Street). In the case of a fire, people in 41 Cooper might also primarily assemble at St. Mark's Place between Cooper Square and 2nd Avenue, and, if necessary, assemble at East 5th Street between Bowery and 2nd Avenue.
- If possible, confine the fire by closing doors as you leave. Evacuate promptly and meet outside the building away from the entrance at a predetermined place. Conduct an attendance/person count of personnel and make sure all are accounted for. If not, notify the FDNY immediately.

The following procedures should be followed in the event of a fire caused by an explosion:

- Immediately transmit the building alarm by activating the manual pull station
- Alert and evacuate all personnel in the immediate area
- Close all doors leading to the affected area and secure area until the fire safety director or other personnel arrive to evaluate the situation. Do not attempt to re-enter the space
- When you call the appropriate emergency contact, be prepared to give the chemical name, location (building and room) and any other pertinent information. Have a person knowledgeable of the incident and laboratory available to provide information to emergency personnel and health care providers, including the SDS for any chemical involved in the fire.
- Attend to any persons contaminated by chemicals by removing contaminated clothing, and when feasible, flush the affected body area with water.

Li-ion fires may occur as a result of thermal runaway, shorting and other conditions that result in increased temperatures. Once the battery begins to vent flammable vapors, it may quite easily catch fire. Cooper Union personnel are not required to fight fires. Trained fire extinguisher users should attempt to extinguish early stage (incipient) fires only if it is possible to do so safely. Portable fire extinguishers that can be used include ABC (dry powder), carbon dioxide (CO_2) and foam (noncombustible). Smothering the fire with sand or sodium bicarbonate may also be effective. After extinguishing the fire water should be used to prevent the affected battery from reigniting and adjacent batteries from overheating.

Fire Evacuation Procedures

This section covers protocols and procedures in the event of a fire on campus.

Evacuation procedures for students in the Residence Hall:

If the building's fire alarm system is activated, all students and guests must leave the building immediately. All alarms should be treated as an emergency. Should the alarm bells and lights stop sounding and flashing, students should continue to evacuate. Upon evacuation, students may not use the elevators and should proceed toward the exits via the stairwells. Students should continue across the street after exiting and meet on the corner of Third Avenue and 9th Street, in front of the NYU Residence Hall. Students are not to re-enter the building until instructed to do so by a Cooper Union staff member. Failure to evacuate, or premature re-entry, will result in disciplinary action. Housing and Residential Staff may enter student rooms during fire alarms to ensure the safety of students. Individuals with disabilities are encouraged to contact the Office of Housing and Residential Life so that appropriate evacuation procedures can be determined.

- Any student who activates a false alarm or tampers with fire or safety equipment (such as fire extinguishers, speakers, smoke detector and sprinklers) is putting the safety of their fellow students in danger. This behavior is strictly prohibited
- Stoves and pilot lights should be monitored regularly for fire prevention purposes. Excess grease and flammable items on or near the stove are prohibited

If there is a fire in your room:

- Close (but do not lock) the door to the room where the fire is and leave the room
- Make sure EVERYONE in the room leaves with you
- Take your Cooper Union ID/keys
- Alert people on your floor by knocking on their doors on your way to the exit
- Use the nearest stairwell to exit the building. Pull the fire alarm manual station at the stair entrance to transmit an alarm signal
- DO NOT USE THE ELEVATOR
- Call 911 or campus Security once you reach a safe location. Do not assume the fire has been reported unless firefighters are on the scene
- Meet the members of your room and floor at your designated assembly area

If the fire is not in your room:

- Feel your room door and doorknob for heat. If they are not hot, open the door slightly and check hallway for smoke, heat or fire
- Exit your room and building following the instructions above for a fire in your room
- If you cannot leave your room or use the stairs, stay in your room
- Seal the doors to your room with wet towels or sheets, and seal air ducts or other openings where smoke may enter
- Call 911 or campus Security and tell them your address, floor, room number, the number of people in your room and where the fire is located (if you know)
- Open windows a few inches at top and bottom unless flames and smoke are coming in from below. DO NOT BREAK WINDOWS
- If possible, open a window and wave a towel/sheet to attract attention of firefighters
- If smoke conditions worsen before help arrives, get down on the floor and take short breaths through your nose and wait for help.

Evacuation Procedures for All Other Cooper Union Facilities:

All fire alarms are to be taken seriously. Evacuation of the facility is mandatory until the signal to re-enter has been given by the fire department or security. This applies to each member of the Cooper community. Staff should be aware of the emergency evacuation plans for their buildings. Assistance and direction should be given to all contractors, vendors, licensees, invitees, and visitors during the emergency.

For all Non-Student Housing Facilities:

- All stairwells in the building will be used for the evacuation of the building
- The elevators will NOT be used
- When the alarm is sounded, all occupants will use the exit nearest them, if that stairway is not usable, go to the next closest stairway
- Doors, and if possible, windows, should be closed as the last person leaves a room/area
- When the alarms sound, evacuate the building quickly (see campus guidelines below), but do not run. Do not panic!
- Persons who walk slowly or have difficulties with stairs should walk to the right
- Leave the vicinity of the building so that the fire fighters will have access to the building
- Proceed to your designated assembly area
- Never re-enter a building without the “all clear” from the Fire Department or Security

Evacuation of Disabled Persons

Pre-planning is of utmost importance to ensure that persons with physical disabilities are provided with the assistance and knowledge to evacuate a building. It is expected that a residence life staff member knows of your immobility, whether it is temporary or permanent. Prior to an emergency evacuation of any kind, it is advised that each person needing assistance should meet with the residence life staff and the safety and security department to discuss a plan of action.

- All persons should proceed toward the nearest safe emergency exit
- When a disabled person reaches a stairway they should request help from others in the area. If assistance is not immediately available, individuals should remain in the exit corridor and if possible call for help
- If the corridor becomes dangerous with fire and/or smoke, proceed into the stairway. Be aware of people exiting the building via the stairway. If the stairway should become unsafe, proceed to a safe area away from smoke and fire, closing doors behind you to isolate the smoke
- Call 911 or campus Security and give your name and location
- Elevators will not be used to evacuate disabled persons until the fire department determines that they are safe to use
- The Fire Department and/or Security should be informed immediately by any member of the Cooper Community as to the location of a disabled person
- In order to evacuate persons with disabilities as quickly as possible, it will be necessary for the Safety and Security Department to maintain a current list of disabled employees and students
- If a disabled person is visiting a department, it is that department’s responsibility to assign sufficient employees to assist in evacuation when necessary and to alert the Safety and Security Department on campus

3D Printer Safety

3D printer use has greatly expanded in recent years. 3D printers may generate microscopic particles (termed ultrafine) that when inhaled can enter the deep lung and penetrate into the systemic circulation, and volatile organic compounds that may also adversely affect health. Due to the emerging nature of these hazards, no agencies have established legally binding exposure limits, and the use of 3D printers is still minimally regulated. Some of the parameters that affect the safety of 3D printers, and that must be considered before purchasing 3D printing equipment, are the following:

- Adequate mechanical ventilation in the space where the equipment is to be used
- Type of printer and material used (e.g. use of metal powders can create a significant risk of explosion and toxic exposure if used without adequate controls in place)
- Type of enclosure to separate the printer from the user and reduce the dispersion of particles
- Other hazards, such as noise, heat and electrical hazards.

Laser Safety

Lasers are potentially hazardous unless used safely. Laser safety in an occupational setting is regulated by the U. S. Occupational Safety and Health Administration (OSHA). Although OSHA does not have a specific standard with lasers used for research, there are requirements for those used in construction. In either case, safe work practices are required under the General Duty Clause, which states that employers must give employees a workplace that is "free from recognized hazards that are likely to cause death or serious harm".

Laser radiation is emitted over a wide range of the electromagnetic spectrum from the ultraviolet region through the visible to the infrared region, but rarely in the microwave or other wavelength ranges. The range of commonly available lasers is from 180 nanometers (nm) to 10.6 micrometers. Laser light is monochromatic (contains one specific wavelength), is coherent (all the photons are in phase) and directional (the beam is very concentrated and strong). Lasers can be continuous wave (emitting a constant beam of laser energy), single pulsed (emitting a short, concentrated packet of energy) and repetitively pulsed.

Specular reflection is reflection of the bream off a flat surface such as a mirror, where the angle of reflection is equal to the angle of the incoming (or incident) light. This means that the overall beam quality is kept intact and the energy and wavelength remain the same, but the direction of the travel of the light is changed and reflected like a mirror. Specular reflection can be caused by inadvertent reflection off a shiny reflective instrument, with the same damage (for instance, to the eye) potentially produced by the reflected beam as well as the original beam.

Laser classes are defined based on the risks associated with them. Each laser class will require different safety measures for people who may be exposed to those lasers. Cooper Union has committed to follow the American National Standards Institute (ANSI) Z136.1 Laser Safety Standard that governs the safe use of lasers as representing the industry standard. The ANSI Laser Safety Standard describes the following classification of lasers based on their capacity to cause injury to human beings:

- Class 1 Lasers (Exempt Lasers) – these lasers are very low power (<1 microWatt) such that they can be considered incapable of causing injury. Also, class 1 laser systems can contain higher class lasers within them; if the laser is fully enclosed with adequate protection and therefore not a risk to users, it can be redefined as a class 1 laser. Some examples of class 1 lasers are laser printers, CD players and laboratory analytical equipment. No one would be expected to be injured by a class 1 laser, and therefore no safety requirements are imposed.

- Class 2 Lasers (Low Power Lasers). These are low power (<1 mW) lasers that always operate in the visible spectrum of wavelengths (400-700 nm). Some examples of class 2 lasers are laser pointers and range finding equipment. They are unlikely to cause injury because of the natural human blink response (eye closure in < 0.25 seconds). If viewed directly for a long time or with certain optical aids, they could be hazardous.
- Class 3R Lasers (Moderate Power Lasers). These lasers are continuous wave, intermediate power (< 5 mW) devices. Class 3R lasers have similar applications to class 2 lasers, with the most popular uses being laser pointers and laser scanners. A class 3R beam could be hazardous to the eye if viewed directly or with specular reflection. The possibility of permanent injury is small.
- Class 3B Lasers (Moderate Power Lasers). These lasers are intermediate power (5-500 mW) devices. Some examples of class 3B laser use include spectrometry, stereolithography and entertainment light shows. Direct viewing of the laser beam is hazardous to the eye.
- Class 4 Lasers (High Power Lasers). These lasers are high power (>500 mW) devices. Some examples of class 4 laser use are drilling, cutting, welding and micromachining. Class 4 lasers can be hazardous to the skin as well as the eye during direct specular reflection or exposure to diffuse reflection. Class 4 lasers can also be a fire or air contaminant hazard.

If directed, reflected or focused upon an object, laser light will be partially absorbed, raising the temperature of the surface and/or the interior of the object, potentially causing an alteration or deformation of the material. The direct beam, diffuse reflection or specular reflection from a laser can damage the eye and skin. Direct intrabeam exposures and specular reflections from Class 3B and Class 4 lasers can cause eye injury or blindness and skin burns, set fires and generate air contaminants. Diffuse reflections from class 4 lasers may also cause these hazards.

Corneal, lens or retinal burns are possible from acute exposure. The location and extent of injury depends on the wavelength and the energy absorption characteristics of the ocular media. Lasers cause biological damage by depositing heat energy in a small area, or by photochemical processes. IR, UV and visible laser radiation are capable of causing damage to the eye. Corneal opacities (cataracts) or retinal injury may be possible from chronic, as well as acute, exposures to excessive levels of either visible or invisible laser radiation. Eye hazards are easily controlled by using laser safety eyewear that is appropriate for the specific laser system. The ANSI Laser Safety Standard recommends maximum permissible exposure (MPE) limits on the basis of retinal damage thresholds and light concentration by the lens. The MPE values are based on several factors, including wavelength, visibility and exposure time. The MPE values are less than known hazard levels. However, exposures at MPE values may be uncomfortable to view. It is good practice to maintain exposure levels as far below the MPE values as practical. In choosing protective eyewear, careful consideration must be given to the operating parameters, MPE and wavelength. To minimize confusion, protective eyewear should be marked with its protective rating such as the effective wavelength and optical density. It is extremely important that laser users wear the appropriate laser safety eyewear correctly. For example, only eyewear such as goggles specifically designed to fit over prescription glasses may be worn with prescription glasses. In addition, prescription laser safety glasses are readily available from most vendors of laser safety eyewear. Please note that general safety glasses, contact lenses or sunglasses are not considered laser protective equipment.

Skin burns are possible from acute exposure to high levels of laser radiation, especially in the IR region. Erythema (skin reddening), skin cancer, and accelerated skin aging are possible effects in the UV wavelength range. Shielding the beam and reflections or covering the skin with opaque materials will help prevent skin effects. During alignment procedures and when working with class 4 lasers, a lab coat and nitrile gloves are highly recommended to be worn to prevent accidental exposure of the skin from direct or stray beams.

Non-beam hazards are important and their risk of occurrence increases with the power output of the laser. Air contaminants may be generated when certain class 3B and class 4 laser beams interact with matter. Whether contaminants are generated depends greatly upon the composition of the target material and the beam irradiance. When the target irradiance reaches approximately 107 W/cm^2, target materials such as plastics, composites, metals and tissues may liberate carcinogenic, toxic and noxious airborne contaminants. Combustible material such as paper and cardboard boxes can be ignited by the beam. Other potential fire hazards include electrical components and the flammability of class 4 laser beam enclosures. The risks of fire can be reduced by using only fire-resistant materials (e.g. inherently flame resistant, or IFR, curtains) to contain the beams of class 4 lasers. Beam blocks and beam stops are preferred to be used as primary barriers. The most common non-beam hazard is electrical in nature. Potentially lethal electrical hazards are particularly an issue in high-powered lasers. High voltage components such as power supplies and discharge capacitors may present an electrical hazard. High voltage equipment should be appropriately grounded.

All windows, doorways and portals of a laboratory where there is a laser in use should be covered or restricted to reduce transmitted laser beams. Additionally, the most salient features of laser safety are to be located in a clearly visible manner near each laser installation.

The following are general safety lab procedures that should be used with any class 3B and class 4 laser:

- Do not enter a room or area where a laser is being energized unless authorized to do so
- Do not work with or near a laser unless you have authorized to do so
- Remove any jewelry or other reflective objects to avoid inadvertent reflections
- Before energizing a laser, verify that prescribed safety devices for the unit are being properly employed. These may include opaque shielding, non-reflecting and/or fire-resistant surfaces, goggles and/or face shields, door interlocks and ventilation for toxic material
- Make sure that a pulsed laser unit cannot be energized inadvertently
- Use appropriate eyewear during beam alignment and laser operation
- Do not stare directly into the laser beam at any time, even with eye protection in place
- Control access to the laser facility. This is done by clearly designating those who have access to the facility
- For invisible laser beams, use viewing cards or lower class visible lasers to define the beam path during alignment
- Never leave the last unattended when it is in operation.

In addition to the above procedures, the following are controls that should be used with class 3B lasers:

- Permit only experienced personnel to operate the laser
- Enclose as much of the beam path as possible. Even a transparent closure will prevent an individual from placing his/her head in the beam path. Terminations should be used at the end of the useful paths of the direct beam and any secondary beams.
- Place shutters, polarizers and optical filters at the laser exit port to reduce the beam power to the minimal useful level
- Use a warning light or buzzer to indicate laser operation. This is especially needed if the beam is not visible (i.e. for infrared lasers)
- Operate the laser only in a restricted area such as a closed room without windows. A warning sign must be placed on the door
- Place the laser beam path well above or well below the eye level of any sitting or standing observers whenever possible. The laser should be mounted firmly to ensure that the beam travels only along its intended path
- Always use proper laser eye protection if a potential eye hazard exists for the direct beam, or a specular reflection
- Never directly view the beam or its specular reflection with optical instruments without sufficient protective filters
- Remove all unnecessary mirror-like surfaces from the vicinity of the laser beam path. Do not use reflective objects such as credit cards to check beam alignment. Note: the reflectivity of an object is a function of the wavelength of the laser beam
- Install a key switch to minimize tampering by unauthorized individuals.

In addition to the above procedures, the following are controls that should be used with class 4 lasers:

- Operate these lasers only within a localized enclosure, in a controlled workplace
- Require eye protection for all individuals working within the controlled area
- If the laser beam irradiance is sufficient to be a serious skin or fire hazard, use suitable shielding between the laser beam and any flammable surfaces
- Use backstops to diffusely reflecting fire resistant target materials where feasible. Safety enclosures should be used around micro-welding and drilling work pieces to contain hazardous reflections from the work area. Microscopic viewing systems used to study the work piece should ensure against hazardous levels of reflected laser radiation back through the optics.

Laser cutting equipment can also generate particulate matter and VOCs during operation. The main hazards associated with the use of laser cutters relates to fire safety considerations, and generation of toxic or otherwise hazardous combustion materials. Before using a laser cutter, be sure to understand the following safety rules:

- Never leave the laser running unattended. There should always be a person in the room watching the laser cutting while it is running
- Never run the laser cutter equipment without all the proper ventilation equipment
- Do not continue a cut if it is creating large flames. Fire is a huge risk to the laser and its ventilation system. Stop your cut immediately and switch to a lower power setting
- Know how to stop the machine and what to do in the case of a fire

- To turn off the laser, simply open the lid of the laser cutter. If you want to keep the lid closed, you can press and hold the pause button
- If there is a fire:
    - Open the lid to stop the laser
    - Put an acrylic sheet or fire blanket over the burning material to smother the fire (always keep a sheet of acrylic handy when cutting for this reason)
    - If you can reach it, push up the blast gate to stop air flow or power down the air compressor
    - Use a fire extinguisher
    - If you cannot put out the fire or feel that you are in danger, call campus security
- Check to make sure that the material you are using is in the allowed list of materials. If you aren't sure, don't cut it! Polycarbonate is hazardous to laser cut and is nearly identical in appearance to acrylic. Never cut PVC or chlorinated plastics, as they release chlorine gas when cut. Do not try to cut metal in the laser cutter
- Before cutting, ensure that there is no risk of the lens housing colling with any objects on the honeycomb table; adjust the focus accordingly
- The laser should be safe within the confines of the machine, and cut-off automatically when the lid is open (although this should not be relied upon). The top window is safe to look through during a job, but do not attempt to interfere with these windows or the laser in any way invent some way to look at the laser
- Check that the lens is clean before using the laser cutter
- As the laser cutter is used, vaporized material will collect on the lens. This material must be cleaned from the lens before further use or it will bond to the lens and cause the lens to crack
- Do not tamper with the laser cutter, or any interlocks. All side panels of the laser should always be closed and locked while the machine is plugged in
- Be familiar with the materials being cut. Ask the supervisor for clarification if needed.

Shop Safety

Cooper Union faculty, students and staff working in a machine shop or other area with machinery are required to receive machine-specific training. They must also be familiar with the operation and hazards of the hand and power tools that are found in these shops. The training covers types of hazards, general shop safety rules, ways to keep the shop clean, and the use of safe work practices and proper PPE for a given task. Refresher training is not required; however, machine-specific training frequency is determined by the department managing the shop. The objective of this training is to establish safe work practices for students, faculty and staff using machine and fabrication shops. Safety guidelines and training requirements are designed to minimize the risk of injury. The plan is intended to assure that individuals are provided training and information on how to protect themselves from shop and machine hazards, recommended maintenance is conducted and standard operating procedures are in place for equipment use, only people trained and knowledgeable in the use of a specific piece of equipment use that equipment, and all work is performed in accordance with applicable regulatory requirements.

Cooper Union's policies have been designed to comply with OSHA standard 29 CFR 1910 Subpart O and 29 CFP 1926 Subpart I. Also included are applicable parts of related OSHA standards relating to housekeeping, means of egress, and hand and power tools. Cooper Union's shop safety plan establishes the minimum requirements necessary to allow for the safe use of various shops located throughout the campus. Each shop shall post a copy of their access policy, hours of operation and shop safety rules and protocols. Questions concerning plan exceptions or clarifications must be directed to the campus wide safety coordinator for review and comment before initiating at the shop level. The campus wide safety officer will periodically conduct safety audits of all student used shops. The health and safety committee has final authority over all safety issues and may immediately halt any operations or procedures it considers unsafe at any time at its discretion.

Technicians, lab managers, and faculty members who supervise work spaces are responsible for enforcing the provisions of this plan, including the provision of required training and PPE for personnel using shop equipment (they are also responsible for enforcing its correct use). They also have the authority to halt unsafe operations at any time and to restrict access to a shop to any worker violating the provisions of this plan. Finally, shop supervisors must keep required machine guards in place and remove damaged equipment from service. Shops are typically not appropriate places for visitors. People that do not have any official reason to be in the shop should stay out unless specifically invited by a technician, manager or faculty member.

Any student using a workshop at Cooper Union is expected to follow all safety requirements as presented in this manual, and as posted within each individual shop. All students must receive required training prior to working with any power tools, woodworking equipment or other shop-related equipment. All students must properly use any required PPE while working in a shop, abide by any individual shop restrictions (i.e. hours of operation) and must only work in a shop when a supervisor is present. Any injury as well as any unsafe conditions or incidents must be reported to the shop supervisor.

Training must be provided before a student is allowed to work in a shop. General shop safety requirements and machine-specific training is required to be provided by the shop supervisor to anyone using a student machine shop. Be thoughtful and helpful toward other workers in the shop. Be sure that the work you are doing does not endanger someone else. Caution other workers if they are violating a safety rule.

Required training must include the following elements:

- Information on the hazards associated with a particular machine or piece of equipment, including a knowledge base of how a piece of machinery functions so the user can anticipate risks and hazards while working
- The necessary safety precautions that must be followed when working with a particular machine or piece of equipment including the purpose and function of any guards that are in place
- The types and limitations of any PPE that is required to be used in the shop
- Limitations of the particular equipment
- Procedures to be followed in the event of a machine malfunction or damage to the equipment
- Procedures to be followed in the event of an emergency and/or injury
- Equipment and general shop maintenance and cleaning procedures
- Use of approved materials on tools. Never use reclaimed lumber or materials with metal hardware on tools.

All training must be documented in writing with the records maintained by the shop supervisor.

When the shop is open for instruction, technicians or lab managers are always on duty. During official shop hours, these supervisors are responsible for the safe operation of the space. When the shops are closed, all electrical machinery is to be turned off and disabled.

Work procedures and shop practices described are effective methods of performing given operations. Use special tools and equipment as recommended. Carefully follow all safety warnings and cautions – but note that these warnings are not exhaustive. Proceed with care and under proper supervision to minimize the risk of personal injury or injury to others. Never use any tools or machinery without first receiving training.

It is important to select the proper size and type of tool for your work. An expert never uses a tool unless it is sharp and in good condition. Inform your supervisor if tools are broken, have loose handles, or need adjustments. When using a tool, hold it in the correct position. Most edged tools should be held in both hands with the cutting motion away from yourself and other workers. Be careful when using your hand or fingers as a guide to start a cut. Test the sharpness of a tool with a strip of paper or a scrap of wood – DO NOT USE YOUR FINGERS! Always keep your hands a safe distance from cutters and blades. Defects in wood can also be dangerous. Check the wood carefully for knots, splits and other defects.

Modern power tools can save large amounts of time. Learning how to use them safely will be an important part of your experience in the shop. The ability to use power tools and equipment will depend on an individual's abilities, as well as policies established by the technician, manager or faculty member. Before operating any power tool or machine you must become thoroughly familiar with the way it works and the correct procedures to follow in its use. As you learn to use a machine the correct way, you will also be learning to use it the safe way. The supervisor is responsible for providing clear demonstrations and directions, while the worker is responsible for understanding and following the general safety rules that apply to power machine operation, as well as the specific safety rules that apply to each machine.

The following are general power safety guidelines:

- Wear appropriate clothing. Remove coats or jackets, and roll up loose sleeves
- You must be wide awake and alert. Never operate a machine when you are tired or ill
- Think though the operation before performing it. Know what you are going to do, and what the machine will do
- Always be sure you have approval from an instructor, technician or supervisor to operate a machine.
- Machines should not be used for trivial operations, especially on small pieces of stock. Do not play with machines
- When you are operating the machine, you are the only one to control it. Start and stop the machine yourself. If someone is helping you, be sure they understand that they are expected to know what to do and how to do it
- Make all the necessary adjustments before turning on the machine. Some adjustments on certain machines will require the instructor's approval
- Never remove or adjust a safety guard without the instructor's permission
- Use approved push sticks, push blocks, feather boards, and other safety devices. Some operations may require the use of a special jig or fixture

- Keep the machine tables and working surfaces clear of tools, stock and project materials. Also keep the floor free of scraps and excessive litter and clutter
- Do not allow your attention to be distracted while operating a machine. Also, be certain that you do not distract the attention of other machine operators
- Allow the machine to reach its full operating speed before starting to feed the work
- Never leave a machine running while unattended
- Feed the work carefully and only as fast as the machine will easily cut
- Maintain the margin of safety specified for the machine – this is the minimum distance your hands should ever come to the cutting tool while in operation
- If a machine is dull, out of alignment, or not working properly, shut the power off immediately, and inform the supervisor
- When you have completed an operation on a machine, shut off the power. Wait until it stops before leaving the machine or setting up another cut
- Stay clear of machines being operated by other workers. See that other people are out of the way when you are operating a machine
- Do not crowd around or wait in line to use a machine. Ask the present operator to inform you at your work station when they are finished. Common standards of courtesy may slow you down, but they will make the shop a safer and more pleasant place to work.

Never work in or around water with power tools. Water increases the chances of severe electrical shock. Most power tool accidents can be avoided. Roughly 80% of accidents are caused by workers without the right safety attitude! Never work alone. At least two people must be present when power tools are in use. No horseplay is allowed. Never work while impaired. These workers do not take safety seriously, and instead put everyone in danger.

Keep your project materials carefully organized on your bench with tools located near the center. Do not pile tools on top of each other. Never allow edged or pointed tools to extend out over the edge of the bench. Close your vise when it is not in use and see that the handle is turned down. Keep drawers and cabinet doors closed. Keep sharp-edged and pointed tools turned down. Do not swing or raise your arms over your head while carrying tools. Carry only a few tools at one time, unless they are in a special holder. Do not carry sharp tools in the pockets of your clothes. Whenever possible, mount your work in a vise, clamp or special holder. This is especially important when using chisels, gouges or portable electric tools. Keep your hands clean and free of oil or grease. You will do better and safer work, and the tools (and your project) will stay in good condition. Keep the machines clean! Remove all tools, lumber and unnecessary materials while working. Never use a tool bed as a worktable. Objects left on the machine can vibrate into revolving cutters. They can then be thrown from the machine with great force. Never clean a machine while it is running. Always use the dust collection system, if one is available. Maintain good housekeeping by regularly cleaning work areas.

Make sure all safety guards are in place. Never remove a safety guard without the permission of a technician, manager or faculty members. The supervisor must check each setup before work is begun. The technician, manager or faculty member also must approve the work that is done in a particular shop. They can decide if the work can and should be done, and will be able to suggest the best, easiest and safest way to do it. As you learn to operate a machine, you will gain confidence – but do not become too confident. Overconfidence leads to carelessness, and carelessness causes accidents. This does not mean you should be afraid of machinery; however a safe attitude is one of respect for what machines can do. Do not rush through your work – a steady, unhurried pace is safest and produces the best work. Allow for machinery to come to full speed before engaging any materials with the tool. Never start a piece of machinery with materials engaged.

Before you plug in a machine, make sure the switch is in the "off" position. You do not want the machine to start unexpectedly! If you use an extension cord, use the correct wire size. This is determined by the length of cord and size of motor. Using a wire size that is too small will cause the tool to overheat. Keep all power cords away from blades and cutters while you work. Make sure the power tool is grounded – one with a double-insulated case need not be grounded. If you are unsure about this, check with your supervisor. If anything unusual happens, turn off the machine immediately. If the machine does not sound right, turn it off immediately. As soon as it stops completely, check with your supervisor. In the event that you need to switch off a tool during an operation where the tool is still in contact with a piece of material, never let go of the material – hold it still until the tool has come to a complete stop.

Always wear proper eye protection when working in a shop - safety glasses or a face shield when performing any operation that may endanger your eyes. Be sure you have enough good light to see what you are doing without straining your eyes. Always keep your eyes on the cutting action, and concentrate on what you are doing at all times. Stand in a comfortable, balanced position when working with power tools. Both feet should be firmly on the floor. Try to be relaxed and comfortable – if you are unsure about a particular piece of equipment, consult a supervisor.

To operate a machine safely, you must know more than just how to turn it on and off - you must also know how to perform basic operations, how to make simple adjustments, and the limits of the equipment. Always keep the machine operating at a safe, steady speed. Never use the machine for a job the machine was not designed to do.

The follow safety rules specifically apply for band saws:

- Wheel guard doors must be closed, and the blade properly adjusted, before turning on the machine
- Adjust the upper guide assembly so it is ¼ inch above the work
- Allow the saw to reach full speed before feeding the work
- Never turn the machine on with stock pressed against the blade
- Never reach close to the blade or under the table while the machine is running
- The stock must be held flat and firmly against the table
- Do not remove stock or scraps until the blade has stopped
- Make multiple angled cuts to achieve a cut with a tight radius
- Feed the saw only as fast as the teeth can easily remove the wood
- Maintain a 2 inch margin of safety
- Plan saw cuts to avoid backing out of curves whenever possible
- Make turns carefully and do not cut radii so small that the blade is twisted
- Use a push stick to finish a re-sawing or ripping cut
- Stop the machine before backing out of a long, curved cut
- Round stock should not be cut unless mounted securely in a jig or hand screw

- If you hear a clicking noise, turn off the machine at once. This indicates a crack in the blade. If the blade breaks, shut off the power and move away from the machine until it stops
- Turn off the machine as soon as you have finished your work. If the machine has a brake, apply it smoothly. Do not leave the machine until it has stopped running.

The follow safety rules specifically apply for jigsaws:

- Be certain the blade is properly installed. It should be in a vertical position with the teeth pointing down
- Roll the machine over by hand to see if there is clearance for the blade, and if the tension sleeve has been properly set
- Make multiple angled cuts to achieve a cut with a tight radius
- Check the belt guard to see that it is closed and tight
- Keep the hold-down adjusted so the work will not be raised off the table
- When the saw is running, do not permit your fingers to get directly in line with the blade. The work can usually be done on either side of the cutting line.

The follow safety rules specifically apply for portable circular saws:

- Stock must be supported in such a way that the kerf will not close and bind the blade during the cut or at the end of the cut
- Thin materials should be supported on benches. Small pieces should be clamped in a vise or onto a benchtop or sawhorse
- Be careful not to cut into the bench, sawhorse or other supporting devices
- Adjust the depth of cut to the thickness of the stock, and add about 1/8 inch
- Check the base and angle adjustment to be sure they are tight. Plug in the cord to a grounded outlet and be sure it will not become fouled in the work
- Always place the saw base on the stock, with the blade clear, before turning on the switch
- During the cut, stand to one side of the cutting line
- Large saws will have two handles. Keep both hands on them during the cutting operation. Small saws should also be guided with both hands when possible
- Always unplug the machine to change blades or make major adjustments
- Always use a sharp blade with plenty of set

The follow safety rules specifically apply for radial arm saws:

- Stock must be held firmly on the table and against the fence for all crosscutting operations. The ends of long boards must be supported level with the table
- Before turning on the motor be certain that all clamps and locking devices are tight and the depth of cut is correct
- Keep the guard and anti-kickback device in position. Do not remove them without an instructor's permission
- Always return the saw to the rear of the table after completing a crosscut or miter cut. Never remove stock from the table until the saw has been returned
- Maintain a 6 inch margin of safety
- Shut off the motor and wait for the blade to stop before making any adjustments

- Be sure the blade is stopped before you leave the machine
- Keep the table clean and free of wood scraps and excessive amounts of sawdust
- Secure approval from your instructor before making ripping cuts or other special setups. When ripping stock it must be flat and have one straight edge to move along the fence
- When ripping, always feed stock into the blade so that the bottom teeth are turning toward you. This will be the side opposite the anti-kickback fingers.

The follow safety rules specifically apply for saber saws:

- Make certain the saw is properly grounded through the electrical cord
- Select the correct blade for your work and be sure it is properly mounted
- Disconnect the saw to change blades or make adjustments
- Place the base of the saw firmly on the stock before starting the cut
- Turn on the motor before the blade contacts the work
- Do not attempt to cut curves so sharp that the blade will be twisted. Follow procedures described above for band saw operation
- Make certain the work is well supported. Do not cut into sawhorses or other supports.

The follow safety rules specifically apply for scroll saws:

- Know and follow the general safety rules for operating power tools
- Make all setups and adjustments with the power off
- Use the correct blade for the stock (thickness) and curve (sharpness) being cut
- Never try to turn a small radius with a wide blade. The radius should not be more than three times the blade width
- Clamp the blade securely in both chucks with the teeth pointing down
- Adjust the guides so they properly support the blade
- Adjust the hold down so that it applies light pressure to the stock
- Rotate the motor by hand to check that all adjustments have been made properly
- Plan cuts to avoid backing out of curves
- Do not force the work into the blade. This can cause the blade to bend the break
- Keep your fingers out of line with the saw.

The follow safety rules specifically apply for sliding miter saws:

- Know and follow the general safety rules for operating power tools
- Make all setups and adjustments with the power off
- Never reach across the path of the blade. When the machine is running, always keep your hand at least 6 inches from the blade
- Keep the safety guard in position at all times
- Wait until the blade is running full speed to start a cut
- Never stand in line with the blade. If you push the blade with your right hand, stand to the left. If you push the blade with your left hand, stand to the right
- Use one hand to push the saw through the stock. Use the other hand to hold the stock against the fence. Keep both hands away from the cutting line
- Cut only one piece of wood at a time

- Feed the blade slowly

The follow safety rules specifically apply for table saws:

- Be certain the blade is sharp and the right one for your work
- The saw is equipped with a guard and a splitter. Be sure to use them
- Set the blade so it extends about ¼ inch above the stock to be cut
- Stand to one side of the operating blade and do not reach across it
- Let the blade get to full speed before cutting
- Never reach under the table to tighten locks, remove scrap or make adjustments while the saw is running
- Never reach over or across the blade while the saw is running, even with the upper guard in place
- Maintain a 4 inch margin of safety by clamping a small piece of stock to a larger piece to cut safely
- Stock should be surfaced, with at least one edge jointed before being cut on the saw
- The position of the stock must be controlled either by the fence or the miter gauge. Never cut stock free hand!
- Use only new stock that is free of knots, splits and warp
- Stop the saw before making adjustments to the fence or blade
- Do not let small scrap cuttings accumulate around the saw blade. Use a push stick to move them away
- Re-sawing and other special setups must be inspected by the supervisor before power is turned on
- Do not rip large sheets of plywood or like materials alone. At least one additional helper/aid must be used for these operations
- The dado or any special blades should be removed from the saw after use
- Workers helping to “tail-off” the saw should not push or pull on the stock but only support it. The operator must control the feed and direction of the cut
- As you complete your work, turn off the machine and remain until the blade has stopped. Clear the saw table and place waste cuttings in the scrap box.

The follow safety rules specifically apply for portable electric drills:

- Select the correct drill or bit. Mount it securely to the full depth of the chuck
- Either clamp a scrap piece under work to prevent splintering the underside, or drill from both sides
- Stock to be drilled must be held in a stationary position so it cannot be moved during the operation
- Connect the drill to a properly grounded outlet
- Turn on the switch for a moment to see if the bit is properly centered and running true
- With the switch off, place the point of the bit in the punched layout hole
- Hold the drill firmly in one or both hands and at the correct drilling angle
- Turn on the switch and feed the drill into the work. The pressure required will vary with the size of the drill and the kind of wood

- During the operation, keep the drill aligned with the direction of the hole
- When drilling deep holes, especially with a twist drill, withdraw the drill several times to clear the shavings
- Follow the same precautions and procedures as when drilling holes with the drill press (see below).

The follow safety rules specifically apply for drill presses:

- Check the speed setting to see that it is correct for your work. Holes over ½ inch should be bored at the lowest speed
- Use only an approved type of bit. Bits with feed screws or those with excessive length should not be used
- Mount the bit securely to the full depth of the chuck and in the center
- Remove the key immediately
- Position the table and adjust the feed stroke so there is no chance of the bit hitting the table
- The work should be placed on a wood pad when then the holes are drilled all the way through
- Work that will be held by hand should be center punched
- Small or irregular shaped pieces must be clamped to the table or held in some special fixture
- Feed the bit smoothly into the work. When the hold is deep, withdraw it frequently to clear the shavings and cool the bit
- When using special clamping setups, a hold saw or fly cutter, have your instructor inspect it before turning it on
- Always have your instructor check setups for routing and shaping.

The follow safety rules specifically apply for routers:

- Know and follow the general safety rules for operating power tools
- Disconnect the power before changing router bits
- Clamp router bits securely in the chuck. At least ½ inch (12 mm) of the shank should be inserted
- Make sure the router switch is in the off position before connecting the power
- Do not make any router cuts unless the stock is securely clamped. The router can throw loose stock with great force
- Before you start cutting, make sure nothing is in the router's path
- Hold the router tightly when starting the motor
- Always feed the router against the rotation of the bit. If you feed with the rotation the bit can dig into the stock. This can cause the router to kick back or throw the stock
- After finishing a cut, wait for the router to completely stop, then lay the router down. The bit should point away from you.

The follow safety rules specifically apply for jointers:

- Be sure you have the approval of a supervisor to operate the machine
- Before turning on the machine, make adjustments for depth of cut and position of fence
- Do not adjust out-feed tables or remove guard without the instructor's approval
- The maximum cut for jointing an edge is 1/8 inch; for a flat surface, 1/16 inch
- Stock must be at least 3/8 inch thick, unless a special feather board is used

- Feed the work so the knives will cut with the grain. Use only new stock that is free of knots, splits and checks
- Keep your hands away from the cutter-head even though the guard is in position. Maintain at least a 4 inch margin of safety
- Use a push block when planing a flat surface. Do not plane end grain unless the board is at least 12 inches wide
- The jointer knives must be sharp. Dull knives will vibrate the stock and may cause a kickback.

The follow safety rules specifically apply for planers:

- Be sure you have the approval of a supervisor to operate the machine
- Adjust the machine to the correct thickness of cut before turning on the power
- Stock should be at least 12 inches long, or several inches longer than the distance between the center of the feed rolls
- Surface only new lumber that is free of loose knots and serious defects
- Plane with the grain, or at a slight angle with the grain. Never attempt to plane cross grain
- Stand to one side of the work being fed through the machine
- Do not look into the throat of the planer while it is running
- Do not feed stock of different thicknesses side by side through the machine, unless it is equipped with a sectional in-feed roll.
- Handle and hold the stock only in an area beyond the ends of the table
- If the machine is not working properly, shut off the power at once and notify the supervisor.

The follow safety rules specifically apply for shapers:

- Whenever possible, install the cutter so the bottom of the stock is shaped. In this way the stock will cover most of the cutter and act as a guard
- Make sure the cutter is locked securely to the spindle
- Always position the left fence so that it will support the work that has passed the cutters
- Adjust the spindle for correct height and then lock in position. Rotate the spindle by hand to make sure it clears all guards, fences, etc
- Check the direction of rotation by snapping the switch on and off; watch as the cutters come to rest. Always feed against the cutting edge – that is, feed the work in to the cutters in the direction opposite to the cutter rotation!
- Some shapers have a reversing switch so that the spindle can be rotated either clockwise or counterclockwise
- Examine the stock carefully before cutting to make sure it is free of defects
- Never cut through a loose knot or stock that is cracked or split
- Hold the stock down and against the fence with hands on top of the material, yet out of range of the cutters
- Use all guards, jigs and clamping devices whenever possible
- Always use a depth collar when shaping irregular work. Put a guide pin in the table to start the cutting
- Do not set spring hold-down clips too tightly against the work. Use just enough tension to hold the work against the fence.

The follow safety rules specifically apply for surfacers:

- Know and follow the general safety rules for operating power tools
- Remove all loose knows from the stock before surfacing
- Do not surface stock shorter than the distance between the centers of the in-feed and out-feed rolls. This is usually about 12 inches, or more
- Never stand directly behind a board being surfaced. The stock could kick back and cause an injury
- Never look into the surfacer while the cutter-head is rotating
- Make sure one face is flat before you surface a board. Place the flat face against the table
- If a board does not feed through the surfacer, turn off the power. Wait until the cutter-head stops completely. Then lower the table and remove the board
- Keep your hands away from the areas around the feed rolls. You could easily pinch your fingers in these areas
- Feed the stock with the grain. Otherwise, the stock can chip and break. The pieces can then be thrown from the surfacer
- Wait for the blade to come to a complete stop before releasing the arm.

The follow safety rules specifically apply for sanding machines:

- Be certain the belt or disc is correctly mounted. The belt must track in the center of the drums and platen. Do not operate the disc sander if the abrasive paper is loose
- Check the guards and table adjustments to see that they are in the correct position and locked securely in place
- Use the table, fence and other guides to control the position of the work, whenever possible
- Never sand without a table supporting the stock
- Small or irregular-shaped pieces should be held in a hand clamp, or a special jig or fixture
- When sanding the end gr ain of narrow pieces on the belt sander, always support the work against the table
- Sand only on the side of the disc sander that is moving toward the table
- Move work along this surface so it will not burn
- Always use a pad or push block when sanding thin pieces on the belt sander
- Do not use power sanders to form and shape parts when the operations could be better performed on other machines
- Sand only clean new wood. Do not sand work that has excess glue or finish on the surface. These materials will load and foul the abrasive.

The follow safety rules specifically apply for lathes:

- Before starting the machine, be sure that the springle work has the cup center properly embedded, the tailstock and tool rest are securely clamped, and there is proper clearance for the rotating stock
- Before starting the machine for faceplate work, check to see that the faceplate is tight against the spindle shoulder and the tool support has proper clearance
- Wear goggles or a face shield to protect your eyes, especially when roughing out work. The lathe should have a guard

- Select turning speed carefully. Large diameters must be turned at the lowest speed. Always use the lowest speed to rough out work
- Wood with knots and splits should not be turned. Glued-up stock should cure the proper amount of time – at least 24 hours
- Keep the tool rest close to the work
- Remove the tool rest for sanding and polishing operations
- Use a scraping cut for all faceplate work
- Replace both the spur and cup centers when they are not in use
- When you stop the lathe to check your work, also check and lubricate the cup center
- Keep the lathe tools sharp; hold them firmly and in the proper position

The follow safety rules specifically apply for wood lathes:

- Never wear loose clothing or a tie
- Wear goggles or a face shield
- Check the wood to make sure it has no defects that would cause it to break when turning
- Check all glue joints before mounting the stock. A weak joint may come apart when revolving at high speeds. Make sure glued-up stock is completely dry before turning
- Fasten stock securely between centers. Make sure the tailstock is locked before turning on the power
- Adjust the tool rest as close to the stock as possible. Then revolve the stock by hand to make sure it clears the rest
- Always stop the lathe before making any adjustments such as changing the position of the tool rest
- Run all stock at the slowest speed until it is rounded
- Hold turning tools firmly in both hands
- Keep the tool rest as close to the work as possible. At intervals, stop the lathe and readjust
- Make sure the stock is firmly fastened to the faceplate before turning
- Remove the tool rest when sanding and polishing. If you don't, your fingers may get caught between the tool rest and the stock.

The follow safety rules specifically apply for finishing materials:

- Wear safety glasses when applying finishing materials
- Wear rubber gloves, goggles, and a rubber apron when applying bleaches and acids
- Thinners and reducers such as naphtha, benzene, lacquer and enamel should be applied in a well-ventilated room. Fumes from these substances can have a toxic effect
- Store all chemicals and soiled rags in proper safe containers. Many chemicals and rags are highly flammable
- Spraying should be performed in a well-ventilated booth or outside to reduce toxic fumes
- Do not smoke while sanding or applying a finish. Not only does dust or vapor mixed with smoke create a hazard to your health, but it may start a fire
- Wash your hands well after applying a finish in order to remove any toxic materials that you have handled

- Know where the sink, shower and eye wash stations are located in the event you are burned by a finishing material
- Know the location of, and proper operation of, an approved fire extinguisher nearby.

The following is a summary of fire protection do's and don'ts. For more information, please refer to the section on Fire Safety.

- (Re)familiarize yourself with the location of all fire alarms and fire extinguishers
- Many finishing materials, thinners, etc are highly flammable – others are toxic. Because of this, it is important that these materials be used only in approved areas. Prior to use, make sure you are in a project space that allows application of such materials
- Close cans of finishing materials and thinners immediately after use
- Use flammable liquids in very small quantities. Be sure the container is labeled
- Consult workers near you to determine whether any potential crossover hazards might be present
- Dispose of oily rags and other combustible materials immediately, or store them in an approved container.

The floor in a shop should be clear of scrap blocks and excessive litter/clutter. Keep projects, sawhorses and other equipment and materials you are using out of places where people routinely walk. Immediately wipe up any liquids spilled on the floor. Periodically sweep up sawdust as you work to prevent slippery conditions on floors. Floor areas must be kept free of debris and other hazards that may result in slips, trips or falls.

Proper attire is also required to work in a shop. Remove coats or jackets, and secure or remove loose clothing that can potentially get caught in power tools or other shop appliances. It is advisable to wear a shop apron that is snugly tied. Wear closed-toe shoes. Keep long, loose hair restrained and securely tied back to prevent machine and tool entanglement.

Store and stack your project work carefully in assigned areas. If the storage is overhead, be suer the material will not fall off. Straighten the lumber rack when you remove a board. Do not leave narrow strips protruding from the end of a storage rack, especially at or near eye level.

All injuries, regardless of severity, must be reported using an incident report form.

Ladder Safety

Managers and supervisors are responsible for implementing, maintaining and ensuring that all personnel are trained in proper ladder safety. All ladders shall be inspected prior to each use; Facilities Management will inspect all ladders every six months.

The following OSHA rules apply to all ladders:

- Maintain ladders free of oil, grease and other slipping hazards
- Do not load ladders beyond their maximum intended load, nor beyond their manufacturer's rated capacity
- Use ladders only for their designed purpose
- Use ladders only on stable and level surfaces unless secured to prevent accidental movement

- Do not use ladders on slippery surfaces unless secured or provided with slip-resistant feet to prevent accidental movement. Do not use slip-resistant feet as a substitute for exercising care when placing, lashing or holding a ladder upon slippery surfaces
- Secure ladders placed in areas such as passageways and doorways, or where they can be displaced by workplace activities or traffic to prevent accidental movement. As an alternative, a barricade can be used to keep traffic or activity away from the ladder
- Keep areas clear around the top and bottom of ladders
- Do not move, shift or extend ladders while in use
- Use ladders equipped with nonconductive side rails if the worker or the ladder could contact exposed energized electrical equipment
- Face the ladder when moving up or down
- Use at least one hand to grasp the ladder when climbing
- Do not carry objects or loads that could cause loss of balance and falling

The following OSHA rules apply to portable ladders:

- Read and follow all labels/markings on the ladder
- Avoid electrical hazards! Look for overhead power lines before handling a ladder
- Avoid using a metal ladder near power lines or exposed energized electrical equipment
- Always inspect a ladder prior to using it. If the ladder is damaged, it must be removed from service and tagged until repaired or discarded
- Always maintain a 3-point (two hands and a foot, or two feet and a hand) contact on the ladder when climbing. Keep your body near the middle of the step and always face the ladder while climbing
- Only use ladders and appropriate accessories (ladder levelers, jacks or hooks) for their designed purposes
- Ladders must be free of any slippery material on the rungs, steps or feet
- Do not use a self-supporting ladder (e.g. step ladder) as a single ladder or in a partially closed position
- Do not use the top step/rung of a ladder as a step/rung unless it was designed for that purpose
- Use a ladder only on a stable and level surface, unless it has been secured (top or bottom) to prevent displacement
- Do not place a ladder on boxes, barrels or other unstable bases to obtain additional height
- Do not move or shift a ladder while a person or equipment is on the ladder
- An extension or straight ladder used to access an elevated surface must extend at least 3 feet above the point of support
- Do not stand on the three top rungs of a straight, single or extension ladder
- The proper angle for setting up a ladder is to place its base a quarter of the working length from the wall or other vertical surface
- A ladder placed in any location where it can be displaced by other work activities must be secured to prevent displacement or a barricade must be erected to keep traffic away from the ladder
- Be sure that all locks on an extension ladder are properly engaged

- Do not exceed the maximum load rating of a ladder. Be aware of the ladder's load rating and of the weight it is supporting, including the weight of any tools or equipment.

Personnel who properly use approved, portable, extension or step ladders and properly constructed fixed ladders less than 20 feet in height will not need additional fall protection unless transferring to another location or surface where a potential fall exposure exists.

If the total length of the climb on a fixed ladder equals or exceeds 24 feet, the ladder must be equipped with ladder safety devices, self-retracting lifelines and rest platforms at intervals not to exceed 150 feet, or a cage or well and multiple ladder sections with each ladder section not to exceed 50 feet in length. These ladder sections must be offset from adjacent sections and landing platforms must be provided at maximum intervals of 50 feet. In addition, fixed ladders must meet the following requirements:

- Fixed ladders must be able to support at least two loads of 250 lbs each, concentrated between any two consecutive attachments. Fixed ladders must also support added anticipated loads caused by ice buildup, winds, rigging and impact loads resulting from using ladder safety devices
- Individual rung/step ladders must extend at least 42 inches above an access level or landing platform either by the continuation of the rung spacing as horizontal grab bars or by providing vertical grab bars that must have the same lateral spacing as the vertical legs of the ladder rails
- Each step or rung of a fixed ladder must be able to support a load of at least 250 lbs applied in the middle of the step or rung
- Minimum clear distance between the sides of individual rung/step ladders and between the side rails of other fixed ladders must be 16 inches
- Rungs of individual rung/step ladders must be shaped to prevent slipping off the end of the rungs
- Rungs and steps of fixed metal ladders manufactured after March 15, 1991 must be corrugated, knurled, dimpled, coated with skid-resistant material or treated to minimize slipping
- Minimum perpendicular clearance between fixed ladder rungs, cleats, and steps and any obstruction behind the ladder must be 7 inches, except that the clearance for an elevator pit ladder must be 4.5 inches
- Minimum perpendicular clearance between the centerline of fixed ladder rungs, cleat and steps, and any obstruction on the climbing side of the ladder must be 30 inches. If obstructions are unavoidable, clearance may be reduced to 24 inches, provided a deflection device is installed to guide workers around the obstruction
- Step-across distance between the center of the steps or rungs of fixed ladders and the nearest edge of a landing area must be no less than 7 inches and no more than 12 inches. A landing platform must be provided if the step-across distance exceeds 12 inches
- Fixed ladders without cages or wells must have at least a 15 inch clearance width to the nearest permanent object on each side of the centerline of the ladder
- Fixed ladders must be provide with cages, wells, ladder safety devices or self-retracting lifelines where the length of climb is less than 24 feet but the top of the ladder is at a distance greater than 24 feet above lower levels
- Side rails of through or side-step fixed ladders must extend 42 inches above the top level or landing platform served by the ladder. Parapet ladders must have an access level at the roof if

the parapet is cut to permit passage through it. If the parapet is continuous, the access level is the top of the parapet
- Steps or rungs for through-fixed-ladder extensions must be omitted from the extension, and the extension of side rails must be flared to provide between 24 and 30 inches clearance between side rails
- When safety devices are provided, the maximum clearance distance between side rail extensions must not exceed 36 inches
- Fixed ladders must be used at a pitch no greater than 90 degrees from the horizontal, measured from the back side of the ladder.

Electrical Safety

The purpose of this section is to prevent electric shock or other injuries resulting from either direct or indirect electrical contacts, when work is performed near or on equipment or circuits which are or may be energized. This includes personnel who may be exposed to electrical hazards from work on, near or with any appliance or piece of equipment that uses electricity, either energized or de-energized; the wiring/circuits that supply this equipment including the building and premises wiring, wiring for connection to electrical supply from the point of use back to the point of generation; and installations of other outside conductors and optical fiber cable. Certain employees, such as electricians, machine operators, painters and welders do not need to be trained if their work, or the work of those they supervise, does not bring them or the employees they supervise close enough to exposed parts of electric circuits operating at 50 volts or more to ground for a hazard to exist.

Everyone engaged in electrical or electronic work should be capable of carrying out the following measures:

- Contact emergency personnel when necessary. Notify campus security of any incident
- Free any person involved from a live circuit. If a person is “frozen” to a live electrical contact, shut off the current if possible. If this cannot be done, use wood boards, poles, or sticks, a belt, a dry piece of rope, an article of clothing, or any non-conducting material of sufficient length to pull the body away from the contact. Act quickly, and remember to protect yourself during this operation
- Cut off the power. Because of the dangers involved in being caught in a live circuit, know how to cut off the power anywhere in your work area.
- Immediately report any shock received, no matter how slight, to your supervisor or appropriate authority. Promptly report any “popping” or sparking as well as any noticeable defects or hazardous conditions that could cause injury, property damage or interference with service.

Electric arcs can generate enough energy to cause shock, sufficient heat to cause severe burns, and ample ultraviolet light at certain wavelengths to cause serious and painful injury to the eyes even after a very brief exposure. To avoid such injuries, never close a switch or circuit breaker slowly or hesitatingly (as arcing may occur) and keep your face turned away to avoid exposing your eyes and skin. Vacuum and cathode ray tubes present a danger of possible implosion. Wear eye and face protection when handling them. Soldering requires use of safety glasses or eye shields and prolonged soldering requires fume extractors. Lift power supplies, oscilloscopes, chassis, and other heavy materials in such a way as to prevent back strains and hernias. Tripping hazards can be avoided by running power cables in cableways, beneath floors, or overhead.

When working with or around electrical equipment you should assume responsibility for your own safety and that of those working with you. The following information, principles and good working practices will help you to avoid electrical shock and injury:

- All new, permanent or temporary electrical installations, or the replacement, modification or rehabilitation of any electrical installation must be made in compliance with the requirements of the National Electrical Code (NEC) of the National Fire Protection Association (NFPA).
- Every effort must be made to eliminate potential hazards in research or development work that involves the design and construction of new systems so that equipment or apparatus will function safely in normal operations.
- Electrical power distribution systems must be equipped with over-current protection such as fuses or circuit breakers, which must never exceed the rated capacity of the circuit.
- All other sources of electrical potential for either service or experimental work must also be adequately fused and grounded.
- All newly installed receptacles must be of the grounding type.
- Multi-outlet bench strips must be grounded and should be equipped with fuses and pilot lights. They must be properly affixed to a bench or chassis frame.
- A switch must be provided in a readily accessible and convenient location for disconnecting the main power to apparatus in the event of an emergency. This switch must be legibly marked to indicate voltage, current, wattage, and the equipment it controls, unless it is located and arranged so that its purpose is evident. Everyone working in the area or on the particular project should know where the switch is located.

Grounding eliminates a difference in electrical potential between a conductive object and the ground by connecting them. Grounding will protect you from electrical shock by providing a path which offers less resistance to the current than you do. Bonding eliminates a difference of potential between conductive objects. All exposed non-current-carrying metal parts of fixed and portable equipment which are liable to become energized must be grounded. Ground paths from circuits, equipment and conductor enclosures must be permanent and continuous, having ample current-carrying capacity, and their impedance be low enough to facilitate the operation of over-current devices in the circuit GroundingBondingFactSheet.ashx (nfpa.org). Bonding keeps separate pieces of conducting material at the same grounded electrical potential. All conducting material, such as metal floor plates, equipment chassis, bench tops, tables, piping, and conduits, should be bonded to each other. Suitable connecting means include lugs, pressure connectors and clamps. Connections that depend upon solder must not be used in grounding or bonding. Where an adapter must be used to fit an old, ungrounded outlet, attach the pigtail on the adapter to the face plate screw before plugging in the adapter. Contact Facilities Management when this condition is discovered. Arrangements will then be made to have the receptacle replaced with a grounded type. Ungrounded electrical fixtures or equipment should be located so that a person cannot touch them and a water pipe or other grounded object at the same time.

If you work continually with or around electricity, you should wear rubber-soled footwear to guard against slipping and to provide insulation. Use rubber floor mats and adequately insulated tools when working with “hot” lines or equipment. When working on high-voltage equipment, have properly rated gloves and matting available for protection. Check the voltages stamped on the gloves and never use them for higher voltages. Also make sure that the gloves are in good condition. They can be checked by holding the end closed and forcing air into the fingers; this enables you to see the cracks or spots that are worn thin. Discard the gloves if these are visible. Never use unstamped gloves. Portable tools or appliances protected by an approved system of double insulation or its equivalent need not be grounded. Where such a system is employed, the equipment must be distinctly marked. Many devices are equipped with commutators; these commutators and contacts can cause a lethal shock if soaked by rain or immersed in water.

All electrical equipment or apparati that may require frequent attention must be capable of being completely isolated electrically. Live parts on electrical equipment operating at 50 or more volts or 10 Joules must be guarded by approved means accident accidental contact. All power supplies must be enclosed so that accidental bodily contact with power circuits is impossible. All access doors must be provided with interlocks which will disconnect all power to conductors and short out capacitors when any access door is opened. In every experimental setup, enclosures must be provided (even in temporary arrangements) to protect personnel against accidental contact with electrical circuits.

Before you start work on any system or circuit, it is your responsibility to make a personal inspection to assure yourself that it is de-energized. Opening a switch is not enough. To ensure that all appropriate systems are isolated it is necessary to investigate and de-energize all possible sources of power. To isolate a system and guarantee that it remains de-energized, OSHA requires that all appropriate disconnecting switches be locked open and tagged with the name of the individual responsible. These locks and tags must be removed only by the person who placed them on the switches. Before anyone begins work on a de-energized circuit or system it should be checked out by the use of a reliable voltage tester or other appropriate device to verify that it is “dead”. After making repairs or alterations, never close a circuit until all personnel are clear of mechanical equipment and circuit breakers. Do not close and switch until you are certain that it is safe to energize the circuit and all of the equipment on it. Before putting equipment to use, test for adequate insulation resistance and ground connections. Always close and open circuits with apparati suitable for the circuits involved. Never work along around energized electrical equipment. Keep personnel away from dangerous situations or places unless their work requires them to be there.

The following is a list of safe work practices:

- Keep hands off connected electrical apparati with which you are not directly involved or familiar.
- Do not permit unauthorized people to work in hazardous areas. Do not hesitate to question unfamiliar faces! People entering areas in which they do not usually work should with whoever is in charge, state their reasons for being there, and receive clearance to perform their duties or to visit.
- Question the methods or procedures of fellow workers if they violate any safety practices or otherwise work in an unsafe manner.
- Provide signs and barriers to warn people of high voltage hazards, particularly on breadboard setups. Use danger signs and flashing lights wherever conditions require them. They should not be used promiscuously, or left where danger no longer exists, as this detracts from their effectiveness.

- Maintain a safe working distance around energized equipment at all times. A minimum of 30 inches on all working sides of equipment operating at 600V or less is recommended.
- A neat, clean work space is essential where work on electrical equipment is to take place. Space behind and under consoles or power supplies should never be used for storage, and should always be kept clear of rubbish or unnecessary equipment.
- Equipment which is found to be defective should be labeled as such before storing. List defects on a tag. The tag must remain on this equipment until it is repaired, junked or dismantled.
- Safe wiring practices call for the use of appropriate insulation, adequate spacing, and proper placement of conductors. When selecting an area for circuits and grounding, avoid dangerous locations. The electrical assembly must be installed in a neat and professional manner. Work deliberately and carefully. Verify your connections as you proceed and be sure that they are secure.
- Avoid exposed wiring and placing any part of your body in a circuit, either to ground or across terminals
- Always connect from the load to the source. Disconnect first at the source and work toward the load.
- Check the supply circuit voltage to see that it is what you expect (either AC or DC) before closing circuits.
- Avoid using electrical equipment or tools where there is moisture present. If it is unavoidable to do so, use ground fault circuit interrupters.
- Rigidly observe the “one hand” habit when throwing open switches, removing leads, pulling lead plugs from apparati such as terminal distribution boards, operating line power rheostats, measuring voltages, or when testing circuits where any voltage may be present.
- Do not wear rings, metal wrist bands, key chains or other metal objects around exposed conducting material.
- Do not use metal rulers, metal flashlights, or metallic pencils when working with or around electricity.
- Use a fiberglass ladder instead of a metal one, if work requires the use of a ladder around electrical equipment.

Provisions should always be made to discharge capacitors capable of storing more than 0.1 Joule when shutting down equipment. It has been found that a discharge of energy exceeding 10 J into the human body can be hazardous to life, while 0.25 J gives a heavy shock. Keep each spare of disconnected capacitors individually short circuited, by a robust connection, when not in use. Similarly, capacitors built into equipment which is not in use must also be individually short-circuited, as they present a shock hazard from discharge, whether wired or series or parallel. Remember that “new” capacitors have already been energized for test purposes, and should also be kept short-circuited when stored. All high-grade capacitors, if left on an open circuit after discharge, will recover a considerable proportion of the original charging energy. This is particularly true of large-energy storage capacitors, such as those used in pulsed capacitor banks. As much as 10% of the original voltage may be recovered, and a 30 kV capacitor may build up as much as 2 or 3 kV in 10 minutes. Dangerous voltages can build up in open-circuited high-capacitors over a period of many months after they have been discharged. This is particularly true where inexpensive paper dielectrics have been used. It is recommended that all discharged capacitors carry a label adjacent to their terminals – for example, "WARNING: Keep short-circuited when not in use."

The provisions of OSHA's electrical standard (1910.331, 1910.332, 1910.333, 1910.334, and 1910.335) do not apply to work performed by "qualified" persons on, or directly associated with, the following installations:

- Generation, transmission and distribution of electric energy (including communication and metering) located in building used for such purposes or located outdoors. This work is covered by 1910.269
- Installations of communication equipment to the extent that the work is covered under 1910.268.

For purposes of this manual, a "qualified person" is anyone with specialized training in avoiding the electrical hazards of working on or near exposed energized parts. No one is considered qualified unless they have been formally trained and designated as such by the campus wide safety coordinator. Qualified persons will be trained in how to avoid the electrical hazards of working on or near exposed, energized parts. They shall also be trained in electrical safety-related work practices and any other safety measures that pertain to the electrical hazards of their jobs. A person can be qualified to work on certain equipment but unqualified to work on other equipment.

To be qualified to work on or around energized (50 volts or more) or de-energized equipment, parts or circuits, the person must:

- Demonstrate knowledge of the safety related work practices and procedures for each of their specific tasks and/or each piece of equipment.
- Know how to distinguish exposed live parts from other equipment parts and to use test equipment to determine the nominal voltage of these live parts, especially whether it is 50V or more.
- Know the required clearance and approach distances for conductors and the voltages to which they may be exposed.

Unqualified persons do not have the training, or their job hazard level does not require the training described above. They must not work on energized parts of 50V or more. They can work on energized parts of less than 50V because the National Electric Code limits the amount of current that these circuits can carry. They must be given awareness-type training on the hazards of high voltages, grounding and the lack of it, arcing and any electrical safety practices that are necessary to do their jobs safely. Therefore, they should know who the qualified people are on campus so that they can ask them to do anything that involves opening equipment and creating an exposure to energized parts operating at 50V or more. Students are considered unqualified because they shall not be permitted to work on or near exposed energized electrical equipment of 50V or more.

The 50 volt cut-off is not an absolute criterion. In certain situations lower voltages can have secondary effects, such as falling off a ladder if one is startled by such contact, or burns from arcing.

Energized parts to which an employee may be exposed will be de-energized, locked-out and tagged-out and verified as being de-energized before any employee works on or near enough to these electrical parts to expose themselves to any electrical hazard. The OSHA regulation on electrical safety-related work practices and our lockout/tagout policy require that electrical equipment be de-energized, locked-out and tagged-out and verified as being de-energized before work can proceed. These practices should be used by everyone at Cooper Union to prevent injuries and deaths caused by electric shock.

The specific work practices that are chosen for a task should be consistent with the level of hazard and must eliminate or minimize the hazard(s). Before working on or repairing parts/equipment (energized or not), unqualified persons must review their plans with their supervisor and may be required to work with a qualified person. Written procedures for specific equipment that must be followed may be available from a supervisor.

Safe techniques to de-energize electrical equipment include:

- Unplug the equipment and tag the plug.
- Open and lockout/tagout the circuit breaker or safety switch.
- Do not rely on control switches and interlocks. They don't provide the same protection as lockout/tagout because these do not protect you from inadvertent re-energization. Lockout/tagout is still required.
- Disconnect/de-energize/isolate all sources of electricity supplying live, exposed, electrical parts/equipment.
- Ask a qualified person to de-energize if they equipment or circuit has 50 or more volts and the equipment can't be unplugged. This qualified person must use the same precautions as working on energized equipment until the equipment has been de-energized, locked- and tagged-out and verified as being de-energized.
- If applicable, release stored electrical energy (charges and capacitive voltage), which could endanger personnel using the same precautions as working on energized equipment. For example, discharge capacitors before working on the equipment.
- If applicable, block or relieve stored non-electrical energy, which could re-energize parts, using the same precautions as working on energized equipment.

In conformance with OSHA regulations and our lockout/tagout policy both tags and locks are required to be used on each means of disconnecting the power to equipment/circuits. All equipment should be considered energized until it is de-energized, locked-out/tagged-out by a qualified person and they have verified that it is de-energized.

Before a tag may be used without a lock, the following must be done:

- Determine that a lock cannot be used.
- Demonstrate that the tag will provide the same level of safety as the use of a lock.
- Supplement the tag with at least one other safety measure to ensure that operating the tagged device will not energize the equipment or circuit (tags alone are not considered as effective as locks). Examples of supplementary measures include opening another disconnect that can be locked-out/tagged-out, removing a circuit element, blocking a control switch, and having someone stand by the disconnect device to prevent accidental actuation.

A lockout may be used without a tag only under the following conditions:

- Only one circuit or one piece of equipment can be de-energized.

- The lock-out period does not extend to the next work-shift.
- The exposed workers (qualified and unqualified) are familiar with the standard operating procedure.

After equipment is de-energized and locked-out/tagged-out, a qualified person must do the following before any circuits/equipment can be worked on as de-energized:

- Use safe test procedures/precautions as if working live until this verification is finished.
- Verify that the equipment will not start.
- Use test equipment to check that the equipment/circuit are de-energized and that all electrical supply sources have been isolated.
- Verify that the test equipment is operating properly before and after each use.

When the above has been completed, any person may work without using the PPE and clothing required for working on energized electrical equipment. When the job is finished, personnel must follow the written safety procedures, in the order listed below, before re-energizing. This is to ensure that no one will be hurt when the lock-out is removed and the equipment is re-energized:

- A qualified person must inspect the area to ensure that all materials and tools are clear of the equipment/circuit
- Warn qualified and unqualified people in the area to stay away from the equipment/circuit that is going to be re-energized
- Remove lock/tag. This should be done by person who applied it. If it is determined that this person is not available at the workplace, follow the instructions in our lockout and tagout procedure
- Visually determine that no one is near the equipment just before re-energizing. Use radios if the area can't be seen
- If 50 or more volts are involved, ask a qualified person to re-energize.

Energized equipment can be work on/repaired only when it meets the test of the following OSHA permitted exceptions:

- The employer can demonstrate that additional hazards may be created. For example, fire and emergency alarms, ventilation of hazardous locations (fume hoods), removal of illumination, or testing or circuits that can only be done energized.
- It is unfeasible due to equipment design.
- The equipment is operating at less than 50V to ground.
- If the task has been reviewed and formally approved in writing by a supervisor or another person designated and qualified to approve such work. Supervisors should not grant any exception without first considering and rejecting alternative methods.
- If all OSHA-required protective measures are completed.

Do not enter/work in any area with exposed live parts if the illumination is too dim. Protective shields, barriers, or insulating materials must be provided and used to avoid accidental contact with energized parts. Secure doors to prevent them from swinging and pushing an employee into energized parts. Works must safely handle conductive materials to avoid accidental contact with exposed, energized parts. Portable ladders used in these spaces must be made of non-conductive fiberglass or a similar material. Employees must remove all metal watches/bands, jewelry, key chains, metal headgear, conductive clothing and PPE if they may be exposed to energized parts. This is to prevent severe burns that could result if current flows through conductive apparel.

Generally, exposed energized parts need to be de-energized, locked out, etc. before employees may do housekeeping or maintenance. When it is not possible to do this, the supervisor must provide adequate safeguards, like insulating equipment or barriers, before work near exposed energized parts begins. In this case, personnel may not use electrically conductive cleaning materials, tools, or solutions unless precautions are taken to prevent electric shock.

Interlocks can only be defeated when a qualified person follows the standard operating procedure for working on or near exposed, energized parts, and on a temporary basis (while the qualified person is working on the normally interlocked equipment). Before the equipment can be left unattended, the interlock must be restored. When the work is completed, the interlock must be tested to verify that it is functioning and it provides an adequate level of safety.

The following section applies to cord and plug-connected equipment and extension cords.

Handling guidelines – do not raise or lower equipment using the cord, do not use staples to fasten a cord, and do not damage the equipment's casing or the cord's insulation.

Inspection – check for external and internal defects, remove damaged equipment from service by attaching a "do not use" or similar tag and giving it to your supervisor, and check that the plus matches the receptacle or extension cord (3 prong or polarized 2 prong are preferred).

Grounding-type equipment – use cords with 3 prong plugs. The continuity of the grounding conductor may not be disrupted by cutting off the third prong or by using adapters, attachment plugs, or receptacles.

Connecting attachment plugs – employees must have dry hands when plugging in/unplugging energized portable equipment and/or extension cords into receptacles, must wear insulated gloves and other PPE if the cord or receptacle is wet, and locking-type connectors should be properly secured after connection.

Employees must use ground fault interrupters (GFIs, either extension cords or receptacles) when working with portable electrical equipment in areas that are flooded or where contact with conductive liquids is likely.

The following section applies to electric power and lighting circuits:

Workers must use properly designed devices (circuit breakers, load-rated switches, etc.) to open, reverse and close circuits under load. Before closing circuits that were tripped by a fault condition (not an overload), employees must determine if it is safe to manually energize the equipment and/or circuits that were de-energized by a GFI, circuit breaker surge protector or other circuit protective device. No workers may modify overcurrent protection, even temporarily. Only qualified people may test circuits/equipment. Test equipment must be visually inspected before using it, and damaged equipment must be removed from service. Rating and design of test equipment must be appropriate to the environment where the equipment will be used.

Employees will be provided with, and shall wear, all PPE that is appropriate for their work, such as when they may be exposed to energized parts, arcs, flashes, explosions, etc. they shall wear appropriate for their work, such as when they may be exposed to energized parts, arcs, flashes, explosions, etc. this includes approved non-conductive head protection, eye and/or face protection. PPE should be periodically inspected and tested, and maintained in a safe condition. Insulating PPE must have an approved, protective outer layer.

When working near exposed, energized parts, employees should only use insulated tools and handling equipment such as the following:

- Tools that are in good repair, double-insulated and grounded
- The insulating material must be protected from damage
- Insulated, fuse handling equipment (when working with energized fuses)
- Non-conductive ropes and hand-lines (caution – wet ropes are conductive!)
- Protective, insulated shields/barriers

Circuits and equipment monitored by fixed or portable Ground Fault Circuit Interrupters (GFIs) are intended to offer personal protection against electrical shock. If you should contact a GFI-protected circuit conductor or energized surface while part of your body is grounded, the GFI will respond by cutting off power before shock or serious injury can occur. Ground faults occur when current-carrying parts of a circuit accidentally contact any grounded conducting material. GFIs provide electric shock protection against this type of accident. High-current ground faults cause an immediate massive current flow to ground. This current, being lower than the rating of the fuse or circuit breaker, will not cause over current devices to cut off the circuit power. Low-current ground faults of 60 cycles (AC) can be extremely dangerous. Just 0.01 A (10 milliamps) can freeze a victim to a power source until the amount of current received reaches lethal proportions. If the current passes through the heart, breathing may become arrested at 18 milliamps. If the current increases to 60 mA, ventricular fibrillation of the heart can occur. A house current of 60 mA can kill a person in seconds.

GFIs monitor both the current to the load (hot wire) and the current flowing from it (neutral wire). Under normal circumstances, these should be equal. When a ground fault occurs, the GFI senses an imbalance between the hot and neutral wires, cause by the leakage of current to ground, and trips out, cutting off the supply of current. Most GFIs are designed to trip within 30 ms after current imbalance of only 5 mA or more had been detected. While harmless, even the common 5 mA trip-level shock can have secondary effects caused by reflex actions or the body (for instance, falling off a ladder). Portable and fixed GFIs are available in various type and trip levels. Devices can be purchased that will trip at levels as low as 0.2 mA or as high as 20 mA.

GFIs will not provide protection if you should contact the hot and the neutral wire while you are not grounded (line-to-line short). As the current through you is not flowing to ground, the GFI will not operate, and you will be at the mercy of the system's overcurrent protection devices. These will trip only if the current is high enough (overload) and serious damage to you may occur before they go into operation. However, should some of the current passing through the body also flow though a grounded object to the earth or ground (simultaneous fault) the GFI will trip the circuit open as with a normal ground fault. The GFI also will not work if faults in another line circuit occur. If a saw or drill penetrates wiring of a circuit other than the one supplying its own power, the operator can be aided only by the protective devices in the penetrated circuit. GFIs or over-current devices in the circuit supplying the tool cannot stop this flow of current. GFIs have proved so efficient in a variety of applications that there is a tendency to place undue reliance on them as a source of protection. It should be emphasized that this device, while extremely reliable, is not designed to be failsafe should an internal failure develop. The installation of a GFI does not obviate the need for recognized practices and procedures developed through the years to ensure safe electrical work.

Electricity is not limited to following the path of least resistance; it will take every other route to ground open to it. Operators of equipment can be subjected to shock hazards due to fault grounding, worn insulation, or bypassed isolation methods. GFIs should also be used in the locations and on locations listed below:

- Underground installations, or concrete slabs or masonry in direct contact with the earth
- Locations exposed to weather
- Partially exposed areas (under canopies or roofed open shelters) and locations subject to a moderate degree of moisture
- Outdoor receptacles, or any receptacles that are used by an operator standing on the ground
- In conductive locations (inside metal tanks, ducts, or boilers) or in any area where a person can be easily grounded.

One of the most frequently occurring violations cited during safety inspections is the use of extension cords. This problem is common to all areas of activity. Because of its universal nature, the use of extension cords is an issue that needs clarification and guidelines in determining the permissibility of its usage.

The NEC does not refer to extension cords specifically but does assign the concept other names where appropriate specifications are outlines. As commonly used, extension cords are alluded to in the NEC in an oblique manner where their utilization is either in violation of, or in compliance with, one or more stated NEC standards. It would be beyond the scope or intent of this outline to attempt any detailed defining of all the above stated standards mentioned in the NEC. <u>However, the NEC standards may be summed up in a general way by saying that the use of an extension cord represents a conflict with the code because it serves as a substitute for a receptacle that should be located near the appliance or equipment.</u>

The primary consideration in determining the legal application of extension cords is that they are intended for temporary use with portable appliances, tools and similar equipment which are not normally used at one specific location. When using extension cords and their connectors, care should be taken to ensure that they are of the proper type and rating for their particular location as a normal source or supply indicates the need for a permanent receptacle outlet. Equipment being supplied by the cord must be properly grounded where applicable. Listed below are some guidelines which can be applied to the use of extension cords and their related equipment:

- Extension cords shall be used only as temporary extensions for portable equipment. These devices may be acceptable in applications where they supply equipment not routinely used in an area where permanently wired receptacles are not available or installed
- Cords shall be unplugged when not in use and never left plugged in while unattended

- Extension cords and their plugs shall be of a type suitable for the application, location and conditions under which they are to be used
- Zip cords and light extensions made up of AWG 18 wire are rated for only 6-10 A. in normal use these zip cords and light extensions are plugged into a 20 A fuse line and therefore offer no over-current protection and are susceptible to overheating, thereby creating a potential fire hazard when supplying loads nearing their rated current
- All cords and plugs should be maintained in a safe condition. Splices are prohibited. Worn our cords should be replaced
- Cords should be checked for proper strain relief connections to the plug so that tension will not be transmitted to the joints or terminal screws
- Plugs should be checked to ensure that the covers for wire terminations are mechanically secure
- This equipment must be used in a safe manner, so as not to constitute a tripping hazard
- Cords should not be draped near open flames, nor used in areas where chemical or other physical damage may be a danger, not wet locations which increase the potential shock hazard.

Electric shock happens when the body becomes part of an energized electrical path and energy is transferred between parts of the body, or through the body to a ground or the earth. Current flowing through the highly sensitive central nervous system can, under certain conditions, cause serious injury or death. Low voltage (up to 40V) of direct current (DC) circuits does not normally present a hazard to human life. Under some circumstances, however, severe burns can result. Even at low voltage, alternating current (AC) circuits can be dangerous and present a lethal threat. At commercial frequencies (50-60 cycles or Hz) and intermediate voltages (50-600 V) lethal current may be conducted through the body.

The resistance of the body and the degree to which the skin is insulated from the ground govern the amount of current flowing through the body. The skin offers the principle resistance which the human body presents to the flow of current. Skin resistance decreases with increased voltage. The current path is from hand to hand, with the palms of the hand moist. If the skin is wet or moist, the resistance is lowered and therefore the greater flow of current and the severity of shock. Both the magnitude and path of the current flowing through the body are of primary importance. When the path of the current is hand-to-hand or hand-to-foot, vital organs (brain, heart, lungs, spinal cord) are affected, possibly with serious consequences.

The length of time the body is in the circuit is also important, particularly with respect to the severity of burns. Burns break down the skin, thereby lowering the resistance. The more extensive the burn, the less resistance provided. Time becomes critical when current flowing through the body causes loss of muscular control, contraction of the chest (which affects breathing) and ventricular fibrillation of the heart. When this occurs, the heart’s pumping rhythm becomes irregular and it ceases to function properly. Age, as well as the physical and emotional condition of the person involved can also affect the severity of an electrical shock.

Fires can have electrical causes. The following are some possible sources of electrical fires and ways to prevent them from becoming hazards:

- Soldering irons should be disconnected when unattended and not in use. Keep them in metal holders when in use. Bench tops should be made of fire-resistive material.

- Motors should have thermal protection devices to protect them against excessive heating due to motor overloads or failure to start [Mine Safety and Health Administration (MSHA) - Electrical Testing Study Material - Article 430]
- Ignitable materials should not be stored in electrical closets [Mine Safety and Health Administration (MSHA) - Electrical Testing Study Material - Article 240]
- Poor contact between plugs and receptacles can cause arcing, leading to a serious fire hazard. Make sure that contacts are secure.
- Overload circuits can, by overheating, be a cause of fires. Do not overload them by using extension cords or cube taps
- Static electricity is generated when a fluid flows through a pipe into a tank. When the fluid is a flammable liquid, the vapors can be ignited by a spark discharge caused by static electricity. Grounding and bonding of flammable liquid containers is necessary to prevent static electricity from causing an explosion or fire
- Make special provisions for electrical service or equipment installed in areas where hazardous mixtures of explosive gases, vapors or dust are present [Microsoft Word - Document1 (awc-inc.com)]. Specially designed equipment is available for use in these and other hazardous locations. Explosion and dust-proof equipment, intrinsically safe circuits, purged enclosures, and positive ventilation are most commonly used. Use equipment of this type in and around solvent and flammable liquid storage rooms, paint spray booths, ventilating systems, compressed gas storage, motors for stirrers of flammable liquids and oil baths, centrifuges used for flammable liquids, exhaust fan motors, and refrigerators storing flammable liquids.

Lithium-Ion and Lithium Polymer (LiPo) Battery Safety

The intent of this section is to provide users of lithium-ion and lithium polymer (LiPo) cells and battery pack with enough information to safely handle them under normal and emergency conditions. Caution must be taken in Li-ion battery storage, use, management, and disposal due to the potential for fire and injury if these batteries are misused or damaged. Typically this occurs when batteries are left on chargers for extended periods of time, they are unattended when charging, they are charged with incompatible chargers, and/or shorts from improperly wired or isolated connections.

Batteries are classified as primary or secondary. Primary batteries irreversibly transform chemical energy to electrical energy. When the initial supply of reactants is exhausted, energy cannot be readily restored to the battery by electrical means. Alkaline and lithium-metal batteries are examples of primary batteries. It is important to note that lithium metal is a water-reactive material, and the handling recommendations for these batteries in an emergency situation are different from Li-ion/LiPo. Secondary batteries can be recharged; that is, they can have their chemical reactions reversed by supplying electrical energy to charging the cell. Secondary batteries age during each cycle so they are not indefinitely rechargeable. Prior to the widespread introduction of Li-ion batteries, lead acid, nickel-cadmium and nickel-metal hydride were the most common types of secondary batteries.

Lithium-ion/LiPo batteries have emerged in recent years as the most popular secondary batteries due to advantages that include light weight, higher energy density, low memory effect and longer life span. They can provide a compact and powerful energy source for vehicles requiring electrical energy. Whit this technology, lithium ions are stored in the anode (negative electrode) and transported during the discharge to the cathode (positive electrode) in a flammable organic electrolyte. The materials used are graphite for the anode and a metal oxide for the cathode.

Li-ion batteries are used in battery packs for portable laptops, power tools, and many other devices requiring electrical power. LiPo are commonly seen in applications like remote-controlled (RC) vehicles, where their relatively light weight and high current draw are an advantage. Since both battery types have similar chemistries they require similar care in charging and handling to avoid unsafe conditions.

All faculty, students and staff who use Li-ion and LiPo batters are responsible for:

- Implementing of all applicable provisions in this manual
- Obtaining and reviewing the battery manufacturer's Safety Data Sheet (SDS), Technical Specification sheet(s) and/or other documentation that is available
- Performing hazard analysis to understand the various failure modes and hazards associated with the proper configuration, type(s) and number of batteries used
- Poor contact between plugs and receptacles can cause arcing, leading to a serious fire hazard. Make sure that contacts are secure.
- Ensuring that written standard operating procedures (SOPs) for lithium and lithium-ion powered research devices are developed and include methods to safely mitigate possible battery failures that can occur during assembly, deployment, data acquisition, transportation, storage and disassembly/disposal
- Ensuring that at the conclusion of testing the battery assemblies are disposed of properly or left in a safe condition for storage

If the cells and batteries are correctly handled, the risk of fire developing from a lithium-ion battery from a reputable manufacturer is very low. Most incidents involving Li-ion batteries find a root cause in the mishandling or unintended abuse of such batteries. Possible causes of lithium-ion battery fires include: overcharging or discharging, unbalanced cells, excessive current discharge, short circuits, physical damage, excessively hot storage and, for multiple cells in a pack, poor electrical connections.

Best practices for lithium-ion cell/battery use:

- Always purchase batteries from a reputable manufacturer or supplier. Cheap or counterfeit batteries may not undergo the same quality control processes and have a higher likelihood of failing
- Be sure to read all documentation supplies with your battery
- Never burn, overheat, disassemble, short-circuit, solder, puncture, crush or otherwise mutilate battery packs or cells
- Do not put batteries in contact with conductive materials, water, seawater, strong oxidizers and strong acids
- Avoid excessively hot and humid conditions, especially when batteries are fully charged. Do not place batteries in direct sunlight, on hot surfaces or in hot locations
- Always inspect batteries for any signs of damage before use. Never use and promptly dispose of damaged or puffy batteries

- Lithium-ion batteries assembled to offer higher voltages (over 60 V) may present electrical shock and arc hazards. Therefore, adherence to applicable electrical protection standards (terminal protection, shielding, PPE etc) is required to avoid exposure to electrical hazards
- Do not reverse the polarity
- Do not mix different types of batteries or mix new and old ones together (e.g. in a power pack)
- Do not open the battery system or modules unless you have training and permission
- Do not use the unit without its electronic management system
- Do not submit to static electricity risks to avoid damages to the Protecting Circuit Board
- Immediately disconnect the batteries if, during operation or charging, they emit an unusual smell, develop heat, change shape/geometry, or behave abnormally

Take precautions to avoid dropping batteries during transport. When you need to transport a battery, protect the battery terminals and uninsulated connections from contact with other objects, and use the original packaging or a suitable plastic container. In general, transporting lithium cells in an elevator is to be avoided if possible.

The Li-ion battery packs found in portable laptops and similar devices usually, if from a reputable manufacturer, require no user input for charging other than connecting it to the charging cable. They contain a batter management system (BMS) in the battery pack that controls the charging process. Be sure to use the manufacturer's AC adapter. Individuals charging these batteries still need to follow all manufacturer recommendations and be alert for anomalies like unusually hot batteries.

Batteries used in RC drones and other research projects require a much more conscious effort by users to charge safely and avoid battery damage. Li-ion/LiPo users for these applications should incorporate the following recommendations into their charging practices:

- Batteries must only be charged with a charger or charging method designed to safely charge cells or battery packs at the specified parameters. Be absolutely sure that the charger settings are correct for the battery pack being charged – both voltage and current settings
- Never leave a battery pack unobserved during charging. Always stay in or around the charging location so that you can periodically check for any signs of battery or charger distress. Occasionally check on output levels and balancing effectiveness
- For series packs (2S and above) always balance charge with a charger capable of monitoring the condition of individual cells to prevent individual cells being overcharged. This charger and the battery should be put on a heat-resistant, nonflammable and nonconductive surface. Fire-safe containers designed for Li-ion batteries are available. Never place them on a car seat, carpet or similar surface
- Keep all flammable materials away from operating area
- Do not overcharge (greater than 4.2V for most batteries) or over-discharge (below 3V) batteries
- Never parallel charge since chargers cannot monitor the current of individual cells
- Best practice is to charge and store batteries in a fire-retardant container like a high quality Lipo Sack
- Do not leave batteries connected to chargers after charging is complete
- Make sure the working surface is made of a material that is not conductive and noncombustible. If you are working on a conductive material cover the surface with an insulating material

- The area should be clear of any flammable or combustible materials such as wood tables, carpet and gasoline or other solvent
- Keep the area free from any sharp objects that may puncture the insulating sleeve on cells
- Ambient temperature should not exceed 60°C. Best working temperatures are between 15°C and 35°C

Proper lithium-ion batteries storage is critical for maintaining an optimum battery performance and reducing the risk of fire and/or explosion. Many recent accidents regarding lithium-ion battery fires have been connected to inadequate storage area or conditions. While lithium-ion spontaneous fires are rare, they need just an internal short circuit to start a series of reactions that may lead to a fire. Other factors that pose a higher risk of fire in a storage area are the type of cell design, chemistry, temperature, state-of-charge, and length of storage period.

Following are some guidelines that if correctly followed will reduce the risk of fire and/or explosion of stored batteries:

- Every time a battery is not used actively (e.g. for more than 3 days), it should be placed in the storage area to avoid being damaged and becoming unsafe
- When not using your LiPo/Li-ion battery pack, store it at 60-70% of the pack's rated capacity. Lithium-ion cells should never be stored fully charged, it is suggested to store them with a voltage around 3.8V. Most of the chargers have a "storage mode" that will either charge or discharge the cell to the proper storage voltage. Experts recommend to put the cells in storage mode after every run, as this will help the battery to lengthen the usable life span
- Remove the lithium-ion battery from a device before storing it
- It is a good practice to use a lithium-ion battery fireproof safety bag or other fireproof container when storing batteries. Always follow manufacturer recommendations on fireproof bags for details on how to correctly use them. Do not buy cheap fireproof bags, they might not be effective
- Cell terminals must be protected by electrical insulating material
- Store batteries in a dry and well-ventilated place at room temperature or lower. While batteries can be used safely between -20 and 60 °C (-4 to 140 °F), it is strongly suggested to avoid storing them at a temperature that is close to the upper or lower range
- Storing batteries in a refrigerator may create internal condensation when the battery is brought to room temperature, and they may become dangerous when operated
- It is best to have a reserved area ONLY for lithium-ion battery storage. It has to be a cool and dry place, away from heat sources
- The area should be maintained free from any materials which can catch fire such as wood tables, carpet, or gasoline containers. The ideal surface for storing lithium-ion batteries is concrete, metal, or ceramic or any non-flammable material
- Batteries can be stored in a metal cabinet such as a chemical-storage cabinet, make sure that batteries are not touching each other
- It is recommended to have in place a fire detector in the storage area
- Never leave batteries unattended where they can be damaged by someone
- Have a class ABC or CO_2 fire extinguisher nearby the storage area

Only trained and authorized personnel are allowed to prepare, package, and ship Li-ion batteries. If you are planning to ship Li-ion batteries, with or without equipment, you are required to contact a lab manager, supervisor, advisor or campus-wide safety officer to establish if your product falls under the Dangerous Goods Regulations. **WARNING: Failure to comply with regulations for shipping hazardous materials can result in significant civil penalties for the shipper of up to $100,000.00 per violation.**

While all batteries need to be handled with caution, Li-ion/LiPo batteries pose additional safety risks due to their high energy density and flammable electrolyte. When these batteries are poorly manufactured, overcharged or over discharged, incorrectly handled and/or connected, or exposed to excessive mechanical and physical stress, conditions may arise and lead to thermal runaway that in turn may lead to the venting, leaking, explosion and/or fire of the battery cell or pack. All lithium-ion cells users must be aware of and equipped to deal with the emergencies mentioned above.

Battery damage may not always be visible. Events that may damage a Li-ion battery include a fall of 12 inch or greater; crash with a speed of 20mph; puncture by a sharp object; expansion due to overheating. Use of a damaged battery may lead to thermal runaway and subsequent fire.

The following outlines a procedure for what to do if a battery is damaged:

- After the impact/accident, if the battery is **not** hot and/or leaking or smoking, disconnect the battery.
- Remove the battery from the equipment wearing gloves, goggles/safety glasses and lab coat (if available)
- To discharge the battery, move in a well-ventilated area and place the battery in a metal or hard plastic bucket
- Fill the bucket with a 3% salt water solution
- After 2 days in the salt water bath, arrange to have the battery disposed of as waste
- Check the voltage across the terminals to ensure it has reached 0 V
- Alternatively, to discharge the battery use a resistor with resistance greater than 10 times the rated internal resistance of the battery
- Keep in mind that there may be no visible damage, a delayed fire can occur hours or days after the impact/accident. It is safest to discharge the battery immediately

When a cell's internal temperature and pressure rise faster than the rate at which they can be dissipated, cell overheating will occur. This may be caused by electrical shorting, rapid discharge, overcharging, manufacturer defects, poor design, or mechanical damage, among many other causes. In series or parallel connected strings of batteries, high connection resistance from a poor electrical connection can lead to overheating. The overheating of a given cell may produce enough heat to cause adjacent cells to overheat in response. If the cell does not return to room temperature it may vent and catch fire, or explode. Sounds like "clicks" and "puffs" may indicate a preliminary vent release. Depending on the cell type and manufacturer, the critical temperature ranges around 120-300 °C (250-570 °F) (see manufacturer manual for details on the battery you are using). Follow this emergency procedure if you have overheating, venting or leaking cells.

The following outlines a procedure for what to do if a battery is overheated, venting and/or leaking:

- If you notice hot cells, disconnect the charger and remove any external short circuit if present

- If a cell is venting or smoking, evacuate all personnel from the area. The area should be secured to ensure that no unnecessary persons enter
- If leaking material is present, do not touch it
- Do not approach the cell until it reaches room temperature. The cell temperature can be checked using a remote device (i.e. infrared thermometer)
- If a remote device is not available, do not handle the cell for a period of at least 24 hours
- As soon as the cell reaches room temperature, arrange to have the damaged battery removed from the working area as hazardous waste.

Like a vented cell, an exploded cell is the result of an overheated or mechanically damaged cell. After the explosion of a lithium-ion battery, the room could fill quickly with dense white smoke that could cause severe irritation to the respiratory tract, eyes and skin. All precautions must be taken to limit exposure to these fumes.

The following outlines a procedure for what to do if a battery has exploded:

- If a cell has exploded, evacuate all personnel from the area. The area should be secured to ensure that no unnecessary persons enter
- If a ventilation system is in place and it is safe to, turn it on, initiate ventilation and continue until the cell is removed from the area and the pungent odor is no longer detectable
- Arrange to have the damaged battery removed from the working area as hazardous waste.

First Aid Procedures in Case of Contact with Electrolyte:

- While the electrolyte composition will vary depending on the type of the battery cell, the general first aid procedures are the same for an exposure to the electrolyte
- EYES -- Immediately flush eyes with a direct stream of water for at least 15 minutes while forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue
- Remove contaminated garments
- SKIN -- Flush with cool water or get under a shower. Remove contaminated garments. Continue to flush for at least 15 minutes. Get medical attention, if necessary
- INHALATION -- Move to fresh air. Monitor airway breathing; if breathing is difficult, have trained person to administer oxygen. If respiration stops, give proper first aid and/or proper CPR procedures only if CPR-trained. GET MEDICAL ATTENTION IMMEDIATELY
- For significant exposures to the electrolyte, get immediate medical attention. The applicable SDS should be sent with the patient to the hospital

Intact Lithium-ion batteries are considered to be Universal Waste (i.e. a subset of the hazardous waste regulations intended to ease the burden of disposal and promote the proper collection, storage, and recycling of certain materials). Damaged Lithium-ion batteries are considered to be Hazardous Waste. The following paragraphs describe the steps needed to comply with the above requirement. It applies to all Cooper Union personnel and researchers that work with batteries.

Intact batteries can be collected for recycling in any type of container. Spent battery terminals must be taped and gently placed into a container, which should then be properly labeled for recycling through the Universal Waste Program. Labels should indicate: “Universal waste – Lithium-ion batteries”. Do not mix lithium-ion batteries with other types of batteries, such as alkaline, cadmium or other rechargeable spent batteries. These units can be brought to a designated area within the building. For damaged batteries and all spills from broken batteries and emergencies, contact the Campus Wide Safety Officer for guidance.

Emergencies, Spills and Chemical Spills

When an emergency occurs in a workspace, the first decision to make is whether additional support is needed. If anyone has been injured or exposed to a hazardous material, additional support is required. Depending on the nature of the emergency, it may be necessary to contact the campus wide safety officer, the director of campus safety and security, emergency medical services, and local police. If any of these need to be called, please provide the following information

- Your name
- Callback number
- Building and room number
- If anyone is injured
- If applicable, the full chemical name (spelled out) and volume spilled

Have a member of the workspace who is knowledgeable about the incident and materials in the laboratory available to provide information to emergency personnel.

For spill cleanups in laboratories, shops and studios, materials such as disinfectant solution, a broom/dust pan, gloves, laboratory coat, eye protection, and paper towels or other absorbent material should be available. If these items are not available, or they need to be replenished, please contact Facilities Management. Any personal exposure or injury takes priority over clean up. If injured, personnel must seek medical attention immediately.

Laboratory personnel must know what procedures to follow in the event of a chemical spill. Chemical spills can be “manageable” and independently handled by laboratory staff, or “unmanageable” and require clean-up support from Facilities Management. Manageable spills are defined as those that do not spread rapidly, do not seriously endanger people or the environment, and can be cleaned up safely by laboratory personnel familiar with the hazardous properties of the materials. All other spills are considered to be unmanageable spills. For any spill, the laboratory/shop manager and/or faculty member responsible for a space must be notified of any release of chemicals, even if deemed manageable.

Manageable Chemical Spill Procedures

- Alert people in the immediate area. Avoid breathing vapors and quickly determine which chemical has been spilled and the quantity spilled.
- Consult the applicable SDS for hazardous properties of the chemical and what substances the chemical is incompatible with, and wear appropriate PPE (safety glasses, gloves, long sleeve lab coat).
- If the spill involves a flammable liquid, turn off all ignition and heat sources.
- If the spill involves finely divided solids such as nitrates, permanganates or perchlorates, they should not come into contact with combustible materials such as wood or paper, or reducing

agents. Use a scoop or dustpan and hand broom to collect the solids in a plastic bag. Use an appropriate solvent to clean up any residue.

- Attend to any persons contaminated by chemicals by removing contaminated clothing, and when feasible, flushing the affected body area with water. An incident report form should be completed and the individual referred to emergency medical services.
- Confine spill to a small area. Absorb and neutralize the spill with an appropriate material and create a dam around the perimeter. Use an appropriate spill kit or sodium bicarbonate for acids; citric acid for caustics; and vermiculite, dry sand or diatomaceous earth for other chemicals. The residue should be placed in a container, labeled and disposed of as hazardous waste.
- Clean the spill area with soap and water.

Unmanageable Chemical Spill Procedures

- Do not attempt to clean up an unmanageable spill.
- Alert people in the immediate area. Avoid breathing vapors and quickly determine which chemical has been spilled and the quantity spilled.
- Consult the applicable SDS for hazardous properties of the chemical and what substances the chemical is incompatible with, and wear appropriate PPE (safety glasses, gloves, long sleeve lab coat).
- If the spill involves a flammable liquid, turn off all ignition and heat sources.
- Evacuate all personnel and close all doors leading to the affected area. Keep all personnel away from the affected area until Facilities Management can evaluate the situation. Attend to any persons contaminated by chemicals by removing contaminated clothing, and when feasible, flushing the affected body area with water.
- Call the campus wide safety officer and/or the director of campus safety and security for assistance, and notify the laboratory/shop manager and/or faculty member responsible for a space.
- After hours spills should be immediately reported to the campus wide safety officer and/or the director of campus safety and security. Be prepared to give the name of the chemical, the volume spilled, the location (building and room) and any other pertinent information.
- Ensure that a person knowledgeable about the incident is available to provide information to emergency personnel.

All laboratories and shops should have access to a chemical spill kit, capable of controlling a spill of any hazardous material used in the laboratory. A spill kit can be assembled by the laboratory or shop technician and should include an organized collection of absorbent pads, corrosive neutralizers, handheld broom and dustpan, etc., or can be purchased from a laboratory supply company. All laboratory personnel should be familiar with the kit's storage location and use.

Laboratories and shops where hazardous substances are used or stored should be equipped with an eye-face wash and overhead shower. These devices are designed to provide a continuous stream of clean, flushing water to rinse the eyes or body in the event of exposure to a hazardous substance. Laboratory personnel must perform a weekly test of eye wash stations by activating the device for a period long enough to verify operation and ensure that clean water is available. Safety showers will be tested annually by Facilities Management.

Biological spills are different from chemical spills in that the primary hazard is direct contact. Accordingly, access to only the immediate area around the spill needs to be restricted. Researchers using biological materials, including recombinant microorganisms, are generally responsible for cleaning up any biological spills they create in the laboratory. The following are clean-up procedures for spills in a biological workspace:

- Alert people in the immediate area
- Make sure you are wearing the proper PPE – at a minimum, a laboratory coat, gloves and eye protection
- Cover an area twice the size of the spill with disinfectant-soaked paper towels or other absorbent material. Alternatively, surround spill with dry disinfectant as per label instructions.
- Allow a 20-minute contact period
- Wipe down any contaminated stationary equipment or furniture with disinfectant
- Use forceps, tongs, or a broom to remove broken glass or other items; dispose of glass and spill materials in a sharps or glass waste container
- Remove towels and reclean the area with disinfectant solution
- Decontaminate (autoclave or bleach) reusable clean-up items and other reusable equipment.
- Inform anyone else working in the space when the clean-up is complete.

If biological exposure occurs (defined as parenteral, non-intact skin or mucous membrane contact with recombinant DNA or other potentially infectious materials), workers should immediately remove contaminated clothing and other protective equipment and wash affected areas with soap and water.

If needed, Facilities Management can assist on clean-up procedures and will assume responsibility for cleaning the spill if it is beyond the scope of the ability of the person working in the space.

If there is a spill of a non-hazardous material in a common area, e.g. a hallway, bathroom or lobby, please contact Facilities Management.

Chemical and Hazardous Waste

Cooper Union has campus wide policies regarding waste management. To ensure that waste is properly managed, it is essential that faculty, students and staff be familiar with our policies prior to commencing their work so that they can make the right decisions about waste identification, collection, labeling and storage. It is the responsibility of each lab manager, technician, faculty member and staff to ensure that his/her space is in compliance with all federal, state and city regulations pertaining to hazardous waste management and hazardous materials shipping.

The Resource Conservation and Recovery Act (RCRA) governs the management of hazardous waste and several categories of non-hazardous and specialty waste. The requirements are enforced by the New York State Department of Environmental Conservation (NYS DEC) and the Environmental Protection Agency (EPA). Both agencies inspect Cooper Union for compliance with RCRA hazardous and non-hazardous waste management. RCRA gives the EPA, operating through the Office of Resource Conservation and Recovery (ORCR), the authority to control hazardous waste from “cradle to grave”. Thus, the law and regulations apply from the moment the chemical waste is generated in a laboratory, through its onsite collection, storage, shipment, processing or recycling and to its ultimate disposal or end product use. Therefore, Cooper Union is ultimately always responsible for the proper end disposal of chemical waste despite its shipment offsite to a permitted treatment, storage or disposal facility.

Facilities Management, in conjunction with the campus-wide safety officer lab technicians, and other staff members, coordinates the disposal of all chemical and hazardous waste. Cooper Union does not permit any chemical or hazardous waste to be poured down the drain. Hazardous waste is defined as any unwanted material, with properties that make it potentially harmful to human health or the environment. This includes unused materials, products of chemical reactions generated in labs, and materials that have no reasonably foreseen intended use. Hazardous waste exhibits at least one of four characteristics – ignitability, corrosivity, reactivity or toxicity. The following is based on the EPA classification for hazardous waste:

Ignitable waste – chemicals likely to cause a fire or exhibit the characteristic of a strong oxidizing agent, such as oils and solvents. Ignitable wastes are spontaneously combustible or have a flash point less than 140 ^{o}F. They include flammable solids, metal shaving or fine powders that can cause a fire through friction or absorption of moisture, ignitable compressed gases (materials which contain a mixture of less than 13% with air that forms a flammable mixture), pyrophoric, water reactive or explosive materials, oxidizers (including peroxides) and compounds that readily yield oxygen to support combustion.

Corrosive waste – chemicals with a high or low pH and (pH less than or equal to 2, or greater than or equal to 12.5) which can also severely damage skin or corrode metal. Battery acid is an example.

Reactive waste – chemicals that react with air and/or water to product toxic gases (such as cyanide or sulfide-generating wastes) or are explosive. This category includes unstable items that react violently with air or when mixed with water or when exposed to pH conditions between 2 and 12.5. Examples would be lithium-sulfur batteries.

Toxic waste – heavy metals (including arsenic, barium, cadmium, chromium, lead, mercury, silver, and selenium) and certain solvents (both halogenated and non-halogenated).

For more information, please consult federal and state regulations where hazardous wastes are specifically defined and listed: Code of Federal Regulations and NYS Dept. of Environmental Conservation

All hazardous wastes must be managed in accordance with USEPA and NYSDEC regulations. If waste is not managed in accordance with regulatory requirements, the EPA may enforce compliance through administrative actions, civil actions and criminal violations including financial penalties. Hazardous waste must be collected in sealable, labeled containers that are compatible with the waste being collected. The hazardous waste label must contain complete information about container contents at all times – for example, no abbreviations or formulas are permitted. The hazardous waste collection containers must be periodically checked for leaks and may not be moved from one room to another. Hazardous waste must be stored in a “satellite accumulation area” near to where the waste is generated. All chemical waste, including even minute amounts, that meet the criteria for being a RCRA Hazardous Waste must be collected in SAAs at the point of generation. SAAs may include collection containers within chemical fume hoods, or elsewhere in the laboratory, shop or studio. Up to 55 gallons of non-acutely toxic waste or one quart or kilogram of acute hazardous waste may be accumulated in each SAA.

Only authorized personnel are specifically qualified under RCRA regulations to move the chemical waste from the SAA to the central accumulation area (CAA).

Containers must be:

- In good condition
- Within the same room as the process that generates the waste
- Always kept closed, except when adding or removing waste. Specifically, an open funnel may not be left in a hazardous waste container. A funnel may be affixed to a large collection container; however a lid that latches must be utilized. This latch must be fastened closed when waste is not being actively added to the drum. For waste containers attached to equipment with effluent lines or tubing, or in cases where waste generation and collection is an ongoing process (such as High Performance Liquid Chromatography, HPLC), a cap that allows tubes to be inserted through a tight-fitting seal must be used. In order to prevent evaporation and potential spills of chemical waste, tubes must not be loosely left in openings of a waste container.
- Compatible with the waste in the container
- Clearly and legibly labeled “Hazardous Waste” with the full chemical name written without abbreviations or chemical formulas and if known, the quantity (percentage) of the contents listed
- Segregated by hazard class (for example, acids separated from bases)

All hazardous wastes that are specifically listed or characteristically hazardous in accordance with RCRA regulations must be collected and properly disposed of. The NYC DEP prohibits the discharge of chemical wastes that are specifically listed or characteristically toxic, corrosive, reactive or flammable into any sanitary sewer system within the five boroughs of New York City. Accordingly, Cooper Union has implemented a strict “No Drain Disposal” policy that prohibits disposal, via a drain, of any laboratory chemical. Hazardous wastes must not be diluted, neutralized, evaporated or treated by Cooper Union personnel.

Hazardous waste may only be removed from laboratories by approved Cooper Union personnel or contracted employees. In order to prevent overflow, hazardous waste pickup requests should be submitted to Facilities Management prior to completely filling the containers (typically 80-90% full). Facilities Management is responsible for providing timely waste collection services to laboratories, shops and studios. The campus wide safety officer is responsible for informing personnel of unsafe or non-compliant waste generation practices, including insufficient collection, missing or inaccurate labeling or improper waste management in SAAs.

Typical and Special Waste Streams

Certain waste streams that are common at Cooper Union, or require alternate handling procedures, listed below.

All empty/unwanted aerosol cans must be handled as hazardous waste. Many aerosols contain ingredients that can damage the environment when improperly disposed of in the trash. They may also explode if compacted or incinerated. When collecting these containers, please ensure that the manufacturer’s cap has been replaced on the can prior to placing it in the collection container, or the spray nozzle has been removed so it does not accidentally discharge, potentially causing a dangerous pressurization and/or fire hazard.

“Universal waste” is waste that contains otherwise regulated RCRA Hazardous Waste, but that the EPA has determined poses little risk to the environment when managed properly. Generally, universal waste is found in household items, but may also be part of the operations in a laboratory, shop or studio. Similar to RCRA Hazardous Wastes, these items must be collected and labeled for disposal through Facilities Management and not discarded in the municipal solid waste.

Universal waste includes:

- Batteries (non-leaking and free from damage)
- Mercury containing equipment that contains elemental mercury integral to its function, such as thermometers, thermostats and barometers
- Fluorescent light bulbs or lamps (intact)

Used batteries are collected for recycling at various locations throughout the campus and are managed as universal waste. Leaking or damaged batteries must be handled as hazardous waste, and must not be deposited with other batteries. If a battery is leaking, place it in a container and label it as hazardous waste. Federal regulations require covering electrical contacts on batteries (other than alkalines) prior to transportation. One such method of compliance is taping the battery terminals to prevent contact and the generation of heat, which could potentially lead to a fire.

Dark room and photo processing labs may use an effluent fixer that contains sliver halides, hazardous materials that must be excluded from sewer discharge. A darkroom log sheet is required to be completed with each use of the darkroom for tracking and maintenance purposes. Scrap film must also be collected in specially marked containers.

Fluorescent lamps may contain mercury and must be handled carefully. Please contact Facilities Management to arrange for disposal of fluorescence lamps.

Computer monitors and other cathode ray tube devices contain quantities of lead that can be harmful to the environment. Most municipal landfills will no longer accept computer monitors for disposal, as EPA considers them hazardous waste. If you have a non-functional or obsolete computer monitor that can be recycled, please contact Facilities Management for assistance.

Old laboratory refrigerators, freezers and ice machines may contain refrigerants that are harmful to human health as well as to the environment. Prior to final disposal, it is required that each item is safely vacuumed of its refrigerant, so that it is ready for disposal.

Devices that contain mercury, such as thermometers, should be replaced with safer alternatives.

Labs and shops that use solder must collect the solder waste as hazardous waste if it contains lead. For lead-based solder, hazardous waste guidelines apply; non-lead-based solder can be collected for metal recycling.

Used pump oil and other oils must be collected in closed contained marked “Used Oil”. Used oil is defined as any oil that has been refined from crude oil or is synthetic oil, that has been used and as a result may have chemical or physical impurities. Used oil includes transmission fluid, hydraulic fluid, machine fluids and lubricating oils, but excludes petrochemicals, solvents, vegetable oils and animal fats. These containers must be kept closed at all times. If the used oil is mixed with a listed hazardous waste, it must be managed as a hazardous waste. To schedule a pickup of used oil, please contact Facilities Management. If the laboratory area requires large volumes of oil (> 55 gallons), it must also use a secondary containment set-up and/or spill containment pallets, as well as have weekly inspections.

Rags and debris contaminated with solvents require a hazardous waste determination to be made by the campus wide safety officer. Specific solvents are treated for flammability and others for both flammability and toxicity; therefore specific containers and labels are required. Prior to generating this waste please contact the campus wide safety officer for guidance. Always use nontoxic, nonflammable solvents whenever possible.

Biological waste may include ethidium bromide, a known mutagen. Gels and debris that contain ethidium bromide must be collected separately in a labeled container.

Health effects of exposure to nanomaterials (substances that have at least one dimension between 1 and 100 nanometers) are poorly understood, though research has indicated that exposure is likely to cause adverse effects similar to those caused by ultrafine particles with similar chemical and physical characteristics. Nanomaterials should be collected and managed as hazardous waste until the health effects are better characterized. It is recommended that their handling be approached with caution, that personal protective equipment (PPE) be used for manipulating them, and that waste streams be managed accordingly as hazardous waste.

Appendix A: Safety Information in Chemistry Labs (adopted from the Ch111 Lab Manual, with permission)

-- TWENTY ESSENTIAL SAFETY RULES --

You will be asked to leave if you do not follow these rules, and your course grade will be lowered. Your lab instructor will be observing your techniques and behavior in the lab and will record any violations of the safety rules or other laboratory rules (see next section).

1. **Know what you are working with: look up the safety information for every chemical that you use in your work.** This is THE MOST IMPORTANT SAFETY RULE. It is your responsibility to consult the Safety Data Sheet (SDS) and/or other chemical safety information for every chemical that you come into contact with in before working in a laboratory at Cooper Union. It is Cooper Union's responsibility to make sure that this information is readily available. Binders have been placed in the hallway outside the labs that contain SDSs for all chemicals in the lab. You can also search databases online.

2. **Wear safety goggles at all times in the lab. Contact lenses are not permitted.** You will not be allowed to work unless you are wearing safety goggles, and you may be ejected from lab for the day if you fail to wear them at all times. Even if you are careful not to splash chemicals into your eyes, someone close to you may accidentally do so. Goggles pushed up onto your forehead (or left on your desk, or worn around your neck) offer your eyes no protection. According to New York State law, no person without eye protection is to be permitted to remain in the laboratory. Chemical safety goggles may be purchased at most local hardware stores.

3. **Wear suitable clothing and shoes, and tie up long hair.** Shorts, shirts with open midriffs, short pants or short skirts, open sandals, or bare feet leave large areas of skin exposed and are not permitted. Long, full sleeves may drag in your chemicals or catch on your equipment; both the sleeves and the equipment could be ruined. Very long hair should not be worn loose. It is highly advisable that you wear a lab coat and / or clothes that you don't mind ruining when working in the lab (lab coats are not provided). Acids and other corrosives will be used for some experiments, and some of them have a nasty habit of eating away your clothes. **Shorts and sandals are not allowed**.

4. **Know the locations of all safety showers, eye-wash stations. and other safety equipment.** Think about what you will do in the event of an accident in advance.

5. **Take precautions to avoid cutting yourself.** Ask your instructor to help clean up and properly discard any broken glass into the “sharps” waste bin. Handle glass wool with tongs and/or gloves, never your bare hands. Use gloves whenever needed. Make sure to use the right gloves for the job.

6. **Return all borrowed equipment, and make sure that it is clean, cool and dry.** Otherwise the stockroom personnel risk injury from chemical contact. Any equipment that is borrowed from the stockroom for a particular experiment must be returned at the end of the same lab period.

7. **No food or drink may be consumed in the lab or brought into the lab.** This is to avoid the possibility of consuming food contaminated by chemicals. Chewing gum is also not a good idea for the same reason.

8. **No "fooling around." Throwing objects or boisterous behavior will not be tolerated.**

9. **Pour chemicals safely.** Never pour from a big container directly into a small container. When pouring into a graduated cylinder, into a small test tube, or into a buret, you should use a funnel.

This will prevent the solution from spilling out of the container, onto your hands, down your elbow, along your body and into your shoes.

10. **Always pour concentrated acid into water (not water into acid).** The heat produced may cause some acid to spatter from the solution and burn you.

11. **Report any injury** -- no matter how minor it may seem -- to your instructor. An incident report must be filed for all serious injuries. Instructions on the incident report must be followed.

12. **Coats and unnecessary books may not be placed atop the benches or on the floor. Do not bring coats and backpacks into the laboratory.** Use your book lockers for storage during lab. Please do not bring anything to lab that you don't have to have, as space is at a premium and safety is always an issue. In particular, coats and backpacks left on benchtops may pick up unseen contaminants.
13. **Never attempt an unauthorized experiment and never work alone.** The procedures in these experiments have been designed with your safety in mind. Don't risk injury to yourself or to others by mixing chemicals randomly or by setting up unauthorized reactions or equipment. Don't work on any experiment unless a professor is supervising your efforts.
14. **Clean up!** You are responsible for cleaning up any chemicals you spill in the reagent or balance area. Also, be sure to clean and wipe down (wet paper towel) your own desktop before you leave the laboratory. **Plan your work so that you have adequate time to clean up.**
15. **Never throw paper towels into the sinks.** You could clog the drains and cause a flood! Dispose of paper in the large trashcans.
16. **Dispose of all used and excess chemicals only in their properly labeled waste containers.** Some salt solutions are okay to flush down the sink, but we operate on the principle of erring on the side of caution. Each chemical waste container has a sign-in sheet which you must fill out.
17. **When carrying a desiccator, one hand supports the bottom; another holds the lid down securely.** Dessicators are made of thick glass which can cause severe cuts if broken, and must be handled with caution.
2
18. **Do not let hot objects cool down in closed desiccators.** Leave the cover ajar for a minute or two to let hot air escape. Otherwise there is a risk of building up air pressure inside the desiccator and the glass lid will be popped off and/or shattered into large, sharp fragments.
19. **Wash your hands immediately after you finish working in the lab for the day.** Your hands may be contaminated without your knowledge. This will protect you from wiping something into your eyes later or contaminating your post-lab burger and fries.
20. **Make sure your name, the date, and the name of the chemical is on anything you place in the drying oven or common cabinet.** Federal law requires that all chemical containers be properly labeled at all times, whether for short-term or long-term use or storage.

-- EIGHT ESSENTIAL CH 111 "HOUSE RULES" --

1**. Dispose of chemicals only by placing them in the appropriate labeled waste containers.**
Protect our environment by following the law. Do not flush any chemicals down the drain.
2. **Take care of the balances.** Do not move a balance for any reason. Moving a balance will destroy its calibration and render it useless. Do not sit on the balance tables. Do not weigh liquids on the balances. Liquids should not even be brought into the balance room. Do not weigh heavy objects (beyond the stated capacity of the balance). By the way, analytical balances are not called "scales," scales have springs, and are used in delicatessens, not laboratories.
3. **Help keep the lab running smoothly for everyone by helping to replenish supplies.** If you find that a reagent bottle is empty, please bring the bottle and its cover to the stockroom and ask for a refill. If there are no more paper towels for cleanups, please ask the stockroom personnel to refill the paper towel dispenser.
4. **Never (!) take reagent bottles to your desk.** Another student's work may be needlessly delayed by searching for a reagent. The proper way to obtain the reagents you need is to use a small clean and dry beaker to obtain sparse quantities of substances from the reagent area. Having a reagent bottle on your desk is inconsiderate to your colleagues.
5. **Handle chemicals properly.** Don't put anything back into reagent bottles. The obvious reason for this precaution is to eliminate the possibility of contamination. Do not place the bottle lid or stopper on a

desk or other laboratory surface. To pour a solid from a bottle, use the spatula supplied by your instructor, or tip the bottle slightly while rotating it; do not use your own spatula. Sometimes mistakes are made: chemicals might be returned to the wrong bottles or contaminated chemicals might be returned to reagent bottles. As a result, the entire contents of a reagent bottle could be contaminated. If you do this accidentally, notify the instructor *immediately.* This rule is extremely important!

6. **Don't waste chemicals.** Large quantities of scarce energy resources are consumed to make and purify the chemicals you use in the laboratory. Some prehistoric animal may have given its earthly remains towards this endeavor! In addition, it costs the school money to get rid of hazardous waste. Take whatever you need, but do not waste resources or unnecessarily increase our school's expenses by taking more of a chemical than you need. Also, remember that any excess chemical you must throw away is a potential air or water pollutant. Solid reagents are usually expensive so take what you need, but be thrifty.

7. **Wash your glassware and other equipment before and after use.** All washings should be done in the large sinks using copious tap water and, as needed, soap or detergent solution. After completely clean, do the final rinse with deionized water. Do not use compressed air from the hood or paper towels to dry the interior of cleaned glassware. All drying is done in the ovens or in the air.

8**. If you want good results, use purified water in your solutions.** Whenever water is to be used as a chemical agent it must be deionized or distilled water. In our case, deionized water is available and is kept in a large carboy at the rear of the lab. Keep a *clean* plastic wash bottle filled with deionized water so that you'll have a supply near you. Rinse your clean glassware with a SMALL quantity of purified water before use. Do NOT wash your glassware at the deionized water station.

Appendix B: Rules for Graduate Students with C-14 Licenses

Policy for Faculty, Staff and Graduate Students with C-14 licenses Working in Chemistry and Chemical Engineering Laboratory Spaces

As a C-14 holder you are a designated "laboratory supervisor". In the past only faculty and staff were permitted to obtain C-14 licenses. The intention of allowing graduate students to obtain a C-14 license is to allow them to work on their research even when their advisor or technician is not on the floor to supervise them.

The following policies have been developed by the Departments of Chemistry and Chemical Engineering, in coordination with the Campus-Wide Safety Officer, regarding the responsibilities and "do's and don'ts" for graduate students with C-14 licenses.

1) During the academic year the labs are normally open and staffed Monday through Friday from 9 AM to 5 PM. During the summer the labs are normally open and staffed Monday through Thursday from 9 AM to 5:15 PM. A student may arrange to work in a lab during these hours as long as a C-14 license holder is present, and they do not interfere with the use of that space (for example if there is a lab course in session). If a faculty or staff member with a C-14 license is present outside of these hours, he/she may supervise a research student. Technicians and professors must make sure all lab doors for spaces they use are closed before they leave for the day. A graduate student with a C-14 license will not be given "swipe" access to any lab spaces and may NOT work outside these hours.
2) No student shall work in a lab without a <u>member of the Cooper Union faculty or staff having a C-14 license holder</u> present on that floor. If a graduate student with a C-14 license is the only C-14 license holder on that floor, other researchers are NOT permitted to work on the floor until a faculty or staff member with a C-14 license is present. Whenever a faculty member or lab technician leaves a floor, it is their responsibility to make sure no students are working or in a laboratory area EXCEPT for a graduate student with a C-14 license.
3) A graduate student with a C-14 license will still need a faculty member or staff member to "swipe in" to a restricted lab space (specifically, rooms 304, 402, 403, 404, 405, 406 and 407). If a graduate student with a C-14 license is in one of these rooms and he/she is the ONLY C-14 license holder in that space (that is, there is no faculty or staff member with a C-14 license present), then he/she is responsible for that space. For example, it is the responsibility of the graduate student with the C-14 license that doors remain closed when he/she leaves a space, that ONLY authorized researchers (i.e the graduate student himself/herself, faculty or staff members with C-14 licenses, and students being supervised by faculty or staff members with C-14 licenses) are in a designated laboratory space, that all authorized researchers must wear appropriate personal protective equipment, that any visitors must wear personal protective equipment and are not allowed to perform any experiments) and that all equipment is used properly. This includes shutting down equipment (i.e. putting the GC-MS in "standby" mode or turning off IR/NMR spectrometers properly). <u>The graduate student with the C-14 license may NOT act as a supervisor to other researchers without C-14 licenses if there is no faculty or staff member present on the floor.</u>

4) All faculty, staff and students working in a laboratory space must make sure that all lab rules and regulations are obeyed while they are in the laboratory. This includes wearing appropriate personal protective equipment, performing all experiment in an appropriate area (for example a fume hood), making sure all waste is labeled properly and stored properly, ensuring all chemicals and equipment are stored and handled properly, and ensuring that all equipment (including gas tanks) that needs to be turned off is turned off properly.
5) Should there be any chemical, instrumental or safety concern that a student (whether or not they have a C-14 license) is not sure how to address, a Cooper Union faculty or staff member who is a C-14 license holder MUST be contacted and/or notified immediately!

Failure to comply with these policies may result in the researcher not being permitted to work in his/her designated lab spaces.

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Appendix C: Studio Use and Responsibilities: The School of Architecture (used with permission)

1. STUDIO USE AND RESPONSIBILITIES: The School of Architecture

It is intended that all students enrolled in the School of Architecture study and work in the School of Architecture studios as a community of individuals.

The studios are your design classroom and personal workspace as well as a workspace shared by others; a place of dialogue, debate and serious work where the needs of scholarship and respect for others should inform all activity.

In the studio, your commitment to your own work as well as the community of the school should be evident at all times. The use of the studios is a privilege, and failure to work responsibly and respectfully in the studio may result in the loss of this privilege.

Please read and familiarize yourself with the following policies. YOU ARE REQUIRED TO OBSERVE THEM AT ALL TIMES.

If you have questions or concerns regarding any of the topics discussed in Studio Use and Responsibilities, please visit The School of Architecture Office.

BUILDING HOURS

It is the responsibility of each student to be aware of the building hours and observe all opening and closing times throughout the academic year. Building hours are available on The Cooper Union website via the link below:

http://cooper.edu/about/building-hours

FIRE LANES

1) Fire lanes and exit passageways in the studios are clearly marked and must be kept clear of all furniture and all materials at all times.

2) Do not store any materials in the entryways of the studios. Materials left in fire lanes or studio entryways will be removed and disposed of by Buildings & Grounds.

3) The Cooper Union Director of Facilities Management as well as the New York City Fire Department monitor compliance with fire lane regulations.

4) Our local New York City Firefighters can and will conduct inspections of The Cooper Union's studios and labs at any time, without notice. Failure to maintain fire lanes that are free of all obstructions at all times is UNSAFE and a violation of the New York City Fire Code that can result in significant fines to the school.

HAZARDOUS MATERIALS

1) It is important for your own health and the health of your colleagues that all products and materials be used in strict accordance with manufacturer's recommendations.

2) You are responsible for familiarizing yourself with the dangers and safe use of materials you purchase by reading the MSDS/SDS (Material Safety Data Sheet/Safety Data Sheet) before using the material. The MSDS/SDS can be obtained by contacting the product manufacturer.

3) The School of Architecture keeps two binders of MSDS/SDS for products stored in the Hazmat cabinet near the sinks in the Big Studio. Please use the binders for reference.

4) All flammable/hazardous material (ie. spray paint, fixative finish, wood stain, adhesive, etc.) must be stored in the yellow Hazmat cabinet located adjacent to the clean-up sinks in the Big Studio. Please follow the rules for storage located on the outside of the cabinet.

5) Any flammable/hazardous materials kept at your desk will be removed and disposed of.

6) Do not use trash cans for disposal of flammable/hazardous materials. Leave them on the bottom shelf of the Hazmat cabinet.

7) The wall above the sinks may be used to post signs about studio safety. Please take the time to read and familiarize yourself with the information, following any and all instructions.

SAFETY GUIDELINES

1) Do not use aerosol cans (spray paint, fixative finish, matte finish, adhesive, etc.) in the studios, 3rd floor lobby, stairways, or any other open space in the Foundation Building. All spraying must occur in the High Ventilation Room located on the 4th floor of the Foundation Building. The High Ventilation Room is open whenever the Foundation Building is open.

2) Do not use power tools in studios, classrooms, or the 3rd floor lobby. If you need to use power tools, you must use them in the 4th floor Art and Architecture Shop. All personal power tools should be kept in your locker.

3) The use of candles, incense or open flames is prohibited.

4) Do not hot cut or sand rigid foam in the studio, the 3rd floor lobby or anywhere inside Cooper Union buildings except the High Vent Room.

5) Do not hang curtains, drapes, or other fabric in the studios.

6) Do not bring upholstered furniture of any kind into the studios.

7) Do not build any structures or enclosures around or over your desk. Partitions and storage lofts will be immediately removed by Buildings & Grounds.

2. STUDIO USE AND RESPONSIBILITIES: The School of Architecture

SAFETY GUIDELINES

8) Cooking and the use of hot plates in the studios is prohibited. The Student Council maintains a hot water kettle, coffee maker and microwave for use by all students. They are located near the sinks at the north end of the big studio. No additional hot water kettles, coffee makers, microwaves or other household appliances are permitted in the studios/at student desks.

9) All electrical floor outlets in the studios should be in good working order. If any outlet sparks or fails to work properly, please report this to the School of Architecture Office immediately.

10) Use only the electrical outlets located in your immediate work area. Extension cords and electrical cords cannot cross fire lanes for any reason. In addition, do not run extension cords into the 3rd floor hallway or lobby. Extension cords used improperly will be removed.

DRUGS, ALCOHOL AND SMOKING

1) The studios are to be free of drugs and alcohol at ALL times. The storage, consumption or exchange of alcohol or drugs is absolutely and unequivocally prohibited.

2) Smoking is absolutely prohibited in the studios and throughout the building at ALL times. Please refer to The Cooper Union Smoking Policy by visiting the following link:

http://cooper.edu/about/policies/smoking-policy

OTHER CONSIDERATIONS

1) All studio furniture must remain in the studios. Do not move furniture out of the studios for any reason.

2) Windows in studios and classrooms must be kept closed AT ALL TIMES. This allows for the proper functioning of the HVAC system as well as the safety of pedestrians and students. Do not open windows or tamper with locks or environmental sensors, etc. in any rooms.

3) Keep windowsills in the studios and classrooms clear of materials at all times for the safety of pedestrians on the sidewalks below the studio.

4) Keep all materials away from the heating convectors along the exterior wall of the studio. The free flow of air around the convectors is necessary to properly heat the studio.

5) When pinning up your work, use pushpins (at pin-up boards) or drafting tape only. Do not use adhesives, glue, staples, etc. Installations that require nailing into the walls, floor or ceiling must be reviewed and approved in advance by the School of Architecture Office and by Buildings and Grounds.

6) The roof of the south portico (in the 3rd floor lobby) is off limits at all times.

OTHER CONSIDERATIONS

7) Rodents and other pests can become a serious problem in the studios, so it is very important for students to keep their work areas clean. Use the marked trash receptacles to separate recyclable materials and throw away garbage. Do not keep open food containers in the studios.

8) Bicycles: The Cooper Union encourages the use of alternative forms of transportation and has developed a policy regarding Bicycle Parking with the Student Council. Please follow the link below for details:

http://cooper.edu/about/policies/bicycle-policy

Bicycles are prohibited in the Foundation Building except as permitted by this policy.

9) Students may register for and use one locker on either the 3rd floor or 7th floor of the Foundation Building. Visit the School of Architecture Office for more information. Please note, all students who wish to continue using their lockers must re-register for the locker at the end of the Academic Year.

VIOLATIONS

A) If the New York City Fire Department conducts an inspection of the school and finds anything out of compliance, they will fine the school. The fines can cost many thousands of dollars.

B) The School of Architecture Student Council has recommended that sanctions be imposed on students who violate policies for studio use.

The following procedure is now in effect:

--A student will receive a formal written warning from the Associate Dean, copied to the Student Judicial Committee, for the first (of any) violation.

-- A student will receive a $50.00 fine for the second (of any) violation during the academic year.

-- A student will receive a $50.00 fine for the third (of any) violation during the academic year AND will be required to meet with the Dean of the School of Architecture for possible disciplinary sanctions, including probation, suspension or dismissal.

Appendix D: OSHA Standard 1910.134 App D (Mandatory) Information for Employees Using Respirators When Not Required Under the Standard

Respirators are an effective method of protection against designated hazards when properly selected and worn. Respirator use is encouraged, even when exposures are below the exposure limit, to provide an additional level of comfort and protection for workers. However, if a respirator is used improperly or not kept clean, the respirator itself can become a hazard to the worker. Sometimes, workers may wear respirators to avoid exposures to hazards, even if the amount of hazardous substance does not exceed the limits set by OSHA standards. If your employer provides respirators for your voluntary use, or if you provide your own respirator, you need to take certain precautions to be sure that the respirator itself does not present a hazard.

You should do the following:

1. Read and heed all instructions provided by the manufacturer on use, maintenance, cleaning and care, and warnings regarding the respirators limitations.

2. Choose respirators certified for use to protect against the contaminant of concern. NIOSH, the National Institute for Occupational Safety and Health of the U.S. Department of Health and Human Services, certifies respirators. A label or statement of certification should appear on the respirator or respirator packaging. It will tell you what the respirator is designed for and how much it will protect you.

3. Do not wear your respirator into atmospheres containing contaminants for which your respirator is not designed to protect against. For example, a respirator designed to filter dust particles will not protect you against gases, vapors, or very small solid particles of fumes or smoke.

4. Keep track of your respirator so that you do not mistakenly use someone else's respirator.

[63 FR 1152, Jan. 8, 1998; 63 FR 20098, April 23, 1998]

Appendix E: OSHA Standard 1910.134 App A Fit Testing Procedures (Mandatory)

Appendix A to § 1910.134 - Fit Testing Procedures (Mandatory)

Part I. OSHA-Accepted Fit Test Protocols

A. Fit Testing Procedures - General Requirements

The employer shall conduct fit testing using the following procedures. The requirements in this appendix apply to all OSHA-accepted fit test methods, both QLFT and QNFT.

1. The test subject shall be allowed to pick the most acceptable respirator from a sufficient number of respirator models and sizes so that the respirator is acceptable to, and correctly fits, the user.

2. Prior to the selection process, the test subject shall be shown how to put on a respirator, how it should be positioned on the face, how to set strap tension and how to determine an acceptable fit. A mirror shall be available to assist the subject in evaluating the fit and positioning of the respirator. This instruction may not constitute the subject's formal training on respirator use, because it is only a review.

3. The test subject shall be informed that he/she is being asked to select the respirator that provides the most acceptable fit. Each respirator represents a different size and shape, and if fitted and used properly, will provide adequate protection.

4. The test subject shall be instructed to hold each chosen facepiece up to the face and eliminate those that obviously do not give an acceptable fit.

5. The more acceptable facepieces are noted in case the one selected proves unacceptable; the most comfortable mask is donned and worn at least five minutes to assess comfort. Assistance in assessing comfort can be given by discussing the points in the following item A.6. If the test subject is not familiar with using a particular respirator, the test subject shall be directed to don the mask several times and to adjust the straps each time to become adept at setting proper tension on the straps.

6. Assessment of comfort shall include a review of the following points with the test subject and allowing the test subject adequate time to determine the comfort of the respirator:

(a) Position of the mask on the nose

(b) Room for eye protection

(c) Room to talk

(d) Position of mask on face and cheeks

7. The following criteria shall be used to help determine the adequacy of the respirator fit:

(a) Chin properly placed;

(b) Adequate strap tension, not overly tightened;

(c) Fit across nose bridge;

(d) Respirator of proper size to span distance from nose to chin;

(e) Tendency of respirator to slip;

(f) Self-observation in mirror to evaluate fit and respirator position.

8. The test subject shall conduct a user seal check, either the negative and positive pressure seal checks described in appendix B-1 of this section or those recommended by the respirator manufacturer which provide equivalent protection to the procedures in appendix B-1. Before conducting the negative and positive pressure checks, the subject shall be told to seat the mask on the face by moving the head from side-to-side and up and down slowly while taking in a few slow deep breaths. Another facepiece shall be selected and retested if the test subject fails the user seal check tests.

9. The test shall not be conducted if there is any hair growth between the skin and the facepiece sealing surface, such as stubble beard growth, beard, mustache or sideburns which cross the respirator sealing surface. Any type of apparel which interferes with a satisfactory fit shall be altered or removed.

10. If a test subject exhibits difficulty in breathing during the tests, she or he shall be referred to a physician or other licensed health care professional, as appropriate, to determine whether the test subject can wear a respirator while performing her or his duties.

11. If the employee finds the fit of the respirator unacceptable, the test subject shall be given the opportunity to select a different respirator and to be retested.

12. Exercise regimen. Prior to the commencement of the fit test, the test subject shall be given a description of the fit test and the test subject's responsibilities during the test procedure. The description of the process shall include a description of the test exercises that the subject will be performing. The respirator to be tested shall be worn for at least 5 minutes before the start of the fit test.

13. The fit test shall be performed while the test subject is wearing any applicable safety equipment that may be worn during actual respirator use which could interfere with respirator fit.

14. Test Exercises.

(a) Employers must perform the following test exercises for all fit testing methods prescribed in this appendix, except for the two modified ambient aerosol CNC quantitative fit testing protocols, the CNP quantitative fit testing protocol, and the CNP REDON quantitative fit testing protocol. For the modified ambient aerosol CNC quantitative fit testing protocols, employers shall ensure that the test subjects (*i.e.*, employees) perform the exercise procedure specified in Part I.C.4(b) of this appendix for full-facepiece and half-mask elastomeric respirators, or the exercise procedure specified in Part I.C.5(b) for filtering facepiece respirators. Employers shall ensure that the test subjects (i.e., employees) perform the exercise procedure specified in Part I.C.6(b) of this appendix for the CNP quantitative fit testing protocol, or the exercise procedure described in Part I.C.7(b) of this appendix for the CNP REDON quantitative fit testing protocol. For the remaining fit testing methods, employers shall ensure that the test exercises are performed in the appropriate test environment in the following manner:

(1) Normal breathing. In a normal standing position, without talking, the subject shall breathe normally.

(2) Deep breathing. In a normal standing position, the subject shall breathe slowly and deeply, taking caution so as not to hyperventilate.

(3) Turning head side to side. Standing in place, the subject shall slowly turn his/her head from side to side between the extreme positions on each side. The head shall be held at each extreme momentarily so the subject can inhale at each side.

(4) Moving head up and down. Standing in place, the subject shall slowly move his/her head up and down. The subject shall be instructed to inhale in the up position (i.e., when looking toward the ceiling).

(5) Talking. The subject shall talk out loud slowly and loud enough so as to be heard clearly by the test conductor. The subject can read from a prepared text such as the Rainbow Passage, count backward from 100, or recite a memorized poem or song.

Rainbow Passage

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

(6) Grimace. The test subject shall grimace by smiling or frowning. (This applies only to QNFT testing; it is not performed for QLFT)

(7) Bending over. The test subject shall bend at the waist as if he/she were to touch his/her toes. Jogging in place shall be substituted for this exercise in those test environments such as shroud type QNFT or QLFT units that do not permit bending over at the waist.

(8) Normal breathing. Same as exercise (1).

(b) Each test exercise shall be performed for one minute except for the grimace exercise which shall be performed for 15 seconds. The test subject shall be questioned by the test conductor regarding the comfort of the respirator upon completion of the protocol. If it has become unacceptable, another model of respirator shall be tried. The respirator shall not be adjusted once the fit test exercises begin. Any adjustment voids the test, and the fit test must be repeated.

B. Qualitative Fit Test (QLFT) Protocols

1. GENERAL

(a) The employer shall ensure that persons administering QLFT are able to prepare test solutions, calibrate equipment and perform tests properly, recognize invalid tests, and ensure that test equipment is in proper working order.

(b) The employer shall ensure that QLFT equipment is kept clean and well maintained so as to operate within the parameters for which it was designed.

2. ISOAMYL ACETATE PROTOCOL

Note:
This protocol is not appropriate to use for the fit testing of particulate respirators. If used to fit test particulate respirators, the respirator must be equipped with an organic vapor filter.

(a) Odor Threshold Screening

Odor threshold screening, performed without wearing a respirator, is intended to determine if the individual tested can detect the odor of isoamyl acetate at low levels.

(1) Three 1 liter glass jars with metal lids are required.

(2) Odor-free water (e.g., distilled or spring water) at approximately 25 °C (77 °F) shall be used for the solutions.

(3) The isoamyl acetate (IAA) (also known at isopentyl acetate) stock solution is prepared by adding 1 ml of pure IAA to 800 ml of odor-free water in a 1 liter jar, closing the lid and shaking for 30 seconds. A new solution shall be prepared at least weekly.

(4) The screening test shall be conducted in a room separate from the room used for actual fit testing. The two rooms shall be well-ventilated to prevent the odor of IAA from becoming evident in the general room air where testing takes place.

(5) The odor test solution is prepared in a second jar by placing 0.4 ml of the stock solution into 500 ml of odor-free water using a clean dropper or pipette. The solution shall be shaken for 30 seconds and allowed to stand for two to three minutes so that the IAA concentration above the liquid may reach equilibrium. This solution shall be used for only one day.

(6) A test blank shall be prepared in a third jar by adding 500 cc of odor-free water.

(7) The odor test and test blank jar lids shall be labeled (e.g., 1 and 2) for jar identification. Labels shall be placed on the lids so that they can be peeled off periodically and switched to maintain the integrity of the test.

(8) The following instruction shall be typed on a card and placed on the table in front of the two test jars (i.e., 1 and 2): “The purpose of this test is to determine if you can smell banana oil at a low concentration. The two bottles in front of you contain water. One of these bottles also contains a small amount of banana oil. Be sure the covers are on tight, then shake each bottle for two seconds. Unscrew the lid of each bottle, one at a time, and sniff at the mouth of the bottle. Indicate to the test conductor which bottle contains banana oil.”

(9) The mixtures used in the IAA odor detection test shall be prepared in an area separate from where the test is performed, in order to prevent olfactory fatigue in the subject.

(10) If the test subject is unable to correctly identify the jar containing the odor test solution, the IAA qualitative fit test shall not be performed.

(11) If the test subject correctly identifies the jar containing the odor test solution, the test subject may proceed to respirator selection and fit testing.

(b) Isoamyl Acetate Fit Test

(1) The fit test chamber shall be a clear 55-gallon drum liner suspended inverted over a 2-foot diameter frame so that the top of the chamber is about 6 inches above the test subject's head. If no drum liner is available, a similar chamber shall be constructed using plastic sheeting. The inside top center of the chamber shall have a small hook attached.

(2) Each respirator used for the fitting and fit testing shall be equipped with organic vapor cartridges or offer protection against organic vapors.

(3) After selecting, donning, and properly adjusting a respirator, the test subject shall wear it to the fit testing room. This room shall be separate from the room used for odor threshold screening and respirator selection, and shall be well-ventilated, as by an exhaust fan or lab hood, to prevent general room contamination.

(4) A copy of the test exercises and any prepared text from which the subject is to read shall be taped to the inside of the test chamber.

(5) Upon entering the test chamber, the test subject shall be given a 6-inch by 5-inch piece of paper towel, or other porous, absorbent, single-ply material, folded in half and wetted with 0.75 ml of pure IAA. The test subject shall hang the wet towel on the hook at the top of the chamber. An IAA test swab or ampule may be substituted for the IAA wetted paper towel provided it has been demonstrated that the alternative IAA source will generate an IAA test atmosphere with a concentration equivalent to that generated by the paper towel method.

(6) Allow two minutes for the IAA test concentration to stabilize before starting the fit test exercises. This would be an appropriate time to talk with the test subject; to explain the fit test, the importance of his/her cooperation, and the purpose for the test exercises; or to demonstrate some of the exercises.

(7) If at any time during the test, the subject detects the banana-like odor of IAA, the test is failed. The subject shall quickly exit from the test chamber and leave the test area to avoid olfactory fatigue.

(8) If the test is failed, the subject shall return to the selection room and remove the respirator. The test subject shall repeat the odor sensitivity test, select and put on another respirator, return to the test area and again begin the fit test procedure described in (b) (1) through (7) above. The process continues until a respirator that fits well has been found. Should the odor sensitivity test be failed, the subject shall wait at least 5 minutes before retesting. Odor sensitivity will usually have returned by this time.

(9) If the subject passes the test, the efficiency of the test procedure shall be demonstrated by having the subject break the respirator face seal and take a breath before exiting the chamber.

(10) When the test subject leaves the chamber, the subject shall remove the saturated towel and return it to the person conducting the test, so that there is no significant IAA concentration buildup in the chamber during subsequent tests. The used towels shall be kept in a self-sealing plastic bag to keep the test area from being contaminated.

3. SACCHARIN SOLUTION AEROSOL PROTOCOL

The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

(a) Taste threshold screening. The saccharin taste threshold screening, performed without wearing a respirator, is intended to determine whether the individual being tested can detect the taste of saccharin.

(1) During threshold screening as well as during fit testing, subjects shall wear an enclosure about the head and shoulders that is approximately 12 inches in diameter by 14 inches tall with at least the front portion clear and that allows free movements of the head when a respirator is worn. An enclosure substantially similar to the 3M hood assembly, parts # FT 14 and # FT 15 combined, is adequate.

(2) The test enclosure shall have a 3⁄4 -inch (1.9 cm) hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.

(3) The test subject shall don the test enclosure. Throughout the threshold screening test, the test subject shall breathe through his/her slightly open mouth with tongue extended. The subject is instructed to report when he/she detects a sweet taste.

(4) Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the threshold check solution into the enclosure. The nozzle is directed away from the nose and mouth of the person. This nebulizer shall be clearly marked to distinguish it from the fit test solution nebulizer.

(5) The threshold check solution is prepared by dissolving 0.83 gram of sodium saccharin USP in 100 ml of warm water. It can be prepared by putting 1 ml of the fit test solution (see (b)(5) below) in 100 ml of distilled water.

(6) To produce the aerosol, the nebulizer bulb is firmly squeezed so that it collapses completely, then released and allowed to fully expand.

(7) Ten squeezes are repeated rapidly and then the test subject is asked whether the saccharin can be tasted. If the test subject reports tasting the sweet taste during the ten squeezes, the screening test is completed. The taste threshold is noted as ten regardless of the number of squeezes actually completed.

(8) If the first response is negative, ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin is tasted. If the test subject reports tasting the sweet taste during the second ten squeezes, the screening test is completed. The taste threshold is noted as twenty regardless of the number of squeezes actually completed.

(9) If the second response is negative, ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin is tasted. If the test subject reports tasting the sweet taste during the third set of ten squeezes, the screening test is completed. The taste threshold is noted as thirty regardless of the number of squeezes actually completed.

(10) The test conductor will take note of the number of squeezes required to solicit a taste response.

(11) If the saccharin is not tasted after 30 squeezes (step 10), the test subject is unable to taste saccharin and may not perform the saccharin fit test.

Note to paragraph 3(a):
If the test subject eats or drinks something sweet before the screening test, he/she may be unable to taste the weak saccharin solution.

(12) If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit test.

(13) Correct use of the nebulizer means that approximately 1 ml of liquid is used at a time in the nebulizer body.

(14) The nebulizer shall be thoroughly rinsed in water, shaken dry, and refilled at least each morning and afternoon or at least every four hours.

(b) Saccharin solution aerosol fit test procedure.

(1) The test subject may not eat, drink (except plain water), smoke, or chew gum for 15 minutes before the test.

(2) The fit test uses the same enclosure described in 3. (a) above.

(3) The test subject shall don the enclosure while wearing the respirator selected in section I. A. of this appendix. The respirator shall be properly adjusted and equipped with a particulate filter(s).

(4) A second DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent is used to spray the fit test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.

(5) The fit test solution is prepared by adding 83 grams of sodium saccharin to 100 ml of warm water.

(6) As before, the test subject shall breathe through the slightly open mouth with tongue extended, and report if he/she tastes the sweet taste of saccharin.

(7) The nebulizer is inserted into the hole in the front of the enclosure and an initial concentration of saccharin fit test solution is sprayed into the enclosure using the same number of squeezes (either 10, 20 or 30 squeezes) based on the number of squeezes required to elicit a taste response as noted during the screening test. A minimum of 10 squeezes is required.

(8) After generating the aerosol, the test subject shall be instructed to perform the exercises in section I. A. 14. of this appendix.

(9) Every 30 seconds the aerosol concentration shall be replenished using one half the original number of squeezes used initially (e.g., 5, 10 or 15).

(10) The test subject shall indicate to the test conductor if at any time during the fit test the taste of saccharin is detected. If the test subject does not report tasting the saccharin, the test is passed.

(11) If the taste of saccharin is detected, the fit is deemed unsatisfactory and the test is failed. A different respirator shall be tried and the entire test procedure is repeated (taste threshold screening and fit testing).

(12) Since the nebulizer has a tendency to clog during use, the test operator must make periodic checks of the nebulizer to ensure that it is not clogged. If clogging is found at the end of the test session, the test is invalid.

4. BITREX™ (DENATONIUM BENZOATE) SOLUTION AEROSOL QUALITATIVE FIT TEST PROTOCOL

The Bitrex™ (Denatonium benzoate) solution aerosol QLFT protocol uses the published saccharin test protocol because that protocol is widely accepted. Bitrex is routinely used as a taste aversion agent in household liquids which children should not be drinking and is endorsed by the American Medical Association, the National Safety Council, and the American Association of Poison Control Centers. The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

(a) Taste Threshold Screening.

The Bitrex taste threshold screening, performed without wearing a respirator, is intended to determine whether the individual being tested can detect the taste of Bitrex.

(1) During threshold screening as well as during fit testing, subjects shall wear an enclosure about the head and shoulders that is approximately 12 inches (30.5 cm) in diameter by 14 inches (35.6 cm) tall. The front portion of the enclosure shall be clear from the respirator and allow free movement of the head when a respirator is worn. An enclosure substantially similar to the 3M hood assembly, parts # FT 14 and # FT 15 combined, is adequate.

(2) The test enclosure shall have a 3⁄4 inch (1.9 cm) hole in front of the test subject's nose and mouth area to accommodate the nebulizer nozzle.

(3) The test subject shall don the test enclosure. Throughout the threshold screening test, the test subject shall breathe through his or her slightly open mouth with tongue extended. The subject is instructed to report when he/she detects a bitter taste.

(4) Using a DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent, the test conductor shall spray the Threshold Check Solution into the enclosure. This Nebulizer shall be clearly marked to distinguish it from the fit test solution nebulizer.

(5) The Threshold Check Solution is prepared by adding 13.5 milligrams of Bitrex to 100 ml of 5% salt (NaCl) solution in distilled water.

(6) To produce the aerosol, the nebulizer bulb is firmly squeezed so that the bulb collapses completely, and is then released and allowed to fully expand.

(7) An initial ten squeezes are repeated rapidly and then the test subject is asked whether the Bitrex can be tasted. If the test subject reports tasting the bitter taste during the ten squeezes, the screening test is completed. The taste threshold is noted as ten regardless of the number of squeezes actually completed.

(8) If the first response is negative, ten more squeezes are repeated rapidly and the test subject is again asked whether the Bitrex is tasted. If the test subject reports tasting the bitter taste during the second ten squeezes, the screening test is completed. The taste threshold is noted as twenty regardless of the number of squeezes actually completed.

(9) If the second response is negative, ten more squeezes are repeated rapidly and the test subject is again asked whether the Bitrex is tasted. If the test subject reports tasting the bitter taste during the third set of ten squeezes, the screening test is completed. The taste threshold is noted as thirty regardless of the number of squeezes actually completed.

(10) The test conductor will take note of the number of squeezes required to solicit a taste response.

(11) If the Bitrex is not tasted after 30 squeezes (step 10), the test subject is unable to taste Bitrex and may not perform the Bitrex fit test.

(12) If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit test.

(13) Correct use of the nebulizer means that approximately 1 ml of liquid is used at a time in the nebulizer body.

(14) The nebulizer shall be thoroughly rinsed in water, shaken to dry, and refilled at least each morning and afternoon or at least every four hours.

(b) Bitrex Solution Aerosol Fit Test Procedure.

(1) The test subject may not eat, drink (except plain water), smoke, or chew gum for 15 minutes before the test.

(2) The fit test uses the same enclosure as that described in 4. (a) above.

(3) The test subject shall don the enclosure while wearing the respirator selected according to section I. A. of this appendix. The respirator shall be properly adjusted and equipped with any type particulate filter(s).

(4) A second DeVilbiss Model 40 Inhalation Medication Nebulizer or equivalent is used to spray the fit test solution into the enclosure. This nebulizer shall be clearly marked to distinguish it from the screening test solution nebulizer.

(5) The fit test solution is prepared by adding 337.5 mg of Bitrex to 200 ml of a 5% salt (NaCl) solution in warm water.

(6) As before, the test subject shall breathe through his or her slightly open mouth with tongue extended, and be instructed to report if he/she tastes the bitter taste of Bitrex.

(7) The nebulizer is inserted into the hole in the front of the enclosure and an initial concentration of the fit test solution is sprayed into the enclosure using the same number of squeezes (either 10, 20 or 30 squeezes) based on the number of squeezes required to elicit a taste response as noted during the screening test.

(8) After generating the aerosol, the test subject shall be instructed to perform the exercises in section I. A. 14. of this appendix.

(9) Every 30 seconds the aerosol concentration shall be replenished using one half the number of squeezes used initially (e.g., 5, 10 or 15).

(10) The test subject shall indicate to the test conductor if at any time during the fit test the taste of Bitrex is detected. If the test subject does not report tasting the Bitrex, the test is passed.

(11) If the taste of Bitrex is detected, the fit is deemed unsatisfactory and the test is failed. A different respirator shall be tried and the entire test procedure is repeated (taste threshold screening and fit testing).

5. IRRITANT SMOKE (STANNIC CHLORIDE) PROTOCOL

This qualitative fit test uses a person's response to the irritating chemicals released in the “smoke” produced by a stannic chloride ventilation smoke tube to detect leakage into the respirator.

(a) General Requirements and Precautions

(1) The respirator to be tested shall be equipped with high efficiency particulate air (HEPA) or P100 series filter(s).

(2) Only stannic chloride smoke tubes shall be used for this protocol.

(3) No form of test enclosure or hood for the test subject shall be used.

(4) The smoke can be irritating to the eyes, lungs, and nasal passages. The test conductor shall take precautions to minimize the test subject's exposure to irritant smoke. Sensitivity varies, and certain individuals may respond to a greater degree to irritant smoke. Care shall be taken when performing the sensitivity screening checks that determine whether the test subject can detect irritant smoke to use only the minimum amount of smoke necessary to elicit a response from the test subject.

(5) The fit test shall be performed in an area with adequate ventilation to prevent exposure of the person conducting the fit test or the build-up of irritant smoke in the general atmosphere.

(b) Sensitivity Screening Check

The person to be tested must demonstrate his or her ability to detect a weak concentration of the irritant smoke.

(1) The test operator shall break both ends of a ventilation smoke tube containing stannic chloride, and attach one end of the smoke tube to a low flow air pump set to deliver 200 milliliters per minute, or an aspirator squeeze bulb. The test operator shall cover the other end of the smoke tube with a short piece of tubing to prevent potential injury from the jagged end of the smoke tube.

(2) The test operator shall advise the test subject that the smoke can be irritating to the eyes, lungs, and nasal passages and instruct the subject to keep his/her eyes closed while the test is performed.

(3) The test subject shall be allowed to smell a weak concentration of the irritant smoke before the respirator is donned to become familiar with its irritating properties and to determine if he/she can detect the irritating properties of the smoke. The test operator shall carefully direct a small amount of the irritant smoke in the test subject's direction to determine that he/she can detect it.

(c) Irritant Smoke Fit Test Procedure

(1) The person being fit tested shall don the respirator without assistance, and perform the required user seal check(s).

(2) The test subject shall be instructed to keep his/her eyes closed.

(3) The test operator shall direct the stream of irritant smoke from the smoke tube toward the faceseal area of the test subject, using the low flow pump or the squeeze bulb. The test operator shall begin at least 12 inches from the facepiece and move the smoke stream around the whole perimeter of the mask. The operator shall gradually make two more passes around the perimeter of the mask, moving to within six inches of the respirator.

(4) If the person being tested has not had an involuntary response and/or detected the irritant smoke, proceed with the test exercises.

(5) The exercises identified in section I.A. 14. of this appendix shall be performed by the test subject while the respirator seal is being continually challenged by the smoke, directed around the perimeter of the respirator at a distance of six inches.

(6) If the person being fit tested reports detecting the irritant smoke at any time, the test is failed. The person being retested must repeat the entire sensitivity check and fit test procedure.

(7) Each test subject passing the irritant smoke test without evidence of a response (involuntary cough, irritation) shall be given a second sensitivity screening check, with the smoke from the same smoke tube used during the fit test, once the respirator has been removed, to determine whether he/she still reacts to the smoke. Failure to evoke a response shall void the fit test.

(8) If a response is produced during this second sensitivity check, then the fit test is passed.

C. Quantitative Fit Test (QNFT) Protocols

The following quantitative fit testing procedures have been demonstrated to be acceptable: Quantitative fit testing using a non-hazardous test aerosol (such as corn oil, polyethylene glycol 400 [PEG 400], di-2-ethyl hexyl sebacate [DEHS], or sodium chloride) generated in a test chamber, and employing instrumentation to quantify the fit of the respirator; Quantitative fit testing using ambient aerosol as the test agent and appropriate instrumentation (condensation nuclei counter) to quantify the respirator fit; Quantitative fit testing using controlled negative pressure and appropriate instrumentation to measure the volumetric leak rate of a facepiece to quantify the respirator fit.

1. GENERAL

(a) The employer shall ensure that persons administering QNFT are able to calibrate equipment and perform tests properly, recognize invalid tests, calculate fit factors properly and ensure that test equipment is in proper working order.

(b) The employer shall ensure that QNFT equipment is kept clean, and is maintained and calibrated according to the manufacturer's instructions so as to operate at the parameters for which it was designed.

2. GENERATED AEROSOL QUANTITATIVE FIT TESTING PROTOCOL

(a) Apparatus.

(1) Instrumentation. Aerosol generation, dilution, and measurement systems using particulates (corn oil, polyethylene glycol 400 [PEG 400], di-2-ethyl hexyl sebacate [DEHS] or sodium chloride) as test aerosols shall be used for quantitative fit testing.

(2) Test chamber. The test chamber shall be large enough to permit all test subjects to perform freely all required exercises without disturbing the test agent concentration or the measurement apparatus. The test chamber shall be equipped and constructed so that the test agent is effectively isolated from the ambient air, yet uniform in concentration throughout the chamber.

(3) When testing air-purifying respirators, the normal filter or cartridge element shall be replaced with a high efficiency particulate air (HEPA) or P100 series filter supplied by the same manufacturer.

(4) The sampling instrument shall be selected so that a computer record or strip chart record may be made of the test showing the rise and fall of the test agent concentration with each inspiration and expiration at fit factors of at least 2,000. Integrators or computers that integrate the amount of test agent penetration leakage into the respirator for each exercise may be used provided a record of the readings is made.

(5) The combination of substitute air-purifying elements, test agent and test agent concentration shall be such that the test subject is not exposed in excess of an established exposure limit for the test agent at any time during the testing process, based upon the length of the exposure and the exposure limit duration.

(6) The sampling port on the test specimen respirator shall be placed and constructed so that no leakage occurs around the port (e.g., where the respirator is probed), a free

air flow is allowed into the sampling line at all times, and there is no interference with the fit or performance of the respirator. The in-mask sampling device (probe) shall be designed and used so that the air sample is drawn from the breathing zone of the test subject, midway between the nose and mouth and with the probe extending into the facepiece cavity at least 1⁄4 inch.

(7) The test setup shall permit the person administering the test to observe the test subject inside the chamber during the test.

(8) The equipment generating the test atmosphere shall maintain the concentration of test agent constant to within a 10 percent variation for the duration of the test.

(9) The time lag (interval between an event and the recording of the event on the strip chart or computer or integrator) shall be kept to a minimum. There shall be a clear association between the occurrence of an event and its being recorded.

(10) The sampling line tubing for the test chamber atmosphere and for the respirator sampling port shall be of equal diameter and of the same material. The length of the two lines shall be equal.

(11) The exhaust flow from the test chamber shall pass through an appropriate filter (i.e., high efficiency particulate filter) before release.

(12) When sodium chloride aerosol is used, the relative humidity inside the test chamber shall not exceed 50 percent.

(13) The limitations of instrument detection shall be taken into account when determining the fit factor.

(14) Test respirators shall be maintained in proper working order and be inspected regularly for deficiencies such as cracks or missing valves and gaskets.

(b) Procedural Requirements.

(1) When performing the initial user seal check using a positive or negative pressure check, the sampling line shall be crimped closed in order to avoid air pressure leakage during either of these pressure checks.

(2) The use of an abbreviated screening QLFT test is optional. Such a test may be utilized in order to quickly identify poor fitting respirators that passed the positive

and/or negative pressure test and reduce the amount of QNFT time. The use of the CNC QNFT instrument in the count mode is another optional method to obtain a quick estimate of fit and eliminate poor fitting respirators before going on to perform a full QNFT.

(3) A reasonably stable test agent concentration shall be measured in the test chamber prior to testing. For canopy or shower curtain types of test units, the determination of the test agent's stability may be established after the test subject has entered the test environment.

(4) Immediately after the subject enters the test chamber, the test agent concentration inside the respirator shall be measured to ensure that the peak penetration does not exceed 5 percent for a half mask or 1 percent for a full facepiece respirator.

(5) A stable test agent concentration shall be obtained prior to the actual start of testing.

(6) Respirator restraining straps shall not be over-tightened for testing. The straps shall be adjusted by the wearer without assistance from other persons to give a reasonably comfortable fit typical of normal use. The respirator shall not be adjusted once the fit test exercises begin.

(7) The test shall be terminated whenever any single peak penetration exceeds 5 percent for half masks and 1 percent for full facepiece respirators. The test subject shall be refitted and retested.

(8) Calculation of fit factors.

(i) The fit factor shall be determined for the quantitative fit test by taking the ratio of the average chamber concentration to the concentration measured inside the respirator for each test exercise except the grimace exercise.

(ii) The average test chamber concentration shall be calculated as the arithmetic average of the concentration measured before and after each test (i.e., 7 exercises) or the arithmetic average of the concentration measured before and after each exercise or the true average measured continuously during the respirator sample.

(iii) The concentration of the challenge agent inside the respirator shall be determined by one of the following methods:

(A) Average peak penetration method means the method of determining test agent penetration into the respirator utilizing a strip chart recorder, integrator, or computer. The agent penetration is determined by an average of the peak heights on the graph or by computer integration, for each exercise except the grimace exercise. Integrators or computers that calculate the actual test agent penetration into the respirator for each exercise will also be considered to meet the requirements of the average peak penetration method.

(B) Maximum peak penetration method means the method of determining test agent penetration in the respirator as determined by strip chart recordings of the test. The highest peak penetration for a given exercise is taken to be representative of average penetration into the respirator for that exercise.

(C) Integration by calculation of the area under the individual peak for each exercise except the grimace exercise. This includes computerized integration.

(D) The calculation of the overall fit factor using individual exercise fit factors involves first converting the exercise fit factors to penetration values, determining the average, and then converting that result back to a fit factor. This procedure is described in the following equation:

$$\text{Overall Fit Factor} = \frac{\text{Number of exercises}}{1/ff_1 + 1/ff_2 + 1/ff_3 + 1/ff_4 + 1/ff_5 + 1/ff_7 + 1/ff_8}$$

Where ff_1, ff_2, ff_3, etc. are the fit factors for exercises 1, 2, 3, etc.

(9) The test subject shall not be permitted to wear a half mask or quarter facepiece respirator unless a minimum fit factor of 100 is obtained, or a full facepiece respirator unless a minimum fit factor of 500 is obtained.

(10) Filters used for quantitative fit testing shall be replaced whenever increased breathing resistance is encountered, or when the test agent has altered the integrity of the filter media.

3. AMBIENT AEROSOL CONDENSATION NUCLEI COUNTER (CNC) QUANTITATIVE FIT TESTING PROTOCOL.

The ambient aerosol condensation nuclei counter (CNC) quantitative fit testing (PortaCount®) protocol quantitatively fit tests respirators with the use of a probe. The probed respirator is only used for quantitative fit tests. A probed respirator has a special sampling device, installed on the respirator, that allows the probe to sample the air from inside the mask. A probed respirator is required for each make, style, model, and size that the employer uses and can be obtained from the respirator manufacturer or distributor. The primary CNC instrument manufacturer, TSI Incorporated, also provides probe attachments (TSI mask sampling adapters) that permit fit testing in an employee's own respirator. A minimum fit factor pass level of at least 100 is necessary for a half-mask respirator (elastomeric or filtering facepiece), and a minimum fit factor pass level of at least 500 is required for a full-facepiece elastomeric respirator. The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

(a) PortaCount® Fit Test Requirements. (1) Check the respirator to make sure the sampling probe and line are properly attached to the facepiece and that the respirator is fitted with a particulate filter capable of preventing significant penetration by the ambient particles used for the fit test (e.g., NIOSH 42 CFR 84 series 100, series 99, or series 95 particulate filter) per manufacturer's instruction.

(2) Instruct the person to be tested to don the respirator for five minutes before the fit test starts. This purges the ambient particles trapped inside the respirator and permits the wearer to make certain the respirator is comfortable. This individual shall already have been trained on how to wear the respirator properly.

(3) Check the following conditions for the adequacy of the respirator fit: Chin properly placed; Adequate strap tension, not overly tightened; Fit across nose bridge; Respirator of proper size to span distance from nose to chin; Tendency of the respirator to slip; Self-observation in a mirror to evaluate fit and respirator position.

(4) Have the person wearing the respirator do a user seal check. If leakage is detected, determine the cause. If leakage is from a poorly fitting facepiece, try another size of the same model respirator, or another model of respirator.

(5) Follow the manufacturer's instructions for operating the Portacount® and proceed with the test.

(6) The test subject shall be instructed to perform the exercises in section I. A. 14. of this appendix.

(7) After the test exercises, the test subject shall be questioned by the test conductor regarding the comfort of the respirator upon completion of the protocol. If it has become unacceptable, another model of respirator shall be tried.

(b) PortaCount® Test Instrument.

(1) The PortaCount® will automatically stop and calculate the overall fit factor for the entire set of exercises. The overall fit factor is what counts. The Pass or Fail message will indicate whether or not the test was successful. If the test was a Pass, the fit test is over.

(2) Since the pass or fail criterion of the PortaCount® is user programmable, the test operator shall ensure that the pass or fail criterion meet the requirements for minimum respirator performance in this Appendix.

(3) A record of the test needs to be kept on file, assuming the fit test was successful. The record must contain the test subject's name; overall fit factor; make, model, style, and size of respirator used; and date tested.

4. MODIFIED AMBIENT AEROSOL CONDENSATION NUCLEI COUNTER (CNC) QUANTITATIVE FIT TESTING PROTOCOL FOR FULL-FACEPIECE AND HALF-MASK ELASTOMERIC RESPIRATORS.

(a) When administering this protocol to test subjects, employers shall comply with the requirements specified in Part I.C.3 of this appendix (ambient aerosol condensation nuclei counter (CNC) quantitative fit testing protocol), except they shall use the test exercises described below in paragraph (b) of this protocol instead of the test exercises specified in section I.C.3(a)(6) of this appendix.

(b) Employers shall ensure that each test subject being fit tested using this protocol follows the exercise and duration procedures, including the order of administration, described in Table A-1 of this appendix.

Table A-1 - Modified Ambient Aerosal CNC Quantitative Fit Testing Protocol for Full Facepiece and Half-Mask Elastomeric Respirators

Exercises[1]	Exercise procedure	Measurement procedure
Bending Over	The test subject shall bend at the waist, as if going to touch his/her toes for 50 seconds and inhale 2 times at the bottom[2]	A 20 second ambient sample, followed by a 30 second mask sample.
Jogging-in-Place	The test subject shall jog in place comfortably for 30 seconds	A 30 second mask sample.
Head Side-to-Side	The test subject shall stand in place, slowly turning his/her head from side to side for 30 seconds and inhale 2 times at each extreme[2]	A 30 second mask sample.
Head Up-and-Down	The test subject shall stand in place, slowly moving his/her head up and down for 39 seconds and inhale 2 times at each extreme[2]	A 30 second mask sample followed by a 9 second ambient sample.

[1]Exercises are listed in the order in which they are to be administered.

[2]It is optional for test subjects to take additional breaths at other times during this exercise.

5. MODIFIED AMBIENT AEROSOL CONDENSATION NUCLEI COUNTER (CNC) QUANTITATIVE FIT TESTING PROTOCOL FOR FILTERING FACEPIECE RESPIRATORS.

(a) When administering this protocol to test subjects, employers shall comply with the requirements specified in Part I.C.3 of this appendix (ambient aerosol condensation nuclei counter (CNC) quantitative fit testing protocol), except they shall use the test exercises described below in paragraph (b) of this protocol instead of the test exercises specified in section I.C.3(a)(6) of this appendix.

(b) Employers shall ensure that each test subject being fit tested using this protocol follows the exercise and duration procedures, including the order of administration, described in Table A-2 of this appendix.

Table A-2 - Modified Ambient Aerosal CNC Quantitative Fit Testing Protocol for Filtering Facepiece Respirators

Exercises[1]	Exercise procedure	Measurement procedure
Bending Over	The test subject shall bend at the waist, as if going to touch his/her toes for 50 seconds and inhale 2 times at the bottom[2]	A 20 second ambient sample, followed by a 30 second mask sample.
Talking	The test subject shall talk out loud slowly and loud enough so as to be heard clearly by the test conductor for 30 seconds. He/she will either read from a prepared text such as the Rainbow Passage, count backward from 100, or recite a memorized poem or song	A 30 second mask sample.
Head Side-to-Side	The test subject shall stand in place, slowly turning his/her head from side to side for 30 seconds and inhale 2 times at each extreme[2]	A 30 second mask sample.

Exercises[1]	Exercise procedure	Measurement procedure
Head Up-and-Down	The test subject shall stand in place, slowly moving his/her head up and down for 39 seconds and inhale 2 times at each extreme[2]	A 30 second mask sample followed by a 9 second ambient sample.

[1]Exercises are listed in the order in which they are to be administered.

[2]It is optional for test subjects to take additional breaths at other times during this exercise.

6. CONTROLLED NEGATIVE PRESSURE (CNP) QUANTITATIVE FIT TESTING PROTOCOL.

The CNP protocol provides an alternative to aerosol fit test methods. The CNP fit test method technology is based on exhausting air from a temporarily sealed respirator facepiece to generate and then maintain a constant negative pressure inside the facepiece. The rate of air exhaust is controlled so that a constant negative pressure is maintained in the respirator during the fit test. The level of pressure is selected to replicate the mean inspiratory pressure that causes leakage into the respirator under normal use conditions. With pressure held constant, air flow out of the respirator is equal to air flow into the respirator. Therefore, measurement of the exhaust stream that is required to hold the pressure in the temporarily sealed respirator constant yields a direct measure of leakage air flow into the respirator. The CNP fit test method measures leak rates through the facepiece as a method for determining the facepiece fit for negative pressure respirators. The CNP instrument manufacturer Occupational Health Dynamics of Birmingham, Alabama also provides attachments (sampling manifolds) that replace the filter cartridges to permit fit testing in an employee's own respirator. To perform the test, the test subject closes his or her mouth and holds his/her breath, after which an air pump removes air from the respirator facepiece at a pre-selected constant pressure. The facepiece fit is expressed as the leak rate through the facepiece, expressed as milliliters per minute. The quality and validity of the CNP fit tests are determined by the degree to which the in-mask pressure tracks the test pressure during the system measurement time of approximately five seconds. Instantaneous feedback in the form of a real-time pressure trace of the in-mask pressure is provided and used to determine test validity and quality. A minimum fit factor pass level of 100 is necessary for a half-mask respirator and a minimum fit factor of at least 500 is required for a full facepiece respirator. The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

(a) CNP Fit Test Requirements.

(1) The instrument shall have a non-adjustable test pressure of 15.0 mm water pressure.

(2) The CNP system defaults selected for test pressure shall be set at −15 mm of water (-0.58 inches of water) and the modeled inspiratory flow rate shall be 53.8 liters per minute for performing fit tests.

Note:
CNP systems have built-in capability to conduct fit testing that is specific to unique work rate, mask, and gender situations that might apply in a specific workplace. Use of system default values, which were selected to represent respirator wear with medium cartridge resistance at a low-moderate work rate, will allow inter-test comparison of the respirator fit.)

(3) The individual who conducts the CNP fit testing shall be thoroughly trained to perform the test.

(4) The respirator filter or cartridge needs to be replaced with the CNP test manifold. The inhalation valve downstream from the manifold either needs to be temporarily removed or propped open.

(5) The employer must train the test subject to hold his or her breath for at least 10 seconds.

(6) The test subject must don the test respirator without any assistance from the test administrator who is conducting the CNP fit test. The respirator must not be adjusted once the fit-test exercises begin. Any adjustment voids the test, and the test subject must repeat the fit test.

(7) The QNFT protocol shall be followed according to section I. C. 1. of this appendix with an exception for the CNP test exercises.

(b) CNP Test Exercises.

(1) Normal breathing. In a normal standing position, without talking, the subject shall breathe normally for 1 minute. After the normal breathing exercise, the subject needs to hold head straight ahead and hold his or her breath for 10 seconds during the test measurement.

(2) Deep breathing. In a normal standing position, the subject shall breathe slowly and deeply for 1 minute, being careful not to hyperventilate. After the deep breathing exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during test measurement.

(3) Turning head side to side. Standing in place, the subject shall slowly turn his or her head from side to side between the extreme positions on each side for 1 minute. The head shall be held at each extreme momentarily so the subject can inhale at each side. After the turning head side to side exercise, the subject needs to hold head full left and hold his or her breath for 10 seconds during test measurement. Next, the subject needs to hold head full right and hold his or her breath for 10 seconds during test measurement.

(4) Moving head up and down. Standing in place, the subject shall slowly move his or her head up and down for 1 minute. The subject shall be instructed to inhale in the up position (i.e., when looking toward the ceiling). After the moving head up and down exercise, the subject shall hold his or her head full up and hold his or her breath for 10 seconds during test measurement. Next, the subject shall hold his or her head full down and hold his or her breath for 10 seconds during test measurement.

(5) Talking. The subject shall talk out loud slowly and loud enough so as to be heard clearly by the test conductor. The subject can read from a prepared text such as the Rainbow Passage, count backward from 100, or recite a memorized poem or song for 1 minute. After the talking exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement.

(6) Grimace. The test subject shall grimace by smiling or frowning for 15 seconds.

(7) Bending Over. The test subject shall bend at the waist as if he or she were to touch his or her toes for 1 minute. Jogging in place shall be substituted for this exercise in those test environments such as shroud-type QNFT units that prohibit bending at the waist. After the bending over exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement.

(8) Normal Breathing. The test subject shall remove and re-don the respirator within a one-minute period. Then, in a normal standing position, without talking, the subject shall breathe normally for 1 minute. After the normal breathing exercise, the subject shall hold his or her head straight ahead and hold his or her breath for 10 seconds during the test measurement. After the test exercises, the test subject shall be questioned by the test conductor regarding the comfort of the respirator upon completion of the protocol. If it has become unacceptable, another model of a respirator shall be tried.

(c) CNP Test Instrument.

(1) The test instrument must have an effective audio-warning device, or a visual-warning device in the form of a screen tracing, that indicates when the test subject fails to hold his or her breath during the test. The test must be terminated and restarted from the beginning when the test subject fails to hold his or her breath during the test. The test subject then may be refitted and retested.

(2) A record of the test shall be kept on file, assuming the fit test was successful. The record must contain the test subject's name; overall fit factor; make, model, style and size of respirator used; and date tested.

7. CONTROLLED NEGATIVE PRESSURE (CNP) REDON QUANTITATIVE FIT TESTING PROTOCOL.

(a) When administering this protocol to test subjects, employers must comply with the requirements specified in paragraphs (a) and (c) of part I.C.6 of this appendix (“Controlled negative pressure (CNP) quantitative fit testing protocol,”) as well as use the test exercises described below in paragraph (b) of this protocol instead of the test exercises specified in paragraph (b) of part I.C.6 of this appendix.

(b) Employers must ensure that each test subject being fit tested using this protocol follows the exercise and measurement procedures, including the order of administration described in Table A-3 of this appendix.

Table A-3 - CNP REDON Quantitative Fit Testing Protocol

Exercises[1]	Exercise procedure	Measurement procedure
Facing Forward	Stand and breathe normally, without talking, for 30 seconds	Face forward, while holding breath for 10 seconds.
Bending Over	Bend at the waist, as if going to touch his or her toes, for 30 seconds	Face parallel to the floor, while holding breath for 10 seconds
Head Shaking	For about three seconds, shake head back and forth vigorously several times while shouting	Face forward, while holding breath for 10 seconds
REDON 1	Remove the respirator mask, loosen all facepiece straps, and then redon the respirator mask	Face forward, while holding breath for 10 seconds.
REDON 2	Remove the respirator mask, loosen all facepiece straps, and then redon the respirator mask again	Face forward, while holding breath for 10 seconds.

[1]Exercises are listed in the order in which they are to be administered.

(c) After completing the test exercises, the test administrator must question each test subject regarding the comfort of the respirator. When a test subject states that the respirator is unacceptable, the employer must ensure that the test administrator repeats the protocol using another respirator model.

(d) Employers must determine the overall fit factor for each test subject by calculating the harmonic mean of the fit testing exercises as follows:

$$\text{Overall Fit Factor} = \frac{N}{[1/FF_1 + 1/FF_2 + \ldots\ 1/FF_N]}$$

Where:

N = The number of exercises;

FF_1 = The fit factor for the first exercise;

FF_2 = The fit factor for the second exercise; and

FF_N = The fit factor for the nth exercise.

Part II. New Fit Test Protocols

A. Any person may submit to OSHA an application for approval of a new fit test protocol. If the application meets the following criteria, OSHA will initiate a rulemaking proceeding under section 6(b)(7) of the OSH Act to determine whether to list the new protocol as an approved protocol in this appendix A.

B. The application must include a detailed description of the proposed new fit test protocol. This application must be supported by either:

1. A test report prepared by an independent government research laboratory (e.g., Lawrence Livermore National Laboratory, Los Alamos National Laboratory, the National Institute for Standards and Technology) stating that the laboratory has tested the protocol and had found it to be accurate and reliable; or

2. An article that has been published in a peer-reviewed industrial hygiene journal describing the protocol and explaining how test data support the protocol's accuracy and reliability.

C. If OSHA determines that additional information is required before the Agency commences a rulemaking proceeding under this section, OSHA will so notify the applicant and afford the applicant the opportunity to submit the supplemental information. Initiation of a rulemaking proceeding will be deferred until OSHA has received and evaluated the supplemental information.

[63 FR 20098, April 23, 1998; 69 FR 46993, August 4, 2004]