Laboratory Safety Manual

Department of Materials Science and Engineering
The Ohio State University

updated 5/28/15

Emergency: phone 9 1 1

(Campus Police, non-emergency…(29)2-2121)

Watts Hall:	**2041 College Rd.**
MacQuigg Labs:	**105 W. Woodruff Ave.**
Fontana Labs:	**116 W. 19th Ave.**
Koffolt Labs:	**140 W. 19th Ave.**
EJTC:	**1248 Arthur Adams Dr.**

Building Supervisor: *Ken Kushner*
(.8), (29)2-7128, 069A MacQuigg Labs

Safety Officers:

- *MSE: Steve Bright (.30)*
  (68)8-3021
  244 MacQuigg
  - Gas cylinders
  - Equipment inventory
  - Hard trash pickup
  - Surplus material pickup
- *WE: Ed Pfeifer (.17)*
  (29)2-4139
  106 EJTC

Office of Environmental Health & Safety
(29)2-1284
www.ehs.ohio-state.edu/

Office of Radiation Safety
(29)2-1284
240-0705 (emergency pager)

OSU Emergency Information:
ap.osu.edu/emergency/
(provides emergency information during crisis situations)

Emergency Operations and Evacuation Plan (EOEP)
available in 177 Watts Hall

Materials Safety Data Sheets (MSDS) available in 177 Watts Hall and on-line at **ehs.osu.edu**

Notes:

Preface and Acknowledgments

This manual contains a number of guidelines which can help all of us perform our research tasks more safely and maintain better order and safety in our laboratories. Each graduate student is expected to read this manual thoroughly and act in accord with the guidelines. This manual should also be kept available for future reference.

One of the most fundamental aspects of safety in research is good laboratory housekeeping. This includes the proper storage and handling of chemicals, gas cylinders, electrical equipment and so on. The appearance and organization of our facilities directly affects their safety and productivity as well as our departmental reputation. There are two golden rules in developing a safe and productive environment:

1) Whenever you use a lab, it is your responsibility to see that unsafe conditions are corrected immediately; and
2) Always leave a laboratory in better condition than you found it.

If we all take this level of personal responsibility, our facilities can only improve.

The text of this safety manual borrows extensively from one issued by the Department of Materials Science and Engineering at Penn State. Their manual was in turn based on one developed at MIT. Rules specific to our University were taken from our Department Procedures Guidelines and Information provided by the Department of Occupational Health and Safety.

We hope to periodically update and revise this manual to make it more useful and more effective. Hence, if you have any comments or additional information which should be added to make this manual more comprehensive or user friendly, I would very much appreciate hearing them.

Here's hoping you stay safe and productive,

MSE Lab Safety Committee
December, 1990 1st edition.
September, 1993 2d edition.
September, 1995 3d edition.
September, 2001 4th edition.
September, 2003 5th edition.

Contents

NOTE: The MSE Department's Emergency Operations and Evacuation Plan (EOEP) is available for review in room 177 Watts Hall.

I. INTRODUCTION

Safety in the laboratory requires the same kind of continuing attention and effort that is given to research and teaching. The use of new and/or different techniques, chemicals, and equipment requires careful preparation. Reading, instruction, and supervision may be required, possibly in consultation with other people who have special knowledge or experience. Each individual who works in a laboratory has a responsibility to learn the health and safety hazards associated with the materials to be used or produced, and with the equipment to be employed.

It is important for you to know what is expected of you and what your responsibilities are with regard to safety to yourself, your colleagues and our environment. In addition, there are safety practices and safety equipment with which you must be thoroughly familiar if you are to work safely in the laboratory. This manual should be used as a guide to the general types of hazards and a reference source for more specific information pertinent to each individual project.

Our Safety Program incorporates only a few principles, but each one is essential. These principles are:

1) Practice Safety

One problem concerning the practice of safety is that it is a subjective matter. For example, some people consider smoking safe while others do not. In order to have an effective safety program, some common ground rules must be established. This is the main purpose of this Safety Manual. Some of the more basic safety practices that you are expected to follow are:

- **a)** Wear appropriate eye protection whenever working with any potential eye hazards (safety glasses, chemical goggles and face shields are available in the Chemistry Store, if not in your laboratory).
- **b)** Use a hood for hazardous, volatile, and noxious chemicals.
- **c)** Label an experiment to show its associated dangers and the persons to contact in case of a problem. There should also be an up-to-date card posted visibly outside each room listing the responsible persons to call in the event of problems in the room.
- **d)** You are further expected to secure all gas cylinders, to label all containers, to observe posted signs, such as no smoking, and so on.
- **e)** While the University provides safety equipment in the hallways of buildings, it is the individual's and their advisor's responsibility to provide safety equipment in the laboratories.

It does not end here, because the list is actually endless. Each situation requires its own safety practices, which you are expected to know or find out before doing an experiment.

2) Be Concerned About The Safety of Others

Your concern for safety must include the people around you. Your experiment must be safely maintained so that everyone in the area is amply protected and warned of inherent dangers. In addition, this principle of looking out for the other person should include the practice of pointing out unsafe procedures to those people committing the unsafe act. This practice could involve something as simple as reminding a friend to wear safety glasses. Another aspect of this second principle involves alerting those around you of an accident. It is your responsibility to alert personnel in the immediate vicinity of a fire or an emergency!

3) Understand the Hazards Associated with Your Particular Experiment

Prevention is the key to safety. Prior to designing any experiment, using a new piece of equipment, or handling chemicals in the laboratory, it is wise to consider the potential hazards and safety precautions involved in the work. Hazards may include toxic substances, electrical circuits, mechanical equipment, and waste chemicals. Safety precautions should include correct materials storage, proper ventilation, proper grounding of equipment, and training sessions when necessary. Whenever possible, information about the unique hazards and precautions necessary for any type work should be prepared and made available to everyone working in the lab. Material Safety Data Sheets (MSDS) and equipment manuals are important sources of information. Prior to starting any experiments, a MSDS which includes toxicological information and special handling requirements should be obtained and read for each chemical to be used. MSDS records for all chemicals in the MSE Department are on file in 177 Watts Hall; chemicals used in individual laboratories should be described by MSDS records kept in the lab, usually near the entrance to the room.

4) Know What to do in an Emergency

You must be prepared to respond quickly and precisely to an emergency. You must familiarize yourself with the laboratory you are working in, its exits, and its associated safety equipment: eyewash stations, showers, sinks, fire blankets, fire extinguishers, and spill kits. **Appendix A** of this manual contains a floor plan which pinpoints the location of each of these in Materials Science and Engineering Complex. Just a few moments spent learning the locations and use of these pieces of equipment prior to an emergency could save a life. **See also Chapter Two.**

If the emergency is of an infiltrating nature, such as a fire, gas leak, release of toxic fumes, or radiation leak, the following procedures should be followed:

- **Alert personnel in the immediate vicinity.**
- **Confine the fire or emergency, if possible.**
- **Summon aid (Dial 911).**
- **Evacuate the building.**
- **Report pertinent information to responding emergency personnel.**

5) Report Hazards or Hazardous Conditions

You must report any incidents without delay. A statement of the problem must be made to the Office of Environmental and Occupational Health and Safety (EOHS) by dialing 292-1284. The building safety officer and your supervisor/advisor should also be notified.

The remainder of this Safety Manual presents examples of hazards that you are likely to encounter in the laboratory and what you should know about them to minimize their danger to you and to others.

II. EMERGENCIES

Use of Emergency Equipment - Everyone working in OSU labs must know how to use emergency equipment such as fire extinguishers, spill kits, safety showers, and eye wash apparatus. Special training on the proper use of all types of emergency equipment is available by calling the Environmental Health and Safety office. Know where these items are located in your laboratories. A floor plan of Materials Science and Engineering Complex which pinpoints the location of safety equipment is located in **Appendix A** and in every office. If a floor plan is not hanging in a prominent position in your lab or office, place a copy of the floor plan in such a position. Safety is the responsibility of everyone.

A. Medical Emergencies

Immediately provide the minimum necessary first aid to prevent further injury to the victim. If the injury requires more than a band aid (use this as a general rule of thumb), call 911 and request assistance. Medical help will be sent to you immediately. Be prepared to describe accurately the nature of the accident and your location (see front cover for building addresses). Provide first aid within the scope of your training while waiting for professional help to arrive. It is important that you do not attempt any medical treatments with which you are unfamiliar. However, there are certain serious injuries in which time is so important that treatment must be started immediately. The proper aid is outlined below according to the type of injury. Report all injuries to your supervisor/advisor after professional help arrives.

If serious medical attention is required, you are expected to call for help by calling 911. Non-emergency victims should go to the third floor of the Student Health Center--1875 Millikin Rd, 292-2112--to the Office of Occupational Medicine.

Stoppage of Breathing

For stoppage of breathing (e.g. from electrical shock or asphyxiation), the mouth-to-mouth method of resuscitation is far superior to any other known. If the victim is found unconscious on the floor and not breathing, rescue breathing must be started at once, seconds count. Do not waste time looking around for help, **yell for help while resuscitating victim**.

Training in the techniques of mouth-to-mouth resuscitation and Cardio-Pulmonary Resuscitation (CPR) is available through the Student Health Center (292-0153 for staff only) and as a course in First Aid through the Department of Health Education (292-6116).

Severe Bleeding

Severe bleeding can almost always be controlled by firm and direct pressure on the wound with a pad or cloth. The cleaner the cloth, the better; however, in an emergency, a piece of clothing will suffice. In addition:

1. Wrap the injured to avoid shock, and call immediately for medical attention.
2. Raise the bleeding part higher than the rest of the body and continue to apply direct pressure.
3. Keep victim lying down.
4. Never use a tourniquet.

Thermal Burns

1. If the burn is minor, apply ice or cold water.
2. In case of a clothing fire:
   a. The victim should drop to the floor and roll. Do **NOT** run to a safety shower. A fire blanket, if nearby, should be used to smother the flames.
   b. After flames are extinguished, deluge the injured under a safety shower, removing any clothing contaminated with chemicals.
   c. Keep the water running on the burn for several minutes to remove heat and wash area.
   d. Place clean, soaking wet, ice-packed cloths on burned areas, and wrap to avoid shock and exposure.
   e. **Never** use a fire extinguisher on a person with burning clothing.

Chemical Burns

1. For chemical burns or splashes, immediately flush with water.
2. Apply a stream of water while removing any clothing that may have been saturated with the chemical.
3. If the splash is in the eye, flush it gently for at least fifteen minutes with clean water. Wash in a direction away from the other eye. Have aid summoned immediately!
4. If the splash is on the body, flood it with plenty of running water for at least 15 minutes. For large scale exposure have someone call an ambulance (phone 911).
5. A safety shower, hose, or faucet should be used in an emergency.
6. For chemicals spilled over a large area, quickly remove contaminated clothing while using the safety shower; treat as directed under the section thermal burns. No time should be wasted for modesty. Seconds count.

7. If safety goggles are worn during a chemical exposure to the face, leave them on until the surrounding area is thoroughly rinsed, they may be the only thing keeping the chemical out of your eyes.

Traumatic Shock

In cases of traumatic shock, or where the nature of the injury is not clear, keep the victim warm, lying down and quiet. Wait until medical assistance arrives before moving the victim. One should treat all injuries as potential shock situations, as they may turn into one. Some common symptoms of shock are cold and clammy skin, paleness, and deliria.

B. Fire

1. **Call 911 and report the location of the fire (see front cover for building addresses).**
2. Pull the hall fire alarm to evacuate the building. These hall fire alarms sound only within the building, and do not alert fire officials. You must call 911.
3. Confine or control the fire if possible.
   a. Immediately turn off gas supplies and electrical power sources.
   b. Use an appropriate extinguisher:
      i. CO_2 extinguisher for flammable liquid (Class B) or electrical (Class C) fires.
      ii. Solid chemical ($NaHCO_3$) extinguisher for paper or wood (Class A), flammable liquid (Class B), or electrical (Class C) fires.
      iii. Yellow extinguisher (MgO sand) for metal (Class D) fires.
   c. Use common sense. A fire in a beaker may often be extinguished by covering the beaker and depriving the fire of oxygen. Using a fire extinguisher on the same beaker of burning solvent may cause the solvent to splatter, increasing the hazard.
   d. If you are absolutely certain that you have extinguished the fire, call 2-2121 to report that the fire is out. The fire truck response will be cancelled, although Fire Safety officials will still come to assess the damage and to complete a report.
4. You are expected to use good judgement. Obviously, it may not be necessary to evacuate the building for a small fire in the lab. However, if there is any chance that the fire may endanger others or may cause serious damage, do not hesitate to pull the alarm. Never feel embarrassed about being over-cautious.
5. Immediately after a fire extinguisher has been used, call Fire Safety (2-2121, non-emergency phone number) to request that the fire extinguisher be recharged. They will remove the extinguisher, fill and re-seal it.
6. See the Lab Supervisor/Safety Officer to complete an 'incident report'.

Building Evacuation

As with any other public building, the Fire Code requires that a plan for the evacuation of our building complex be established. Your cooperation with the directives of the evacuation officers and floor wardens is mandatory

The procedure to be followed is as follows:

1. A continuous ringing of the fire bells located in the corridors means everyone is to leave the building.
2. Shut down and secure any laboratory equipment that is in operation.
3. Leave your laboratory. Close but do not lock the door and proceed down the nearest stairs (elevators are prohibited due to the high potential for electrical or mechanical malfunctions coupled with the increased risk of smoke inhalation.) Persons on elevators when the alarm bells sound are advised to exit at the first opportunity and evacuate via the nearest stairway and exit the building. Unless unusual conditions dictate otherwise, the best evacuation route is the nearest stairway and then out the nearest exit.
4. Go to the Emergency Evacuation Assembly point (see page 37)
5. Permission to re-enter the building will be signaled by the Door Wardens at all building entrances.
6. Do not loiter in the streets. They must be kept clear for access by emergency vehicles.

Physically Disabled Persons have the initial responsibility to request assistance. It is suggested that instructors determine, in advance, if any students require assistance during an emergency. If assistance is requested, the instructor should so advise the class without making any specific individual arrangements. Should the evacuation alarm sound, the instructor should request assistance to move the handicapped person to the nearest stairway. Unless specifically requested and considered advisable by those providing the assistance, the movement of a disabled person down a stairway is not recommended. One individual should remain with the handicapped person, if this can be done without unreasonable personal risk, while the others evacuate the building and advise the firemen of the location of the handicapped person so that the evacuation may be completed by the firemen. Elevators should not be used to move handicapped persons due to the reasons outlined above.

The first floor passageway between the shipping dock and the hallways of MacQuigg Laboratory is an access for emergency equipment. Do not block this area with equipment, supplies, waste materials, etc.

Classroom instructors are expected to interrupt class activity and advise students to evacuate the building. Students are obliged to follow emergency procedures in accordance with the

Code of Student Rights and Responsibilities. Faculty are similarly obliged by the provisions of the Ohio Revised Code as referenced in the University Operating Manual.

C. Tornado Warning

Identified by:

Emergency sirens (continuous) for **three minutes** followed by
Seven minutes silence.

A tornado warning indicates a tornado has been sighted by ground observers or has appeared on radar within Franklin County. The warning signal sounds repeatedly for the duration of the watch. The watch is considered over when there is no siren after seven minutes silence. There is no all-clear signal. An on-off siren indicates that a test of the alarm system is being carried out.

All University personnel are expected to promptly respond to the sounding of the sirens and to take the following precautions. In most university buildings the safest area is in the basement. If a basement is not available, occupants should move to the central portion of the building on the lowest floor possible, away from outside walls and glass. Large, unsupported roof structures, as typically used in auditoriums and gymnasiums, should be avoided. Personnel should anticipate the tornado warning will extend for a significant period of time, perhaps thirty minutes or longer. A battery-powered radio tuned to any local AM or FM station will provide current weather information. Personnel should not leave shelter until a period of at least ten minutes has elapsed without the sounding of the sirens, or the local news media have announced an "all clear".

Classroom instructors are expected to interrupt class activity and advise the students to move to the safest area available. Physically disabled persons should be provided assistance, if requested, on the same basis as described for building evacuations. The advisability of moving a handicapped person from one floor to another as discussed in that section applies equally to a tornado warning. It is recommended that handicapped persons be assisted to the safest area on the same floor. The decision to remain with the handicapped person would be the option of any individual providing assistance. Elevators should not be used to move handicapped persons during a tornado warning as the potential for electrical and mechanical malfunction is considered to be too high to warrant the risk.

D. Earthquake

OSU does not have an official policy for warnings or procedures for earthquakes, but it is recommended that in the event of one, you should take cover under a sturdy object (like a heavy desk). The idea is to protect yourself from falling debris if the building collapses.

Use of Emergency Equipment - Everyone working in OSU labs must know how to use emergency equipment such as fire extinguishers, spill kits, safety showers, and eye wash apparatus. Special training on the proper use of all types of emergency equipment is available by calling the Environmental Health and Safety office. Know where these items are located in your laboratories. A floor plan of Materials Science and Engineering Complex which pinpoints the location of safety equipment is located in **Appendix A** and in every office. If a floor plan is not hanging in a prominent position in your lab or office, place a copy of the floor plan in such a position. Safety is the responsibility of everyone.

For further information about the MSE Department's emergency operations, please review the Emergency Operations and Evacuation Plan (EOEP) found in 177 Watts Hall.

III. Safety Rules

A. General Laboratory Practice

1. Working alone is not good laboratory practice. An individual is advised to work only under conditions in which appropriate emergency aid is available when needed. In other words, try and work when others are around to provide help if it is needed. If others are working nearby, let them know where you will be working so that they can occasionally check on you and you can check on them.
2. Eye Protection. In all laboratories where chemicals are used there is the hazard of splashes or dust particles entering the eyes. Pressurized or vacuum vessels may explode or implode sending shrapnel through the lab. While working with electrical wiring there are hazards from molten solder and debris. When testing samples on Instrons or other equipment, pieces can chip and enter the eye. All of these activities, and many others, require the use of either safety glasses, chemical goggles or face shields. Most lab operations simply require the use of safety glasses. However, when any chemicals are being used at least chemical goggles should be used or in some cases a face shield is required. The appropriate eye protection is generally specified on the Materials Safety Data Sheets (MSDS) found with the chemical, in the lab room, or on file in 177 Watts Hall.
3. Ear Protection. The healthy ear can detect sounds ranging from 15 to 20,000 hertz. Temporary exposure to high noise levels will produce a temporary hearing loss. Long term exposure to high noise levels produces permanent hearing loss. There appears to be no hearing hazard (although possible psychological effects) to noise exposure below 80 dB. Exposure above 130 dB is hazardous and should be avoided. Ear muffs offer the highest noise attenuation, and are preferred for levels above 95 dB. Ear plugs are more comfortable and are preferred in the 80-95 dB range. If you suspect that a hearing hazard exists then notify EOHS to have the sound level measured.
4. Respiratory Protection. Use only respirators provided and/or recommended by EOHS. There are many shapes and sizes of respirators and in order to be effective it must be properly fitted. There are also a variety of cartridges available each having a specific application. Respirators should only be used following proper fitting and instruction by EOHS personnel.
5. Clothing. In situations where splashing or spills may occur it is wise to protect your body with lab coats. Goggles and face shields, splash aprons, and gloves may be needed for chemicals that are corrosive or easily absorb through the skin. Shorts and open-toed shoes are **NOT permitted** when working in the lab. Do not work in a laboratory wearing loose hair,

loose clothing or dangling jewelry. Any questions regarding appropriate protective equipment can be directed to EOHS.

6. Hand Protection. For any laboratory procedure requiring the use of gloves, make sure you are using gloves made of a material suitable for the operation. Gloves are made of a variety of materials and have specific uses, if used improperly they may not provide the necessary protection. The MSDS should specify the glove type but if in doubt call EOHS for assistance.
7. Consumption of food and beverages in laboratories where chemicals are being stored or used is not permitted.
8. Wash hands and arms prior to leaving the laboratory.

B. Chemical Safety

Care should be taken to see that chemicals are not only stored, transported and handled safely, but also that they are disposed in a way that harms neither equipment and plumbing, nor other people.

Transporting Chemicals

When chemicals are carried by hand, they should be placed in a carrying container or acid-carrying bucket to protect against breakage and spillage. Rubber buckets can be bought from the Chemistry store, if they are not available in your lab. When chemicals are transported on a wheeled cart, the cart should be stable under the load and have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly. Provisions for the safe transport of small quantities of flammable liquids include a) the use of rugged pressure-resistant, non-venting containers, b) storage during transport in a well-ventilated vehicle, and c) elimination of potential ignition sources. Chemicals should not be carried in open containers in hallways or elevators where they may be spilled.

Storage & Handling of Chemicals

Every chemical should have a specific storage space. They should not be stored on counter tops where they can be knocked over or in hoods where they interfere with proper air flow. Flammable liquids should be stored in ventilated storage cabinets. They should not be stored near ignition sources or in areas where accidental contact with strong oxidizing agents is possible. Oxidizing agents include; chromic acid, permanganates, chlorates, perchlorates, and peroxides.

1. All containers must be labeled (including such harmless items as distilled water). The label should contain the proper name of the chemical and, if appropriate, a statement of hazards

(with the most severe first), precautions, date of purchase or synthesis, and the name of the user.

2. Do not use chemicals from unlabeled containers. The need for adequate labeling extends far beyond the immediate requirements of the individual users, since they may not be present in case of fire or explosion, or when containers are broken or spilled. Also, they may no longer be associated with the laboratory years later when containers have deteriorated or otherwise lost their value. Prior to graduation each person must properly dispose of his/her waste or unwanted chemicals. All useful chemicals should be reassigned to another person who will assume responsibility. Proper labeling is extremely important as it is impossible to dispose of unlabeled chemicals.
3. Do not pipet by mouth. Never taste or smell any chemical.
4. Clean spills immediately! Small spills may be safely handled by lab personnel familiar with handling precautions for that material. EOHS has a special Hazardous Material Response Team and a fully equipped emergency vehicle to handle larger spills. If in doubt of your ability to handle the situation, evacuate the lab, close the door, and call 911 and explain the nature of the emergency.
5. Avoid direct contact with any chemical, what might be considered safe today may eventually be found to be unsafe. The first step in using any chemical should be a review of the Material Safety Data Sheet (MSDS) supplied by the manufacturer. If you happen not to have an MSDS for a particular chemical, an MSDS for all chemicals used in the MSE Dept. are also on file in 177 Watts Hall (you may also wish to check with EOHS). The chemistry warehouse also has some MSDS's on file. If both these sources fail, the local supplier of the chemical or the manufacturer should be able to provide you with an MSDS. Pay specific attention to the potential hazards and safety equipment required for working with the material. Be familiar with the proper emergency procedures recommended for the chemical in case of accidental exposure.

The following are specific examples of potentially hazardous conditions and how to prevent them.

i) Unattended chemical reactions

Take great care in setting up chemical reactions that are to be left unattended for any period of time. Note that unattended operation should be avoided if at all possible. The possible hazards that might arise from failure of a heating mantle (overheating), failure of a water cooling system (hose becoming disconnected or bursting), and failure of an exhaust (if flammable solvents or toxic gases are involved), are obvious points to check before leaving a reaction unattended. Any reaction that is left unattended should be clearly labeled as to the nature of the reaction and its

components, the possible hazards (i.e., poisonous vapors), and the name and phone number of the experimenter. A notice describing the nature of the unattended experiment, emergency procedures, and who to contact in case of emergencies should be posted on the outside of the door to the laboratory in which the experiment is being conducted.

Before beginning a chemical reaction the experimenter should have an idea of how it will proceed. Thus, ice baths can be ready if it is exothermic, a vent is available if gases are generated, automatic shutdown incorporated in the event of loss of electrical power, cooling water, etc. The experimenter should also notify his/her advisor that the experiment will be running overnight. If your research presents a hazard of chemicals being splashed into your face, locate the nearest eye bath for emergency use.

ii) Toxic hazards.

Researchers should be aware of the toxic hazards of the materials they are using, and those being used by others in their vicinity. Toxic materials may enter the body through the skin, inhalation, and/or ingestion. Care should be taken to prevent these means of entrance when handling toxic materials. A large number of common substances are acute respiratory hazards and should not be used in a confined area in large amounts. They should be used only in a hood. Some of these include; ammonium hydroxide, carbon monoxide, chlorine, fluorine, hydrochloric acid, hydrogen sulfide, and sulfur dioxide. These may form as by-products of certain reactions. Control of these by-products should be part of the experimental procedure.

iii) Acids and Bases

Acids and bases are found in most laboratories since there are a variety of applications for them. Three important hazards are associated with acids and bases: chemical burns suffered from spills, inhalation of caustic vapors, and fires or explosions caused by strongly exothermic reactions occurring when strong acids are diluted rapidly. Strong bases may often cause more severe burns than acids as they don't often provide a warning, such as a burning sensation until damage to the skin has already occurred.

1. Always dilute acids by adding them to water and not vice versa.
2. Use dilute acids and bases whenever possible.
3. Keep bottles of strong acids and bases closed when not in use since they can react with moisture in the air to form caustic fumes.
4. If acids or bases are accidentally splashed in the eye or on the skin, flush with water immediately, continue flushing for 15 minutes, and call for help.

Hydrofluoric Acid**:** Hydrogen fluoride (HF) is a very serious hazard since both its gas and solutions are extremely toxic and it is rapidly absorbed through the skin without immediate warning (such as a burning sensation), but causes long term excruciating pain and burns which take a long time to heal. Prompt removal of contaminated clothing while the injured person is being flushed with water is essential. Continuous flushing with cool water is vital until any whitening of the tissue has disappeared. Cover the exposed area with wet, iced cloths and get immediate medical help. Do not apply any ointments. In all cases of contact with HF obtain medical aid. Simple flushing with water does not remove HF deep in the tissues and additional treatment is required.

Perchloric Acid and Perchlorates**:** Cold perchloric acid has the properties of a strong acid. When hot it is also a strong oxidizing and dehydrating agent. It becomes unstable with time and will detonate under shock. Perchlorate compounds will often explode from heating, or from contact with flame, by impact, or friction, or spontaneously. Perchloric acid forms explosive compounds with both organic and inorganic chemicals. Because of this, it must be used in a special ventilation hood equipped with water spray and wash down in which no other types of chemical reactions have ever been vented, and which is not lubricated with organic lubricants. It is imperative that no one attempts to store or use perchloric acid or perchlorate compounds without the prior knowledge, instruction, and supervision or approval of your advisor/supervisor. A safety review by the safety officer and selected faculty prior to experimentation is recommended.

iv) Organic Solvents

Many organic solvents possess harmful vapors or pose health hazards because they can be easily absorbed through the skin. Most solvents are quite volatile and the vapors are flammable. Always refer to the MSDS of a solvent before using it to become aware of the hazards, safety precautions, and emergency procedures associated with that specific solvent. Always store them according to the guidelines for storage of flammable liquids. A few examples of the hazards of some common solvents are provided below, but this list is by no means complete.

Acetone — Possesses toxic and flammable vapors. Use proper ventilation, safety glasses, and gloves. Store in a flammable liquids storage area.

Methanol — Possesses harmful vapors that can cause dizziness, central nervous system depression, and shortness of breath. Severe exposure can lead to coma and eventually death. Less severe exposure can cause blurring of vision, conjunctivitis,

headaches, gastrointestinal disturbances, and definite eye lesions. Methanol should be used in a ventilation hood and neoprene gloves should be worn.

Benzene — Carcinogenic. Chronic poisoning can occur by inhalation of relatively small amounts over a long time. Can also be absorbed through the skin. Vapors are flammable and it should be stored in a flammable liquids storage area.

Ethers — Ethyl ether, isopropyl ether, dioxane, tetrahydrofuran and many other ethers tend to absorb and react with oxygen from the air to form unstable peroxides which may detonate with extreme violence when they become concentrated by evaporation or distillation, when combined with other compounds that give a mixture that can be detonated, or when disturbed by unusual heat, shock or friction (sometimes as little as unscrewing the bottle cap). This class of compounds should be avoided if there is a safer alternative. It is generally recommended that ethers which will form peroxides should be stored in full, airtight, amber glass bottles, preferably in the dark, or in metal containers. Although ethyl ether is frequently stored under refrigeration (explosion proof), there is no evidence that refrigerated storage will prevent formation of peroxides. Furthermore, leaks can result in explosive mixtures even in refrigerators, since the flash point of ethyl ether is -45°C (-49°F).

v) High Energy Oxidizers

Very small amount of strong oxidizers (0.25g) can result in severe explosions and must be handled with the proper protective equipment, such as: protective clothing, leather gloves and face shields. Larger amounts require special procedures involving explosion barriers. Specific procedures are included in the MSDS for the chemical or available by discussion with EH&S personnel.

vi) Powders

Most ceramic materials are considered inert with the human body however submicron particles in the lungs may cause respiratory irritation. Whenever working with fine powders correct respiratory protection is recommended. Cloth dust masks available in the stockroom are not appropriate for work with extremely fine powders. Some powders such as SiO_2, cause lung diseases such as silicosis. BeO and PbO are considered extremely toxic and must be handled with great care. If possible use powders in a hood so as to not contaminate the laboratory. The specific requirements for each powder are generally listed on the MSDS. Some fine powders are pyrophoric and may explode when dispersed in air.

vii) Whiskers and Fibers

Since the cancer causing nature of asbestos was discovered, other mineral and ceramic fibers are under suspicion for their health hazards. It is not well known whether this health risk involves a chemical or physical reaction in the body. Fibers and whiskers must be handled with care so that they may not be inhaled or brought into contact with the skin.

viii) Note: Many other compounds have serious hazards associated with them. You should make it a point to learn about the proper handling of the compounds that you use.

Disposal of Chemicals

i) Organic Solvents

Contaminated organic solvents such as acetone, alcohol, MEK should never be poured into the sink. These solvents should be put into metal safety cans. If you plan to use a large quantity of organic solvents, you should buy a safety can for your lab. There are three cans in the Materials Science and Engineering complex located in Room 061 and 648 MacQuigg Lab. However, these are for use only by people using the specific areas which they serve.

Every time you add a compound to the safety cans, you must do the following.

1.List the compound name and quantity each time. Estimate quantity in millimeters. (We suggest transferring the waste in a graduated beaker). For mixtures, estimate the component quantities, eg., 750 ml of 50:50 methanol:t-butanol would be written 375 methanol/375 mg., t-butanol/375 ml. Use the back of the tag if more entries are made than there is space provided.

2. Initial your disposal.

3. Write legibly.

DO NOT PUT ACIDS IN SOLVENT WASTE CANS. THIS INCLUDES ELECTROPOLISHING ELECTROLYTES AND ETCHANTS.

ii) Non-Organic Waste

To dispose of non-organic wastes:

1. Place in 'Primary ' container (or original glass container). Label this with the amount and identity of the contents.

2. Place all primary containers in a secondary (cardboard box) filled with packing material. Label this box with the contents of primary containers, your room number and the building number.
3. Fill out a chemical disposal sheet (see department Safety Officers) and mail it to the office of EOHS (020 Wilce Student Health Center, 1875 Millikin Road). They will come and pick it up.

This procedure is to be followed for all inorganic waste including acids and toxic substances. Always label all waste material. It is extremely expensive to identify unknown material and without identification EOHS will not handle it. Never mix two chemicals that are to be disposed: they might form explosive or otherwise harmful mixtures.

C. Glassware

1. Use only Pyrex or shatterproof glassware.
2. Never use cracked or chipped glassware.
3. Insert tubing properly into stoppers (i.e., use lubricants such as a few drops of glycerine and always wear gloves).
4. Broken glass that is contaminated with harmful materials must be disposed of separately: consult the department safety officer or the EOHS office for the proper procedure. Broken glass thermometers containing mercury should be treated in the same way as a mercury spill. These should never be thrown in a broken glass container or trash receptacle.

D. Gas Cylinders

There are three locations to store empty gas cylinders in the Materials Science and Engineering Department. They are: on the 6th floor of MacQuigg Lab across the elevator ; on the 5th floor of MacQuigg Lab in room 562 (near the common phone) ; and on the first floor of MacQuigg Lab opposite Rooms 147J and T near the loading dock. All cylinders must be stood upright and placed behind chain or wire restraints. Never lay cylinders on the floor. Call 2-2543 to have cylinders picked up. Remember, your project is charged a demurrage (usually $5/cylinder) every month that you have these cylinders. **See also Appendix B.**

1. Secure gas cylinders with a strap or chain to a stable object (preferentially a wall or a heavy lab bench), whether or not they are in use. Always leave the cap on when the tank is not being used.
2. Transport gas cylinders with cap on, and use a proper cart.
3. Do not use an open flame near gas cylinders.

4. Never use grease or other lubricants on gauges or connections (This may form explosive mixtures with oxidizing gases).
5. Before using gas in an experiment, be sure there are no leaks in the system.
6. Learn directions for closing and opening valves. (All main valves close clockwise). Before connecting a non-toxic gas cylinder to a system, remove the valve cap and open the valve for an instant to clear the opening of particles or dirt. To turn on a system, open the main cylinder valve completely and open remaining valves successively further from the main cylinder. To shut down a system close the main cylinder first and close remaining valves in the order in which they were opened to avoid storing high pressure in the system.
7. Do not use adaptors to connect regulators. Use only regulators specified for the particular gas. Have all regulators inspected and serviced regularly. Regulators open by turning the handle clockwise, this increases the pressure in the system.
8. Only use regulators, pipes, and fittings specified for the type of gas you will be using. Hydrogen embrittlement may cause hazards such as leaks or ruptures. Consult the department safety officer to determine the correct materials for your application.
9. Do not locate gas cylinders near heat sources, like furnaces, where they may heat up and explode.
10. Familiarize yourself with the toxic properties and safety hazards of each gas you work with. Post any safety information that may pertain to others working in the lab.
11. Store oxygen cylinders and combustible gases separately.

i) Inflammable and Explosive Gases Such as Hydrogen and Methane

Wherever possible, copper tubing should be used to transfer gases. Exhaust hydrogen and hydrocarbons should be vented outside into the open air (through copper tubing). Laboratories using these gases must be ventilated with exhaust fans equipped with explosion-proof motors, etc. Rooms containing these gases should have entrance doors marked:

'Hydrogen - No Smoking' or 'Flammable Gases - No smoking'

ii) Oxygen

Care must be taken so that oxygen of high concentration does not come into contact with combustible substances such as oils and cotton.

iii) Toxic Gases

Carbon monoxide must be vented to the air outside through copper tubing. A carbon monoxide alarm in frequently tested working order must be in the room. Entrance doors must be marked:

'Danger - Carbon Monoxide - No Smoking'

Hydrogen sulfide must be vented to the outside air after passing through a suitable adsorption tower (aqueous solution of sodium hydroxide). Laboratories using these gases must be equipped with exhaust hoods. The entrance to the room should be marked:

'Danger - Hydrogen Sulfide - No Smoking'

The use of other toxic gases must be approved by the Department Safety Officer.

E. Equipment

1. Before using an instrument or machine, be sure you have been instructed and authorized by the person responsible for the equipment. Become familiar with potential hazards associated with the equipment, emergency shutdown procedures, as well as the operating procedures.
2. Check all electrical connections and mounting bolts before each use.
3. Check that all rotating parts are free to turn, and that there are no mechanical obstructions before starting.
4. Attach an "emergency shutdown card" to any piece of equipment left operating unattended outside normal working hours. This card should contain your phone number and all information that would be required by anyone who might be faced with the need to shut down the equipment.
5. Laboratory equipment is not to be placed in corridors.

Waterlines

All waterlines connecting apparatus to water outlets must be copper tubing with proper metal fittings or high pressure water hoses fitted with proper clamps. The bursting pressure of the hose must safely exceed the highest pressure attainable in the water mains (100psig). Do not use Tygon tubing. The tube system must be able to handle >100 psig, even if the water flows at a low pressure and low rate since an obstruction in the hose can subject it to line pressure.

Vacuum Systems

Mechanical vacuum pumps used in laboratories pose common hazards. These are the mechanical hazards associated with any moving parts and the chemical hazards of contaminating the pump oil with volatile substances and subsequently releasing them into the lab. A few guidelines will help in the safe use of these devices. Distillation or concentration operations requiring large concentrations of volatile substances should be performed using a water aspirator. If a vacuum pump is required for lower pressures, the pump must be fitted with a cold trap to condense the volatiles. The output of the pumps should be vented to a hood or alternate exhaust system. The pump oil should also be replaced when it becomes contaminated and disposed of by the chemical waste disposal guidelines presented earlier in this manual.

1. Be certain that your vacuum system has a trap.
2. Use only containers that can withstand evacuation. When possible, tape containers to be evacuated and use a standing shield to guard against implosion.
3. Always close the valve between the vacuum vessel and the pump before shutting off the pump to avoid sucking vacuum oil into the system.
4. All moving belts on mechanical pumps must have a safety cover.

Distillations and Condensers

Superheating and sudden boiling frequently occur when distilling under vacuum. Therefore it is important that the assembly be secure and the heat be distributed evenly (i.e. with a heating mantle or liquid bath). A standing shield should be in place to guard against implosion. An additional thermometer should be inserted near the bottom of the distilling flask to warn of a dangerous exothermic reaction. After finishing a vacuum distillation, cool the system before slowly bleeding in air, since air may induce an explosion in a hot system. Be sure that hoses carrying cooling water are securely attached with hose clamps to prevent accidental floods. Glass joints should be secured with clips available from the stockroom to prevent accidental disconnection or disconnection caused by vapor build up.

Drying Ovens

Electric ovens are often used in laboratories for removing solvents or water from samples and to dry laboratory glassware. These ovens if not properly vented or used in a hood, discharge the volatile substances into the laboratory atmosphere which can accumulate in toxic concentrations. Small amounts of vapor can accumulate inside the oven and mix with the air to form explosive mixtures.

Ovens should not be used to dry any chemical known to possess toxic vapors or that might volatilize and pose an explosion hazard or acute chemical hazard unless special precautions have

been taken to ensure continuous venting to a hood. Organic compounds should not be dried in ovens whose heating elements or temperature controls (which may produce sparks) are exposed to the interior atmospheres. It is recommended to have blow out panels in the rear of a drying oven so that an explosion will not blow the door and contents into the lab. Bimetallic strip or alcohol thermometers rather than mercury thermometers should be used in ovens.

Removal of Organics in Furnaces

When removing binders or other organic substances from ceramic powders prior to sintering, one must observe similar precautions to those discussed for drying ovens. During decomposition, binders breakdown into shorter chain molecules and volatilize from the sample. These decomposition products often contain carbon monoxide as well as other toxic gases. If not properly vented, these gases may pose acute or chronic toxicity hazards to people in the lab and they can also form explosive mixtures when combined with the furnace atmosphere. Prior to burning out any organic material in a furnace one should estimate the chemical composition of possible decomposition products and ensure the heating cycle and furnace atmosphere are properly controlled so that the explosive limits of the by-products are not reached. The CRC Handbook of Chemistry and Physics lists explosion limits for some substances. If in doubt contact EH&S for additional assistance.

Rules for Specific Areas

All areas of the Department of Materials Science and Engineering must be kept neat and clean at all times. Occupants are responsible for the housekeeping of their areas.

i) Foundry: MacQuigg Lab, Room 050

Persons using the foundry laboratory shall protect their eyes by the use of safety glasses provided in the room. Operations in this area must be carried out in the presence of an instructor and only when two or more persons are present. Only the instructors are permitted to ignite the gas-fired furnaces and to remove molten material from the furnace. Pouring and casting must be supervised. No one can be forced to pour - the act must be voluntary. Water should not be present in the working area. It produces a violent explosion in contact with molten metal.

Before operating the induction furnace, the water should be turned on. While the induction furnaces are in operation, be sure no conductive material touches the coils which are at very high voltage and current conditions. Turn off the power to the induction furnace before removing the crucible.

No crepe shoes or ties may be worn while working in the foundry. Shirts should long-sleeved and buttoned at the collar. Hard hats, goggles, face shield, heat-resistant clothing and gloves should be worn.

Cranes can only be operated under the supervision of an instructor.

ii) Mill Operation: MacQuigg Lab, Room 061

Two or more persons must always be present during mill operation. Work must be inserted and removed from the mill with tongs or pushed in with a stick, never by hand.

iii) Heat Treatment: MacQuigg Lab, Room 061

Exhaust fans in the hood must always be on when furnaces are being heated. Goggles, safety masks and heat-resistant gloves must be used at all times. Tongs of proper length must be used with proper care. Any cyanide pot used for carburizing must be used with special care. If contact is made, immediately wash off the salt with copious quantities of water. Students must be authorized by the instructor and faculty advisor to use apparatus in this room. Water must not come in contact with the contents of pot furnaces. Sampled and crucibles immersed in salt baths must be absolutely dry. The charcoal powder is for use only on the lead pots - do not use on salt pots.

iv) Cutting and Grinding: MacQuigg Lab, Room 259

Persons using cutting and grinding equipment shall protect their eyes by the use of safety glasses provided in the room.

v) Computer Labs: Watts Hall, Room 097

No food or drinks are allowed in this computer facility.

F. Electrical Safety

While electricity is in constant use by the researcher, both within and outside the laboratory, significant physical harm or death may result from its misuse. With direct current, a man can detect a "tingling" feeling at 1 mA and the median "let-go" threshold (the current at which he cannot release the conductor) is 76 mA. For 60 Hertz alternating current, the values are 0.4 mA and 16 mA, respectively. Women are more sensitive to the effects of electrical current; approximately 2/3 of the current is needed to produce the same effect. Higher currents produce respiratory inhibition, then ventricular fibrillation, and ultimately cardiac arrest.

If an electrical hazard is suspected, the device in question should be disconnected immediately and the cause ascertained by a person competent in such matters. Work on electrical

devices should be done only after the power has been shut off in such a manner that it cannot be turned on accidentally. Since malfunctioning equipment may contain shorts, merely turning off the equipment is not sufficient to prevent accidents. Equipment should be unplugged before being inspected or the circuit the equipment is wired to deactivated by putting the circuit breaker in the off position or removing the fuse. Equipment wired to a safety switch should be turned off at the safety switch. Internal energy storage devices such as capacitors must be discharged.

All electrical wiring and construction must conform to standard safety practice. The minimum safety practice must conform to the coded regulations of the City of Columbus and the State of Ohio. High voltage equipment must be labeled: "Danger. High Voltage". Switches to turn off all electrical power to the equipment in case of emergency should be prominently labeled.

The following are a list of rules for working with electrical equipment:

1. Turn off the power to equipment before inspecting it. Turn off circuit breakers or unplug the equipment. To turn off a safety switch, use your left hand (wear insulating gloves made of leather or heavy cotton or rubber), turn your face away from the box, and pull the handle down. Circuits may discharge violently when being turned on or off and the cover to the junction box may be blown open.
2. Use only tools and equipment with non-conducting handles when working with electrical devices.
3. All current transmitting parts of any electrical devices must be enclosed.
4. When checking an operating circuit keep one hand either in a pocket or behind your back to avoid making a closed circuit through the body.
5. Maintain a work space clear of extraneous material such as books, papers, and clothes.
6. Never change wiring with circuit plugged into power source.
7. Never plug leads into power source unless they are connected to an established circuit.
8. Avoid contacting circuits with wet hands or wet materials.
9. Wet cells should be placed on a piece of non-conducting material.
10. Check circuits for proper grounding with respect to the power source.
11. Do not insert another fuse of larger capacity if an instrument keeps blowing fuses - this is a symptom requiring expert repairs. If a fuse blows, find the cause of the problem before putting in another one.
12. By the Ohio Fire Code, extension cords must be connected to a power strip equipped with a fuse.
13. Do not use or store highly flammable solvents near electrical equipment.
14. Multi-strip outlets (cube taps) should not be used in place of permanently installed receptacles. If additional outlets are required have them installed by an electrician.
15. Keep access to electrical panels and disconnect switches clear and unobstructed.

Static Electricity and Spark Hazards:

Sparks may result in explosions in areas where flammable liquids are being used and therefore proper grounding of equipment and containers is necessary. Some common potential sources of sparks are:

1. The making and braking of an electrical circuit when the circuit is energized.
2. Metal tanks and containers.
3. Plastic lab aprons.
4. Metal clamps, nipples, or wire used with nonconducting hoses.
5. High pressure gas cylinders upon discharge.

G. Fire Safety: Precautionary Procedures

1. Know the location of fire exits, fire alarms, fire blankets and extinguishers. Appendix A of this manual contains a floor plan which pinpoints the location of each of these in Materials Science and Engineering Complex. Fire extinguishers are primarily for use on fires in their incipient stages. Make it your business to learn about the proper use of fire extinguishers. See the following Guide to Classes of Fires.
2. Keep all fire doors closed at all times.
3. Do not block access to fire escape routes.
4. Neatness prevents many fires. Fire spreads much faster when it has cluttered waste materials to feed on. Oily rags, waste or papers improperly stored are common causes of spontaneous combustion. Store these materials in covered metal containers. Overloaded electrical circuits are potential fire hazards. Flammable vapors can ignite far away from their source and thus should be vented properly.

H. Cryogenic Safety

Generally, only liquid nitrogen, acetone and dry-ice mixtures, and liquid helium should be used for trapping and cooling. Liquid hydrogen can only be used upon express permission of the Safety Officer. Equipment venting and transferring apparatus must receive approval of the Safety Officer.

1. When using a liquid nitrogen cold trap, charge the trap only after the system is pumped down. Since the boiling point of liquid nitrogen is -196°C and the boiling point of liquid oxygen is -183°C, liquid oxygen as well as volatile organic substances could condense in the

cold traps. These mixtures may explode. When shutting down a system, charge the lines with nitrogen gas to prevent oxygen from entering the system.

2. Do not mix any organic material with liquid nitrogen for the reasons explained above.
3. Handle any liquefied gas carefully: at extremely low temperatures it can produce an effect on the skin similar to a burn caused by a hot object. Eyes should be protected with a face shield or safety glasses. Gloves should be worn.
4. Stand clear of the boiling and splashing liquid and its issuing gas. Should any liquefied gas contact the skin or eyes, immediately flood that area of the body with large quantities of unheated water and then apply cold compresses.
5. Large quantities of liquid nitrogen can condense oxygen and thus remove it from the air. Use liquid nitrogen only in a well ventilated area so that the ambient oxygen concentration does not drop lower than 16% (the same applied to liquid helium).
6. High pressure gas hazards are always present when cryogenic fluids are used as they are usually stored at their boiling point. Never obstruct the vent valve on cryogenic containers.
7. Glass dewars used for holding and transferring small quantities of liquid gases must either be surrounded by a protective metal shield or wrapped with tape to prevent injury from flying glass resulting from implosion. Large containers for liquid gases must be all-metal dewars.
8. Safety goggles must be worn at all times around glass apparatus subject to possible implosion or explosion.

An excellent reference which is strongly recommended for anyone working with cryogenic materials, is: Safety with Cryogenic Fluids, Michael G. Zabetakis, Plenum Press, New York, NY, 1967.

I. Radiation Safety

A number of acute and long term effects on humans have been related to exposure from various types of ionizing radiation. Radiation hazards arise when using radio-isotopes, lasers, x-ray generators and plasma torches. Each is hazardous in a unique way. A thorough knowledge of the device or the isotope which is to be used is mandatory. The precautions vary widely. Information pertaining to the particular hazard should be obtained from the faculty or research staff member or technician in charge of the equipment prior to use, or from the Office of Radiation Safety (ORS: 292-1284). However, several precautionary procedures should always be followed:

a) Radioactive Materials

1. All work with radioactive material or radiation producing equipment must be registered with the Health Physics Office. All persons using radioactive material and x-ray machines must be instructed in the potential hazards and the necessary safety precautions. Training sessions are offered by the ORS . All persons working with radioactive materials or equipment must obtain radiation film badges from the ORS and complete the training session before beginning their work.
2. Do not wear another person's badge or allow another person to wear yours.
3. Return your old badge to the ORS immediately after receipt of new badge (every month) whether you used it or not. Notify the ORS to terminate service when you no longer need the badge or are leaving the university.
4. Review with the ORS any potential exposures to non-ionizing radiation such as ultraviolet, visible, infrared and microwave radiation.
5. Clearly mark areas in which lasers, ultraviolet, or high intensity light sources are in use.
6. Wear eye protection appropriate to the type of radiation being used when working with these sources. Consult ORS to find out the correct type of protection for your work.

b)X-ray Equipment:

Persons using the X-Ray Diffraction equipment must have permission and must have received adequate instruction as to the safe use of the equipment. Any experimental set-ups deviating from standard practice must be checked out by the Safety Officer and a representative of the Office of Radiation Safety (part of EOHS). The door to the laboratory must be locked when it is not being used by authorized personnel.

1. Under no circumstances should any part of the body be placed directly in primary x-ray beams.
2. Whenever possible turn the x-ray beam off before working on the machine. If this cannot be done, double check to be sure that the shutter on the port involved is closed.
3. Never align samples with the eye in such a position that it might be exposed to the primary beam.
4. Do not defeat any interlock devices, e.g. wiring shutters in the open position.
5. Do not use any x-ray machine that is not working properly.
6. Wear any required personnel monitoring devices at all times while using the x-ray machine.

7. Have the radiation levels around the x-ray machine checked anytime a configuration is used which has not previously been surveyed. The ORS will perform such surveys upon request (292-1284).
8. Report any suspected overexposures to the ORS immediately.
9. Do not depend upon lead foil or sheets for permanent shielding. Shields should be constructed of more durable materials. If lead is to be used it should be as a liner inside brass or some other material.
10. Remember the additional high voltage hazard associated with x-ray machines.

c) Lasers

There are many types/intensities of lasers and therefore only general guidelines are given.

1. Never look directly at the beam or pump source.
2. Never view the beam pattern directly; use an image converter or other safe, indirect means. To decrease reflection hazard, do not aim by looking along the beam.
3. Do not allow any object which could cause specular reflections in or along the beam, such as spherical buttons, screw heads, or jewelry.
4. Keep a high general illumination level where lasers are in operation to cause contraction of pupils and reduced hazard.
5. Always wear goggles that offer protection against specific wavelength of the laser in use.
6. Post warning signs outside and inside the laboratory to warn of potential hazards. Clearly mark any areas where laser beams are in use.

d) Ultraviolet Lamps:

1. All radiation of wavelengths shorter then 3500 Å should be considered dangerous.
2. Protective safety glasses with UV absorbing lenses should be worn when the eyes may be accidentally exposed.
3. Skin exposed to UV radiation can receive painful burns , analogous to sunburns and should be protected.

IV. Safety Procedures

A) Chemical Spills

If a hazardous spill occurs:

1. Assess the severity of the hazard to yourself before attempting to clean it up.
2. If you are unable to SAFELY remove the spill,
   a. Alert everyone in the area.
   b. Post a warning
   c. Contact Steve Bright, 688-3021
   d. Contact a Faculty member or call

Environmental and Occupational Health and Safety: 292-1284

i) Acid Spills. Anyone using acids for etching, electroplating or other experimental work should have available in the immediate work area a five pound bottle of sodium bicarbonate. In case of an acid spill, put sodium bicarbonate on the acid to neutralize it. Environmental Safety recommends a 1 to 1 ratio of sodium bicarbonate to spilled acid. There will be a foaming reaction and sodium bicarbonate should be added until the foaming subsides. This mixture can then be put in a sink and diluted with copious amounts of running water.

ii) Mercury Spills. Extreme caution should be used in handling mercury as a spill can contaminate a whole area. Environmental Safety recommends that procedures using mercury be confined to high-sided plastic trays to prevent the escape of mercury droplets. All spills must be reported to Environmental Safety at 2-1284. They will clean up the spill and test for toxic levels of mercury in the area.

B) Disposal of Equipment

The following is the procedure for disposing of equipment:

1) Someone in authority should determine if the item is no longer useful and should be discarded.
2) If the item is to discarded, then the item should be looked over carefully to find any identifying inventory numbers. These numbers are usually found on four different kinds of tags:
   a) The very old type label with stamped letters (not many of these)
   b) The most common "stick-on" type tag
   c) The Research Foundation aluminum tag
   d) The new OSU Bar Code tag
3) Write down any number that appears on the tag and check it against the master inventory list (available with Building Coordinator). If it is not on the list and is small enough to throw in

the trash, pitch it. If it is too large or too heavy to trash, call one of the MSE Safety Officers (see cover for numbers). If it is on the inventory list, obtain a "Release of Surplus Property Form" from Building Coordinator, fill it out, and have him send it to either the Treasurer's Office or to the Research Center if the item is Research Foundation equipment.

C) Electrical Fires

1. Turn off power source at the breakers or the junction box and unplug.
2. Use CO_2, or dry chemical extinguisher to put out fire. Never use water.
3. When fire is extinguished check circuit to determine cause.
4. Do not turn on circuit until cause of fire has been established and the fault corrected.
5. Report fire to Safety Officer.

D) Classes of Fire and Methods of Extinguishing

Class A Fire

Material:	Wood, paper, textiles and other ordinary combustible materials.
To extinguish:	Pressurized water
	Multi-purpose dry chemical
	Halon

Class B Fire

Material:	Flammable liquids: oils, solvents, grease, paint, etc.
To extinguish:	BC dry chemical, regular
	Carbon dioxide (if fire is contained in a small area).
	Multi-purpose dry chemical
	Halon

Class C Fire

Electrical Fires

To extinguish:	Carbon dioxide
	Halon
	BC dry chemical, regular. Effective, but will destroy electronic gear.
	Multi-purpose dry chemical. Effective, but will destroy electronic gear.

Class D Fire

Material:	Metals: Magnesium, Aluminum, Sodium, Potassium, Zirconium, Titanium etc.
To extinguish:	Special metal extinguishers
	The ordinary extinguishers found in the building should not be used on metal fires because a violent reaction may result.

V. REFERENCES

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Toxic and Hazardous Industrial Chemicals Safety Manual, International Technical Information Institute, 1978.

Prudent Practices for Handling of Hazardous Chemicals in Laboratories, National Academy Press, Washington, D.C., 1981.

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Occupational Health Guidelines for Chemical Hazards, NIOSH-OSHA, Jan., 1981.

Materials Safety Data Sheets published by chemical manufacturers are available through the safety office.

Safety in Academic Laboratories, American Chemical Society, 1155 16th St. N.W., Washington D.C., 1979.

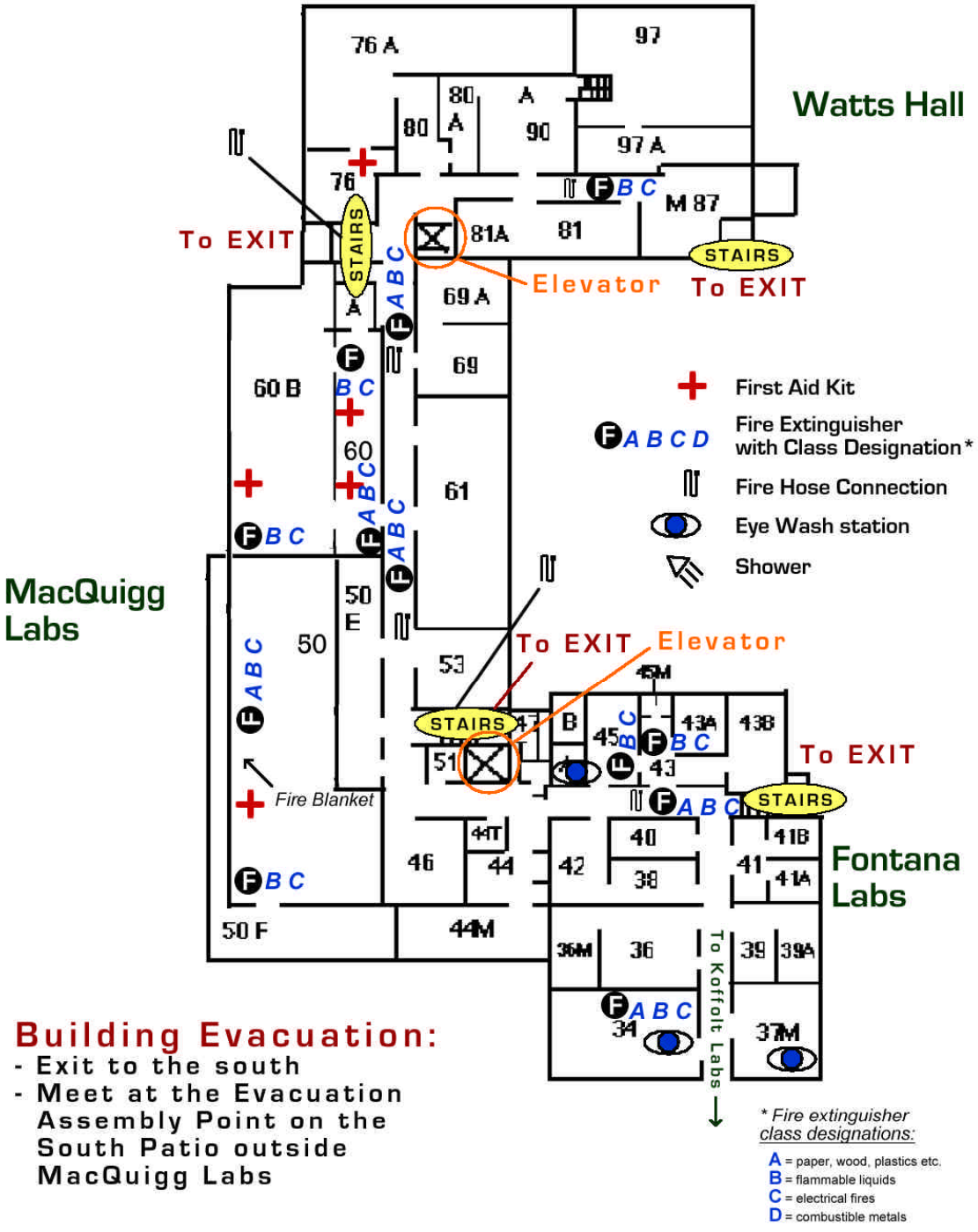
APPENDIX A

Floor Plan of Materials Science and Engineering Complex Exhibiting the Location of Fire Extinguishers, Eye Wash Stations, and Fire Blankets

Basement

Exit Routes and Emergency Equipment Locations

North



Building Evacuation:

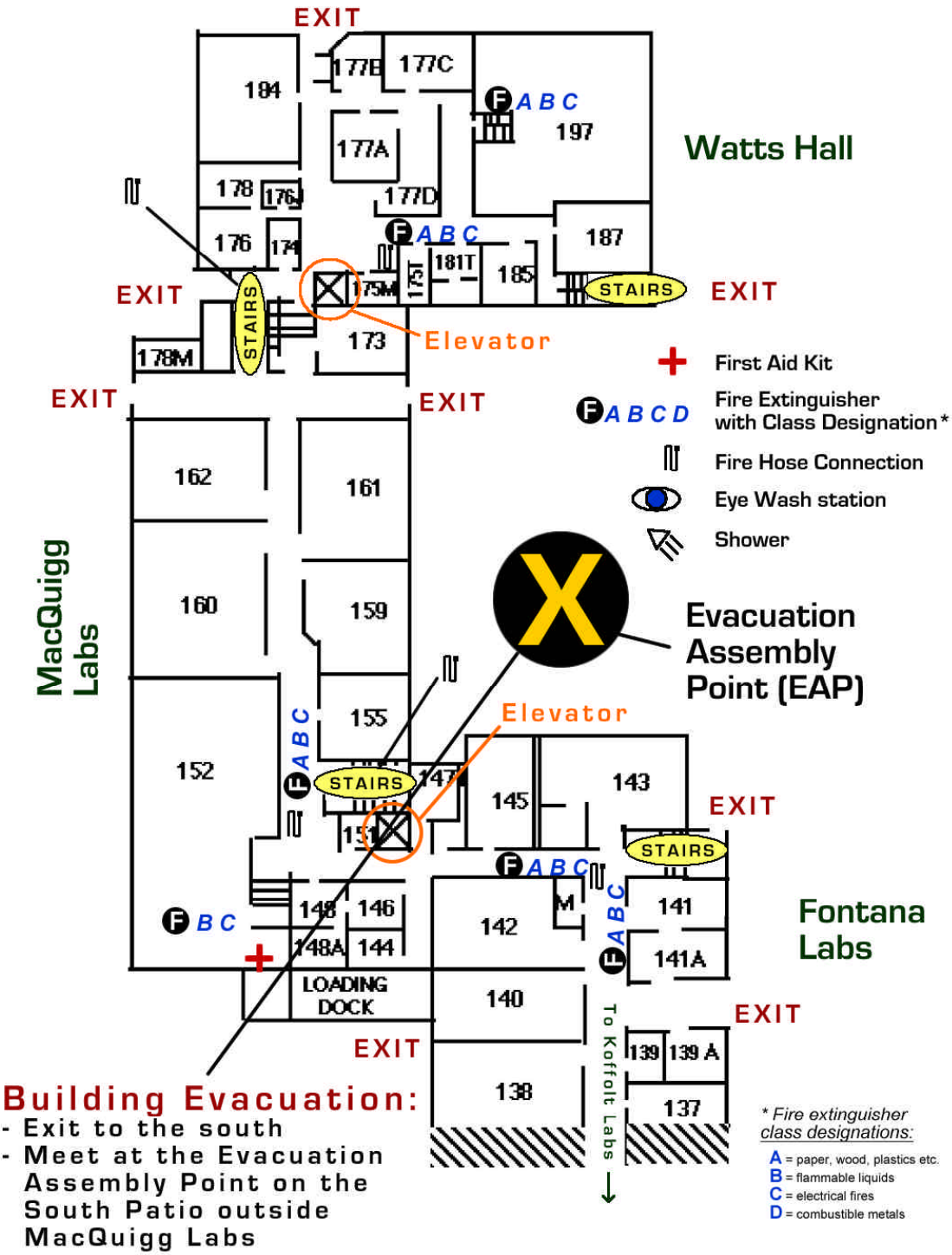
- Exit to the south
- Meet at the Evacuation Assembly Point on the South Patio outside MacQuigg Labs

** Fire extinguisher class designations:*

A = paper, wood, plastics etc.
B = flammable liquids
C = electrical fires
D = combustible metals

First Floor

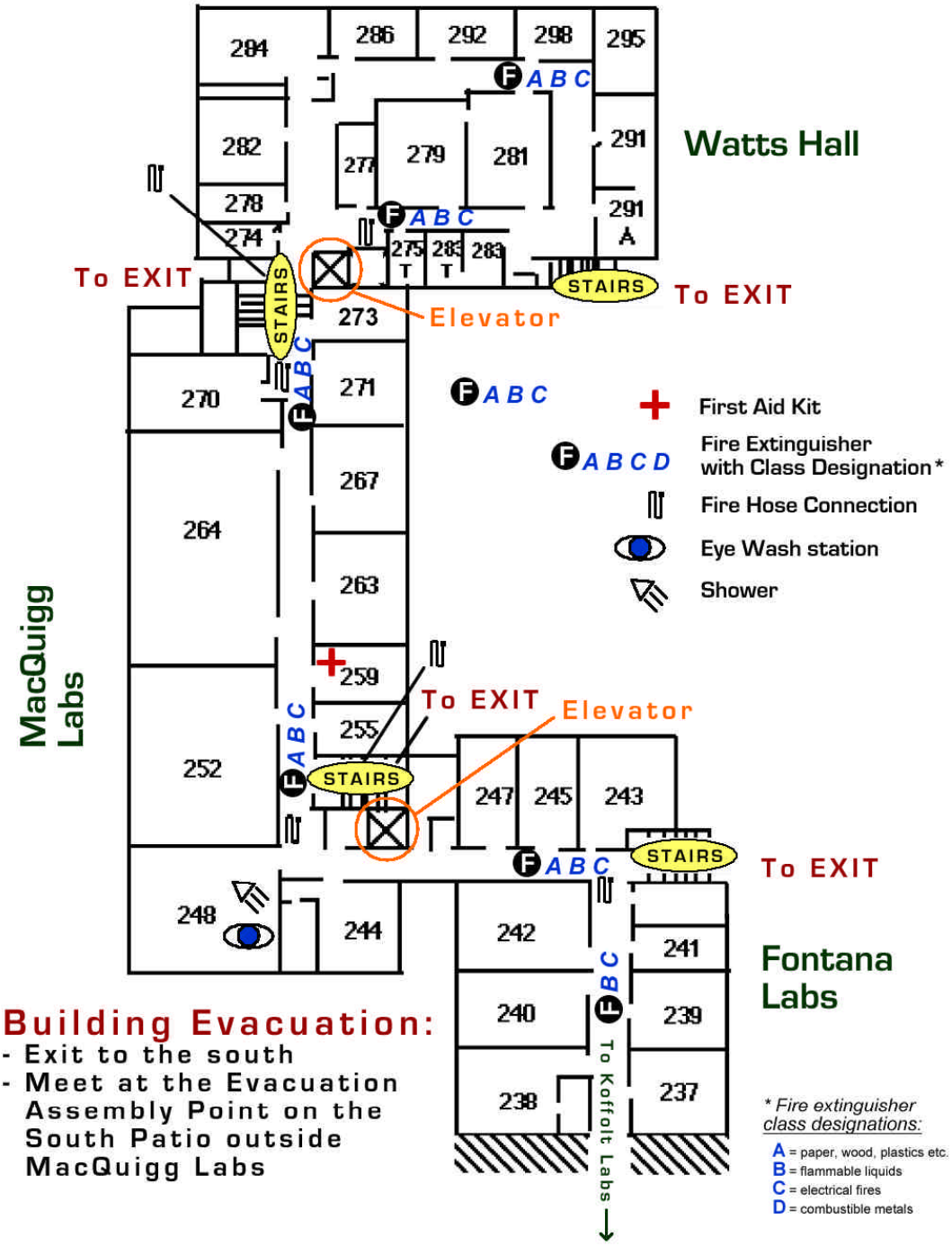
Exit Routes and Emergency Equipment Locations



Second Floor

Exit Routes and Emergency Equipment Locations

North



Building Evacuation:

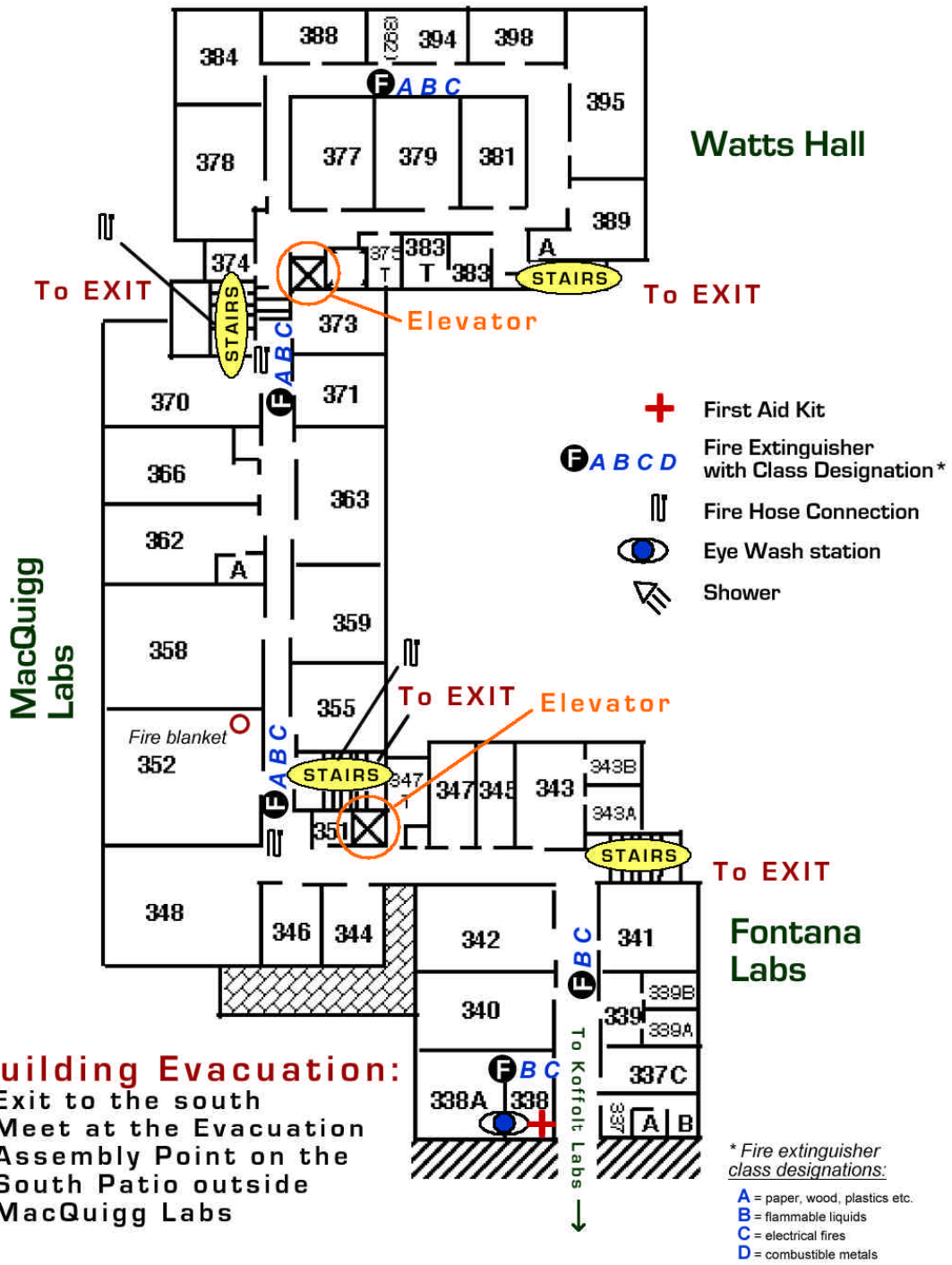
- Exit to the south
- Meet at the Evacuation Assembly Point on the South Patio outside MacQuigg Labs

** Fire extinguisher class designations:*

A = paper, wood, plastics etc.
B = flammable liquids
C = electrical fires
D = combustible metals

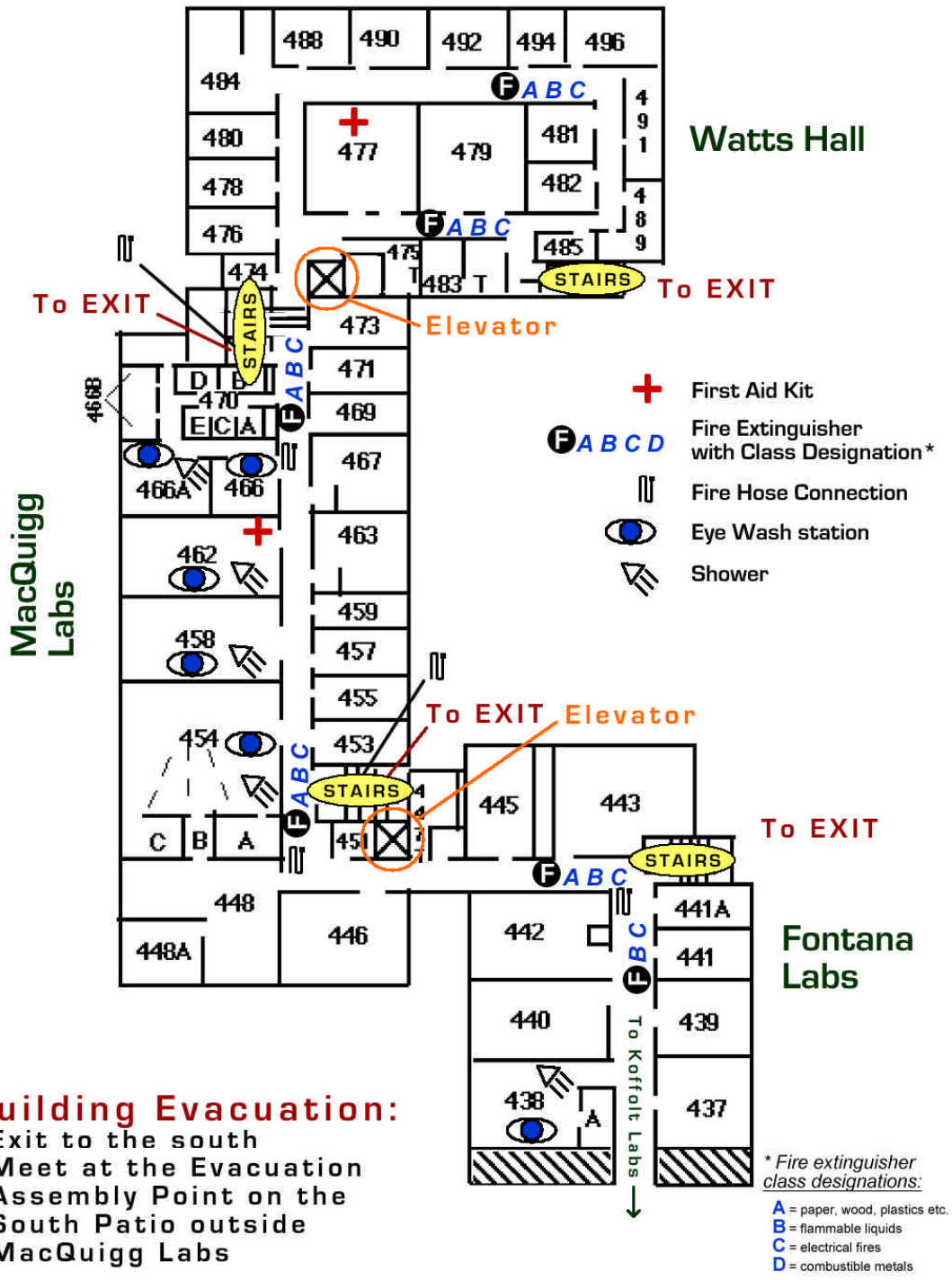
Third Floor

Exit Routes and Emergency Equipment Locations



Fourth Floor

Exit Routes and Emergency Equipment Locations



Building Evacuation:

- Exit to the south
- Meet at the Evacuation Assembly Point on the South Patio outside MacQuigg Labs

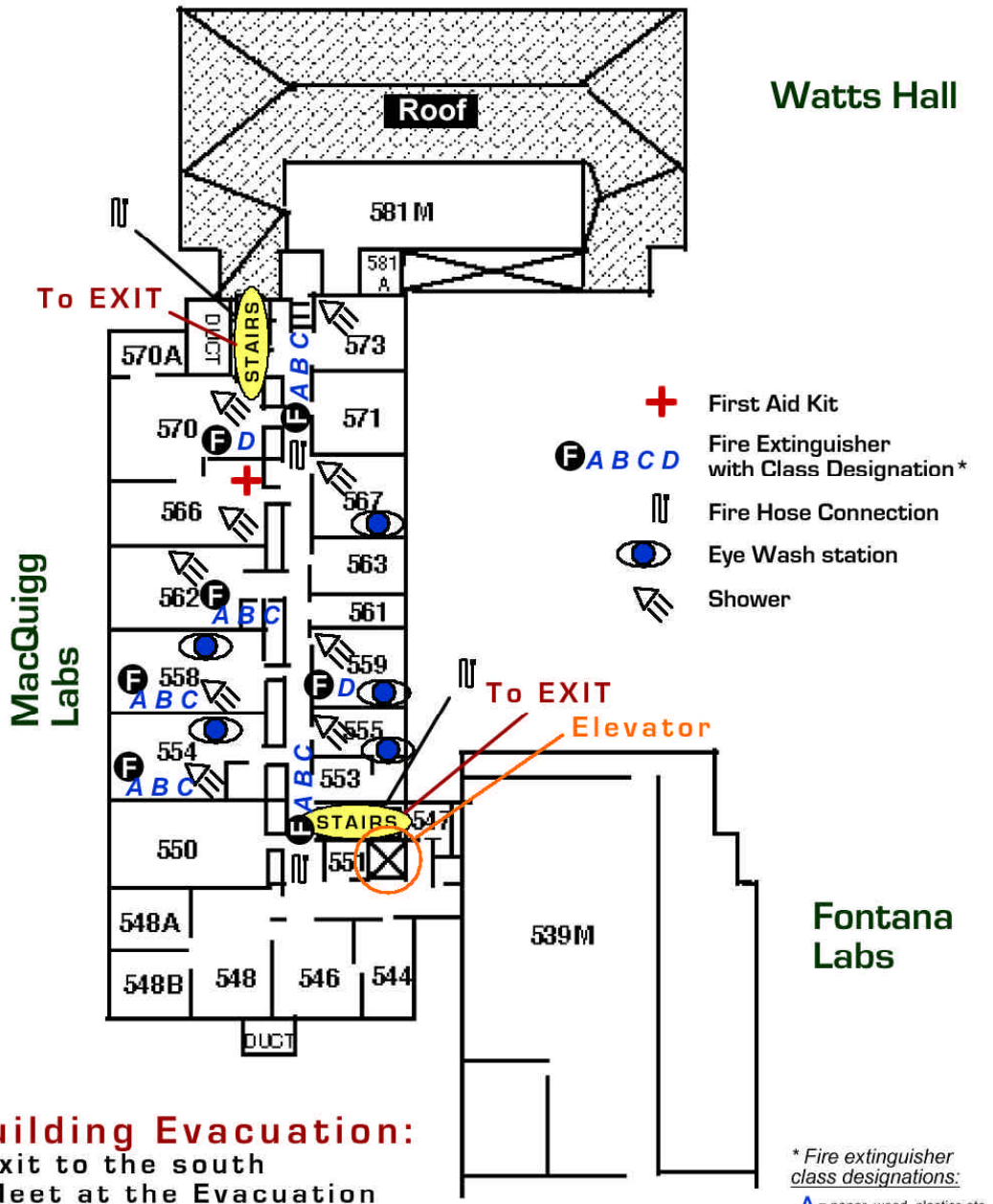
** Fire extinguisher class designations:*

A = paper, wood, plastics etc.
B = flammable liquids
C = electrical fires
D = combustible metals

Fifth Floor

Exit Routes and Emergency Equipment Locations

North ←



Building Evacuation:

- Exit to the south
- Meet at the Evacuation Assembly Point on the South Patio outside MacQuigg Labs

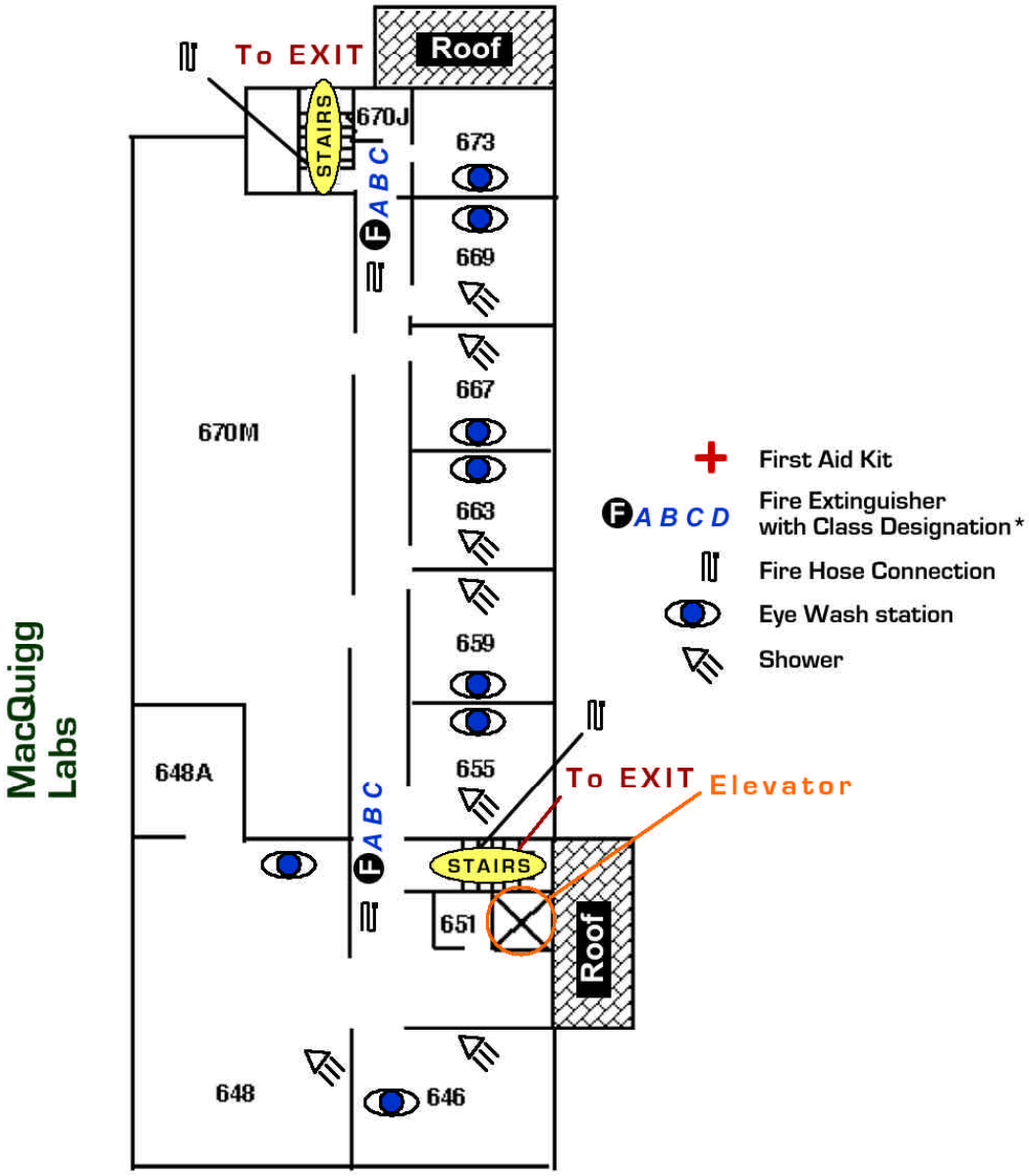
** Fire extinguisher class designations:*

A = paper, wood, plastics etc.
B = flammable liquids
C = electrical fires
D = combustible metals

Sixth Floor

Exit Routes and Emergency Equipment Locations

North ←



Building Evacuation:

- Exit to the south
- Meet at the Evacuation Assembly Point on the South Patio outside MacQuigg Labs

** Fire extinguisher class designations:*

A = paper, wood, plastics etc.
B = flammable liquids
C = electrical fires
D = combustible metals

APPENDIX B
Compressed Gas Cylinder Safety

INSPECTION AND STORAGE

1. Upon delivery, inspect cylinders for damage (dents, gauges, bulges, evidence of leakage or cracks).
2. Check for a tag to identify cylinder contents - do not rely on color codes!
3. Cylinder valves should be closed tightly and the valve protection cap in place.
4. Check for a current hydrostatic test date.
5. Post the storage locations: avoid blocking exits or access to fire equipment.
6. Store empty - full cylinders separately.
7. Maintain adequate ventilation in the storage area.
8. Avoid storage near high heat sources.
9. Fasten cylinders securely (use chains of special cradles) while in storage.
10. Cylinders must not be placed where they might become part of an electrical circuit.
11. Oxygen cylinders must be stored 20 feet from combustible materials of flammable gas containers.
12. Outdoor storage areas should be above ground, dry and protected from extremes of weather.

HANDLING

1. Valve protection cap should be in place when moving a cylinder.
2. Unless cylinders are secured on a special truck, regulators must be removed.
3. When cylinders are to be handled by a crane or derrick, use a cradle or similar device.
4. Do not slide, drag or bang cylinders against one other.
5. Do not use cylinders as rollers or supports for other objects.
6. Use a suitable hand truck or dolly for transporting cylinders. Use lift platforms to move cylinders from one level to another.

SAFE USAGE

1. Cylinders should be operated and handled only by personnel who have been instructed in proper procedures for their use and the hazards involved. Read the Material Safety Data Sheet.
2. Never strike an arc against a cylinder.
3. Cylinder valves should be kept closed except when in use.
4. Do not intermix regulators or attempt any repairs. Return damaged equipment to the manufacturer.
5. Do not tamper with any safety devices.
6. Do not use compressed gases to dust off clothing
7. Pressure regulating devices must be in place and operable.
8. Oil, grease or other combustible material should never be used to lubricate, or clean valves, regulators, gauges, or fittings on cylinders holding oxygen of other oxidizers.
9. Never use copper fittings with acetylene cylinders.
10. Before removing a regulator, close the valve and release the gas from the regulator.
11. Cylinders must not be refilled except by the owner or those authorized to do so.
12. Cylinders should be safely secured while in use.
13. Cylinders of toxic, flammable, or reactive gases should be used in fume hoods only.
14. Do not expose cylinders to temperatures above 130 F. Flames should never touch the container.
15. Never use a cylinder whose contents cannot be positively identified.
16. All cylinder connections should be tight and hoses should be inspected before use.
17. If a fuel gas cylinder begins to leak, extinguish all ignition sources, leave the area and call 911.

Notes: