SAFETY IN THE LABORATORY

As a junior officer, your basic responsibility is for the safety and well-being of your shipmates. The naval history of the last few years has included carrier fires, explosions in paint lockers and numerous other serious accidents with fatalities. In all of the cases investigated since 1970, the underlying cause was failure to follow prescribed safety practices. A number of Navy careers ended because of bad fitness reports arising from these events.

Working in a laboratory should be a safe experience. This will happen, however, only if certain precautions are followed without exception. The practice of safety requires (1) the desire on the part of the individual to protect himself or herself as well as those around him or her and (2) the need to rigidly follow a well-defined set of laboratory rules. The safety rules to be followed by all midshipmen in the Chemistry Department laboratories will be discussed by your instructor during the first laboratory class period of the semester. These rules are posted in the laboratory spaces and are outlined on the following pages of this manual. While it is the obligation of the instructor to explain these rules, it is the responsibility of everyone in the laboratory to follow the safety regulations. They will be rigidly and impartially enforced, with non-compliance resulting in the dismissal of the guilty party from the laboratory.

A. Safety Equipment

The location and use of the safety equipment in laboratory will be discussed by your instructor the first day that the class meets in the lab space. All midshipmen should become familiar with the proper use of the:

- safety shower
- eye-wash fountain
- fire extinguisher
- cut-offs for gas and power

The location of the equipment is important, as well as when to use each piece of equipment.

Safety goggles for eye protection are to be worn by all midshipmen while in the laboratory. The instructor may decide to override this when all hood sashes are down. Goggles will be issued to each midshipman during the fall semester book issue. If a midshipman fails to bring the goggles to class, he or she will be sent back to Bancroft Hall to get the goggles.

Laboratory aprons are provided on the hooks outside each laboratory and are to be worn by all midshipmen while in the lab. A midshipman who is especially small in stature can obtain a shortened apron by seeing their instructor. An apron which is too long and drags on the floor can be as much of a hazard as no apron at all.

B. Laboratory Do's and Don'ts

The following is a list of do's and don'ts which must be adhered to by all midshipmen.

1. If any ventilation hood sash in your laboratory is up, you must wear your approved chemical splash goggles. **Hood up – Goggles on!**

2. **The laboratory stools belong to the lab islands.** They are not designed to be used by the hood – the stools are too wide to fit two per hood and though the passageways are wide, they are not wide enough to allow someone to pass easily by a stool that has someone sitting on it. You may only move them away from the island with instructor permission.

3. **The slide-out writing surfaces are to be stowed whenever not in use.** We have orange tape on the front top edge, but they are difficult to see when you have your goggles on and they are at a height that will maximize discomfort if you walk into it (I will not elaborate, but use your imagination.).

4. Bring only the necessary materials into the laboratory: lab manual/notebook, pencil/pen, calculator, computer, goggles and apron. Coats and covers should be left in the hallway on the hooks. Bookbags, books, briefcases, menus, rate books, newspapers, etc., should be left along the walls in the corridor.
5. Do not touch chemicals with your hands. Spatulas and forceps have been provided for handling solid materials.

6. No wet chemicals should be placed on the islands or the pull-out writing surfaces. In addition, no stock solutions bottles are to go to individual lab stations. Midshipmen should take an appropriate container to the stock solution to obtain the needed amount.

7. **Do not eat or drink** in the laboratory. All surfaces in the lab are potentially contaminated with radioactive or chemical residues, which could be transferred and ingested. Leave water bottles outside in the hall. **Do not taste** any chemical. **Do not smell any chemicals directly.** Use your hand to waft the odor to your nose. **Wash your hands** before leaving lab.

8. Do not pipet solutions by mouth. Rubber pipet bulbs are provided at each lab station.

9. Do not put flammable liquids near an open flame.

10. When heating a test tube, make certain that the open end of the tube is directed away from other students. If overheating or superheating causes the contents to bump out, no one in the laboratory will be splashed.

11. When finished with your Bunsen burner for a given portion of an experiment, turn it off. Be careful not to place lit burners under gas hose.

12. Do not sit on the lab benches. We give you nice stools – use them and save your uniform from damage.

13. Do not engage in games or horseplay in the laboratory. Failure to follow this rule will result in immediate dismissal from the lab and subsequent conduct action.

14. Do not pour any chemical into a sink without authorization from the instructor.

16. All broken glassware should be reported to your instructor immediately. In most cases the instructor will deal with it as a minor cut on a Mid requires quite a bit of action, but a minor cut on an instructor can be dealt with at a lower level (See Section E below). If the instructor designates you to clean up, a dust pan and foxtail brush are located in each lab to assist with cleanup. Broken glass should be disposed of in the specially marked receptacles ONLY.

18. Do all reactions, particularly those involving malodorous, noxious or dangerous chemicals, in a ventilation hood.

19. If a chemical gets on your skin, immediately wash the affected area with large quantities of water. The instructor should be notified, no matter how insignificant the incident might seem.

20. When pouring one liquid into another, do so slowly and cautiously. To dilute an acid, pour the acid into the water; **never** pour water into an acid.

21. No student shall be permitted to work alone in the lab. You may not do unauthorized experiments or variations of any experiment.

22. Exercise good housekeeping practices in the laboratory. Be sure that the lab benches remain free of clutter during the experiment. In the event of a spill, clean the area immediately. Be sure to use a wet sponge to wipe off the work station at the conclusion of the lab. In addition, all midshipmen should help police the shared areas of the lab for debris before dismissal.

23. Know what you are to do before entering the lab. **Read the experiment carefully before coming to the lab.** Be cautious and think about what you are doing. Use common sense.
C. "Safety Data Sheets (SDS)" and "National Fire Protection Association (NFPA)" Labels

All midshipmen should become familiar with two safety items in particular. These are "Safety Data Sheets (SDS)" and "National Fire Protection Association (NFPA)" labels. A "Safety Data Sheet" is a required document which describes a given, chemically-based material. The SDS format is consistent with a worldwide standard for hazard information communication, and the information included on the sheet is prescribed by law (see Figure 1) and monitored by the Occupational Safety and Health Administration (OSHA).

Figure 1. SDS contents (U.S. Occupational Safety and Health Administration, https://www.osha.gov/Publications/HazComm_QuickCard_SafetyData.html, accessed 15 August 2017.)

Chemical manufacturers are required to make available a complete SDS with any chemical purchased. The purchaser is required to maintain a file of these data sheets in an area accessible to those individuals working directly with the chemical. Employees have the right to see the SDS on request. Such forms will be common-place in all working areas throughout Naval installations and as a result, all midshipmen should be aware of their existence and the types of information which they contain. An example is provided in Figure 2.
Figure 2. SDS for H₂SO₄ (Teck Metals, Ltd., http://www.teck.com/media/Products-Sulphuric-Acid-SDS-2015.pdf, accessed 16 August 2017.)
SECTION 5. FIRE FIGHTING MEASURES

Fire and Explosion Hazards: Sulphuric acid is not flammable or combustible. However, fires may result from the heat generated by contact of concentrated sulphuric acid with combustible materials. Sulphuric acid reacts with most metals, especially when heated with water to produce hydrogen gas which may accumulate to explosive concentrations inside confined spaces. It reacts violently with water and organic materials resulting in a considerable amount of heat and is a very hazardous mixture when in contact with catalysts, cyanides, and sulfides.

Extinguishing Media: Use dry chemical or carbon dioxide extinguishers to extinguish small fires in surrounding combustible materials. Use water sprays or fog in cool, fume-exposed compartments to knock down large fires. Use water streams only if absolutely necessary and DO NOT USE WATER DIRECTLY ON ACID as a violent reaction may result in splashing of the acid. Do not use water in the fire control methods to exhaust or cool materials.

Fire Fighting: Fire fighters must be fully-trained and wear full protective clothing including an approved, well-maintained breathing apparatus which supplies a positive air pressure with a full face-piece mask. For fires close to a spill or where vapours are present, use acid-resistant personal protective equipment.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Precautions for Clean-Up: Contain spill with a pyrophoric acid-resistant material. Do not add water to the material. Descrump from surrounding space and recover solution. Dilute with water to a safe level for disposal. Use a water spray or fog to cool spilled material and prevent re-evaporation of a large amount of material. Do not allow the material to contact water bodies. Do not allow the material to contact water. Contact of water with the material will cause a violent reaction.


Environmental Precautions: Avoid the use of ozone-generating or pyrophoric acid-resistant materials. Do not handle the material with bare hands. Do not dispose of the material in the environment without proper disposal procedures.

SECTION 7. HANDLING AND STORAGE

Store in a dry, cool, well-ventilated area away from incompatible substances. Keep in tightly closed containers which are not pressurized. Do not allow contact with water. Do not store near flammable substances.

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational Exposure Guidelines:

<table>
<thead>
<tr>
<th>Component</th>
<th>ACGATLY</th>
<th>OSHA PEL</th>
<th>NIOSH REL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphuric Acid</td>
<td>0.2 mg/m³</td>
<td>1 mg/m³</td>
<td>1 mg/m³</td>
</tr>
</tbody>
</table>

NOTE: Values for individual exposures may be set at the values above. Check with local authorities and for the appropriate values in your jurisdiction.

ACGATLY - American Conference of Governmental Industrial Hygienists; OSHA - Occupational Safety and Health Administration; NIOSH - National Institute for Occupational Safety and Health. TLV = Threshold Limit Value; REL = Permissible Exposure Limit; REL = Recommended Exposure Limit.

NOTE: The selection of the necessary level of engineering controls and personal protective equipment will vary depending upon the condition of use and the potential for exposure. The following are therefore only general guidelines that may not fit in all circumstances. Control measures to consider include:

Ventilation: Use adequate local or general ventilation to maintain the concentration of sulphuric acid aerosols below recommended occupational exposure limits.

Protective Clothing: Protective clothing and gloves as well as goggles, respirators may also be used. Protective clothing should be made from any material that the skin contact can occur. Use closed-fitting safety goggles or a combination of safety goggles and a face shield where any possibility exists that eye contact can occur. An eyewash and face wash shower should be provided near the work area. Workers should wash immediately whenever skin becomes contaminated.

Respirators: Use a respirator with a P100 or P100 particulate filter and an acid gas cartridge. Note: sulphuric acid may also cause eye irritation at high concentrations and a full face respirator or supplied air respirator may be necessary in some cases.

General Hygiene Considerations: Avoid all contact with mucous membranes. Wash hands before eating, drinking, or smoking in work areas. Thoroughly wash hands before eating, drinking, or smoking.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Clear, colorless, oily liquid (melted with water to form a thick, amber-colored liquid)</td>
</tr>
<tr>
<td>Odor</td>
<td>Odoless when cold; odor upon heating</td>
</tr>
<tr>
<td>Odor Threshold</td>
<td>&gt; 1 mg/m³ (A)</td>
</tr>
<tr>
<td>pH</td>
<td>Concentration dependent</td>
</tr>
<tr>
<td>Vapour Pressure</td>
<td>0.046 kPa (0.13 mm Hg) @ 29°C</td>
</tr>
<tr>
<td>Vapour Density</td>
<td>1.75 (air = 1)</td>
</tr>
<tr>
<td>Melting Point</td>
<td>-10°C</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>121°C</td>
</tr>
<tr>
<td>Relative Density (vs. air)</td>
<td>1.84 (30%)</td>
</tr>
<tr>
<td>Exothermic Rate</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Coefficient of Water</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Solubility in Water</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Flash Point</td>
<td>Not Flammable</td>
</tr>
<tr>
<td>Auto-Ignition Temperature</td>
<td>None</td>
</tr>
<tr>
<td>Decomposition Temperature</td>
<td>None</td>
</tr>
</tbody>
</table>

SECTION 10. STABILITY AND REACTIVITY

Stability and Reactivity: Sulphuric acid is stable and not considered reactive under normal conditions and conditions of use. If concentrated sulphuric acid is allowed to contact water, it will react vigorously with water and create a potentially explosive mixture. Contact of water with sulphuric acid is highly exothermic and can result in the formation of hydrogen gas, which may explode. Dilution of a sulphuric acid solution may also cause the formation of hydrogen gas, which may explode. Always dilute acid in water. NEVER ADD WATER TO ACID. Combustible materials including dust, metal, copper, aluminum, zinc, etc., especially when ignited below 100°C.

Incompatibilities: Combustible materials, organic materials, reducing agents, ammonia, bases, water, excess heat, and metals.
Hazardous Decomposition Products: Sulfur dioxide, sulfur trioxide and sulfur oxides.

SECTION 11. TOXICOLOGICAL INFORMATION

General: Concentrated sulfuric acid is a direct acting irritant, producing local effects at the site(s) of contact but no systemic effect. It causes a strong corrosive action on all tissues due to its severe dehydration action (removing water from tissues). The severity of the chemical burn produced by the concentrated acid is proportional to the strength of the acid and the duration of contact. Burns are deep but typically not severely painful.

Acute:
- Skin/Eye: Sulfuric acid can cause severe eye burns and may cause irreversible eye injury and possible blindness. Skin contact results in severe burns and may result in permanent scarring. High levels of sulfuric acid and mists and aerosols are also irritating to the eyes and skin.
- Inhalation: Inhalation may cause severe irritation of the respiratory tract with sore throat, coughing, shortness of breath, cyanosis and discolored sputum. These symptoms may be accompanied by physical weakness. Asthmatics may be more sensitive to irritation caused by sulfuric acid and mists and aerosols may be agitated by exposure to sulfuric acid.
- Ingestion: Ingestion is unlikely in industrial use but would result in severe burns to the mouth, throat, esophagus and stomach, which could also be permanent damage to the digestive tract. Small amounts of acid can also enter the lungs during ingestion or subsequent vomiting and cause severe lung injury.

Chronic: Prolonged exposure to dilute solutions or mists may result in eye irritation (chronic conjunctivitis) and produce skin irritations. Exposure to high concentrations of acid has caused edema and desquamation of the upper respiratory tract. Burns of the upper respiratory tract may be caused by aspiration of concentrated acid.

Sulfuric acid, par asix, is not listed as a carcinogen by USPHS, the National Toxicology Program (NTP), or the IARC. IARC has concluded that there is sufficient evidence that occupational exposure to strong morgans and mists containing sulfuric acid is carcinogenic to humans, resulting in an increased incidence of primary lung cancer. The AS/MSHA has declared sulfuric acid and mists containing sulfuric acid as a suspected human carcinogen (AOS) and the NTP has classified sulfuric acid mists containing sulfuric acid as a known human carcinogen. OSHP does not list sulfuric acid mists as a carcinogen.

Animal Toxicity:

<table>
<thead>
<tr>
<th>Hazardous Ingredient</th>
<th>Acute Oral</th>
<th>Acute Inhalation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfuric Acid</td>
<td>2140 mg/kg</td>
<td>250 mg/kg</td>
</tr>
</tbody>
</table>

SECTION 12. ECOLOGICAL INFORMATION

Sulfuric acid is highly toxic to aquatic organisms and terrestrial plant life, however, it does not bioaccumulate or biodegrade through the food chain.

SECTION 13. DISPOSAL CONSIDERATIONS

Do not allow drain down or allow to flow into natural watercourses. Disposal of neutralized waste consistent with regulatory requirements. If neutralized with lime or soda ash, good ventilation is required during neutralization because of the release of carbon dioxide gas.

SECTION 14. TRANSPORT INFORMATION

PROPER SHIPPING NAME: Transport Canada

PROPER SHIPPIING U.S. DOT: Transport Canada

U.S. DOT CLASSIFICATION: Class 3 Flammable Liquid (RQ), 1,000 lbs.

PRODUCT IDENTIFICATION NUMBER: U.S. Coast Guard: USCG 18300

MARINE POLLUTANT: No

IMO CLASSIFICATION: Class 8
In addition to SDS forms, all midshipmen should become conversant with the information encoded on the labels referred to as "NFPA" labels. These are diamond-shaped labels placed on bottles, cylinders, doors, cabinets, etc., in a conspicuous place to identify health, flammability and reactivity associated with the contents of the container. Health hazards are identified by a blue-coded area including a number from zero through four, with "4" indicative of a deadly hazard. In a similar fashion, flammability information is included by number on a red background and reactivity precautions are encoded in a yellow section. For these three sections, "0" indicates a normal or stable material and "4" indicates an extremely hazardous material. A fourth section of the NFPA label is a white section, reserved for designation of a specific hazard such as acid, corrosive or oxidizer. The information included on such labels and how the label is encoded is outlined in Figure 3.

D. Standard Operating Procedure of the Chemistry Department for Classroom or Laboratory Evacuation due to Fire, Fire Drill or Bomb Threat

In the event of a fire, fire drill or bomb threat during a class period, a quite distinguishable alarm will sound. In response to the alarm, the midshipmen will take the following actions.

1. All students will exit the class in an orderly and safe fashion. All students will form-up, by section, in a pre-designated area. This area will be specified by your instructor on the first day of class, each semester.

2. Section leaders will take a muster of the section as soon as possible after evacuation of the building. The section leaders should promptly report the results of the muster to the instructor.

3. No midshipmen will be allowed to leave the muster area until directed to do so by the instructor.

4. Instructors will advise the department chairman (or designate) of the results of the muster for his or her sections.

5. Fire department personnel will advise the instructors when it is safe to return to the building to resume the normal schedule of classes.

E. Standard Operating Procedure for Student Injuries in Laboratory

1. Students should report all injuries, no matter how small, to the instructor.

2. The instructor will use conservative judgment about the severity of the injury. For anything more serious than a paper cut the student will be sent, with escort, to the Medical Clinic.

3. If the injury is a chemical burn, the burned area is to be flushed with water for fifteen minutes before departure to Medical. During this time Medical is to be informed of the situation and given the Prep Room phone number. The SDS for the specific chemical will be obtained by the instructor from the Lab Manager's office and this SDS will be sent to Medical with the injured student and his/her escort.

4. The escort accompanying an injured student to Medical should deliver the Prep Room phone number to medical personnel at the reception desk, along with the SDS, if appropriate. The escort should then report back to the instructor with any pertinent information.

5. The instructor will enter time and date of injury, a detailed description of the injury, and remedial steps taken in the injury log in Prep Room office. Discuss reporting requirements with the Lab Manager.

6. Follow up inquiry should be made by contacting Medical or the injured student.