

## Safety Information for Common Laboratory Equipment

Many common laboratory instruments and equipment are associated with physical or chemical hazards. Each researcher is responsible for using all laboratory equipment in a safe manner. The following simple guidelines for operating common laboratory equipment have been compiled here for reference.

### Drying Ovens (other than vacuum drying ovens)

1. Drying ovens should not be used to dry any organic compounds or glassware that has been rinsed with organic compounds. These ovens rarely have any provisions to vent the interior, thus all evaporating substances go into the laboratory environment.
2. Avoid measuring the inside temperature of an oven with a mercury thermometer. Accidental breakage of the thermometer will cause a serious hazard.

### Heating Devices

The actual heating element of any heating device should be enclosed in a glass, ceramic or metal case. Heating devices (such as heating mantles) require auto-transformers to control the temperature. Such auto-transformers must be wired according to code and have a two-pole switch, a three-prong plug, and a power overload device. Unattended heating devices must be protected with overload circuitry and with a temperature-sensing device that will turn the power off in the event of overheating. When cooling water is used in connection with heating (as in the condenser of a solvent still), an automatic device to turn off the power when water flow is interrupted is absolutely necessary.

### Hot Plates

1. Hot plates with heating elements that are not totally enclosed must be discarded.
2. Hot plates with temperature control devices must be spark-free.

### Heating Mantles

1. When used with auto-transformers (variac or powerstat), make certain that the auto transformer is properly wired.
2. The temperature of heating mantles can be effectively controlled with solid state controllers (approximate cost, \$100) with a feedback sensor sensing the temperature of the heated liquid.
3. If a solid state controller is used, make sure that the feedback device is fail-safe (i.e. if the circuit opens the power is turned off).
4. Always support the heating mantle with a ring so as to allow air circulation around it to prevent overheating of the exterior of the mantle.
5. Never support a heating mantle with any combustible material

### Oil Baths

1. The temperature of electrically heated oil baths must be carefully controlled so as not to exceed the flash point of the oil (check the MSDS for the flash point).

2. Oil baths must be protected with temperature sensing devices to turn off the power in the event of overheating.
3. Bare wires should never be used to heat oil baths.
4. Heated oil should never be contained in breakable containers; containers should be mounted on solid, flat surfaces to avoid spilling.
5. Insure that water or volatile materials do not come into contact with oil baths. Oil baths are used for temperatures in excess of 100 °C--a hot oil explosion will result if these materials come into contact with the hot oil.

### **Fused Salt Baths**

Great care should be taken to understand all the properties of the salts used in such baths, especially when mixtures of salts are used. Because of the high operating temperatures of these baths, salts have been known to react and cause catastrophic explosions.

### **Heat Guns**

The heating element of most heat guns consists of exposed wire which typically becomes red hot during use. In addition, the on-off switch on a heating gun is not spark-free. Therefore, heat guns must never be used near flammable liquids.

The power cords on heating guns often fray near the handle. Heat guns must be continually inspected for this problem and repaired immediately if frayed.

### **Refrigerators**

Because there is never a satisfactory arrangement for continuous venting of the interior of a refrigerator, material escaping from stored containers will accumulate and could form a flammable, explosive, reactive, or toxic mixture. Additional information regarding laboratory refrigerators is provided in a Campus Fact Sheet in Section 7 of the College of Chemistry Health and Safety Manual.

1. Flammable liquids may only be stored in UL listed Flammable Storage Refrigerators. In house “de-sparking” of conventional refrigerators for use with flammable materials is prohibited by the State Fire Marshal.
2. Laboratory refrigerators must be labeled as to the compounds that can be stored inside.
3. Laboratory refrigerators must be provided with a temperature alarm to enunciate failure of cooling or must be checked regularly to assure that they are functioning properly.
4. If the material in a refrigerator will produce hazards if the refrigerator warms, it should be listed on the College “Critical Utility List” (contact College Physical Plant 3-4220 for more information).
5. Uncapped materials should never be stored in a refrigerator. Containers of chemicals should be capped in such a way as to achieve a seal that is both vapor tight and unlikely to permit a spill if the container is tipped over.

### **Stirring and Mixing Devices**

Stirring and mixing devices are used commonly to maintain uniform temperature in a reaction mixture. Failure of such a device to operate can cause excessive local heating resulting in an uncontrolled reaction that could cause an explosion or fire. When the temperature control of a reaction is critical, interlocking the function of the stirrer with the heating mechanism is a prudent procedure. Stirring devices are usually operated by motors;

such motors must be spark-free. For stirring devices that are used in a fume hood, provisions should be made to turn off such devices from the outside of the hood.

### **Mechanical Vacuum Pumps**

Distillation or concentration operations that involve significant quantities of organic compounds are usually carried out with aspirators. When vacuum pumps are used for such operations, they are usually trapped (see section page 46). Volatile compounds inevitably go through the traps and condense in the pump oil. Even though pumps are available with “ballast valves” (valves that allow a small amount of air to enter the pump through the first stage to sweep volatile compounds), eventually the oil degrades and the performance of the pump is reduced. Mechanical vacuum pumps require frequent oil changes in order to maintain their performance.

Pumps must be placed in a tray to avoid oil spilling on the floor where it would present a serious slipping hazard.

Pumps should be maintained in good working order with frequent oil changes; if they are belt driven, the belts must be inspected often.

The pump exhaust must be connected to a local exhaust system.

Belt-driven pumps must have belt guards that cover the entire belt and pulley assembly.

### **Vacuum Systems**

#### **Rough Pumps**

These pumps are motor-driven and oil sealed; occasionally the motor and pump are coupled with a belt.

1. The pump must be trapped to delay the contamination of the pump oil.
2. The pump oil must be compatible with the material that is being pumped--Oxidizers such as O<sub>2</sub>, NO<sub>2</sub>, CO and F<sub>2</sub> can react violently with hydrocarbon oils.
3. The motor must be spark-free and protected from overload.

#### **Diffusion Pumps**

Most common diffusion pumps use oil as a pumping fluid. Some old types of diffusion pumps use mercury and are made of glass. The use of such pumps must be discontinued unless there is a compelling reason for their use. In such a case, these pumps must be used with local ventilation.

The cooling mechanism of the diffusion pumps must be interlocked with their heating mechanism so that in the event that the cooling mechanism fails, the power to the heater will be interrupted. Overheated diffusion pump oil at a minimum will react and decompose; and in some cases could react with the material that is pumped causing a fire or explosion.

#### **Cold Traps**

Cold traps are used to freeze and trap volatile compounds so that they are prevented from entering and contaminating the oil of a pumping system.

1. The common practice of using acetone-dry ice as a coolant should be avoided.

2. Isopropanol or ethanol work as well as acetone and are less toxic, less flammable and less prone to foaming.
3. After completing an operation in which a trap has been used, the system must be vented. Venting is important because volatile substances that have collected in the trap will vaporize when the coolant is exhausted and cause pressure build-up that can result in exploding the apparatus.
4. When cold traps with liquid nitrogen are used, care must be taken not to open the vacuum system to the atmosphere when the trap is still immersed in liquid nitrogen because oxygen rich air will condense in the trap and might react violently with organic compounds condensed in the trap.

### **Rotovaps**

1. Water aspirators must never be used to pump volatile organics.
2. To avoid damage to the pump and to avoid release of compounds into the lab air, dry ice traps must be used when pumping volatile organics.

### **High Pressure Equipment**

The design and use of high pressure equipment must be made with great care. Compressed gases store large amounts of energy which can cause a great deal of damage when released.

#### **Safety Factor**

Pressure vessels must be designed with a safety factor of 5. This means that the vessel must be designed to hold five times the working pressure without rupturing.

#### **Material**

The material used must be compatible with the material the vessel is designed to contain to avoid corrosion. The operating temperature of the vessel must also be considered.

#### **Testing**

Pressure vessels must be tested at the operating temperature and at 130% of the working pressure without exhibiting 0.2% permanent deformity. The design working pressure must be permanently stamped on the vessel. A record of the test must be made and kept.

#### **Safety Devices**

The vessel must be equipped with at least one tamper-proof pressure relief device to relieve at 110% of the working pressure. When the vessel contains toxic gases, it must be stored in a ventilated enclosure and the relief device must be discharged into the local exhaust system (see Campus Fact Sheet on the Toxic Gas Program).

#### **Pressure Gages**

Pressure vessels must be equipped with appropriate gages so that the operator is aware of the conditions inside the vessel.

#### **Glass Vessels**

The use of glassware for pressure work should be avoided. If it is to be used as such, tests must be conducted to determine design parameter. Shielding should always be provided for glass equipment under vacuum or pressure.