PULSED POWER LABORATORY
SAFETY GUIDELINES
TEXAS TECH UNIVERSITY

I HAVE READ AND UNDERSTAND
THESE SAFETY REGULATIONS.

_____
Name

_____
Signature

_____
Date

General Electrical

1. Be well aware of the hazards that exist with the standard 120VAC power. This is potentially more dangerous than any other power source in the laboratory due to its commonplace use and high-current capabilities. The main breaker panels are capable of delivering in excess of 200 amps per phase.

2. Familiarize yourself with the location of the main breaker panels and auxiliary panels and the general areas which they service. Keep panel areas and access to them free of clutter.

3 Make positive connections to your power outlets. Do not use faulty plugs, cords, connectors, or receptacles. Have them replaced or repaired immediately.

4. When repairing or assembling a power cord or extension, learn and use the proper wiring code to insure correct polarity. For most cases in this lab, our extension cord cable is black, three conductor cable, 16/3, one black, one white, one green. Most commercially available plugs, connectors, and receptacles are color coded. Make connections as follows:

   Black (or hot) to brass screw.
   White (or neutral) to silver screw.
   Green (or ground) to green screw.

   Some cables may not be color coded in this same manner but remember, you still have hot, neutral, and ground.

5 Never work on a live circuit or tap into live wires. Locate the switch, fuse, or circuit breaker and disconnect the power before starting to work on the circuit. Label this service so others will know not to reconnect while work is in progress.

6. Do not replace a fuse or reset a circuit breaker on a "blown" circuit until the cause of the trouble has been found and corrected.

High Voltage

Consider any voltage level greater than our nominal 120VAC/3P phase as being "High Voltage".

2. Never work alone when using "High Voltage". You must have at least one other person present during a "High Voltage" experiment.

3. The experimenter shall provide some warning that the "High Voltage" is `on'. This can best be done by means of a flashing red light and a "Danger High Voltage" warning sign. Also extend a verbal warning to those persons working on other projects in close proximity: "Charging", "High Voltage".

4. Confine all "High Voltage" experiments to controlled access areas. Depending on size, this can be done by placing the experiment within a grounded screen room or metal box or by blocking off the area by a rope barricade. Be aware of other persons close-by, and be well aware of "passers-by". Be sure that you yourself do not disregard someone else's barricades.

5. Designate some point of your experiment as "experimental ground". Reference all equipment grounds to this point. Then connect with one 6 AWG cable, or larger, that point to the grounding grid or to building ground.

6. Provide some method of discharging "High Voltage" points of your experiment to insure safe approach and handling. This can be automatic or manual, by means of a "high voltage" relay or by "shorting sticks". The discharge should be back to "experimental ground" through some resistance. In case of a capacitor being used with no reference to ground, the discharge must be between the capacitor terminals. This short circuit should remain in place when the experiment requires maintenance or is not in operation.

7 Before handling energy discharge/storage capacitors, make sure they are discharged by means of "resistive shorting sticks", then insure that they do not acquire a static charge by attaching "direct shorting sticks". Finally, attach a metal strap or wire between the terminals.

8 Never view a high energy discharge with the naked eye Make use of filters and remote monitor.

9 Use protective shields to insure safety in case of catastrophic apparatus or component failure. Do not take for granted that your designs and assemblies are without fault or defect. Watch for signs of material fatigue.

10. Protect your ears. Hearing protectors are available, so make use of them. An open-air discharge of most experiments in this lab are of high enough energy to cause hearing loss.

Laser

1. Lasers will be operated in controlled access areas. Precautions will be taken by the user to insure:
   a) no unauthorized or accidental entry into area.
   b) controlled areas are clearly marked.
   c) audible and visual warnings are in use during operation of laser.

2. Avoid uncontrolled reflections of laser beam. (e.g. watches, bracelets, rings, pens and pencils).

3. Always wear proper goggles designed for the laser in use and never peer directly into beam regardless of laser power level.

4. In case of an accidental exposure to your eyes, notify an advisor at once. He will help set up an immediate eye examination and medical care if needed.

5. For further information on regulations refer to Texas Laser Safety Manual, EE 103E.

Radiation

1 Keep the radiation level as low as possible.

2. Keep maximum distance from radiation source.

3. Use shields (e.g., lead).

Chemicals/Gases

1. MSDS (Material Safety Data Sheets) are available in Room 103c Rear in the MSDS File. Utilize this information to familiarize yourself with new chemicals and review safety practices for common chemicals-solvents. If MSDS is not available, notify advisor and that MSDS will be added to the file. Annual training will be provided by the department to inform employees of their rights under the Hazardous Communication Act and to instruct employees on basic procedures.

2. After using any chemicals, wash your hands thoroughly with soap and water. Do this immediately upon completion of task, do not let the substance absorb into your skin.

3. Clean up any chemical spill immediately and thoroughly. If the spill is of a toxic nature, notify an advisor immediately. It may be necessary to get help from Environmental Health and Safety (742-3876).

4. Use extreme caution when working with liquefied gases. At cryogenic temperatures these gases are possible sources of serious cold burns. Wear proper clothing when handling liquefied gases (e.g. gloves, goggles, face shields).

5. Compressed gas cylinders will be stored in an upright position and secured. Caps will be on bottles which are not in use.

6. When the gas cylinder is not in use, the valve hand wheel shall be shut off. Even non-toxic gases can be deadly if they displace the oxygen in the room.

7. Never use a defective regulator. Repair or replace it. Before disconnecting a regulator, make sure the valve hand wheel is turned off.

8. Remember to turn the gas on slowly so you don't damage the regulator with a 2000 psi blast.

9. Exhaust gases from mechanical vacuum pumps must be vented. The vapors produced are poisonous/carcinogenic. Use a vent hose to the venting system or outside.

10. Polychlorinated Biphenyls or PCB's are a toxic environmental contaminant requiring special handling and disposal in accordance with EPA. We have tried to locate and dispose of all capacitors and transformers which might contain PCB's. If you come across a capacitor which has a leak, handle it with care and try to avoid contact with the oil. Wash your hands thoroughly when finished. Make this capacitor known to an advisor so it can be removed and/or disposed of.

<u>General</u>

When you are not familiar with a tool or piece of equipment, electrical or mechanical, obtain some qualified help before you try to put it to use. Manuals are available.

2. Use the tools and equipment for their intended purpose. Use the proper tool for the job.

3. When using a hand drill or the drill press, be sure the bit is installed firmly in the drill and the stock is held firmly in place with a clamp.

4. Remove all jewelry (rings, bracelets, etc.) and roll up sleeves above elbows before working with any power tools or electrical equipment.

5. Keep work areas clean and free of clutter, cans, bottles, food, etc. Clean up any spills immediately.

6. When working on electrical equipment, be sure the power is disconnected and all capacitors are shorted to ground.

7. Learn to protect your eyes, wear safety glasses, goggles or face shields where there is a possibility of being injured by flying chips, metallic or non-metallic, or electrical flashes.

8. It is the policy of this department and this laboratory that no undergraduate student shall work in the laboratory without the supervision of a faculty member, staff member, or graduate student associated with one of the projects of the laboratory.

9. (Update 3-9-2010) Never turn on an experiment or operate a device that you are not familiar with or that has been tagged. Also refer to OP 60.06: Lockout/Tagout Program.

10. (Update 3-9-2010) Shut down / de-energize your experiment before you leave. Unattended experiments need to have proper monitoring and safety features. A contact name and phone as well as emergency shutdown procedures need to be visibly posted.

Supplement to Rules

1. If you unlock it, lock it.

2. If you open it, close it

3 If you move it, put it back.

4 If you turn it on, turn it off.

5. If you make a mess, clean it up.

6. If you borrow it, return it.

7 If it belongs to someone else, and you want to use it, get permission before taking it.

8. If you break it, report it

9. If you don't know how to operate it, leave it alone.

10. If it doesn't concern you, leave it alone!

Radiation Safety

In many pulsed power experiments, electrons are accelerated to high voltages (> 10 keV energy). These electrons can produce direct ionization, or they can generate X-rays, which in turn produce ionization. Energy absorption processes for either electrons or X-rays are localized in few atoms, and either ionize (threshold energy 10 eV) or excite (threshold energy 1 eV) these atoms. Biological systems are very sensitive to these ionization and excitation processes, and a single event of this type in a biological cell can trigger processes which have drastic consequences. Any exposure to radiation, therefore, should be kept to an absolute minimum.

In traversing matter, the energy of either electrons or X-rays is degraded, and at the same time radiation of lower energy is generated. The question of what fraction of the resulting mixture of primary and secondary radiation is still capable to excite or to ionize cannot be answered in general terms, and it depends on many factors (primary electron energy, electron current, materials in the environment of the experiment, distance, geometric setup of the experiment, etc.). Principle guidelines for radiation protection and safety are given below. They include kinds of radiation which do not occur in "every-day pulsed power", such as neutrons, alpha particles, fast protons etc., and radioactive material, for completeness.

Some quantities and units used in radiation dosimetry

1) Unit of activity of radioactive material:

   number of decays per second
   (former unit: 1 Curie = 3.7×10^{10} decays/s)

2) Ionization dose D_II:

   number of electron/ion pairs produced in air per unit mass
   unit: Coulombs/kg

3) Energy dose D_E:

   absorbed energy per unit mass
   units: 1 J/kg = 10^{-2} rad

4) Equivalent dose D_{eq}:

   biological effects of exposure to ionizing radiation depend on the kind of radiation, i.e., energy dose, D_E, is multiplied by a "quality factor", Q, to yield the equivalent dose, which would produce the same amount of damage

$D_{eq} = Q \times D_E$, where Q=1 for electrons and X-rays
Q=20 for protons, alphas, etc.
Q=2...10 for neutrons, dependent on energy
unit: 1 rem = 1/100 J/kg

Typical equivalent doses are:

medical X-rays: 0.1 . . . 5 rem
natural dose rate, average: 0.15 rem/year

CONTROL IS REQUIRED IF DOSE RATE > NATURAL DOSE RATE

In these cases, radiation dosimeters have to be placed at critical points around the experiment, and the readings have to be checked periodically.

The quantities above and their units should serve as guidelines for radiation protection schemes. For a given experiment, the possible exposure to radiation has to be estimated based on the data of the experiment (beam current, voltage, X-ray production efficiency, distance, etc., and electron to x-ray conversion efficiency, as well as the absorption coefficients of the materials used), and a proper shielding has to be designed. For X-rays, high Z (atomic number) material, such as lead, has to be used. To absorb electrons, and to avoid or minimize X-ray production, low Z material (for practical cases plastic or aluminum) is appropriate.

THE SIMPLEST PROTECTION AGAINST RADIATION HAZARDS IS DISTANCE
(Intensity proportional distance^{-2}).

Typical ranges of radiation in water are tabulated below, multiply these numbers by 1000 to estimate typical ranges in air, for lead multiply by roughly 1/20:

alpha-particles:		5 MeV		40 μm
electrons:		20 keV		10 μm
		1 MeV		7 mm
X-Rays:		20 keV		6 cm
		1 MeV		70 cm

Texas Tech University

Pulsed Power Laboratory
Department of Electrical Engineering

October 12, 1988

To: Pulsed Power Laboratory Personnel
From: M. Kristiansen
Subject: Disposition of Chemicals

I want to call everyone's attention that as a general policy we should not dispose of chemicals in a common sewer drain. If you have the need to get rid of chemicals by pouring them into a drain then prior approval must be obtained on a case by case basis from Environmental Health and Safety. Obviously, oils, acids, bases and flammables are not candidates for drain disposal. One of the major disposal problems encountered is that although a given chemical may be tolerated in a drain the following chemical that is disposed may explosively mix with residues of the first. Therefore, always get Environmental Health's approval (by phone from Mr. Bob Morris at 2-3786) before using drain disposal for chemicals. When approval is not granted for whatever reason, they will simply ask that the chemical in question be placed in a leak proof container and properly identified. It is their policy to pick up all chemicals at no charge within 24 hours of notification.

Don't call them to dispose of old coffee, but let's honor their request to obtain approval even when we are dealing with solutions that we believe are fairly safe, e.g., aluminum chloride and copper sulfate solutions are not to be poured down drains.

Lubbock, Texas 79409-4439 / (806) 742-3468 / FAX (806) 742-1900

TWELVE RULES FOR SAFE HANDLING OF COMPRESSED AND LIQUEFIED GASES

Most workers who handle gases are careful and safety con scious and have good accident prevention records. But in activi ties where compressed or cryogenic gases are only occasionally used, or are only minor components in a system, vigilance if often relaxed - sometimes with unfortunate results. A few simple rules can help save months of work, thousands of dollars in equipment, and perhaps some lives.

1) When moving cylinders, use hand carts or trucks specifi cally designed for gas cylinders to prevent slipping, rolling, or falling. Keep caps on all cylinders until they're put into use. And wear safety glasses at all times.

2) Secure all cylinders to walls or bench tops during stor age or use. An elbow or foot can topple a tall cylin der, dislodging or breaking connected piping, and fracturing toes. If a cylinder is damaged so that its valve shears, it can become a projectile traveling at deadly speed - known to penetrate masonry walls.

3) Don't use guesswork or intuition in determining cylinder contents. Color codes are not the same everywhere and cannot be relied on in the absence of labels and tags. All identification should be kept intact. When in doubt about a cylinder, get your gas supplier to identify its contents or inspect it. Before using any gas, familiar ize yourself with the data in the Material Safety Data Sheet (MSDS).

4) Watch fittings and connections. Make sure all gas han dling equipment that connects to a cylinder has threads that mate properly to the cylinder outlet valve. Though one CGA fitting may serve for several gases, it is wise to dedicate equipment to a single service. Beware of cross-threading. Don't force threads, and use washers where indicated. Never try to jury-rig adaptors between non-mating cylinders and equipment. CGA fittings are designed to prevent dangerous mismatches of gas and equipment.

5) Before any connections are made, inspect the cylinder carefully. Is there any hissing or sign of escaping gas? If so, follow the procedures outlined on the MSDS and contact the safety department, gas supplier, or a hazardous chemical information hotline. Also, inspect valves for damaged threads. Clean away any oil, grease, and dirt - unless the cylinder contains oxygen or anoth er strong oxidant. In that case do not clean the valve. Return the cylinder to your supplier promptly. Traces of organic matter left in the oxygen valve can cause explosions when the cylinder is opened.

6) Never tighten a leaking connection under pressure.

7) Most cylinder valves (some toxic gases excepted) have pressure relief devices. Don't change, modify, repair, or tamper in any way with these pressure relief devices. Use pressure regulators and relief valves to protect downstream equipment and piping from excessive pressure. Any pressurized system requires proper regulators, valves, tubing, fittings, and other equipment designed to withstand the pressures.

8) Make sure materials of all downstream equipment and pip ing are chemically compatible and appropriate for the gases being used. Do not install a regulator on a cyl inder valve containing oxygen or another oxidant if grease or oil is present on either.

9) Consider the entire assembly or system that will contain gas. With toxic, flammable, or pyrophoric gases, all lines must be purged with inert gas before opening the cylinder valve or breaking connections. Your gas sup plier is the best source of information on purge proce dures.

Test systems thoroughly for leaks, using inert gases.

Have adequate safety equipment on hand including gas detectors, gas masks, self-contained breathing appara tus, and protective clothing. The location of safety showers, eye washes, first aid kits, fire-fighting equipment, and alarms should be known and easily acces sible.

Oxidants, toxic, and flammable gases should be stored separately. It is wise to keep minimum inventories of toxic and corrosive gases. All cylinders should be stored in dry, cool, well-ventilated areas protected from the weather. Do not expose cylinders to open flame or to temperatures above 125@F. Cap empty cylinders, mark them with a big "MT," and store them away from full ones. Always leave some pressure (25psig or more) in depleted cylinders to keep out air, moisture, and con taminants.

When in doubt - contact your safety department or gas suppli er. Remember, service and technical assistance are part of your specialty gas purchase package!

Sanford, Glenn D., Technical Service Representative, "Gas Facts, New Products from Scott, A Publication of Scott Specialty Gases, Inc., Vol. 1, No. 3, Sept./Oct. 1989.