Mechanical and Aerospace Engineering

Laboratory Safety Training Manual

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Overview

It is essential that all users of laboratories and shop facilities be knowledgeable of basic safety principles. This is most important for your own health and safety in all research labs and shop facilities. It is also important for these reasons:

1. There are penalties and fines for improper use of equipment and materials. This is especially true for chemical and waste products. We are periodically inspected by the Fire Marshall and the Environmental Health and Safety Office for violations. The Department must pay fines for violation of regulations. The University must operate under strict adherence to procedures from the Occupational Health and Safety Administration as well as state and local regulations.
2. If one is injured in a lab or shop, the Department has to fill out all sorts of forms! And we have to justify that the person involved has been trained and made aware of the hazards. Plus we have to verify that a proper procedure was being followed. Otherwise we run the risk of State penalties and potential lawsuits.
3. All industries and research facilities now require employees to go through extensive training in safety procedures and regulations. So you will be exposed to this material everywhere you work. Some safety instruction here will thus be of benefit to you later.

This manual provides an overview of safety in general. Some items will not apply specifically to activities in the MAE Department. But the general knowledge is essential.

IMPORTANT ITEMS TO ADDRESS

Take time to look at your lab or shop to see that things are in proper order and the workplace is safe. Check yourself on these items

1. Do you have the proper training to perform the tasks?
2. Do you know where fire extinquishers, emergency stop buttons, emergency contact phone numbers, and personal protective equipment are located?
3. Are there maintenance and inspection procedures for critical equipment and materials?
4. Is the work area clean and liter free?
5. Are all containers labeled?
6. Is there a list on the outside of the door showing what potential hazards are in the lab (high voltage, chemicals, lasers, etc.) and who to contact in case of an emergency?
7. Are there procedures for you to follow in case of an emergency, fire, or injury?
8. Is the area secure so that people cannot just wander in and potentially get hurt?
9. Are the proper guards on power equipment?

AND REMEMBER!

1. Never work alone in a lab or shop!
2. Never work with the door locked. If you are injured, no one can get in to help you!
3. Always wear shoes that cover your feet!
4. Always use safety glasses!
5. Remove clothing, hair or jewelry that can become tangled in moving machine parts!

You can get additional information and training by visiting the Environmental Health and Safety Office website. In particular, there are on line training courses that you can take. ALL University employees who use hazardous chemicals, chemical products, or generate hazardous waste MUST receive this training.

You may want also to perform an annual safety inspection of your area. In that case, the general checklist below is a place to start.

MAE SAFETY INSPECTION CHECK LIST, 2005

Room______________________________________ Responsible person__________________

III. GENERAL ITEMS

Clean/orderly work areas	
Covers, guards in place	
Loose boards, protruding nails, splinters, shart edges	
Railings around tanks, openings, stairs	
Exits marked	
Aisles clear	
Emergency lighting	
Potential for falling objects	
Zero energy states	
Proper lighting	
Proper ventilation	
Proper drainage	
Compressed gases secured	
Warning signs	
Fire hazards	
Equipment locked to prevent use by untrained	
Heat hazards	
Utilities routing, shutoffs	
List of hazards and phone numbers on door	
Dust hazards	
Maintenance schedules	
Lockout/tagout materials as needed	
Personnel sufficiently trained	

II FIRE/FIRST AID/PERSONAL PROTECTION

First aid supplies	
Hearing protection	
Eye protection	
Respiratory protection	
Gloves	
Extinguishers accessible, charged, sufficient	
Eye wash/showers as needed	
Document on the door tells people about hazards inside and gives a contact person	

III. MATERIALS

Proper storage	
Proper labeling	
Proper handling procedures	
MSDS on file for all chemicals	
People have training in chemicals and hazardous waste	

IV. ELECTRICAL

Uncovered boxes, wires	
Ungrounded equipment	
Extension cords and non-permanent wiring	
Free access to circuit breakers/panels	
High voltage hazards labeled	

V. MACHINE GUARDING

Belts and pulleys	
Point of operation guards	
Rotating parts	

VI. OTHER

WORPLACE SAFETY BASICS
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WORKPLACE SAFETY BASICS

1: INTRODUCTION

The Romans often tested the blades of new swords by hacking off the appendage of a slave. Today they would be sued. Safety in experimentation has come a long way.

Concern with safety as a specific topic for study is a relatively new concept. As the number of injuries began to cost companies money, safety became more and more important. Today there are strict regulations on what we can and cannot do in laboratories and just about everywhere else. An engineer has to be aware of the potential hazards of any test program. This means that you will have to consider safety as part of the testing process.

Safety and environmental protection is now an integral part of worker training in every aspect of engineering and manufacturing. You will be given extensive training when you assume a position at a company. Because of legal consequences, your adherence to strict safety standards will be a mandatory part of your job description. Failure to comply can cost you your job and, in some cases, your career. In this chapter we will provide a brief overview of safety and how it relates to laboratory practice. On your job, you will receive additional training and safety reference material. You may also be called upon to create safety guides and training materials.

There are a great number of good references on this subject. Here are a few you may consider examining.

1. U.S. Dept. of Labor, General Industry Guide for Applying Safety and Health Standards, 29CFR, 1910, OSHA (Occupational Safety and Health Administration)
2. National Safety Council, Accident Prevention Manual for Industrial Operations
3. National Fire Protection Association, Fire Protection Handbook
4. Wadden, R.A., and Scheff, P.A., Engineering Design for the Control of Workplace Hazards, McGraw-Hill, 1987
5. Ridley, J., Safety at Work, Butterworth, 1990
6. Hunter, T.A., Engineering Design for Safety

2: HISTORICAL BACKGROUND

When human life was cheap, safety was not very important. Slaves were expendable so sword testing and pyramid building were carried out without regard to the human cost.

As technology advanced, the loss of a skilled human represented a significant economic loss. The need for safer machines in industry became important enough 200 years ago to initiate scientific studies of what caused accidents and how to prevent them.

For centuries, safety was not considered amenable to scientific study. Work stations were laid out based on experience. An injury was treated as an error on the part of the person injured. The prevention was to simply be more careful. Companies did not take care of injured workers. If you could no longer work due to injuries, you were replaced because, after all, your injuries were your own fault anyway.

The invention of "scientific management" is generally credited to Frederick Taylor who began time and motion studies at the turn of the century. Taylor showed that work processes could be studied and improved upon. Changes in work layout increased worker efficiency considerably. As the need for higher productivity increased, more jobs were "designed".

Companies and their insurers were the first to apply the same ideas to safety. These studies showed that injuries and loss of productivity could be reduced by re-design of the workplace. Thus the idea that injuries were solely the fault of the injured was shown to be false. Government regulations to insure the safety of the worker took the form of worker's compensation laws that forced the employer to pay for some or all of the injuries.

Worker compensation laws first appeared in the U.S. in 1911 and have since spread and expanded. These laws require companies to compensate workers for injuries on the job, pay for medical treatment and lost wages regardless of the cause of the injury. The effect of this kind of legislation has been profound. It is now to the advantage of the company to provide safety training of workers to reduce carelessness and to create a safe work environment.

This legislation represented a significant change. Previously, damage to the physical equipment and buildings due to an accident were addressed by management because it was obviously in their best interest to do so. Workers compensation laws forced concern for the human element. The final step, taken in the last twenty years, has been the inclusion of the environment outside the workplace such as surrounding air, water, populations, and natural resources on both a short and long term basis. Occupational safety and health now includes environmental safety and health. The consequences of plant operation are widespread and closely regulated with severe penalties imposed.

3: LEGAL ASPECTS OF WORKER COMPENSATION

These worker compensation laws also serve to reduce the number of lawsuits filed against companies for damages by injured workers. For example, if an arm is lost by a worker, compensation laws require the employer to pay for medical costs and provide sufficient money to support the worker if he or she can no longer work. The worker must settle for whatever compensation the law provides for and cannot sue the company for additional damages. For example, a soldier, injured by a truck in the base warehouse cannot sue the Sergeant who ordered the truck to move or the private who drove the truck or the U.S. Army. He or she must take whatever compensation the law allows. Were this not the case, lawsuits against everyone would bankrupt us all and everyone would be afraid to do anything.

But there are strange "holes" in the legal process that can still cause great discomfort. For example, the soldier run over by the truck may sue the manufacturer of the truck in civil court on the grounds that the truck was improperly designed. Or, he or she may sue the contractor who erected the building in which the injury occurred on the grounds that the lighting installed was not adequate and the truck driver thus could not see well enough to avoid the accident. In a lawsuit like this, the contractor can counter that the U.S. Army told them what kind of building it wanted and approved the building by their act of paying for it when it was completed. Thus the contractor is not responsible. If that is so, then the Army is responsible again and the lawsuit fails. You can see the kinds of legal messes that result, especially when there are so many attorneys ready to take on such cases for injured clients.

The job of determining who is responsible falls on the jury and the judge in such situations. Decisions are not always based on the best rationale. Juries may award large sums of money for emotional reasons, for example.

It is quite possible that you can become involved in such litigation either as a witness for your company or as a defendant. For example, suppose you design a test rig for use by some other company. Or suppose that a worker from a supply company is injured because he or she is walking by your test rig when it explodes. That worker may be covered by worker's compensation at his or her company. But the damage was done by your company. So the worker or his or her company may sue your company. Or they may sue you as the engineer in charge of the test rig.

The key to the outcome in such situations is often whether or not the accident was "reasonably foreseeable" and thus preventable. Then the question becomes who was responsible.

All this does not mean that you should live in constant fear of being sued. Such things are rare and, in many cases, as unpreventable by you as an auto accident or plane crash you are involved in. You can be sure, however, that if the technician is killed when the test rig explodes, you will share some of the blame and may lose your job. Your best protection is to follow the company safety policy closely.

It is also possible that your exploding test rig kills 5000 rare birds roosting on the roof. In that case, all hell can break loose! Damage to the environment is extremely costly. In the dead bird case, your company is liable. So it may not cost you any money but might cost you your job.

4: SAFETY IN EXPERIMENTATION

Many regulations apply principally to production where processes are repetitive and of long duration. Application of such regulations to experimental work is often indirect since many experimental test rigs are custom built one-of-a-kind devices. In this case, the responsibility for establishing test procedures that anticipate possible safety issues will fall to those who design and use the equipment in the laboratory.

Most regulations apply to general activities such as safe handling of hazardous materials, insulation against electrical shock or burns, following specific procedures in the reporting of accidents, and so on. These apply to experimental test rigs in the same way they apply to any other operation in the plant. So general safety principles will cover most of what you do. Always keep the safety officer or safety office informed of your activities. And be sure to ASK before performing any activity that might discharge chemicals or present a potential hazard! Feel free to ask for someone to review your equipment.

It is not possible to apply all regulations to a test rig because, unlike a machine on a production line where the worker is discouraged from climbing inside the machine to watch what is happening, what is going on is precisely what the experimentalist needs to know. If you put all the safeguards on an experimental test rig that are required on a production machine, you are not able to gather much test data! This does not mean, however, that you can ignore human or environmental safety when designing a test rig. Careful planning of the experiment in advance will help to address safety issues. One may also create checklists for operation of the equipment to insure that mistakes are avoided.

When you start out on a job in industry. Someone else will be responsible for these activities. But if you fail to bring potential hazards to the attention of management or do not practice good safety in your work, you can find yourself in considerable trouble.

5: SAFETY BASICS

A **HAZARD** is any activity or situation with the potential of harming people, equipment, or the environment. **SAFETY** involves the two-step process of:

1. HAZARD RECOGNITION
2. HAZARD ELIMINATION OR AVOIDANCE

Thus the first goal of safety is to **keep an accident from happening**.

The second goal is to **be trained and equipped to RESPOND** to an accident in such a manner as to minimize the damage.

Armed with these two goals, anyone with reasonable intelligence can figure out what to do to operate safely. Stand in front of your experiment and ask three questions:

1. What could go wrong with this equipment that might harm people, equipment, or the environment?
2. What can I do to prevent this from happening?
3. If it does happen, what actions should be taken to minimize the resulting damage?

So safety is basically simple common sense. You practice it every time you approach an intersection in your car. Formal safety training and procedures are designed to help you not overlook something!

5-1: HAZARD RECOGNITION

Hazards can be classified into various categories or types of threats.

a. Kinematic hazards
b. Energy hazards
c. Electrical/chemical/nuclear hazards
d. Human factors hazards
e. Misuse and abuse hazards
f. Environmental hazards

and the magnitude of these threats can be evaluated based on.

a. Magnitude of the danger severity
b. Length of exposure
c. Short or long term effects
d. Frequency of occurrence
e. Environmental impact

5-1a: Kinematic Hazards

Kinematic hazards are the mechanical type that we associate with moving machines. Kinematic hazards are possible whenever material is in motion. Vehicles, saw blades, and other moving objects represent a potential kinematic hazard. Kinematic hazards are often broadly classified as those due to translational or rotational motion. The human injuries that result are classified as pinching, nipping, cutting or crushing.

The region of a machine in which the actual operation is taking place is called the point of operation. The contact point between the saw and the wood is the point of operation of a chain saw, the point where the press die is in contact with the metal to be stamped is the point of operation of a punch press, and so on. Point of operation injuries occur when some part of a human body is in the operating zone at the time the machine is performing the operation. Kinematic hazard exists elsewhere on a machine as well. The moving shaft, belts, pulleys, etc. of a drill press are danger points too.

5-1b: Energy Hazards

Energy hazards refer to the potential of stored energy to cause harm. A pressurized hydraulic cylinder, a compressed spring, a heavy box on a high shelf, and a charged capacitor are examples of energy hazards. Energy hazards are most dangerous when the worker assumes that the machine is safe because it is turned off. When not operating, many machines retain stored energy in various forms. Injury occurs when this stored energy is unexpectedly released.

5-1c: Electrical/Chemical/Nuclear Hazards

Uninsulated wires, ungrounded wires, high voltage transmission lines, exposed electrical contacts, open pans of gasoline, oily rags, biologically or nuclear toxic materials, are all forms of electrical and chemical hazards commonly found in the workplace. These cause injury by shock, fire, chemical burns, radiation and asphyxiation.

5-1d: Biological Hazards (Pathogens)

Laboratories in which experiments involving human tissue or pathenogenic organisms take place are classified by the Centers for Disease Control (CDC). There are four biosafety levels based on the degree of risk to the health of personnel working in the lab.

The CDC manual, Biosafety in Microbiological and Biomedical Laboratories establishes strict guidelines for each level. These govern appropriate policies and procedures that must be in place and routinely followed in day-to-day laboratory operations.

Included in these lab-specific policies and procedures may be stipulations governing:

a. Access to the lab when work is in progress.
b. The appropriate personal protective equipment (PPE) that must be worn. [See section 7].
c. The safe handling of “sharps” (anything with a sharp edge or point).
d. The creation of aerosols.
e. Decontamination of work surfaces.
f. Clean-up of spills
g. Handling of Regulated Waste.

If human tissue is present in the lab, OSHA Standard 1910-1030, “Bloodborne Pathogens” may also apply. An important element of this standard is the concept of “**Universal Precautions**”. This policy assumes that **all human tissue or body fluid is treated as if it is infected with an infective agent** such as HIV or hepatitis whether it actually is or not!

The standard mandates additional measures such as the offering of immunizations to those who come in contact with such materials, and the development and adoption of a lab-specific biosafety manual and exposure control plan.

At UVa, Compliance with these standards is monitored by the University’s Institutional Biosafety Committee , (vprgsecure.web.virginia.edu/bio/home.cfm) (434-982-4911) This group also conducts yearly training sessions regarding biosafety issues.

5-1e: Human Factors Hazards

Carelessness is one of the most common forms of human factors hazards. Carelessness can be caused by lack of training or by simple inattention due to overwork, illness, emotional or psychological problems. Training and work regulations such as "Do not work if you are tired!" were standard solutions to this problem for centuries. Now we know that workplace design can contribute to human factors hazards. Poor lighting of the workspace, poor layout of machine controls, and lack of sufficient rest time (breaks) on the job are common causes of human factors hazards.

Mismatch between human and machine capabilities is also an important form of human factors hazard. Expecting an operator to feed parts to a machine at the machine's speed, for example, is a potential human factors hazard. A machine can operate continuously at a high rate but a human can only sustain high speeds for short periods. An accident is bound to happen when such a mismatch continues.

5-1f: Misuse and Abuse Hazards

Poor training or a bad attitude can cause humans to damage machines they are working on or maintaining. Maintenance schedules that are not enforced or cannot be effectively carried out cause unexpected machine failures and subsequent injuries to the human, the machine, and often to the environment as well. So there are two causes of misuse and abuse hazards: deliberate or lazy human attitudes and improper maintenance.

Failure to store hazardous chemicals properly, leaving tools on the floor for others to trip on, not cleaning up spilled materials, not fixing the broken rung on the ladder, are more hazards that fall into this category.

5-1g: Environmental Hazards

The environment in which the worker is required to operate presents numerous potentials for injury. Often this injury occurs long after the hazard itself. Examples are cancers due to asbestos, hearing loss, radioactive materials, x-ray machines, etc. In other cases, reaction may be immediate. Working in too hot an environment or with poor ventilation may cause unconsciousness within minutes.

Environmental hazards are often subtle destroyers of the environment in general. Strip mining, dumping of hazardous wastes into local water supplies, etc. can cause harm and continue to harm long after the source of the hazard is gone.

NEW IDEAS:
When one goes into the workplace to evaluate the potential for safety hazards, classification schemes such as these help one create a checklist. With such a checklist, one can systematically look for problems with a degree of confidence that none will be missed.

How severe a hazard is dictates whether or not we need to take action to eliminate or avoid it and how diligently we should work at this task. A kinematic hazard that causes death is more dangerous than one that causes a broken fingernail.

Death or dismemberment of humans is a very severe hazard. So is one that causes delayed or long term suffering. In evaluating the severity of a hazard, one has to consider all of the factors:

a. Magnitude of the danger severity
b. Length of exposure
c. Short or long term effects
d. Frequency of occurrence
e. Environmental impact

together. A single exposure to loud music is harmless but repeated exposure is dangerous. One can recover quickly from a short human overload but repeated requirements to exert ones muscles can lead to a heart attack.

Each hazard may require consideration of all of the five factors above in different combinations.

Safety officers are trained to create checklists of potential hazards during safety inspections and prioritize them according to criteria such as those given above.

One thing we have not discussed is the criterion:

"How much trouble will we get into if this hazard causes an injury?"

Often this criterion is important. The legal costs of certain injuries are much higher than others even though the consequences to human or environmental health are the same. Unfortunately, decisions as to which hazards are addressed and which are ignored are made by managers or legal councils more concerned with public opinion or financial gain or loss than preservation of human life. From the Titanic to the Challenger O-ring seal, history is rich with examples of improper application of this criterion.

Interestingly, studies have shown that safety inspectors, engineers, and other trained professionals have consistently pointed out potential hazards correctly. It is management overriding this council that is the cause of most major disasters.

5-2: HAZARD REDUCTION METHODS

5-2a: Hazard Elimination

The most effective and desired method of reducing a hazard is to eliminate it.

In some cases this is easy. Eliminate the energy hazard of a box stored on a high shelf by moving it to the floor. Eliminate the potential of a human factors hazard by replacing the human operator with a machine.

In eliminating the hazard, beware of creating another hazard. Moving a box to the floor creates a potential for someone to trip over it, for example.

Elimination is always the preferred method of reducing a hazard. Total elimination of all hazards is not possible, of course, and the cost/benefit ratio of elimination may be too high. Clearly we cannot reduce auto accident injuries by elimination of cars and driving. Or can we? The answer is yes. But socially we are not prepared to adjust.

Sometimes is takes legal or social pressure to eliminate hazards completely. But in the laboratory, great societal pressures rarely penetrate. So the engineer or company safety officer must work to eliminate hazards whenever possible. Never assume that a hazard cannot be eliminated. Always consider elimination as a possibility until you prove to yourself that it is not possible or practical.

5-2b: Hazard Avoidance

Hazard avoidance involves reducing the probability of occurrence or the severity of an accident. The four most common methods for hazard avoidance are:

a. Modify b. Guard c. Warn d. Train

Modification means changing the machine or the operating procedure to reduce the probability that an accident can occur. A common modification for kinetic hazards is to remove the worker's body from the operating point of a machine. One may, for example, install an automatic feeder so that the worker is further away from the operating point. Other modifications involve insulation of hot pipes or electrical wires, installation of exhaust hoods, better lighting, or smoke detectors. Thus one may modify the machine, the environment, or the operating procedure.

Guarding was one of the first techniques used to reduce the potential danger of kinematic hazards. Guards are physical objects placed between the worker and the operating point of a machine or between the worker and any moving or otherwise hazardous parts. Covers on belts, pulleys, and rotating shafts are now common and required. These were not present in factories 100 years ago.

Modern machines have elaborate guard systems that cover the operating point of machines during operation. Often sensors are present that will not allow the machine to function until guards are in place and human appendages are clear. All electrical equipment is now contained in grounded boxes. Safety glasses, ear protectors, and chemical resistant suits are also types of guards.

Guards are not as effective as hazard elimination because guards and guard systems can fail. Or humans can fail to use personal protective equipment.

Warnings take visual, tactile, and audible form. All industrial trucks are now required to have flashing lights and buzzers that active whenever the vehicle is in motion. You will notice these warnings on garbage trucks and electric trucks in airports. Machines too often have lights or buzzers that go off when the machine is operating.

Signs are another common form of warning. Traffic signs are obvious warnings. Other signs alert us to hazards in the workplace. Entrances to hazardous areas may have signs indicating that eye protection is required for all those entering. Machines now have warning signs on critical areas, pipes are labeled to indicate what kind of fluid is flowing within, and trucks carrying flammable or toxic chemicals must have warning signs attached.

The labeling of hazardous waste is now commonplace. But labels are also required on all materials, especially chemicals. Safety officers inspect frequently to see that all containers are properly labeled.

Warnings are only effective if people can see them, understand them, and take the time to do so. Misuse and abuse and human factors make warnings less than 100% effective. Yet the strict enforcement of warning and labeling procedures has drastically reduced injuries to both humans and the environment.

Training is the final element in hazard avoidance. This means proper training in machine operation and maintenance to reduce misuse and abuse hazards. It also means training in safety principles for everyone. The law requires companies to establish formal safety training programs. The law also certifies professional safety trainers and consultants.

5-2c: Accident Response

The severity of an accident is greatly reduced when:

a. Personnel are trained and drilled in safety procedures such as CPR, first aid, fire fighting, and chemical spill cleanup.
b. Equipment for response to accidents is readily available, appropriate, and properly maintained.

Fire extinguishers, stretchers, first aid kits, eye washes, showers, chemical spill cleanup kits, emergency communication systems, backup power and light systems, alarm stations, and a host of other facilities must be provided within easy access of workers. You will find such facilities generously distributed throughout modern companies. These are checked regularly.

Emergency training and practice drills are also commonplace and required by law in many instances. You will be put through such training programs wherever you work. Remember that both items a and b above must be in place if the accident response part of hazard reduction is to work.

NEW IDEAS:

These are the basic principles of safety that apply to almost every situation. They are concepts that you need to understand as a first lesson in safety awareness. Safety can be dealt with in a rational and scientific manner. The application of reason to the problems of workplace hazards has dramatically reduced injuries to both people and the environment.

6: GENERAL SAFETY CONSIDERATIONS

There are vast lists of specific safety procedures and suggestions for every conceivable situation. Some are more useful than others and some are more applicable to experimental laboratories. We will now discuss some of the most general ideas that should form a basis for your further study.

6-1: INSURE YOUR PERSONAL SAFETY

You can run around barefoot in your backyard for years and suffer no damage. If you do suffer damage, it may be a bee sting or a puncture from a sharp stick or rock. So parents warnings often go unheeded with little consequences.

In the workplace, the probability of many hazards is equally low. But the consequences are often much higher. For example, you can probably work in a machine shop without safety glasses for several years without getting something in your eye. Just as you can ride in a car for years without wearing seat belts and not get hurt. But the consequences of one occurrence are so injurious that adherence to basic personal safety is much more important. Still, many people are careless, especially when young. One close call, however, will scare you enough to change your attitude. Do not wait for this kind of warning!

Most large companies now have strict policies that <u>force</u> you to practice personal safety. But even if such policies do not exist, you should take great care to protect yourself. Evidence shows that such care is justified. Here are some of the basic things you should do.

1. Always wear eye protection if there is even the most remote possibility that something could get in your eye. "Something" means splashes of liquids as well as flying parts from machines. You should wear eye protection when clipping hedges, mowing your lawn, and operating any tools in your home. Doing this will get you in the habit of reaching for your safety glasses automatically.

2. Ties, long hair, dangling jewelry, and other items that can get caught in machinery should never be worn.

3. Never go barefoot in facilities where anything could be on the floor or where any machines are operating. Always wear hard shoes.

4. Never work in an experimental or shop area alone.

5. Always inform someone as to where you will be, what you will be doing, and when you will return.

6. Look where you are going!

7. Be aware of all warning signs.

8. Learn where emergency shutoff switches, first aid kits, alarms, fire extinguishers, eye washes, showers, and other safety items are located.

9. Pay attention to all safety regulations and safety or first aid training programs.

10. Learn about other personal safety protection items available where you work. These include safety suits, masks, ear protection, gloves, etc.

6-2: DEVELOP THE PROPER ATTITUDE ABOUT YOU AND SAFETY

A number of simple phrases that convey personal safety messages can be found in various training aids and pamphlets from the safety office in your company. Here are some quoted from a training brochure compliments of the Newport News Shipbuilding Safety Department.

Safety is a state of mind. Don't trust your luck. Most accidents are caused by factors you <u>can</u> do something about. For example:

1. Don't pretend you're immune to danger. You're inviting trouble if you think "it can't happen to me."

2. Expect the unexpected. The more types of accidents you can foresee, the better you can guard against them.

3. Decide not to gamble with your safety or someone else's. Your best bet is to use common sense.

Some major causes of accidents relate to your attitude.

1. Lack of awareness: "The tree just stepped out in front of me".

2. Lack of knowledge: "I'm really not too sure how this works, but here goes...".

3. Unsafe attitudes: "Who cares about the safe way. I want to do it the fast way".

4. Errors in judgment: "I guess I should have checked on the proper procedure before I started".

Distorted thinking can cause you to make the <u>wrong</u> decision. Watch out especially for these risks:

1. FATIGUE. Tiredness due to overexertion or lack of sleep or rest affects a person's ability to perform even the simplest task.

2. ALCOHOL. Even small amounts of alcohol can reduce coordination, slow reflexes, and lead to over confidence.

3. DRUGS, Drugs, both legal and illegal, can impair judgment, coordination, vision, concentration, and other abilities a person needs to perform efficiently.

4. OUT-OF-CONTROL FEELINGS also help to cause accidents. Learn how to manage your emotions. Any of these can set the stage for an accident:

* Quick temper
* Frustration
* Depression
* "Get-even" attitude

Take time to cool off. Count to 10. Relax. You'll be safer.

Errors in judgment make us take risks that invite accidents.

"I think this bottle contains the aspirin"
"I have time to pass that car"
"That other driver must see that I am here"
"I can swim across that river"

Learn to analyze each situation. Ask yourself:

a. Do I know enough about what I am doing?
b. Should I get help? Who should I ask?
c. Do I have enough skill?
d. Is my mind clear and free of distraction?
e. What risks are involved?
f. Which ones can I avoid?
g. What can I do to keep from getting hurt by hazards I can't control?

The above are just some of the "buzzwords", slogans, and checklists that are part of standard safety training programs. They are good advice.

6-3: WORK TO REDUCE ALL ENERGY SOURCES TO A ZERO ENERGY STATE

This means that, whenever possible, a device should come to a zero energy state when shut off. Examine each machine for potential stored energy. Release hydraulic or pneumatic pressures, discharge capacitors, lower weights to floor level, release springs, etc. Especially in experimental test rigs, go over the rig carefully and find ways to eliminate stored energy.

6-4: THE LOCKOUT/TAGOUT CONCEPT

A frequent cause of injury is the sudden startup of a machine that is down for maintenance. The lockout/tagout concept is a procedure to insure that no one can accidentally turn on a machine while you are working on it.

1. The control panel of the machine should be constructed so that a positive lock such as a padlock can be engaged to lock the controls in the off position. Only a safety officer and the individual repairing the machine should have a key to this lock. This guarantees that no one can come up and turn the machine on.

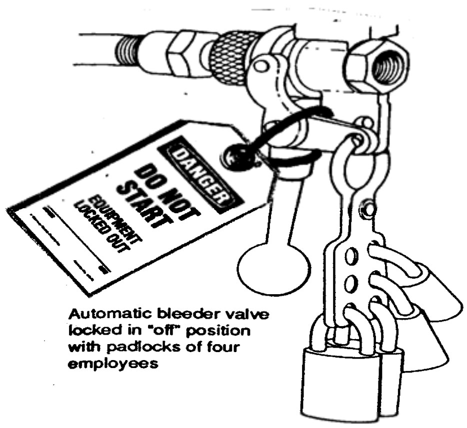
2. If more than one person is working on a machine, each worker should have his or her own lock and only he or she should have the key. Each worker applies his or her own lock to the control so that it cannot be turned on unless each worker has removed his or her lock.

3. When possible, the control panel or other shutoff switch should be visible to the worker repairing the machine so that he or she can look up and verify that it is off.

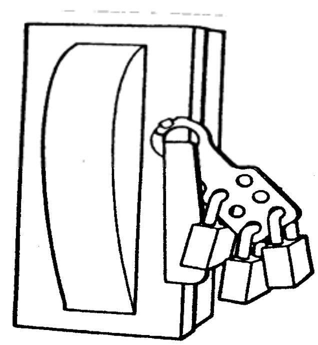
4. Some other visible sign such as a red light should indicate when the machine is off. Also, the "lockout" should not be possible unless the switch is really "off". Instances have occurred in which the maintenance worker thought that he or she had turned the switch to the off position. But the switch may have been worn out and did not index completely to the off position. Or the worker reached over the control panel and did not actually look at the switch when turning it to the supposedly off position.

5. A large sign or "tag" should be place on the controls of the machine saying that the machine is being worked on and is not to be turned on.

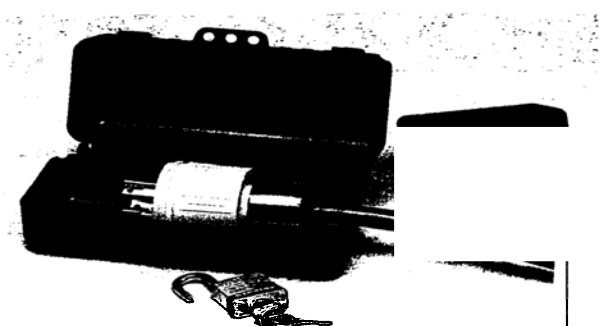
Figure (1) illustrates some applications of the lockout/tagout principle.



Pneumatic control lockout



Electrical Box lockout



Lockout box for electrical cord

Lockout/tagout supplies station to place on walls throughout the building

FIG. 1: Lockout/Tagout Equipment Examples

6-5: LEARN TO RECOGNIZE POINTS OF HAZARD ON MACHINES

Figure (2) illustrates typical danger points on some common machines. You need to train yourself to notice these danger points.

The point of operation is generally defined as the place where the machine comes on contact with the material being processed. This is generally the most dangerous part of the machine. But other places where parts are in motion are also dangerous. The "jargon" of the safety community refers to these are "pinch" or "nip" points.

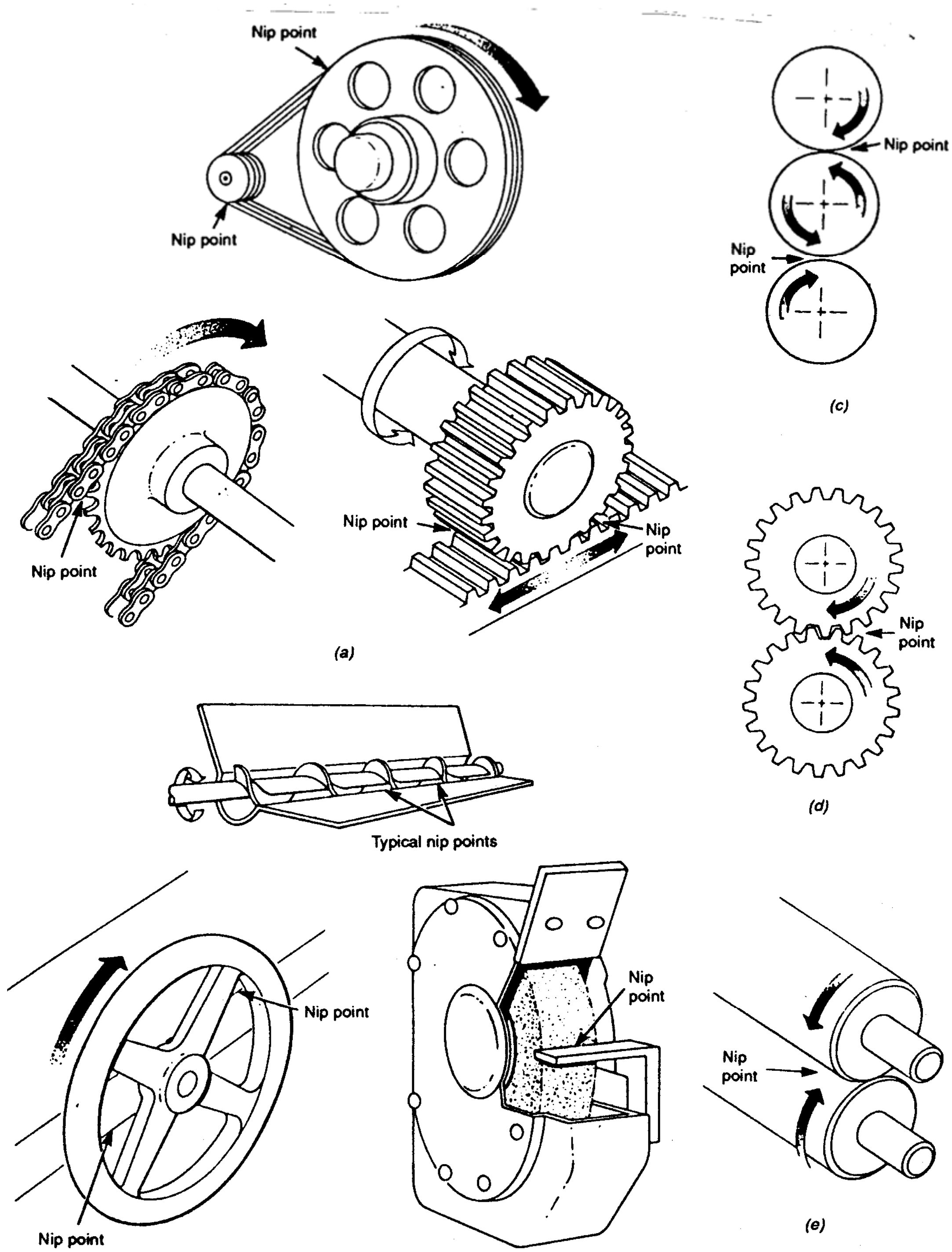


FIG. 2a: Examples of Nip or Pinch Points on Typical Machine Elements

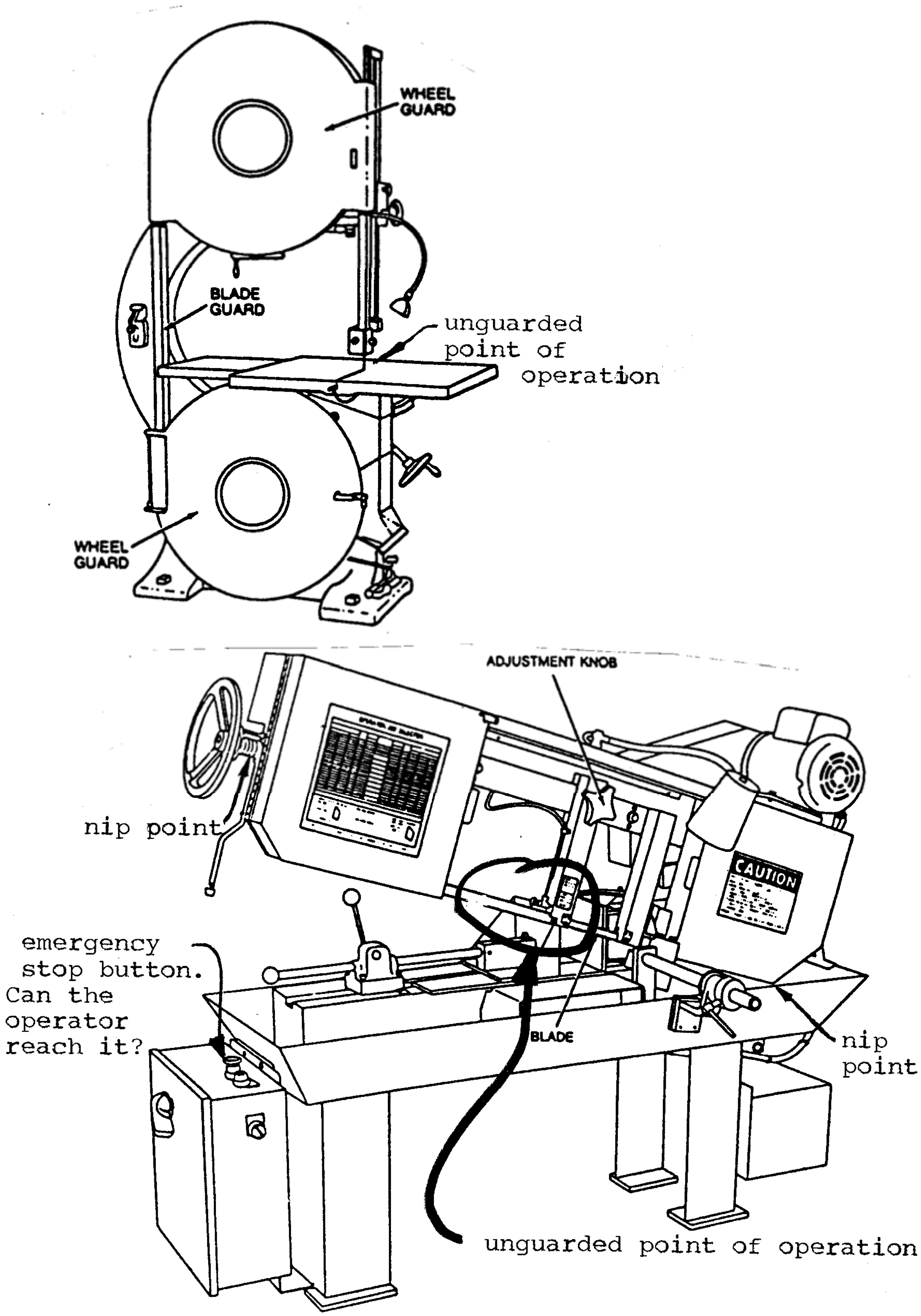
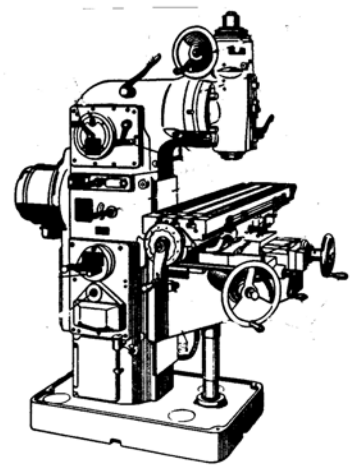


FIG. 2b: <u>Some Hazard Points on Band Saws</u>

If you do not know how basic machines and tools work, then you will not be able to anticipate danger or locate points of hazard. We discussed some basic tools and the value of experience in Chapter 6. You should not consider your own safety inspection of a test rig complete if you do not have the experience. Contact a safety officer to do such inspections. Then <u>decide</u> that you are going to <u>learn</u> about tools and machines. You certainly cannot expect to be given promotions to positions of responsibility without such knowledge.



Could you locate danger points on this vertical milling machine?

6-6: LEARN ABOUT GUARDING METHODS

Guards on machines can be very simple or very complex. Figure (3) Illustrates some simple guards.

In your home shop, a push stick is generally adequate for table saw operation. You generally are more careful when you only cut a few boards at a time.

In a production process where an operator cuts many boards for long periods of time, the probability of an accident increases. Note how the adjustable guard system positively keeps the worker's hands away from the blade.

A lot of care goes into the design of guard systems for production machines. Most laws now require guards on machines. I am sure you have seen all of these on lawnmowers and other devices you buy for home use. Larger machines in industry have more involved guard systems.

Always inspect any device you purchase for the laboratory. Often the manufacturer will meet only the <u>minimum</u> legal requirement for guards. <u>You</u> should design additional guards if those supplied are not adequate.

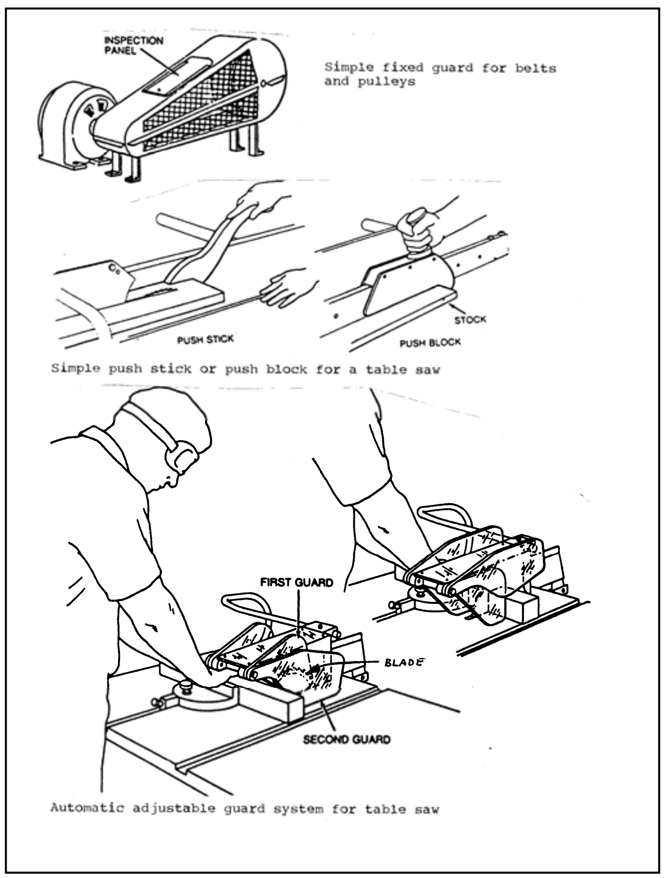


FIG. 3: <u>Some Simple Guarding Systems</u>

Figure (4) Shows a typical two-hand control system on a press. The worker inserts the work piece into the point of operation. Then he or she must place both hands on the two control buttons to activate the machine. This insures that the hands are out of the point of operation when the press comes down. Note also the two large emergency stop buttons.

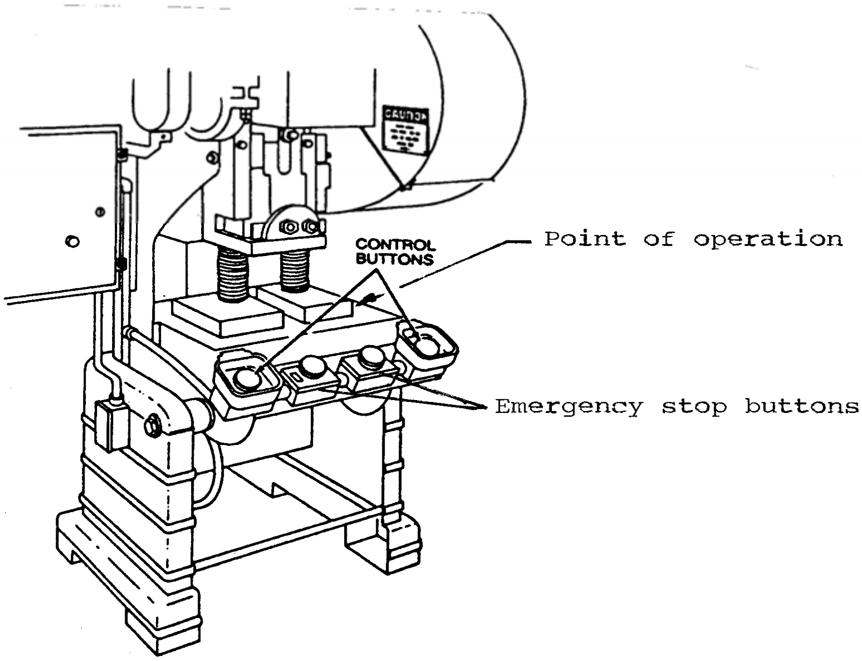


FIG. 4: Two-hand Control System for a Press

Figure (5) shows a guard system that uses a photoelectric sensor. The danger area is the point of operation into which the worker inserts the part to be operated on. The two buttons that operate the machine are above along with two emergency stop buttons. Can you locate them? The sensors will not let the machine operate if any obstruction is in the danger zone.

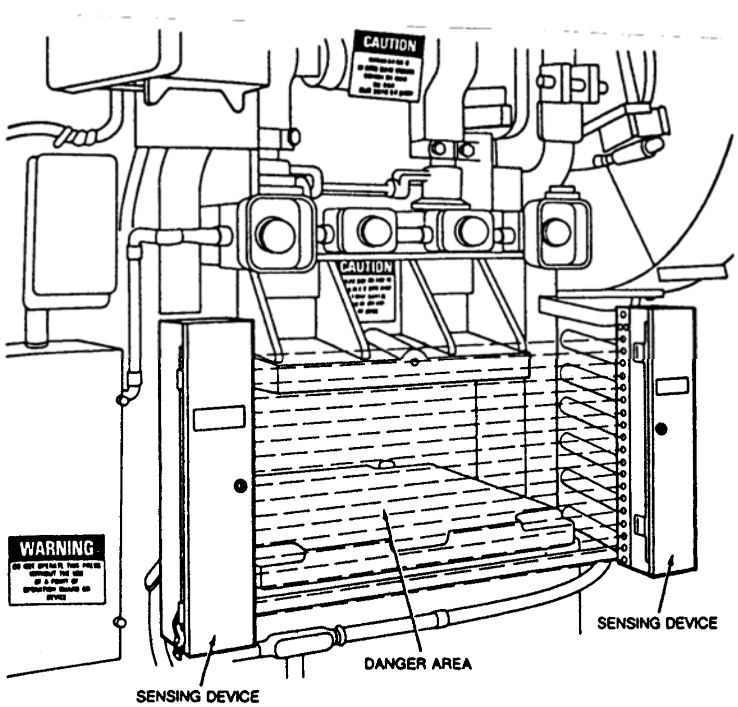


FIG. 5: Photoelectric Sensor for Guard System

Figure (6) illustrates another kind of positive guard system. The worker inserts a part to be punched. Then the press is activated by a foot pedal.

As the press comes down, cables attached to the wrist bands are pulled back so that the hands cannot be within the danger zone.

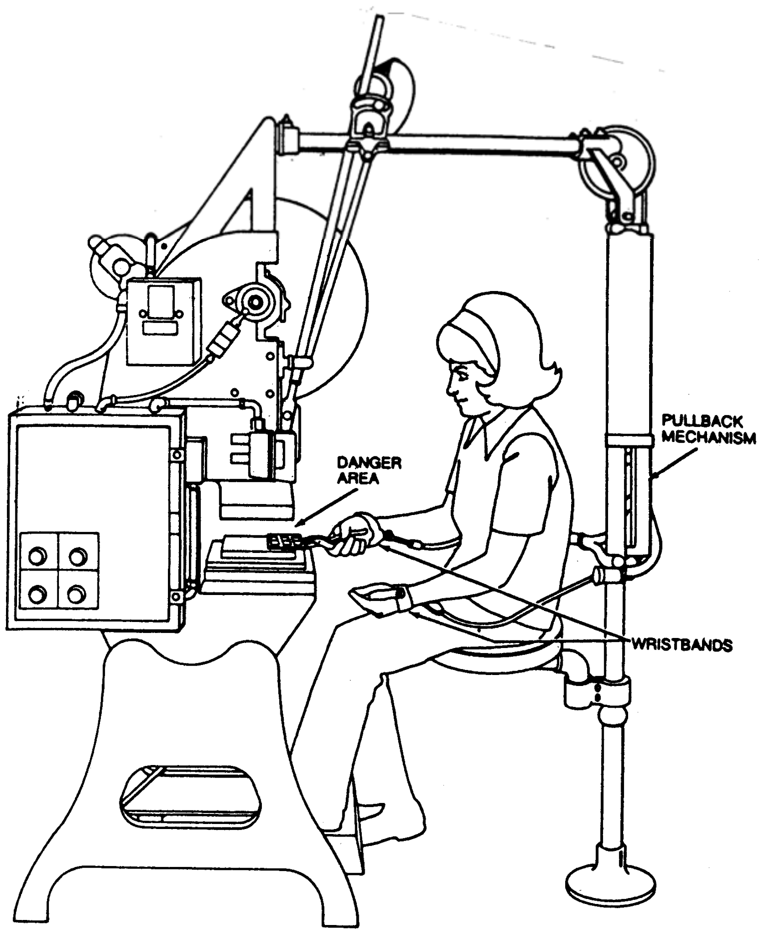


FIG. 6: Pullback Device on a Power Press

Systems such as this are in place on most large machines that require repetitive operation because of the potential for carelessness. And, some workers will ignore or try to override guard systems in order to increase production. Sophisticated guarding systems are designed to prevent these kinds of "misuse or abuse" hazards.

Your ability to recognize hazards in the laboratory is greatly enhanced when you have seen lots of examples. This teaches you what to look for and how to design safeguards. So take the time to tour production facilities and laboratories to increase your knowledge.

6-7: SIGNS AND LABELS

Go back and look at all of the previous figures. Note the labels and signs on the machines.

Signs are now mandatory on just about every potential hazard. Thanks to regulations, laws, and the work of professional engineering and safety societies, such signs have been standardized.

There are three basic classifications of signs:

1. DANGER: When it is 100% certain that exposure to the hazard will result in severe property damage or fatal injury to the user.

2. WARNING: When the probability of severe injury or damage is less than 100% but the possibility is still present

3. CAUTION: When the probability of injury is less than 100% and severity is absent but minor injury is possible.

A properly designed sign should meet the following criteria:

1. It must attract the person's attention IMMEDIATELY

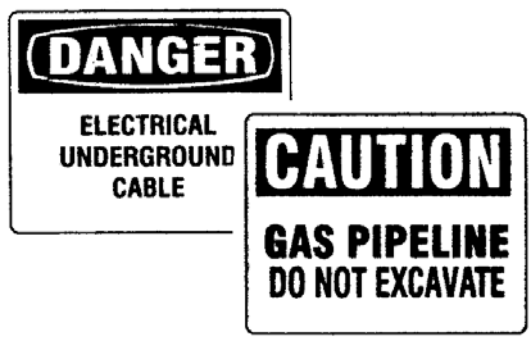
2. It must be strong enough to be CLEAR AND CONVINCING

3. It must show how to AVOID EXPOSURE

DANGER signs are normally red and black

WARNING signs are normally orange and black

CAUTION signs are normally yellow and black



One can be at great risk if he or she fails to provide signs on critical areas of exposure. A lawsuit can be lost if it can be proven that the injured was not properly informed of the dangers. Great care must be taken to insure that the wording on the sign satisfies the above criterion. Criteria for signs and labels are now set by law.

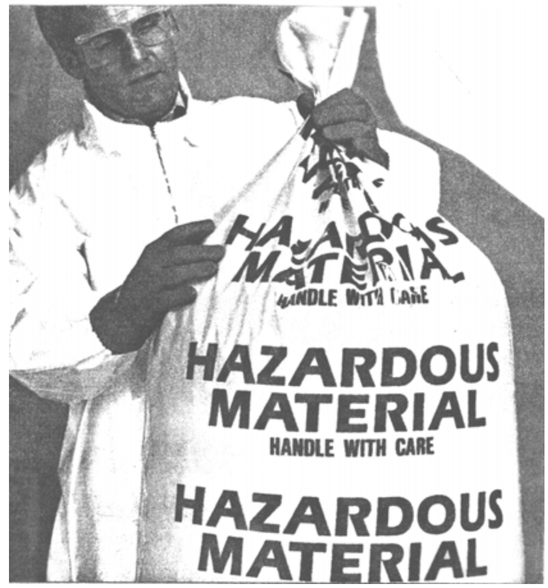
In a laboratory where custom built test rigs are used, safety during the development of the test rig must rely on the good training and actions of the technicians and the engineers. Once the test rig is complete, you should consider using signs to warn of danger and remind operators of potential hazards. This is not often done. <u>You</u> should plan to do this. A safety officer will not patrol your lab every day to watch for violations. And, compared to the frequency of occurrence of accidents elsewhere in the plant, your lab may be insignificant. But it only takes one accident!

Labels must be affixed to all containers and devices such as fire extinguishers. Even a container for water should have a label so that everyone can see what is inside and what should be put inside. Thus a label should read "water only" both to show that the contents are safe and to prevent misuse.

Labels on containers of potentially hazardous materials need to be very concise. They should indicate:

1. Precisely what is inside
2. Consequences of misuse
3. Date filled, stored, or sealed
4. Who to contact in the event of an accident
5. How to contain the accident and treat the injury

Failure to comply with labeling requirements can result in severe penalties, especially when the substance contained is classified as hazardous by laws, codes, and standards.



Labels on containers are important to reduce disposal costs. All hazardous substances such as waste oil, dirty rags, debries from machining operations, and various solvants, etc. that are no longer used must now be processed and neutralized before disposal. Unless the exact nature of the contents is known, the procedure for disposal cannot be determined. In such an event, the environmental office will have to have a chemical analysis run at a cost of $500 or more for a single container!!! Even if the material inside is harmless (such as water), such analysis must be run. So be sure to have a label on every container!

If you enter an area and observe containers whose contents are not labeled, be sure to take steps to get labels on them!

6-8: SAFETY PROCEDURES

Accident prevention and response procedures are now highly stressed and strictly enforced in most companies. The volumes of legal regulations regarding procedures is extensive as are various company policies and procedures manuals. These polices govern, among other things.

1. The required training and certification of personnel
2. Use of protective gear
3. Routine inspections of space and equipment
4. Regulations as to who is authorized to enter various areas and operate specific equipment
5. Accident reporting requirements
6. Employee safety training
7. Storage and disposal of hazardous waste
8. Placement of safety and environmental control equipment
9. Safety compliance record keeping

The beginner, exposed for the first time to rigid environmental health and safety procedures on the job, will be amazed at the amount of attention paid to this subject. Do not underestimate the importance that corporate management places on adherence to these procedures. Legal consequences alone are enough to justify such concern. Recall the personal injury and environmental lawsuits that have occurred in your lifetime. Many have ruined companies and careers.

The first response to all these procedures is to treat them lightly. This is foolish because it will not be tolerated and because these procedures are ultimately designed to protect you.

In an experimental laboratory, procedures for the handling of materials, responding to and reporting accidents, and maintaining awareness through training and inspection are the most common formal procedures encountered. The other item to pay attention to is good design practice. This is a subject that only those with technical training can fully appreciate. Since experimental test rigs are unique items, specific rules and procedures will not be available. Safety regulations for the operation of the equipment used to fabricate such rigs, along with lockout/tagout and similar maintenance related procedures will be in place. But beyond that, the responsibility for employing good design practice falls on the designer.

6-8a: <u>Potentially Dangerous Substances</u>

Potentially dangerous substances come in solid, liquid, and gaseous form. In the laboratory, the most common are:

1. Flammable liquids such as cleaning fluids and paint.
2. High pressure gases such as nitrogen, refrigerants, acetylene, propane, air and steam.
3. Waste oils and lubricants.
4. Glues, sealants, and resins.
5. Powders and particles from fabrication of metal, wood, plastic and fiberglass parts.
6. Mercury.

Formal procedures for dealing with these substances are too lengthy to discuss here. But we can list some of the most fundamental caretaking methods that you should know.

1. Flammable, corrosive, or toxic chemicals must be stored in labeled containers in a clean, cool, and well ventilated storage facility that is locked, inspected, and inventoried frequently. The proper storage procedures for particular substances can be obtained from environmental health and safety officers.

2. No substance should be discharged into the atmosphere or into the sewage system without specific permission from the safety department. Used oil, paint thinners, and especially heavy metals such as mercury must never be allowed to enter the environment. The best procedure is to have the company safety department dispose of all waste chemicals for you. Legal penalties for improper discharge are extreme. This means that you must collect and store lubricating oils and other substances.

3. Exhaust hoods should be used when cleaning equipment using toxic chemicals. But consult with safety officials to establish the proper procedure.

4. Protective clothing including face and breathing protection is required when working with many chemicals that were considered less dangerous 5 of 10 years ago. So ask first. Then request the required protective gear, keep it maintained, and insist on its proper use

5. Refrigerants burn and produce deadly phosgene gas. So be particularly careful to drain all refrigerants before using a torch to unsolder pipe joints. Remember too that refrigerants can no longer be discharged directly into the atmosphere.

6. The FLASH POINT of a chemical is the minimum temperature at which vapor escapes and forms an ignitable mixture with air. Flammable liquids are defined as those that have flash points less than 37.8°C. These are called CLASS I LIQUIDS. Combustible liquids are those with flash points between 37.8 and 60°C. These are called CLASS II LIQUIDS.

The maximum allowable size of a glass or approved plastic container of a class I or class II liquid is 1 GALLON. Metal storage cans for class I liquids must be less than 1 gallon and for class II liquids, less than 5 gallons. Metal safety cans must be less than 2 and 5 gallons respectively. You should not store more than 1 or 2 gallons of any class I or class II liquid in your own area. Try to keep such storage to a minimum. Dispose of or transfer larger quantities.

typical class I liquids	typical class II liquids
gasoline	oil
acetone	paint thinner
alcohol	

7. Adequate ventilation of rooms in which flammable or combustible liquids are used or stored is required. Have your area inspected to insure that ventilation requirements are being met.

8. Aluminum and magnesium dust can be an explosive hazard in the right concentration and the right temperature. These are class 3 explosive hazards because of the energy released upon rapid combustion. Be careful.

9. Magnesium shavings from machining operations can ignite due to the heat of the cutting process. There are precautions for machining magnesium. Find out about them as required.

10. Glass beads from sandblasting operations will cause lung damage. So too will dust from sanding and grinding of certain plastics, fiberglass, asbestos, etc. These operations may require protective gear and ventilation.

6-8b: <u>Material Safety Data Sheets</u> (MSDS)

"MSDS" stands for Material Safety Data Sheet.

Any potentially hazardous material that you purchase MUST have a sheet that accompanies it to explain the contents, potential dangers, and what to do in case of an accident.

You are required to keep this information on file as long as you are in possesion of the material.

MSDS sheets can be quite extensive. Here are the typical items on such sheets

PRODUCT NAME
1. Ingredients
2. Physical data (density, solubility in water, odor, etc.)
3. Fire and explosion hazard data: (flash point, fire fighting equipment required, etc.)
4. Reactivity data: (What not to mix it with, what it reacts with, etc.)
5. Environmental and disposal information: (what to do if it spills, restrictions on dumping, etc.)
6. Health hazard data: (Eye, skin contact issues, breathing it, level if toxicity, etc.)

7. First aid: (What do to for ingestion, contact with skin, etc.)
8. Handling precautions: (Ventilation requirements, personal protective gear required, etc.)
9. Additional information: (Misc.)

So pretty much everything you need to know to store, handle, use, and protect yourself from is listed. You need to memorize the "MSDS" acronym since everybody is familiar with what it stands for.

6-8c: Other Recommendations

Some other general safety recommendations are as follows:

1. All electrical wiring for voltages over 50 should be grounded and insulated. Beware also of the danger of fire from electric sparks in a combustible atmosphere.

2. All electrical wiring for power to equipment must be done by a trained electrician. It must be inspected and approved before being put to use.

3. The pain threshold of human skin is 111°F. Any hotter surface will make you say "ouch". Plan to insulate all pipes and tubes that will be hotter than this. Label these lines with signs that identify what is inside and warnings about burns. Provide warnings on all exposed hot surfaces. Use guards to prevent injury.

4. Provide warnings to prevent entrance to dangerous parts of a laboratory. When lasers or other hazards are operating, provide some form of additional warning. Do not assume that the only people in your area will be your personnel who know what is going on and don't need elaborate warnings.

5. Pipes and tubes carrying high pressure steam or air must be labeled. Any welded pipe carrying high pressure (>100 psi) must be constructed by a certified welder, pressure tested and approved.

6. Pressure vessels that are fabricated must be inspected and approved. Purchased pressure vessels must be certified to meet specific codes. All pressure vessels should have gauges installed so that you can see what the pressure inside is and they are required to have pressure relief valves that meet certain codes.

7. You should let plant maintenance or construction personnel make any major modifications to your facilities. They know the codes and regulations and will provide the properly trained workers. Always inform these people before you begin any major construction project or if you have any doubt about even a small project.

8. Provide eye protection, first aid stations, alarm stations, showers and eye washes, and other accident response or protective equipment liberally throughout your area. Have posted regulations concerning the use of protective gear and enforce them with vigor.

9. Set up a formal procedure for scheduled safety inspections of your area by yourself and company safety officers. These inspections should include reviews of your safety and accident response procedures and tests for levels of toxic materials, radiation, and noise levels.

10. Keep the workplace clean and uncluttered at all times.

11. Have labels and signs on all equipment.

12. Practice strict lockout/tagout procedures.

13. Have everyone attend safety and environmental training frequently.

14. Have a maintenance schedule for all major pieces of equipment. Provide for inspection and record keeping of this maintenance.

15. Maintain simple items such as ladders, shelves, carts in good order.

16. When designing a new test rig, review the design for safety:

a. Are all moving parts properly guarded?
b. Are sharp edges present?
c. Are gauges and other instruments provided so that the condition of the rig can be assessed quickly at all times?
d. Is a zero energy state reached upon shutdown?
e. Are hazard detectors in place to prevent catastrophic failure? These include high pressure relief valves and shutoff switches, accessible emergency stop buttons, warning lights and audible signals.
f. Is a maintenance and inspection procedure established?
g. Is an accident response procedure established?

7: PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) ranges from simple ear plugs to full body garments. Most companies now have strict rules for their required use and training in how to use them. OSHA (Occupational Safety and Health Administration) provides information, standards, and recommended procedures for PTE use.

All personal protective equipment must be manufactured and maintained according to strict standards set down by the American National Standards Institute (ANSI).

The statistics show that 60% of workplace eye injuries occurred to people not wearing eye protection. Eye injuries occurred in only 1% of those wearing protection. So personal protective equipment is a proven success. The problem is that too many people do not use the equipment that is provided for them!

Personal protective equipment may be categorized as follows

7-1: EYE PROTECTION

Figure (7) illustrates some of the many types of eye protection.

The type of eye protection required depends on the task being performed. Spectacles with full side shields are required for work in a machine shop, faceshields are required for handling hazardous liquids, goggles that cover the entire eye area are used when working with fine particles such as insulation, etc. Be sure to consult with the company safety office to determine what kinds of protection are required in your case. **And always use this equipment at home!**

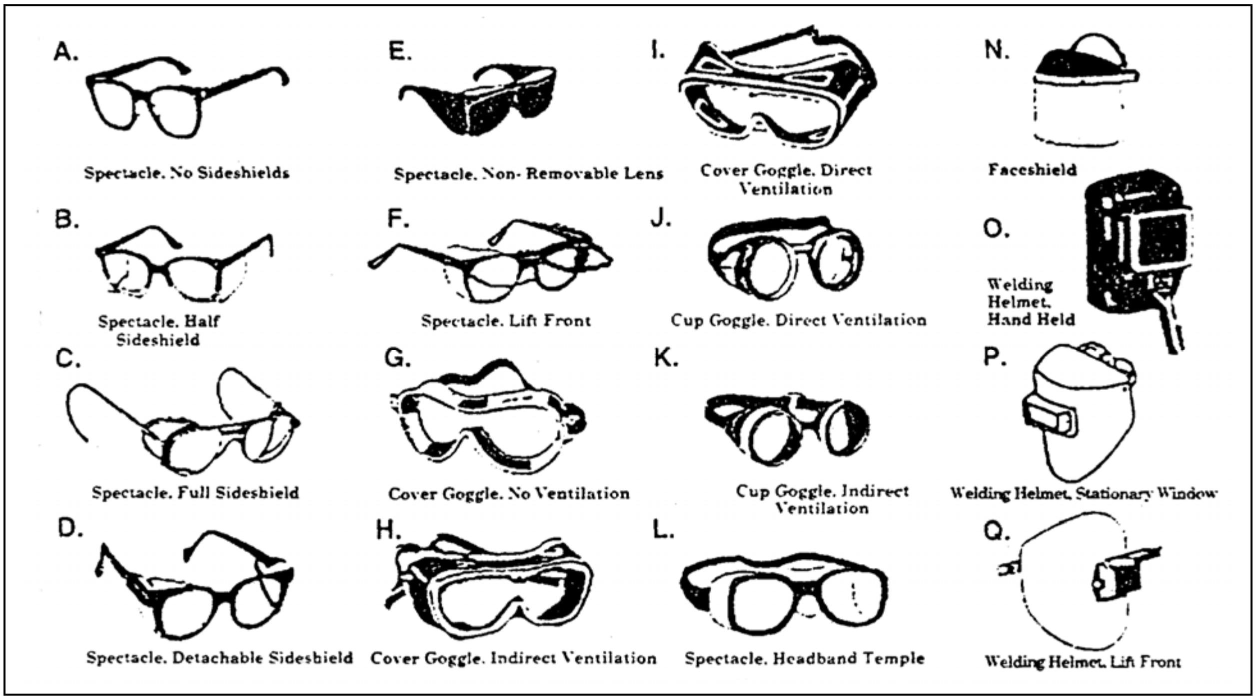
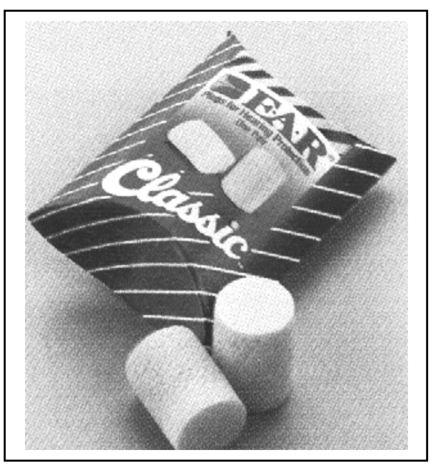


FIG.7: Some of the Many Types of Eye Protection

7-2: HEARING PROTECTION

The simplest hearing protection is the disposable foam plug that one simply presses into each ear. These are commonly provided for people taking tours of industrial plants. Workers in such plants may use more expensive plugs or muffs that cover the entire ear. Each type of protection is rated by the decibel reduction or "noise reduction rating, NNR". Typical NNR is 20-30db.



For short term exposure, simple foam plugs costing $0.10/pair

For long term use costing $25.00

FIG. 8: Two Common forms of NRR 20-30 Hearing Protection

Typical noise levels in decibels are as follows:

Lower threshold of human hearing = 10-20 db
Typical quiet office = 50 db
Normal city traffic noise = 65 db
Close to a large truck = 85 db
Jackhammer = 110 db
Close to a load rock band = 120 db
Gunshot, explosion, next to jet plane = 140+ db

Any noise that causes you to have to raise your voice to be heard at a distance of 3 ft. is generally above 85 db. Continuous exposure to this level requires ear protection. A NNR of 20 will reduce this to 65 db at the ear which is safe.

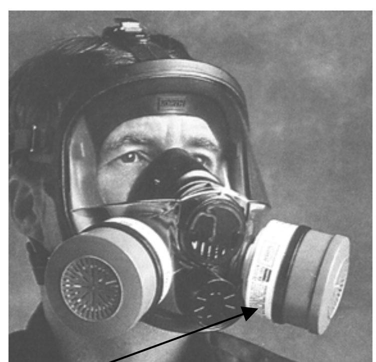
Generally, one can withstand several hours of 110+ db noise if taken intemitently over a long period. There is no immediate damage for short exposure until 130 db. Note that even "classy" looking ear muffs are no better at hearing protection than simple foam plugs. So if you have to be in 100+db surroundings for a long time, use both foam plugs and muffs. Fortunately, OSHA will not allow workers to in very loud surroundings for long periods even with ear plugs.

7-3: BREATHING PROTECTION

Lung damage can be from particles which lodge in the lungs and result in cancerous tumors or liquids/gases that actually damage lung tissue.

Simple masks are adequate for most particulate matter. One can find many of these in the local building supply store. You should examine these when you are in such stores. There you will find a large number of different types based on the activity.

More sophisticated masks and respirators are available from safety equipment suppliers. Here is a picture of a full facepiece respirator/eye protection mask that costs $200.

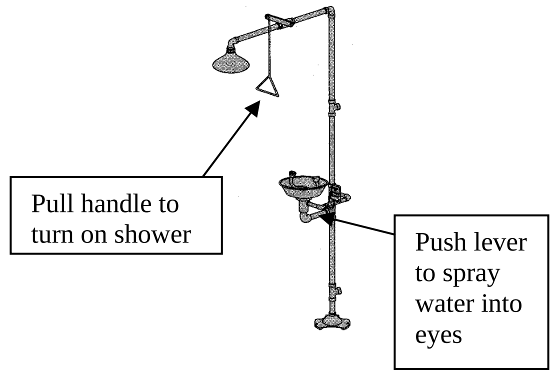


Modern respirators use disposable canisters that are color coded for the application and can be easily replaced.

In extremely hazardous environments, masks and full body suits are provided with their own oxygen supply because the contaminants cannot be filtered out or there is danger of asphyxiation. Firemen use these breathing apparatuses quite often. But a lack of oxygen can easily occur in confined spaces. Here one can use up the available oxygen supply without noticing it and simply pass out suddenly. Any small unventilated space should be avoided without proper equipment.

7-4: SHOWERS AND EYEWASHES

In any situation where it is possible to splash liquid on the skin or in the eyes, a shower or eyewash station is required. Here is what such a station looks like.



This equipment is now common in most manufacturing facilities and laboratories.

7-5: SKIN PROTECTION

There are hundreds of gloves designed for every situation:

Gloves for protection from sharp objects
Chemical resistant gloves
Pathogen/biohazard resistance gloves
Insulated gloves
Tough plastic and metal mesh gloves for cut protection
Tough plastic and leather gloves for protection against abrasion

Gloves represent a very effective, low cost protection against loss of fingers, abrasion, and various contaminants.

In extreme environments, complete body suits are available. These range from simple plastic disposable coveralls to expensive sealed garments.

7-6: FOOT PROTECTION

In this age of running shoes, sandals, and similar footware, some people do not even own a pair of leather shoes. In the work environment, anyone entering a lab or manufacturing facility must generally have sturdy shoes that cover the foot and provide protection against spills and falling objects. On a construction site or heavy manufacturing, steel toes boots are generally required. Clean room facilities may also require plastic covers for the shoes and sleeves

7-7: HEAD PROTECTION

Simple plastic bonnets that keep hair from falling in the workplace are common in facilities dealing with electronics or other items that require a clean environment. When first forced to wear such, most people feel rather silly (especially men). But you get used to this when everyone around you is similarly attired.

Helmets of various kinds are required in many manufacturing facilities and construction sites.

7-8: FALL PROTECTION

Working any area where there is a potential for a fall now requires that you wear a harness. This consists of a set of straps around your body (like a parachute harness) and a connecting line that is secured to some solid object. The connecting line has slack in it and contains a stretchable section which brings you to a stop gently (like bungie jumping). The shock absorbing element is adjustable for people of different weight.

You may not personally use all of these personal protective items. But many people under your supervision may be required to. Thus you need to be aware of the equipment and the requirements for its use. The biggest problem you will face is the need to continually remind people to use PPE

8. EMERGENCY RESPONSE

When an accident occurs, what do you do?

If you have done your safety planning correctly, a procedure is in place at your facility in anticipation of the most common accidents. You should have an evacuation plan for fire, tornadoes, and similar situations. Procedures for chemical spills and personal injuries should also be in place, documented, and people trained.

Local health and safety officials can help you create such procedures that apply to your specific area.

When you start work in a new area, you should inquire about such procedures and make yourself familiar with them.

In general, if there is doubt, you should FIRST take action to minimize further damage to human life. In the event of fires and chemical spills, the first action is always to GET OUT OF THE AREA! Then contact sources of help. This means that you leave and you make sure that others leave also. If you have to take time to determine whether you can fix the situation without leaving, then you have compromised your chances of escaping. If there is any doubt about your ability to put out a fire or clean up a spill, etc. then GET OUT and let trained personnel fix the problem.

IF you have been trained in accident response, chemical spill cleanup, etc. and IF you have the time and IF you have the proper equipment and IF there is no threat to life that will result from your dealing with the accident immediately, ONLY then should you proceed to clean up, etc. If there is any doubt, GET OUT!

First aid materials in your area can help you deal with some injuries provided you know where the materials are and how to use them.

9: SUMMARY

The subject of safety is large enough to fill several books. Our objective in this chapter is to provide a general overview which stresses the increasing importance of safety and generates and awareness. Start now to think seriously about safety. And plan to spend considerable time with this subject at your place of employment.

10: STUDY REVIEW

Fill in the answers to the following questions or comments for a review of this manual

1. Workplace safety became important at about what time and for what basic reason(s)?

2. How do worker compensation laws work?

3. The two basic fundamental goals of safety involve the word "hazard". Write them down.

   1.

   2.

4. Hazards can be classified into various catagories or types of threats:

   a.

   b.

   c.

   d.

   e.

   f.

   The magnitude of these threats can be evaluated based on:

   a.

   b.

   c.

   d.

   e.

5. Name an example of each type of hazard threat.

6. In evaluating the severity of a hazard, one has to consider all of the following factors together:

a.

b.

c.

d.

e.

7. The four most common methods for hazard avoidance are:

a.

b.

c.

d.

8. Major causes of accidents that relate to your attitude are:

a.

b.

c.

d.

9. Distorted thinking can be caused by:

a.

b.

c.

d.

10. Describe the lockout/tagout concept and how it works.

11. What is the point of operation of a pair of pliers?

12. Why is guarding more important on operations that are repetitive?

13. Describe the three types of warning signs and their colors.

14. List the five things that the label on a container should indicate:

1.
2.
3.
4.
5.

15. What are the definitions of class I and class II liquids

16. What does MSDS stand for?

17. What is the fundamental goal of safety?

18. What is the "Universal Precautions" philosophy about biohazards?