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ABSTRACT

This manual is designed to involve both teachers and students in planning and controlling a safety system for technology education classrooms. The safety program involves students in the design and maintenance of the system by including them in the analysis of the classroom environment, job safety analysis, safety inspection, and machine safety design. The guide is organized in 3 sections comprising 12 units and an appendix. The first section, safety system design, focuses on the following topics: environmental factors; human factors; tools and equipment; processes; materials; outside influences; and feedback. The second section presents example applications of the safety system in communication, manufacturing, transportation, construction, and research and development. The appendix includes student activity forms, safety report forms, emergency action procedures, and suggested organizational resources. (KC)

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The Technology Education Safety Guide, Safety System Design for Technology Education, is the vision and product of authors, V. William DeLuca and William J. Haynie of North Carolina State University. In developing a systems approach to safety, Dr. DeLuca and Dr. Haynie:

1. Sought the advice of practicing educators and engineers.

2. Developed the document within a systems framework to allow application in classrooms without "dating" the contents because of changing technologies and changing curriculums.

3. Provided model lessons in safety as an integrated part of study in technological systems.

Because Dr. DeLuca and Dr. Haynie recognized the need for continued learning for teachers and students, the safety guide was developed to provide theory and understanding of a new approach to safety to teachers while providing interest and application for students.

Preface

In this era of history, human life is being affected by rapidly changing technologies and by increasing accessibility to these technologies. As more people use technology to extend their capabilities, the issue of safety becomes an essential element in daily living.

The purpose of this document is to provide safety education to insure that individuals live and work in a safe environment. By teaching safety as a system, dependent on interaction of varied elements, people will develop appropriate knowledge, practices, and attitudes for safe and healthful living. Thus, safe practices will become a "habit" of living that readily accommodates changing technologies throughout the life span of the individual.

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SECTION I

SAFETY SYSTEM DESIGN

Introduction

Safety is more than a body of content which is taught as a prerequisite to performing in technology education classrooms. Safety is an attitude, a level of consciousness that should exist as people drive on highways, cut the grass, perform home repairs, or build a new porch. Safety is a perception that hazards are present throughout our environment and these hazards must be controlled to minimize human suffering.

This manual is designed to involve both teachers and students in planning and controlling a safety system. The role of the teacher is that of manager, coordinator, and leader of safety system design. This safety program involves students in the design and maintenance of the system by including them in the analysis of the classroom environment, job safety analysis, safety inspection, and machine safety design.

Of course, the negative effect of technology is also present when students leave the laboratory. Too often we hear about people disconnecting the safety devices in products, disregarding warning labels, improperly storing hazardous material, or failing to wear protective equipment when doing hazardous work at home. With stories of neglect, come stories of disabilities. Children die from drinking poisonous cleaners, toes are severed because the lawn mower's safety stop was disconnected, lives and personal property are lost because a heater was not properly maintained.

One of most dangerous machines that people use daily is the automobile; yet many people do not wear a seat belt, a fundamental piece of personal protective equipment provided on this machine. Many people will disconnect the pollution control system to gain an insignificant amount of horsepower while contributing to a problem that is affecting the health and well being of the community and our society as a whole.

It is the teacher's responsibility to address the safety implications of manufacturing, communication, construction and transportation as it affects students, their classmates, their community, and society. Current events reported in newspapers are all that is needed to provide content for instruction on hazards resulting from the utilization of technologies. Use this information to help students understand the effect of technology on our lives as well as to provide a focus for reinforcing the importance of safety in the classroom.

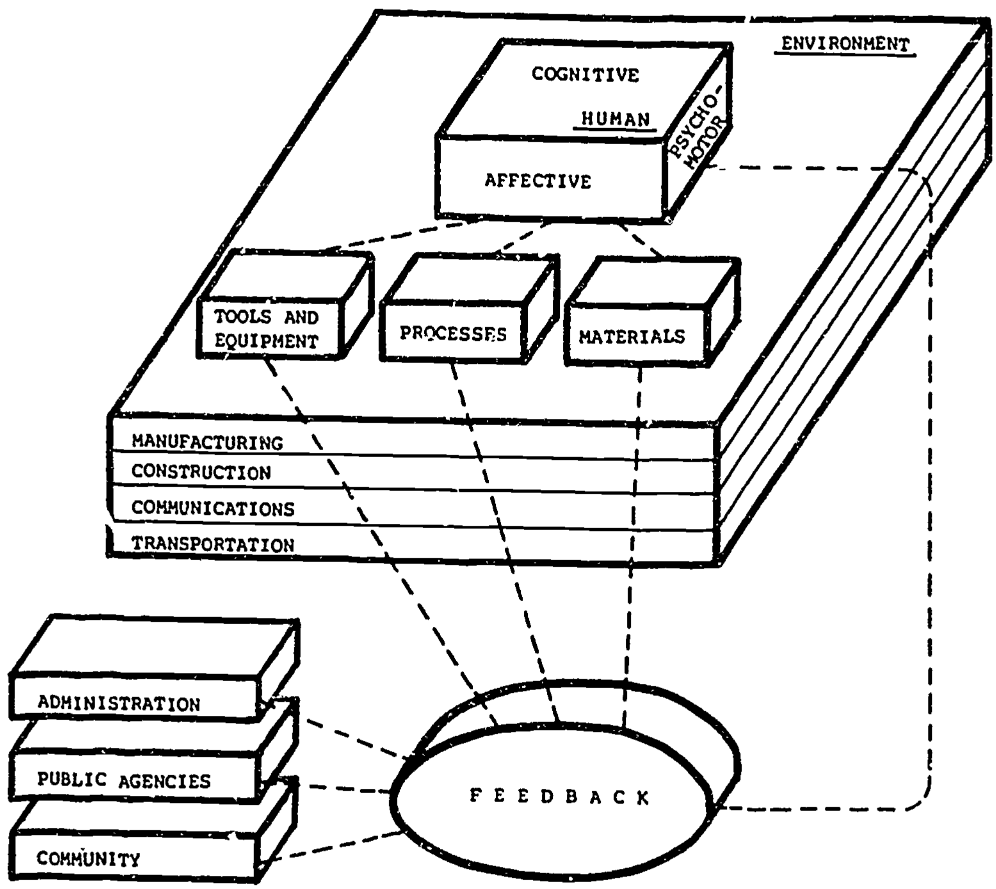
The Systems Approach to Safety

One of the most significant changes in modern technologies is the application of systems theory and control technologies. The systems theory recognizes the effect of components or subsystems on the performance of the entire system. Since each subsystem serves a function that contributes to the operation of the system, there is an interactive relationship between subsystems. If one subsystem fails, the entire system fails.

To maximize the effectiveness of the system, controls must be set up to maximize the effectiveness of each subsystem. This process is called suboptimization. The process of safety is monitored through a set of feedback loops, and decisions are made to

optimize the function of each subsystem while considering the combined influence on the system. A complete set of forms which aid in the development and implementation of a safety system are provided in the Appendix. These forms, ACT-1 through ACT-7 and REC-1 through REC-3, are intended for student and teacher use. The forms and their uses are introduced in the text (Section I) and then reinforced with practical examples in Section II (Example Applications).

This system design seems complicated, and in some respects it is. However, once the safety system is understood and feedback and controls are in place, the safety of your students will be insured with routine management. The first step in designing a safety system for your laboratory is to understand the components of a comprehensive safety system.



Safety System Components

Safety systems are designed to minimize injury. The components of the system include factors within the environment that have the potential to cause injury. The figure above shows a model for a safety system in technology education. A brief explanation of the components of this system follows.

Environment-- The environment defines the physical facilities that the students will occupy while participating in a technology education program. This environment is characterized by the technological system (manufacturing, construction, communication, or transportation) studied. There are many common tools, safety equipment and personal protective equipment across each of the technological systems; however, each system has unique characteristics that differentiates its laboratories.

Human Factors-- The developmental level of the student ultimately determines the safety climate of the classroom. Students must have a knowledge of safety rules and procedures (cognitive domain) and possess the attitudes and values necessary to apply their knowledge of safety (affective domain). The skill level of students regulates the activities that can be performed safely (psychomotor domain). Of course, the most important person is the teacher who is responsible for planning, controlling, and projecting an atmosphere of safety in the classroom.

Tools and Equipment-- Tools and equipment have been the focus of safety instruction for years and rightly so. These devices have the potential to inflict severe injury if they are not treated with respect. Look at it this way--every tool is designed to increase mechanical advantage so materials such as wood, plastics, or metal can be processed. Compared to these materials, human body parts offer little resistance.

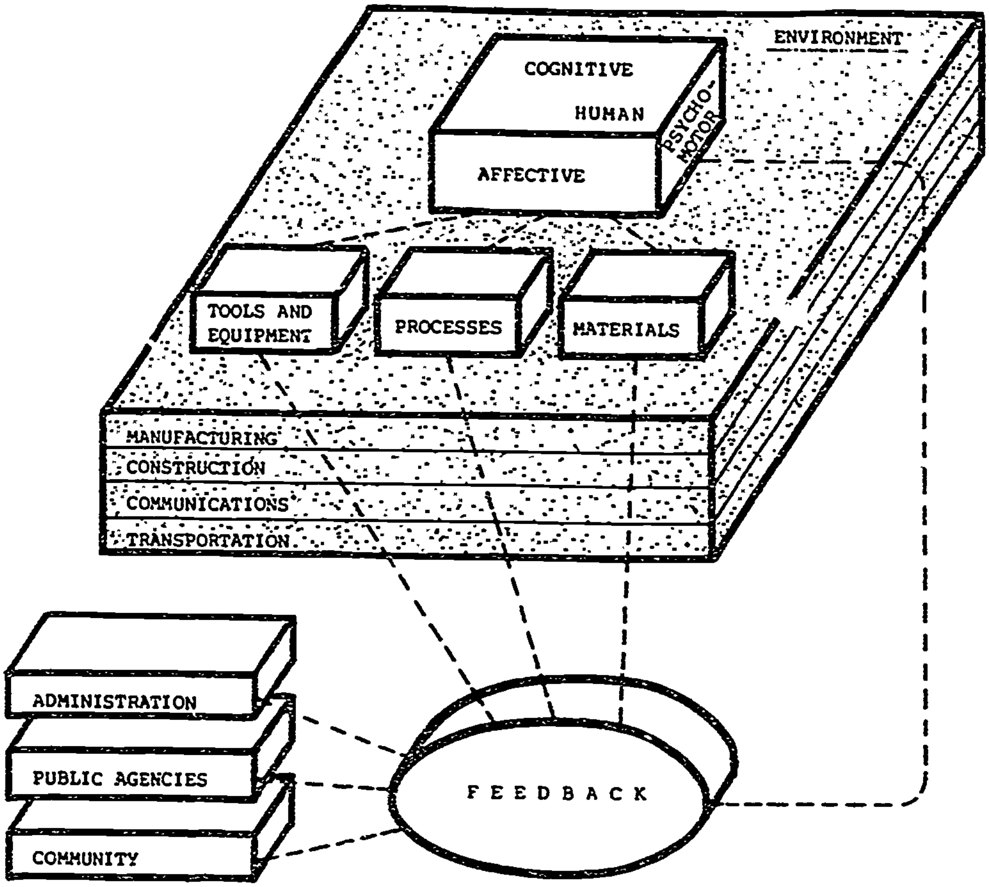
Processes-- Within the context of tool usage, there are a variety of processes which present unique hazards. Students must learn the proper way to complete processes--and the proper way is always the safe way.

Materials-- Material handling, storage, and disposal have become more of an issue in recent years. Many materials when handled improperly have cumulative effects which can lead to serious diseases years later. In addition, the improper disposal of hazaradous wastes can have an adverse effect on the natural environment.

Outside Influences-- As with industry, in technology education safety is regulated by local and national policies. Outside influences are discussed in this manual under the headings: Public Agencies, School Administration, and Community Influences.

Feedback-- Teaching methods and instructional activities are an integral part of the feedback component of this safety system. The first six components of this system establish a content base for system planning. The feedback component integrates the content into an activity based teaching system that gets students involved in planning and maintaining the safety system.

In the sections that follow, we will describe the factors that affect the components, provide evaluation tools for recognizing potential hazards and provide methods for developing a feedback system to allow you and your students to control your classroom safety system.



1.0. Environmental Factors

People have created tools and materials to extend the natural limits on their physical abilities. Unfortunately, in doing so, we have placed ourselves in human-made surroundings which are sometimes hazardous. Whether in the home or laboratory, people must be aware of hazards in the environment they occupy.

1.1. Lighting

Lighting provides the visual contrast needed for safe operation of machines and movement around the lab. A well lit laboratory includes both natural and artificial lighting. In general, a 5:1 ratio of floor space to window area is recommended for natural lighting. Artificial lighting should provide a minimum of 50 to 100

footcandles. For laboratory areas where detailed work is performed, such as drafting, upward to 200 footcandles is recommended. Lighting should be diffused to reduce glare and local lighting should be used for certain activities such as grinding and machining operations. Lighting systems must also be designed so that stroboscophic effects, which would make turning machines appear to be still, are not present. A uniform color scheme should be used throughout the laboratory. Walls should reflect about 60% to 70% of the light which strikes them. Ceilings should always be painted white. No color, however, should be extremely brighter than another surface. This eliminates glare and excessive contrasts which tire the human eye.

Computer workstations can quickly cause eye strain if not properly lit. Two factors which contribute to eye fatigue are screen contrast and strobe effect. The contrast of the screen is controlled by the settings on the monitor, color of the foreground and background, and the intensity of room lighting. Adjust the monitor with the internal contrast and brightness settings balancing the foreground and background to display the sharpest image. Eliminate any glare from room lighting that may interfere with the screen image. Viewing the monitor in a well lit room can quickly cause eye strain because the strobe frequency of room lighting is different from the scan frequency of the monitor. It is recommended that low-intensity indirect room lighting be used to illuminate a computer room. The work area at each station should be locally lit with spot reflector bulbs being sure to reduce the interaction of monitor light and local light as much as possible.

Don't forget, intense light, such as the energy emitted from lasers, can cause severe eye damage. Always wear eye protection when using a laser and never observe the beam or its reflection. The work area should be free of reflective material and suitable shielding to contain the beam should be provided. Similarly, the ultraviolet light and intense visible light created by electric arc equipment requires eye protection and an environment that will contain the harmful light waves.

1.2. Sound Control

Excessive noise can have psychological effects (startle, annoy, and disrupt concentration), interfere with communication, or induce loss of hearing. The risk from noise exposure increases with sound level and duration of exposure. For a typical length of a class period (3/4 to 1 hour) an exposure of 90 decibels is permissible. A good rule of thumb to determine if there is a noise hazard is:

1. If it is necessary to speak loudly or directly into the ear of a student, then noise level is excessive. This level of noise can cause a hearing problem and it also presents a communication problem that can interfere with teacher-student interaction.

2. If student's ears are ringing or if speech is muffled after the exposure period, then the noise level was excessive.

To insure the well being of your students, sound proofing materials should be used and activities should be arranged to keep sound level below the 90-decibels level. Sound reflective material (glass, tile, etc.) should be kept to a minimum and acoustical tile and carpet should be used whenever possible. If there are situations

in your laboratory where the sound level exceeds 90 decibels, then personal hearing-protective devices should be worn. Teachers should remember that students only occupy the lab for an hour or less, but teachers are there all day. Therefore, teachers may need extra protection.

1.3. Temperature

Temperature has varied effect on individuals depending on age, weight, and general health. Excessive temperatures can lead to medical problems (heatstroke, heat exhaustion) and can have psychological effects. The greatest hazard of temperature extremes is the reduction of mental awareness and concentration which increases the potential for accidents. When analyzing the effects of extreme temperature, consider the individual differences and the activity that students are involved in. It may be necessary to alter your plans due to extremes in climate.

1.4. Safety Zones and Color Coding

Consideration must be given to student movement in and out of the laboratory as well as traffic flow within the laboratory. Major aisles should be four feet wide while other traffic lanes may be three feet wide. A minimum of three feet on each side of stationary power machinery is recommended.

The laboratory should be arranged according to the activities involved. Paint, welding, and foundry areas should each be isolated as special hazards. Machines which are normally used for rough stock should be placed near the material storage area. For example, radial arm saws should be placed near the lumber storage area. This reduces the hazard of moving large pieces of stock through the laboratory. Machines which exceed 4 feet in height should be placed in close proximity to walls to avoid obstructing the instructor's vision. Special attention should be given to the direction of chip throw or kickback and these danger zones should be marked.

The way equipment and furniture is arranged in your laboratory is very important. Many accidents occur from being in the wrong place or from conflicts in traffic flow. Color coding improves the environmental condition by establishing boundries which identify safe or unsafe areas. Color coding is a method of communication that tells the student where safety zones and equipment are and what is or is not safe. A standard for this communication system follows:

Red -- Identifies fire protection equipment, danger, and emergency stops for equipment. Fire extinguishers and fire alarm housing should be red to identify their location. Safety cans and containers of flammable liquids must be painted red with a clearly visible identification either in the form of a yellow band around the container bearing a contents label or the contents clearly printed on the container in yellow. Danger signs, and emergency power switches must also be painted red.

Orange -- Alerts users of hazardous parts of machines that may shock, cut,

crush or injure. Use orange on exposed edges of cutting devices, pulleys, gears, inside surfaces of guards, transmission cases, and fuse boxes.

Yellow -- Used to indicate hazard from stumbling, falling, bumping, or collision. Used to designate safety zones in aisles and around machines, hand rails, guard rails, low overhead hazards, approach to stairs and floor areas around open pits. To attract attention, yellow and black strips may also be used.

Green and White -- Used to identify first aid and safety equipment. Use on first aid equipment and personal protective equipment storage areas.

Blue -- Indicates precaution to mark equipment or controls that should not be used.

Purple -- Denotes radiation hazards.

Black and White -- Used separately or in combination to denote housekeeping areas such as the location of waste containers, brooms, and other clean-up material.

1.5. Storage

Designated storage facilities are essential in laboratories to maintain good housekeeping, prevent fires, and prevent personal injury. Permanent and temporary storage for tools, materials, and projects should be located in low traffic areas that are easily accessible. Ergonomic factors and the relationship of storage facilities to machines and fire equipment must also be considered.

When planning storage facilities, locate the tools or materials close to areas where related processes will be performed. Hand tools should be stored close to work benches, paints and solvents in the paint booth area, and raw stock close to the machines used for rough cutting. The location of storage areas must not obstruct the normal walkways or block access to fire extinguishers or emergency power switches. It is easy to violate these conditions while temporarily storing stock during the class. When production is in progress, designated temporary holding areas for tools and materials are essential.

Insure that storage racks, shelves, bins and cabinets are constructed sturdy enough to support the material. Because of strength and to reduce fire hazards, steel or pipe is recommended over wood as construction material for storage shelves. When designing storage devices, consider the weight of objects, size of objects, and the nature of the material. Store heavy objects and dangerous chemicals on low shelves. Tools with sharp edges should not be stored in a box that disregards proximity of the cutting edge. Dangerous tools or chemicals should always be locked in a limited access cabinet. Like many other safety rules, well designed storage areas make good common sense. Organized tool cabinets, raw material stored adjacent to processing facilities, temporary holding facilities, and project storage facilities enhance the safety of the work environment as well as aid in the management of the laboratory. Specific guidelines for storage of various materials are given in section 5.1 of this

manual.

1.6. Fire Prevention and Control

The most important factor in fire control is fire prevention. To prevent fires, you must first know how fires start then implement plans to eliminate these conditions.

1.6.1. Causes of Ignition. There are five primary sources of ignitions which are prevalent in technology education laboratories.

1. Electrical-- Electrical sparks can easy ignite flammable material. Sparks can occur during processing (i.e. electric welder) or any time an electrical contact is made such as in light switches or relays. In areas where materials with a low flash point are present (i.e. paint booths or dust collection rooms), special spark suppressant switches and sealed light sockets must be used.

   Fires can also start from heat created by excessive electrical resistance. Electrical connections on all equipment should be checked periodically. The improper use of electrical equipment, such as extension cords, can result in excessive heat production. Be familiar with and follow the manufacturer's recommendations when using and maintaining electrical equipment.

2. Friction-- the resistance to motion of mechanical energy produces heat and the potential for fires. In most cutting processes, heat is produced. Friction heat can also be produced by moving parts on machines that are improperly adjusted, poorly lubricated, or worn.

3. Open Flames-- There are many material processing procedures that use an open flame. Common tools that present an open flame fire hazard include: welding and cutting torches, propane and gas torches, furnaces, and matches.

4. Hot Surfaces-- Electric lamps, soldering irons, hot plates, and strip heaters can cause fires if improperly used or maintained.

5. Overheating-- Overheating material during processing or accidently overheating flammable liquids can result in flammable or explosive situations.

1.6.2. Fire Control Systems. Public buildings are equipped with fire alarm and suppression systems. Students should be aware of built-in fire protection systems such as automatic sprinklers and fire detection sensors. Every student should know the location of the nearest building fire alarm switch. A fire in the laboratory endangers the lives of the every person occupying the buildings so, in the event of a fire, evacuation is a priority.

Fire extinguishers, placed in convenient and unobstructed locations, are required in technology education laboratories. The location of fire extinguishers should be clearly marked, visible from every part of the room. The distance to an extinguisher must be 75 feet or less for class A extinguishers or 50 feet or less when class B

extinguishers are used. When selecting locations for a extinguishers, place them near normal paths of travel, near exits and entrances, and in areas free from the potential for temporary obstruction or physical damage. An extinguisher forty pounds or less should be mounted no higher than 5 FT above the floor. Heavier extinguishers should not be mounted higher than 3.5 FT. There should be at least 4 inches from the bottom of the extinguisher to the floor.

There are five types of extinguishers for various classes of fires. The fire classifications are:

Class A -- Ordinary combustible materials such as wood, plastic, paper.

Class B -- Flammable liquids, oil, paints, solvents.

Class C -- Fires near live electrical equipment where a nonconductive extinguishing agent is required.

Class D -- Fire from combustible metals such as magnesium.

Selection of the proper type of fire extinguisher depends on the type of fire it is designed to extinguish. Multipurpose dry chemical extinguishers are available for class A/B/C fires. Class D fires require a dry powder extinguishing agent. Every extinguisher should have a plate indicating the class of fire for which it is intended. Check to make sure you have the proper extinguishers for your lab. Using the wrong type of agent can spread a fire or cause injury.

Periodic inspection of fire control equipment is essential. Fire extinguishers should be inspected weekly to be sure that they are in their designated places, that they have not been tampered with, and that they are not obstructed. A yearly inspection should be conducted to check pressure and operational integrity. Hydrostatic testing on most extinguishers must be conducted at five year intervals. There should be a tag on each extinguisher indicating the last test date. If the time indicated on the tag is greater than five years or if a tag is not present, inform your administration.

1.7. House Keeping

Untidy appearance of the laboratory is a hinderance to an effective safety program and reflects unsafe work habits. Cluttering of the laboratory with tools, raw materials, scraps, paints, solvents etc., creates a physical hazard and a fire hazard.

Suggestions for maintaining an orderly and safe environment include:

1) Provide adequate space for tool storage and material storage. Everything should have a place.

2) Provide space for temporary storage of materials during processing.

3) Include as part of your machine and tool demonstrations the proper disposal of scrap or waste materials.

4) Employ an effective management scheme for clean-up. Utilization of class TSA (formerly AIASA) officers is a good technique.

5) It takes the right tools to do a good job. Be sure that the tools for housekeeping are accessible-- brooms, brushes, waste containers, vacuum, oil dry, cleaning fluids, etc.

1.8. First Aid Requirements

Prompt medical attention in the event of an accident can prevent permanent impairment and may lead to complete recovery. If the nearest medical facility is greater than 15 minutes driving time, then a person must be available at the school who has a valid certificate in first aid. Teachers and students should be aware of trained personnel in the school system and the location of the nearest emergency medical facility. The ultimate situation would be for all technology education teachers to be trained in first aid.

To insure prompt treatment, post emergency telephone numbers near the telephone and have first aid supplies on the premises. Following are suggested supplies for first aid items and equipment.

1. Medical

   - Scissors
   - Slings
   - Mirror (for contact lens)
   - Ammonia capsules

2. Sterile Dressings

   - Gauze pads
   - Band aids
   - Telfa pads

3. Non-Sterile Dressing

   - Gauze roller bandages
   - Absorbent cotton
   - Elastic bandage
   - Combine roll

4. Adhesive Tape

   - Medical tape
   - Butterfly closures

5. Ointments

- Bacitracin

6. Solutions

- Eyewash and cup
- Antiseptic
- Hydrogen peroxide
- Antiseptic soap
- Sterile normal saline

Physicians or professional emergency care personnel should be consulted to specify first aid needs for each laboratory situation and to make recommendations on first aid supplies that should be in your kits. Further information on actual first aid procedures may be found in Appendix C of this manual.

1.9. Ergonomics

Ergonomics deals with a study of the person-to-machine interface in order to optimize the working condition. Ergonomics includes: biomechanical factors (stress on muscles, joints, bones and nerves), sensory factors (eye fatigue, noise, and heat), and external environmental factors (lighting, noise, and vibration). Simply stated, a situation that extends physical limits is a hazardous situation. An ergonomic study requires a task and motion analysis to identify components of a task that can be altered to improve safety. The analysis involves breaking down a task into major functions, then analyzing those functions for possible hazards.

Task functions can be divided into the following categories:

1. Preparation

2. Task Performance

3. Physical Demands

4. Termination

Begin the analysis by determining the operational characteristics and physical characteristics of each category to determine safe operating procedures.

1. What steps must be carried out to perform the task?

2. What machines and accessories will be used?

3. Is there sufficient work area for processing?

4. What knowledge and feedback is needed to perform safely?

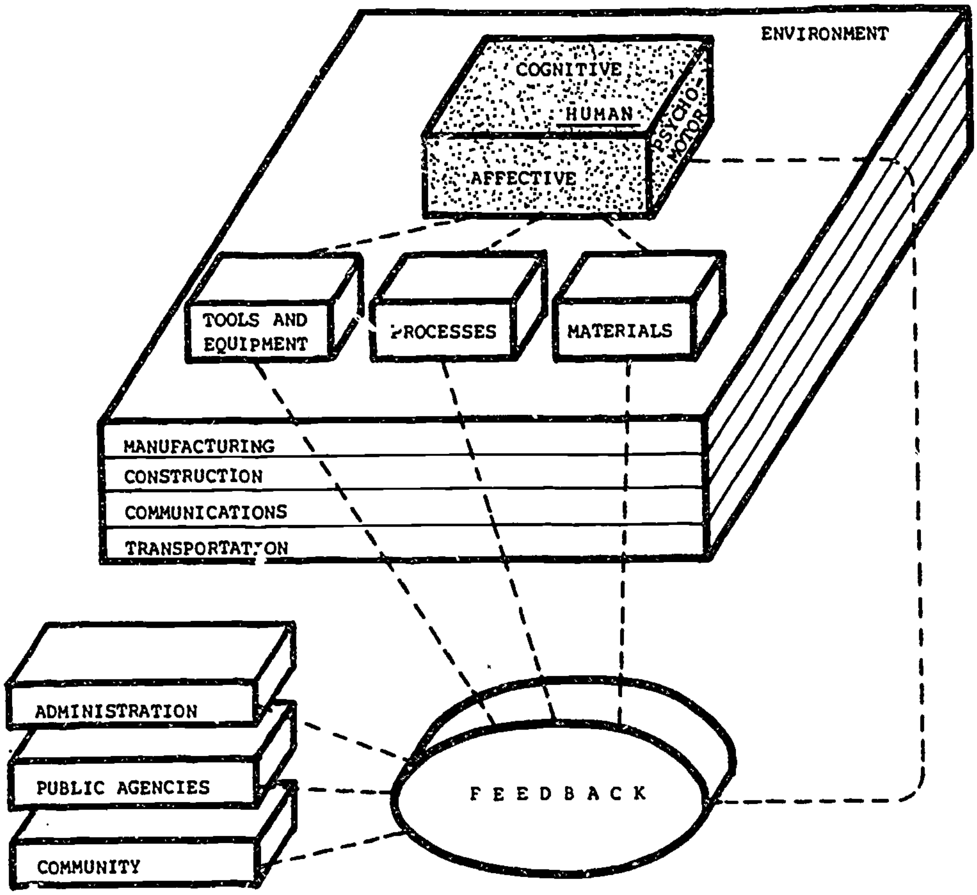
5. What potential errors are possible?

6. What physical demands are placed on the student?

7. What is the reaction necessary to perform safely?

These factors should be considered for machine operation as well as all other acts performed in the laboratory. For example, storing a 50lb. box of nails on a 5 Ft. shelf would violate ergonomic principles because this would place excessive physical demands on the student. Location of controls, switches, and accessories on equipment is also very important. Make certain that switches are placed so that machines may be quickly turned off in an emergency, but not accidently turned on during set-up procedures. Accessories and controls should be positioned to maximize ease of use and safety.

Study the ergonomics factors of machine operation, storage, and material handling and either eliminate conditions that exceed normal physical capacity or provide tools (such as a carts or power lifts) were necessary. Require students to follow the proper procedures when lifting, wear gloves and other protective equipment, and think before acting. Activity form ACT-3 provides a structure for conducting ergonomic studies.



2.0. Human Factors

Safety is important in any industrial or school laboratory setting and there are many factors which together determine the relative safety of a given situation. Key among those are the Human Factors. There are three domains of human endeavor which are important in regard to learning and safety. These are: Cognitive (knowing about safe practices), Affective (having the desire to maintain a safe environment and the necessary "safe attitude"), and Psychomotor (having the physical ability to perform and then actually performing safe practices). These three factors will be explored individually in this section.

2.1. Cognitive Factors

Your students are in your course to learn the proper way to do things, and the proper way is the safe way. To a large extent, the cognitive part of a technology education safey system is automatic--when students are shown how to perform operations and operate equipment, they are shown the safe methods and peculiar hazards are pointed out. This makes it unnecessary (as many teachers have traditionally done) to set

aside long periods of time in the beginning of the term to discuss safety as an isolated topic. In fact, such is a poor practice because many of the safety practices which need to be taught are not easy to understand until they can be demonstrated with the equipment "in hand". For instance, it does little good (if any) to require students to memorize that the acetelyne pressure should not exceed 15 pounds two months before they ever touch or even see the oxy-acetelyne rig. It would be far better to teach this important safety caution when demonstrating the use of the equipment. Then students will use the torches that very week and their memory will be further aided by the redline on the guage. Such "timely" instruction is far superior to the separated mass safety lessons approach. Form ACT-3, Ergonomics and Job Safety Analysis, provides a format for integrating equipment operational procedures and safety.

2.1.1. General Safety Rules. There are, however, a few general safety considerations which apply nearly equally to all laboratory situations and which should be taught very near the beginning of the term. They should be taught clearly and evidence should be collected which documents both that they were presented and that students learned them. It is important to keep the list of such rules brief and generic so that they can become foundational for all technology education laboratories and to promote students' learning of them. An effective approach to use in presenting these rules is to have students copy their brief form from the chalkboard or an overhead transparency while the teacher discusses the rules and their meanings and applications. Teachers may produce the transparency from the enclosed master. The students should sign and date the list of rules which they have copied in their own hand. The list of rules should include a "Safety Pledge" in which students promise to make safety a priority. These signed copies should be collected and stored carefully. Then, the students should be given a printed handout (again, made from the enclosed master) to keep in their notebooks and study for the safety test. The safety test should be administered a few days later and no student should be allowed to work in the lab until a perfect score is made on the safety test. The completed, scored safety tests should also be stored with the lists of rules. These documents constitute good evidence that safety was taught and valued in the class in the event of litigation following accidents due to student negligence. The general safety rules and their explanations follow:

> 1. *Always wear safety glasses in the laboratory.* -- In many states, it is now a law that safety glasses must be worn by everyone in a school laboratory any time the room is being used for work. This means that every student (and teacher or guest!) in the lab must be wearing eye protection as soon as one person in the whole room begins to work--even if they are far across the room drawing their project plans. This may seem like overkill, but many accidents injure people who are "innocent" bystanders. If a grinding wheel explodes or a photographic chemical is sloshed, those who are working are not the only ones who are likely to be hit. They are not usually even the most likely because guards on equipment generally are carefully designed to protect the user, but they are not always as effective on the "back" sides of equipment. In fact, the 100 percent eye protection rule (everyone with glasses all of the time) is the only one which can be effectively monitored. If exceptions such as "I'm only sanding" or "I'm only drawing" are allowed, students are going to forget to put their glasses on when they begin to do more hazardous work. Not only that, but the teacher will become a lax observer and fail to remind students. It is best to fully enforce the 100 percent rule all the

time. Teachers must also obey the rule themselves--for both personal safety and to teach by example. The specific eye protection required depends upon the situation. Welding, sawing wood, and handling offset blanket wash all require eye protection but different sorts of goggles are appropriate for each.

2. *Never run in the laboratory.* -- Labs have many tables and benches with fragile and hazardous equipment and some heavy tools. A person who runs may slip or bump into another student and cause cuts from a sharp tool, force a hand into a machine, or bring about some other injury.

3. *No "horseplay" allowed.* -- It is a lot of fun when done in its proper place, but that place is NOT in the laboratory. Horseplay is a hazard very similar in nature to (and often involving) running. Throwing things is never allowed in a laboratory.

4. *Never operate equipment until you have been taught how.* -- Because machines and tools vary from one manufacturer to another, and to insure that the peculiar requirements of equipment in a specific lab are met, students should not be allowed to operate any equipment until they have been instructed on that particular piece of equipment. Many teachers require separate safety tests on certain hazardous machines before students are allowed to use them. This practice makes good sense. Individual oral and performance tests are very effective methods of safety testing.

5. *Clean up spills and scraps immediately.* -- In any laboratory, small amounts of liquids will be spilled occasionally and scraps will naturally accumulate on the floor because of the work being done. It is important, however, to clean up these hazards immediately--especially ones which overflow into traffic lanes and ones which are larger than what is "typically expected" in amount.

6. *Ask permission before using equipment.* -- There are certain machines in each laboratory which are more hazardous than others. Teachers need to be available and aware to monitor students' use of these items. Students should be instructed to ask permission before using those particular pieces of equipment and should also ask permission before performing operations which are unusual or beyond the range of the general instructions given in class.

7. *Never carry more than you can handle safely.* -- There are two meanings here: 1. Do not carry more weight that you can safely handle without hazard of back or muscle injury, and 2. Do not carry a large quantity of items at the same time causing hazard of dropping them or striking another person with parts which protrude from the pile. Make two trips or get help.

8. *Do not talk to anyone while operating a machine.* -- This is a double-sided rule too: 1. People cannot pay full attention to the machine they are operating while talking to someone else, so do not interrupt them, and 2. Do not distract your own attention by talking to a friend when you operate a machine.

9. *Never use dull or damaged tools.* -- Dull tools do not cut as well as they

should, requiring extra pressure which could result in slipping or breakage. Any dull or damaged tools should be put out of service immediately for repair and reported to the teacher. Tools with broken handles, loose parts, and other defects can cause serious injury.

10. *Never work when you are impaired.* -- Students and teachers who are using any medicines or other substances which could cause drowsiness, lack of attention, or hyperactivity must not work in the laboratory. Persons with temporary or permanent injury or deformity to their limbs may need special arrangements to perform certain operations safely as well. Most important, never allow anyone to work in the laboratory who is under the influence of alcohol or any other drug--they are a danger to themselves and everyone else in the room too.

11. *Remove loose clothing and jewelry.* -- Long, loose sleeves, and hair must be bound, covered, or tied back when working with machines. A person could be dragged into a rotating machine by them. All jewelry should be removed to prevent it from being caught as well. Further, rings can become red-hot when influenced by nearby AC currents or magnetic fields.

12. *Use commonsense.* -- Most of the above safety rules are direct applications of good commonsense. Although there are some hidden hazards in a laboratory, everyone should be reasonably safe if each person is mindful to use good commonsense while in the lab. If you are not sure about something, ask your teacher. Don't take chances in any situation. Don't rush, and keep a serious attitude about safety.

(Teacners may add other general safety rules here which apply particularly to their laboratories.)

The transparency master follows on the next page.

GENERAL LABORATORY SAFETY RULES

1. Always wear safety glasses in the laboratory.
2. Never run in the laboratory.
3. No "horseplay" allowed.
4. Never operate equipment until you have been taught how.
5. Clean up spills and scraps immediately.
6. Ask permission before using equipment.
7. Never carry more than you can handle safely.
8. Do not talk to anyone while operating a machine.
9. Never use dull or damaged tools.
10. Never work when you are impaired.
11. Remove loose clothing and jewelry.
12. Use commonsense.

SAFETY PLEDGE

I promise to do my best to follow the above safety rules and others which my teacher will present at later times during this course. I realize that safety is important, is partially my own responsibility, and that my privlege to use this laboratory depends upon my developing and demonstrating safe work habits.

Signed: ______________________________

Date: _____________

2.1.2. Electrical Safety Considerations. When handling electrically powered equipment and working on electrical circuits, there are special safety considerations and precautions required due to the electrical power involved. Students must be made aware of all of these which apply to a given laboratory situation.

1. Make certain that all equipment and electrically powered tools are in good condition and that there are no frayed wires, loose connections, or damaged plugs. All items should be either properly grounded or of the modern "double-insulated" design.

2. Do not work on electrical or electronic circuits when the power is on except when this is the only possible way to make the needed measurements. Only persons trained to measure "live" circuit values (including, of course, students learning to do so) should attempt to work on a powered circuit.

3. Follow the one-hand-rule. This means that only one hand should be used to make measurements or adjustments in circuits--the other one should be kept in a pocket. This prevents current from finding a path through the working hand, the body trunk, and back to ground through the other hand which could otherwise be touching the case of the equipment or another source of ground potential. Even heavy shocks can be survived when the body trunk is not involved, but a very slight current passing through the heart-lung area may mean certain death. Currents as low as 0.1 ampere and from sources as low as 40 volts have been known to cause death. Lesser currents and voltages are not likely to cause more than mild pain, but they can create serious muscular spasms or jerking motions which stimulate the victim to physically hurt himself by crashing limbs (or the entire body) into other hazards. Serious burns are also possible outcomes of electrical shocks. Observing the one-hand-rule can help to avoid accidental contacts with current.

4. Never work with or on electrical or electronic equipment while standing on a damp floor or leaning against any metal object. These are paths for current to take to ground which many people fail to recognize.

5. Capacitors and some other components may store a large electrical charge for long periods of time after the power is turned off. Be certain to properly discharge them before handling. Persons who are not knowledgeable about such dangers should not open the cases of electrical devices for any reason.

6. Be aware of the dangers of heat and fire when working with electricity. Some components get quite hot during normal operation, others can cause fires, explosions, or burns when they fail. Know the locations and proper operation of fire extinguishers and other safety equipment.

7. Though normal dry skin resistance is over 100,000 ohms, the resistance of moist or injured skin is considerably less. Even stress or fear can greatly reduce body resistance. These conditions increase the chances that sufficient current can pass through the body to cause injury.

8. If the teacher is not properly trained and certified in first aid and cardiopulmonary resuscitation (CPR), he should know the names and locations

of others in the school who have these qualifications and could be summoned immediately to treat any victims of electrical shock. Even minor shocks warrent treatment by the school nurse. See Appendix C for more information concerning emergency actions after electrical shock.

2.1.3. Specific Safety Practices. Once the general safety rules are known by the students, specific safety practices and guidelines should be presented and tested when students are taught the operation of each item of equipment. This makes safety an important and integral part of all instruction--a very natural thing--rather than something set aside to be memorized at the beginning and then forgotten. During these specific instructions, remind students of the crucial general rules that also apply (i.e. no demonstration on the drill press is adequate if students are not again reminded to wear glasses and remove loose clothing). Examples of how to include safety instruction in the natural course of specific instruction on selected topics (from Manufacturing, Transportation, Communication, Construction, and Research and Developlment) appear in Section II. The Systems Approach to safety demands that safety be part of every lesson on every topic--almost an omnipresent condition--rather than a separate topic.

2.2. Psychomotor Factors

It is one thing to think and talk about safety, but quite another thing to "do" safety. The second domain of human endeavor which we will examine is the psychomotor domain or physical activity aspects of safety. The first part of the teacher's job in this regard is to analyze assignments to make sure that they are within the students' safe physical capabilities--can students this age and size physically perform these tasks safely? Teachers will draw heavily from their background in developmental psychology and teaching methods courses in making these decisions. Selection of which equipment is to be used (both when purchasing new items and when making specific assignments) is also affected by these factors. Some school districts make local regulations concerning the minimum age for students operating certain hazardous machines.

2.2.1. Demonstrate Safe Practices. When the teacher demonstrates the use of a machine or the performance of a new operation, it is imparative that safety be stressed in two ways: By telling students the safe way to do it, and, more importantly, by the teacher actually doing it the safe and correct way during the demonstration. Likewise, the teacher's general behavior in the laboratory, both during class and non-class hours, has a great effect on student learning. The first important aspect of the psychomotor domain in the systems approach to laboratory safety is for teachers to always be meticulous to use the safest possible methods for every action they take in the lab--to demonstrate safety in action. This includes wearing eye protection and observance of all general and specific safety rules at all times.

2.2.2. Monitor Student Performance. An excellent way to insure that students actually apply the safety knowleoge they gain in class is to monitor it closely. Effective monitoring demands some method of recordkeeping. One way to accomplish this is for the teacher to carry a clipboard during laboratory activity periods. The clipboard would have a listing of student names and spaces for recording daily grades (Form

REC-3, found in Appendix B, is one example of a daily grade recording sheet). The daily grades could include many factors: diligence of effort, level of cooperation, safety, and others. Marks, both positive and negative, could be made while the teacher observes students at work. A simple "Joey!" followed by the teacher pointing at his own safety glasses and then obviously making a mark on the chart becomes a very effective way to insure that Joey and his peers do not remove their safety glasses in the lab. The daily grades do not have to be very formal, nor do they have to count for a large portion of the final grade, in order to be very effective motivators. They also provide tangible ways to encourage and recognize positive efforts of students in all psychomotor actions--including safety. Completed sheets from the daily grade system which demonstrate that the teacher values safety and frequently reminds students of safety can also become useful evidence in negligence lawsuits. Some organized and effective means of monitoring safety in action should be used, even if it is not as formal as the example above.

2.2.3. Recognize Safety in Action. The teacher should recognize students who work safely, while they are working, by commending them for demonstrating safe practices. This encourages the safe actions of the student receiving the reinforcement and of other students who overhear it as well. Some students are able to make an easy "A" on the written safety test, but then still have difficulty actually "doing safety". The psychomotor domain is where the "rubber meets the road" as far as safety is concerned--teachers must encourage safety in action whenever possible.

2.2.4. Psychomotor Safety Objectives. It is widely recognized that good education includes attention to learning in all three domains (cognitive, affective, and psychomotor) in all courses. The only way to insure that these three domains receive appropriate attention in a course or unit is to include performance based objectives from each domain in every unit of instruction. Thus, it is appropriate and advisable to include psychomotor objectives relating to safe practices within the course. This often merely involves altering the wording of previously included objectives--in fact, the objectives already in place frequently include safety without further attention. For example, in the Construction Systems Course (number 8116 in the North Carolina curriculum), Objective Number 2 for Module 6 (Building Superstructures) reads: "Build a wood frame structure". Many lessons and activities will lead to the accomplishment of this clearly psychomotor objective. Among them could easily be the following example lesson objectives --

Upon completion of this lesson, students will be able to:

Saw wood to length safely and accurately.

Assemble wood frames with nails safely and securely.

Demonstrate safe practices in erecting wood frames.

Notice how the performance of safe practices is stressed in each of these objectives and how the systems approach to safety--making safety integral and ongoing rather than separate and sporatic--is applied in a "natural" way.

2.3. Affective Factors

The final domain of education is the affective or attitudinal domain. It involves how we feel about things and our value system. Just because students can perform well on cognitive tests and even actually put safe practices into action while they are under the watchful eye of their teacher, it is not adequate to assume that they follow safe practices on their own at home, work, or in other settings. What will help to assure that students do this is to develop in them a safe attitude--to teach safety in the affective domain.

2.3.1. Levels of Affective Safety Behavior . Taxonomies of objectives in the affective domain have been developed by various professionals. One by Krathwohl (1964) has been widely used. These taxonomies generally begin with low levels of affective behavior which basically mean the student is aware of stimuli or paying attention to it and progress through differing levels of responding, valuing, organization and characterization. Characterization means (in general terms) that the person values some set of attitudes and actions so greatly that he organizes other actions in accord with it, behaves consistently in accord with it, and even tries to influence others toward it. This would be the highest level of affective domain behavior as applied to education. There are few areas of education in which it is appropriate to deal with this level of affective behavior with the mass majority of students. For example, in English literature, it may be practical to attempt to make all students value Shakespeare's sonnets enough to regard them as great literature, but probably impractical to try to make all students choose them first for all pleasure reading. Safety, however, is a matter of such universal importance that it should be taught at the highest levels of the affective domain. It should be our desire and effort to make students value safe practices enough to work safely at home as well as in school, to transfer their safe practices to the workplace, to help remind others about safety, and to promote safety in every way they can.

2.3.2. Safety Objectives in the Affective Domain. To accomplish safety education in the affective domain, specific course, unit, and lesson objectives should be used in all technology education programs. It does not matter that attainment of the objectives is difficult (perhaps impossible) to measure--they still will serve as goals to promote attitudinal change among students. Examples could be:

> After completing this course, students will willingly wear eye protection when working in their home shops or in other non-school settings.
>
> After completing this course, students will actively encourage others to wear safety glasses when working with tools and materials.

These are the sorts of goals which characterize educational efforts at the highest levels of the affective domain--they are the type that all technology education programs should strive to attain, regardless of the specific technical information under study.

2.3.3. Affecting Students' Attitudes Toward Safety. The first and most important thing the teacher can do to build the desired safe attitude in students is the same thing which was stressed under 2.2.1 above (Psychomotor Domain-- Demonstrate Safe Practices): The teacher must use safe practices at all times. If the teacher tells

students in class to always use the guard on the table saw and then students who come back after school observe the teacher cutting with no guard, the battle to instil safe attitudes in them is lost. That "actions speak louder than words" is even more true in the affective domain than it is in either of the other two. Show students the right and safe way to do things at all times.

2.3.4. Monitoring Safety. The second way to foster safe attitudes is to stress them by monitoring them. The methods explained under 2.2.2, 2.2.3, and Form REC-3 work well here too. If the teacher merely says safety is important, and then does nothing to show students that he really FEELS it is important enough to take note of it; then students do not see that he values safety. Teachers play a large role in developing the attitudes of their students. Especially in the case of teenagers, what teachers believe and make known to their students is very important input to their developing attitudinal system. If teachers say safety is important and then back that verbage up with a monitoring system, students will really believe that the teacher values safety. That belief helps develop their own safe attitude.

2.3.5. Using Visual Cues. Utilization of safety posters, awards, public commendations, and other non-direct teaching methods is effective for promoting safety in several ways. Despite the information they can transmit, their chief effectiveness is in establishing safety awareness and a safety concious environment. Visual cues help students to see that the teacher values safety and they serve as gentle reminders. Specific visual cues placed near certain high hazard areas are especially effective in this regard.

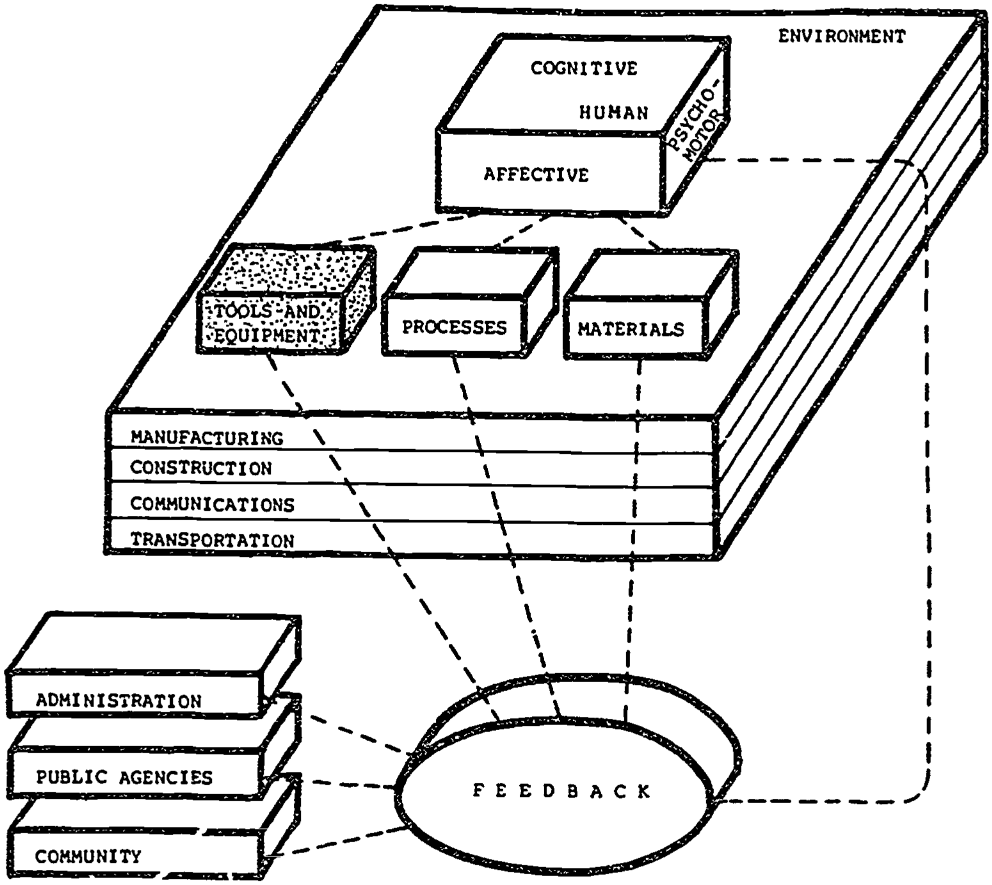
2.4. Disabled and Special Needs Learners

Many students in today's technology education classes have special needs due to physical disabilities or limited intellectual ability. Those with physical handicaps sometimes require alterations to equipment and modified strategies for adequate instructional delivery. Such changes should be made in a manner which does not impede the learning or safety of other students. Frequently, all that is needed to overcome mild disabilities is careful instruction followed by one-on-one conferences or demonstrations with the special needs learner. No evidence is available that properly taught and managed special needs learners are any greater risk than other students in a laboratory--in fact, if they are like disabled adult workers, they could be safer than their able bodied peers. If students are slow to learn, make sure that instruction is thorough and keep the list of safety precautions short and simple. Illustrated safety placards are often very effective aids. Once limited ability students know what to do, they are often more careful about following established procedures and less likely to deviate from the teacher's suggested methods than other students. Affectively, what many limited ability students lack in intellectual prowess may be made up for by their eagerness to cooperate. Emotionally disturbed students who are prone to outbursts of rage do need careful monitoring and could become safety hazards under given conditions--consult with the guidance department, school nurse, administration, and parents for advice about particular students. Likewise, students with very low intellectual ability may not recognize safety hazards which are obvious to others--especially careful instruction, monitoring, and safety guarding is needed for these learners. Generally, the safety records of disabled industrial workers are very good and special needs learners in technology

education courses should be expected to live up to those standards.

2.5. Conclusion

There are three aspects of human behavior, and each must be dealt with in teaching about and promoting safety. Students must be taught about safety cognitively in a "natural" manner that makes safety forever important. They must be shown the correct and safe way to do things and then caught in the act of doing them safely. Finally, they must come to value safety highly enough to make it their most important priority in the lab--far above craftsmanship, knowledge of materials, or technical expertise. These last two goals can best be attained by example and monitoring in a consistent manner. The systems approach to laboratory safety demands that this three-pronged attack be applied in a thorough way in all technology education labs.



3.0 Tools and Equipment

Many of the injuries in technology education laboratories are associated with the improper use of tools and equipment. Training and supervision are essential for handling and operating tools and equipment safely. Critical factors for safe use of tools and equipment include:

1. Each student must have a firm knowledge of operational procedures for each tool or machine including the procedures for preparation, performing the operation, and terminating the operation.

2. Each student must possess the motor skills needed to perform the operation safely. There are two factors to consider when designing instructional programs for skill development--the developmental level of the child and the proper sequence of instruction designed to develop increasingly complex motor skills.

3. Tools and equipment must always be kept in good working order. Electrical or mechanical failure can cause serious injury so a preventative maintenance program is a must. This program should include periodic inspection and service.

4. Machine safeguarding is a must. Properly installed guards will insure the safety of the user and protect students in the event of equipment failure. There should never be an instance when a student is using a machine with the guard removed!

3.1. Hand Tool Safety

A common misconception is that everybody knows how to use hand tools. Technology educators realize the importance of using hand tools properly but, typically, students treat these tools with little respect. Often students will use hand tools to perform operations for which the tools were not intended (i.e. a chisel used as a screwdriver) or students will fail to wear personal protective equipment when using hand tools (i.e. not wearing safety glasses while hammering). Again, instruction and supervision are essential. Teachers must be a role model exemplifying the proper use of hand tools.

There are four classes of hand tools each of which present unique hazards. Following is a discussion of each class.

3.1.1. Cutting Tools. Cutting tools include saws, chisels, planes, files, abrasive paper, taps and dies, snips, axes, and knives. As with any tool, concentration and control are essential for safe operation. Therefore, it is very important that cutting tools are kept sharp and in good working order. A dull tool can be more dangerous than a sharp tool because of the lack of control. Cutting edges should be sharpened to the proper angle given the material that they are designed to cut. Saw teeth should be set to insure proper control when cutting. Teachers should insure that students are instructed in the proper selection of these cutting tools for various materials and operations.

Many injuries are caused by burrs and chips created while cutting. The material should be continually inspected for these hazards. Students must wear gloves when processing materials that are prone to burring or chipping. They should always use care in chip removal--never brushing the material with their hands. And in all cases, safety glasses must be used during any cutting operation.

3.1.2. Torsion Tools. Common torsion tools include wrenches, pliers, tongs, allen wrenches, and screwdrivers. These tools are probably misused more than any set of tools. Screwdrivers are not pry bars and vice-grips are not wrenches. Each of these tools are designed for a specific purpose and the misuse of these tools can cause injury.

The most common injury which results from using wrenches occurs when the wrench slips from the nut or bolt. Always be sure that the proper size wrench is used. With the combination of metric and English sizes, the proper size may be obscured, so pay close attention to the standards with which you are working. Inspect the bolt or nut to insure that it is not damaged, then select the proper tool size. Generally, socket wrenches are the safest and offer the most flexibility. Box wrenches are safer than open-end wrenches. Adjustable wrenches, because of the safety factor, should have limited application.

Screwdrivers are commonly abused by students and subsequently a source of frequent injury. The use of screwdrivers as punches, wedges, pry bars, etc. should be prevented. The tips of screwdrivers should always be kept clean and ground to their original shape when necessary. The proper fit of a screwdriver to the screw slot is a must so an adequate selection of drivers should be readily available.

Control of torsion tools depends on the ability of students to match the proper tool with the type of job. A torsion tool with too large a handle can cause excessive torque and too small a handle will require excessive force. Each situation can cause injury. Proper fit and consideration of the degree and direction of force will insure a safe procedure. If a student is using these tools for electrical work, insulated handled tools should be used and, in some instances, rubber gloves should be worn.

3.1.3. Shock Tools. Shock tools include the various types of hammers used for driving, riveting or forming. Hammers have three common unsafe conditions: split handles, loose heads, or chipped and mushroomed heads. Periodic inspection and maintenance of hammers can eliminate these hazards. Every time a hammer is used there is always a chance for objects to fly from the blow. Therefore, safety glasses should always be worn by the user and every student within the work area. The head of a hammer should be free of material build-up, oil, or grease. When using a hammer with small fasteners, tongs or pliers should be used to hold the fastener so that fingers are a safe distance from the strike area.

3.1.4. Thermal Processing Tools. Thermal tools generate heat energy to condition or assemble materials. Some commonly used thermal tools are lasers, torches, heat guns, hot glue guns, welders, soldering irons, strip heaters, hot waxers, hot wire cutters, kilns, furnaces, and ovens. Heat producing tools have the potential to severely burn the user and they are sources of ignition. When using this equipment, keep the work area clear of flammable materials and wear protective equipment to minimize the hazard. Energy sources such as natural gas or acetylene are very dangerous, so keep equipment in good working order and inspect it often.

Tools such as lasers and electric arc equipment produce visible and non-visible radiation that can burn skin and produce corneal burns or retina damage. Always wear eye protection when using this equipment and provide appropriate shielding to contain the radiation. When purchasing a laser, select one that emits visible light and is low powered enough for safe use by students.

3.2. Power and Mechanics

Power tools are similar to hand tools in that they perform many of the same operations as hand tools. The difference is the external power source used to perform the operation. Power tools can be divided into four groups depending on the power source: Electric, pneumatic, internal combustion, and explosive. Electric and pneumatic tools are commonly used in the laboratory. When an air or electric source is not available, internal combustion engines are commonly used. With these three power sources, emergency shut-down switches or valves must be located in accessible locations. Explosive tools such as anchor drivers for concrete are generally inappropriate for use by students because of their high hazard potential.

Power tools can be extremely dangerous. The potential for disabling injuries is very great, so safety precautions should be strictly followed. Factors that contribute to the hazard of power tools are the velocity of the functional machine parts, the force applied to the work, and mobility of the tool. As the velocity of machine parts increase, the reaction time of the user becomes more critical and the required safety zone increases because of a greater potential for kick-back. As the force that is applied to the work increases, the greater the potential for severe injury. If a machine is portable or the functional parts are movable (i.e. blade of radial arm saw), the safety zone increases and guarding becomes more difficult.

Teachers should analyze each tool against these criteria to determine the potential hazard of a machine. For example, due to the velocity of the blade on a table saw, a person can sever their fingers before there is time to react. Given these factors, a portable circular saw is extremely dangerous because of the velocity of the blade, mobility of the tool, and restrictions on guarding. For these reasons, great care must be exercised in selecting any power tool for student use and in instructing the students.

3.3. Automated Equipment and Robots

Automated equipment and robots are powered-mechanical equipment, so the same safety precautions observed while operating any power equipment should be followed when operating a computer-controlled machine. In some respects, automated equipment can be safer than standard equipment because the user is often removed from the point of processing; however, in many ways automated equipment can be more dangerous. Since users are less involved during processing, they can easily become distracted and lose concentration. There is no physical feedback, so potential machine failure is difficult to detect and unanticipated programming or communication errors can result in machine failure, tool or part breakage, robots striking objects or people, and other hazards.

When using automated equipment:

1. Be aware of the tool limits or robot work envelope. The movement of the machine during the process is not directly controlled by the operator so special caution must be taken to insure safe operation. Guards with emergency shut-off switches which trip when the guards are opened are a good method to prevent injury.

2. Keep cables neat and inspect connections periodically. Poor connections or signals induced by overlapping wires can cause errors in data flow between the controller and the machine, causing erratic machine movements.

3. When programming a computer-controlled machine, check machine movement using the "step" option on the controller. This option allows the user to individually check each program line avoiding situations in which incorrect programming creates hazards.

4. There are usually two emergency shut-off systems on CNC and robotic equipment-- A mechanical power-off switch and a soft-switch which immediatly stops program execution. Be sure students are aware of both systems. Sometimes, quick reaction is necessary to prevent injury or machine damage.

3.4. Equipment Safety

Following is a list of generic safety rules for the safe operation of most power tools. These rules are catagorized according to the ergonomic factors described in section 1.9. Power tools should be demonstrated along with the specific safety rules for the machine and recorded by students using form ACT-3. Definitive safety practices for any specific piece of equipment, however, must conform to those prescribed by the machine manufacturers. These manufacturers' recommendations should be on file and posted with each machine. (You may use this page as a master.)

A. Preparation

1. Wear safety glasses for all machine operations.
2. Secure loose clothing and remove jewelry or clothing accessories that may get caught in the machine.
3. Clear area of scraps.
4. Position guards.
5. Set-up machine for the specific operation. If the machine is computer controlled, step through the program.
6. Position stock for the machine operation.
7. Consider physical demands and use a helper if necessary.
8. Check with instructor before performing the operation.

B. Task Performance

1. Mentally review the operational procedure and machine safety rules.
2. Focus full attention on the machine operation.
3. Never leave the machine.
4. If a problem is encountered, stop the machine at a safe point.
5. Make machine or stock adjustments only when machine motion has stopped.

C. Termination

1. Make sure machine is turned off and all motion has stopped.
2. Remove scrap material that accumulated during the operation.
3. Return the machine to its customary set-up.

3.4.1. Safety Zones. Distance of hands and other body parts from the source of a hazard is related to the hazard potential. Generally, the greater the distance, the less the hazard. Thus, zones can be established to emphasize critical areas of concern.

1. Danger Zone-- Mechanical, electrical, heat, or radiation hazards typically at the point of material processing. Machine parts within this zone require guarding or other types of fail-safe systems.

2. Critical Zone-- Work surfaces and machine components that are an integral part of the processing procedure. Special care must be taken to insure that this zone is free from scraps or tools that may interfere with the operation. Precautions must be taken to prevent injury in case of machine failure.

3. Safety Parameter-- Commonly three feet from the machine plus any area were material can be thrown from the machine. No one should be inside this zone except the operator and, if necessary, a helper. If a student is helping the operator, then the responsibilities of the helper for maintaining a safe work environment are the same as those of the operator.

Safety zones should be analyzed while conducting the environmental study (Form ACT-2). This information should be reinforced by the teacher during machine demonstrations.

3.4.2. Machine Safeguarding. Machine safeguarding includes: a) fixed and movable machine guards that prevent fingers from entering the machine's danger zone, b) enclosures that prevent access to mechanisims of the machine that can cause injury, c) protective devices or systems to eliminate shock hazards, and d) fail-safe systems that automatically limit the potential for injuries.

There are six basic types of safeguarding systems.

1. Fixed Enclosures-- Fixed enclosures are non-movable devices that are commonly used to prevent access to pulleys, gears, belts and other movable parts. Fixed enclosures can also be used at the point of processing if they are designed in such a way as to allow stock to be fed but not admitting hands or fingers.

2. Adjustable Enclosures-- Adjustable enclosures are commonly used at the point of processing (danger zone) and allow for various sizes of stock. Many of these enclosures have anti kick-back devices, chip removal accesories, or other built in safety features. Adjustable enclosures may allow hands to enter the danger zone, so operator compliance with safety rules is essential.

3. Enclosure with electric or mechanical interlock-- These enclosures shutoff or disengage the power when the guard is open. This type of enclosure is commonly used with computer-controlled machines and robots.

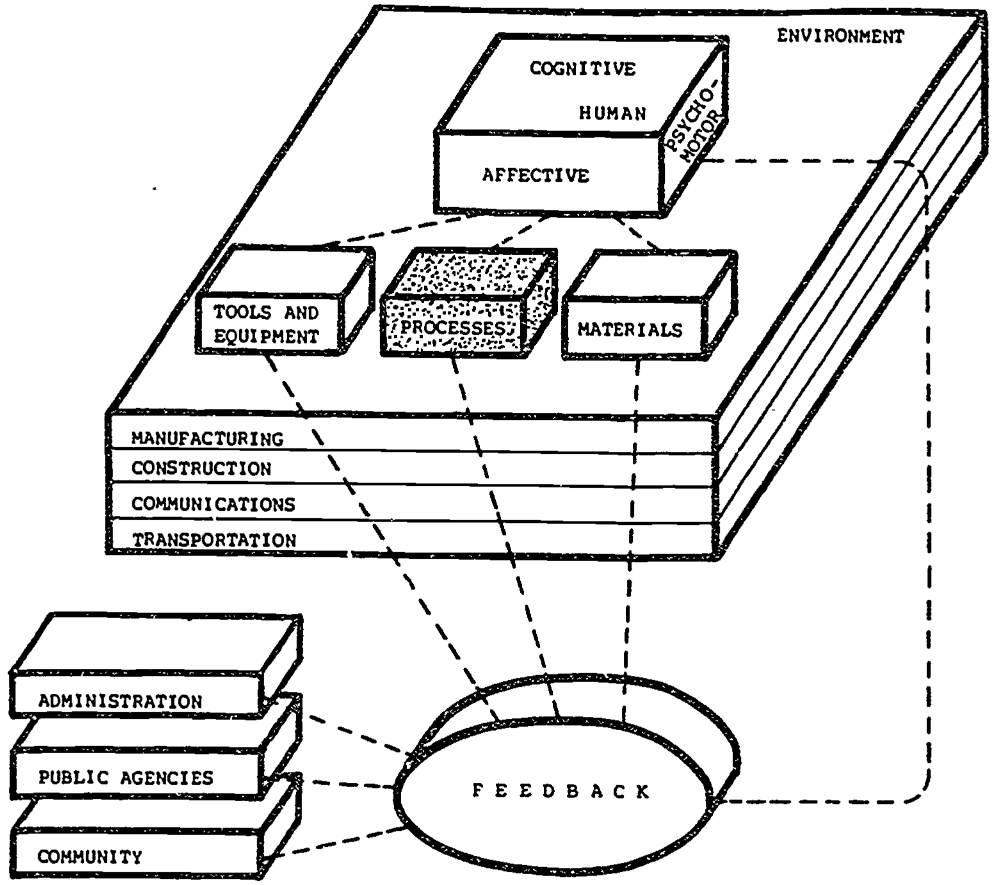
4. Automatic or semiautomatic feed-- Automatic feed systems reduce the machine hazard by elimating the need for the operator to work in or near the danger zone. They do, however, bring other safety hazards which require

careful attention by the operator.

5. Two-hand trips-- Two-hand mechanical or electrical control mechanisims which must be activated simultaneously, by both hands, prevent hands from being free to enter the danger zone.

6. Hand clearing devices-- Fixed bars, or straps which prevent hands from reaching the danger zone. Other types of devices move into position to clear hands from the danger zone immediately before impact or cutting.

For machines in technology education laboratories, fixed and adjustable enclosures are installed by the manufacturer. Other types of safeguading systems are used frequently by industry. Teachers may want to consider safeguarding options to "design-out" hazards in the laboratory. When designing machine set-ups for mass production, this information should be incorporated in the content and made part of the machine set-up design criterion. Form ACT-7 provides a structure for including this content in machine set-up design. Safety guidelines and guarding accessories from the manufacturer of each machine should be incorporated whenever possible.



4.0. Processes

Processes may be classified in various ways. Traditional ways of classifying processes involved naming the specific machines on which the processes would be done. This method, however, fails to point out that sawing a dado joint in wood on a tablesaw is essentially the same process as cutting a slot in steel on a horizontal mill--both are "separating" processes. New curricular trends attempt to make these similarities known to students. This safety manual also uses the contemporary approach. Therefore, safety considerations concerning six widely accepted secondary processes will be discussed here: Casting or molding, forming, separating, conditioning, assembling, and finishing. Specific safety rules and cautions for a specific piece of equipment will not be given here. This is partially because they sometimes vary from one brand or style machine to another--consult information published by the manufacturer of any given machine for special safety recommendations. Additional information on safety considerations for processes may be found in sections 3 and 7 of this manual, in technical manuals and textbooks on those processes, and in equipment operation manuals.

4.1. Casting and Molding

Casting and molding involve pouring or forcing liquid or plastic state materials into a prepared mold. The material is allowed to become solid. Then it is removed from the mold. The chief hazards in casting and molding are related to the methods used to make the materials liquid or plastic. These methods generally use either heat or chemicals. The safety precautions appropriate require protective clothing and special eye protection. Care is needed when handling liquid materials. Other potential hazards include (dependiing upon the techniques and size of equipment used): a) mashing or smashing hands and limbs in molds or during the ramming of a mold, b) explosion of the heating furnace or of the molten material due to introduction of water or chemicals, gas leaks, or breakage of a crucible of molten metal, c) spilling liquid plastics or metals onto skin or clothing, d) splashing of molten materials during pre-pouring conditioning (fluxing or mixing), e) opening molds before proper curing and cooling, and f) handling freshly cast products while still hot. Full face shields are generally required. Gloves, aprons, and sometimes even leggings and sleeves of leather (for high temperature protection) or appropriate rubber or plastic (for chemical protection) are needed. Instruction about these processes must include mention of the above and other safety hazards and how to avoid them. Specific safety information and instructions may be found in textbooks, in technical manuals, on the container labels of the products used, and from product manufacturers.

4.2. Forming

Forming involves using force to cause a material to permanently take a shape. A die, mold, or roll is used to shape the material. There is no change in the volume of the material. Some examples of forming processes are metal spinning, thermoforming plastic, bending band iron by hand, and steam bending wood. The hazards found in forming relate mostly to the forces used and the manner in which they are applied. These may involve (depending upon the materials used and the type of processes) heat, pressure, rotating machines, chemicals, pneumatic or hydraulic action, mechanically amplified forces, and heavy equipment. The hands are sometimes very near the point of application of the force (as in metal spinning). Some of the hazards which should be considered are: a) smashing, pinching, or crushing hands and limbs; b) dangers associated with heating sources; c) entanglement with rotating and powered equipment; d) fragments breaking away from the product and becoming missiles as dies and molds close; e) handling hot products too soon after processing; and f) application of excessive force which causes equipment or product breakage. Instruction on forming processes must include mention of these and other hazards and how to avoid them. The most accurate and definitive source of additional safety information on forming processes is found in the instruction manuals for the equipment used. Textbooks, and technical manuals on these materials and processes are also helpful.

4.3. Separating

Separating involves converting material size and shape by removing excess material. The material is cut or sheared by these processes. Separating processes once

dominated much of traditional industrial arts. They include a broad family of operations such as sawing, planing, grinding, sanding, glass cutting, slicing, etching, chip removal, drilling, boring, turning, machining, and even electro-chemical machining processes. This is still, by far, the largest family of most frequently used hazardous processes found in technology education laboratories. Eye protection is essential for all of these processes. Other hazards which are shared by many of these processes involve: a) moving parts and blades (sometimes at very high speeds); b) potential of the workpiece becoming lodged in or pulled into the machine at higher than desired rates (as in climb milling or crosscutting on the radial arm saw); c) potential of the workpiece being thrown out of the machine at the operator (as in a kickback from the tablesaw); d) hands or limbs positioned near moving blades; e) blades, drills, or abrasive wheels shattering from excessive impact or poor condition; f) tools or accessories being thrown by centrifugal force (chuck keys from drill presses, and lathe tools); g) improperly set-up or attended CNC machines or automatic feeds on traditional equipment causing collisions between parts and workpieces; h) improperly clamped workpieces being grabbed by machines (spinning on drill presses, etc.); i) inappropriate uses of portable power tools; fingers cut by shears or blades; j) dust and chips being discharged from machines; k) attempting to cut large pieces of material without adequate support or help; and l) failure of equipment due to poor maintenance which results in injury. Aside from proper instruction, the most important duties of the teacher are to insure that equipment is in good order, has appropriate guards and shields in place and functioning properly, and bears signs or placards bringing attention to specific hazards. Students should be mointored especially well when they perform operations on these hazardous items of equipment Manufacturers' operating instructions should be consulted directly and followed closely. Generic instructions for operation of these types of equipment may be found in textbooks and technical manuals on the processes and materials involved, but manufacturers' instructions are the only source of information on conditions unique to a specific brand or model machine. Students should be cautioned extensively about the potential hazards of operations in the separating processes studied.

4.4. Conditioning

Conditioning involves using heat, mechanical force, or chemical action to change the internal properties of a material. Examples of conditioning include curing thermoseting plastic with heat, forging steel, annealing copper, curing epoxy with a catalyst, and others. Eye protection is required for all of these operations. Hazards which are common to many of these processes are: a) those associated with heating equipment and handling of hot materials; b) danger of spilling or splattering chemicals; c) hazards involved in hammering or compressing as in forging; and d) other special hazards of specific processes. Protective clothing should include gloves and aprons of leather for high temperature protection or plastic or rubber for work with chemicals. Full face sheilds are generally needed. Textbooks about the processes and materials involved, manufacturers' instruction sheets on specific chemicals and materials, and warning labels on original containers are the best sources of complete information regarding safety for conditioning processes.

4.5. Assembling

Assembling involves temporarily or permanently holding two or more parts together. This is a large family of operations including gluing, welding, brazing, hemming, nailing, pressing, clamping, bolting, stapling, sewing, heat sealing, riveting, threading, jointing, taping, binding, soldering, and a host of other assembly techniques. Some of these operations are low in hazard potential, requiring only eye protection and reasonable care, but others are quite hazardous and demand much special provision for safety. Specialized eye protection and heat sheilding apparel is required for all of the processes in the welding and brazing areas. Machinery with moving parts and hammering are used in riveting, sewing, pressing, stapling, and other processes--these require attention to placement of hands and limbs. Chemicals are often involved in gluing operations. Specific instructions and safety precautions for these operations can be found in textbooks and technical manuals on the processes involved and in manufacturers' instruction sheets and manuals for equipment and products. The processes used should be carefully demonstrated to students and unique hazards should be clearly identified. Students should be monitored carefully to insure that they wear appropriate clothing and eye protection while performing hazardous operations.

4.6. Finishing

Finishing involves protecting and/or adding beauty to the surface of a material. The finishing process which is used depends upon the material to be finished and its intended use. Wood demands different finishing techniques than metal, and wooden picnic tables require different finishing processes than wooden floors. Despite these variations, many finishing processes involve paints or other chemicals of some sort which must be mixed, brushed, spread, poured, sprayed, dried, and/or cleaned-up. The solvents for these products are often hazardous to health due to their fumes and their effects on unprotected skin. Goggles which protect the eyes from splashes are a must for all finishing operations. Plastic or rubber gloves (depending upon the chemicals used) are often needed. Adequate ventilation and sometimes respirators of special types are also important safety considerations. Concentrated fumes can also explode from heat sources as small as the arcing inside an electrical switch or a cigarette. Unlike separating or forming, where the hazards are visible and their effects immediate, finishing has many "hidden" dangers which will neither be easily seen nor immediately diagnosed. It is easy to see a cut finger. It is not so easy to detect lung diseases from breathing paint spray mist. Students do not understand this. Therefore, it is important to make students aware of these hidden dangers and just how debilitating some of the conditions they could cause can be. Due to the unfortunate popularity of "sniffing" as a method of drug abuse, it is important that teachers carefully monitor students while they use finishing materials. This is particularly true in cases where students can isolate themselves in a small, concealed space such as a finishing room with ready availability of vapor producing chemicals. Teachers must warn students of the dangers they encounter when they sniff.

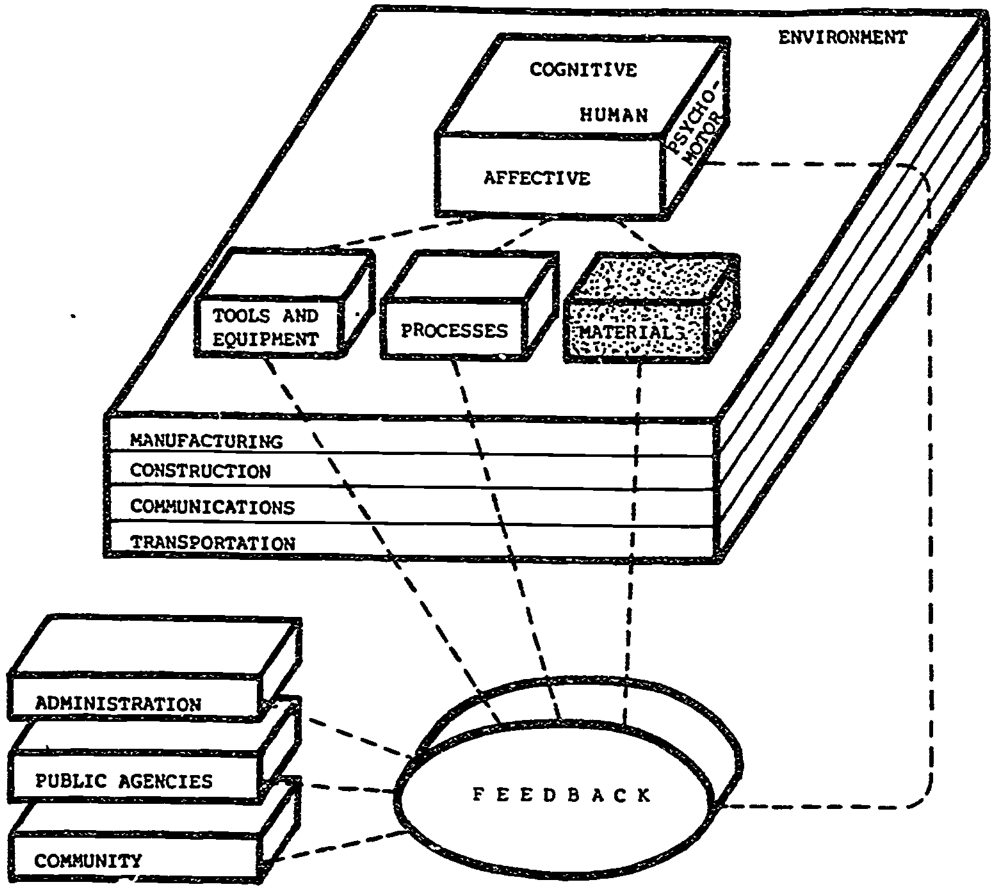
For many students, finishing operations are also their first use of compressed air sources. They must be warned about the great potential dangers involved here. Horseplay with compressed air hoses can result in blindness, foreign objects or air

injected into the skin or bloodstream, internal damage to organs, or even death--students must be thoroughly warned of these dangers and carefully monitored. A few finishing processes also require heat, so these have unique hazards too. Safe storage of finishing materials is also important, this will be discussed further in Section 5.

More specific information on the hazards and precautions regarding finishing processes can be found in textbooks on the materials to be finished, technical manuals on finishing, and manufacturers' instruction sheets and manuals on the products used. The instructions and precautions printed on the containers for the various paints and chemicals are also excellent sources of this information. For this reason, it is best to keep the materials in their original containers whenever possible so that precautionary statements are easy to find.

4.7. Conclusion

The processes used in technology education courses vary greatly from one course to another and from one school to another, but they all emulate industrial practices in some way. Each process has unique hazards and potential dangers which must be understood by the teacher, taught to the students, and have definite steps taken to avoid its causing injury. General guidelines and procedures are published in textbooks and technical manuals, but in almost all cases, the best source of specific safety information on equipment, materials, and products is the original manufacturer. Providing a safe environment, keeping equipment in good repair and well guarded, finding accurate product information, teaching the correct and safe techniques, and careful monitoring are the most important duties of the teacher with regard to safety while teaching about processes.



5.0. Materials

Materials are the third major necessity for producing products (along with processes, and tools and equipment). Materials differ greatly in shape, size, composition, form, and their requirements for safe storage and handling. There are some materials which are hazardous if not stored and used properly. The guidelines presented here are generic to most materials, but more specialized information on the proper handling and storage of specific materials is available from their manufacturers. Additional information concerning storage of materials may also be found in textbooks and technical manuals about the materials used and in books and articles on laboratory organization and management. Because so many various materials are used in technology education courses, many methods of storing and handling materials must be employed. The teacher should become familiar with the proper methods for storing and using all materials incorporated in the classes taught and teach this information to students as appropriate.

5.1. Storage

Because so many different types and shapes of materials are used in technology education courses, and because their storage techniques are often so dependent mostly on their composition and shapes, this section is arranged by these factors rather than by type of material. For instance, a sheet of plywood and a sheet of plasuc can be stored in much the same manner from the standpoint of safety.

5.1.1. Rigid Linear Solids. Examples of rigid linear solids are lumber, angle iron, extruded structural shapes of plastic, conduit (EMT), and other long pieces which may not be rolled or coiled. These materials may be stored either horizontally on racks or leaning in a nearly vertical position with separating partitions between types. If they are stored horizontally, their weight has a great deal to do with how high they may be placed safely. Light aluminum channels, for example, can be placed much higher on shelves or racks than can heavy steel I-beams. Any shelves or racks for horizontal storage must be designed so that they lean toward a solid wall rather than away from it or back-to-back with another set of similarly loaded racks. Stresses and loads should be arranged so that the entire filled rack has a low center of gravity and a wider base than its top. Vertical racks should also lean toward a wall or other stable structure. They have the advantage that very heavy materials may be stored closely together because their weight is on the floor rather than on the rack. However, getting pieces out of the rack can become dangerous because much of the weight of the pieces is sometimes higher than the point of the person's grasp. For this reason, it is safest to limit the length of materials stored vertically to about 8 to 10 feet, allowing an average height person to grasp the pieces above their midpoint. Materials should be arranged neatly in the rack so that ajacent pieces are not dislodged and knocked out while removing stock. It is not safe to mingle heavy and light materials together in either vertical or horizontal racks because this greatly increases the likelihood of entangling them or disloging them accidentally. "Shorts" should not be stored with standard length stock for the same reason. Often used materials should be placed in the spaces which are easiest to load and unload. Students should be encouraged to get help when removing long pieces of material from either type rack. It is possible to get into a situation in which either forward or backward motions will result in falling pieces and safety can only be assured with the aid of another person.

5.1.2. Rigid Solid Sheets. Rigid solid sheets include plywood, sheetmetals, acrylic plastic sheets, particle board, and other sheets of materials which are stiff enough to stand on edge or end without bending excessively. These materials may be stored horizontally or vertically on either the long or short edge. The weight and stiffness of the material and amount and type of available space are the factors to consider in designing storage for rigid sheets. Because of the amount of space it monopolizes, horizontal storage is generally only used when it can be combined with some other use of the same space--such as a few shelves under a large worktable. Materials which are very stiff but not too heavy may be stored safely in a leaning vertical position resting on their short edges. Heavy pieces and materials which are not as rigid are better stored vertically if they rest on their long edges. Adequate space is needed surrounding the storage rack to make it possible to remove and store materials safely. Dividers should be strong enough to prevent materials from falling in domino fashion and of appropriate spacing to permit resonable amounts of material in each slot. Slots which are too wide permit excessive lean and may lead to failure of the

rack.

5.1.3. Flexible Linear Solids. Flexible linear solids include wire, thin tubing, plastic hoses, ropes and yarns, tapes, and other materials which may be coiled or rolled. These materials present few safety problems in terms of storage. Spools may be mounted on racks so that desired lengths may be rolled off and cut. When removal of the whole spool is required, the spools should be arranged with heavier ones nearest the floor and lighter ones may be in racks or on shelves at greater heights. Though it seems to be convenient at times, it is NOT safe to hang rolls or coils of materials on the ends of rack dividers for other materials because they are easily knocked off when removing other materials. Cut ends of these materials should not be allowed to protrude far from the body of the coil where they may become hazards to the eyes or faces of bypassers.

5.1.4. Flexible Sheets. Flexible sheets include paper, chipboard, thin plastics, cloth, screen wire, thin metal foils, and other similar materials. Sometimes these are flexible enough to be rolled or folded, but some require flat storage. Those which must be kept flat are best stored horizontally on wide shelves or vertically between full size dividers which are spaced closely enough to prevent sagging and bending. For these materials, the storage safety considerations are the same as those for rigid sheets. For rolls, the considerations are very similar to those for spools and coils (5.1.3.). The rolls may be supported on horizontal racks which permit cutting off needed lengths or (sometimes) stood on end. The biggest safety hazard with these materials involves the weight of a full roll. When large rolls of heavy material must be transported, they can become unstable and fall or cause injury to those who try to control them. Therefore, storage near enough to the point of useage so that the stock roll does not need to be moved is desirable. Any racks for holding rolled stock should be designed so that they do not tip over. Racks should also be strong enough to support the weight of the rolls when they are all full. Racks should not become unstable if the rolls on the lower levels are consumed before the ones higher up. Generally, heavier materials should be stored nearest the bottom of the rack.

5.1.5. Small Solid Shapes. Small solid shapes include materials as different from each other as concrete blocks and wheels for Metric 500 Cars. Their storage depends upon their sizes, shapes, and weights. Small light items may be placed in drawers, boxes, kegs, or other containers. Larger items such as concrete blocks, bricks, wood shorts, foundry metal ingots, and packages of paper should be stacked neatly on the floor or on very sturdy shelves. The stacks should be arranged so that removal of items does not place the body in a strained position. If items need to be packaged or bundled in any way, the combined units should not be of excessive weight or size and should stack well. Heavy items should always be stored at low levels. Small pieces should be in containers which prevent them from scattering around on the floor as they are moved. Drawers should have stops which prevent them from being pulled completely out of their slides and dropped on the feet. Containers should have appropriate handles positioned so as to make them stable during transport. Containers should also be labeled to avoid excessive moving just to see what is inside. Containers must be sturdy enough to support the weight of their contents during transport.

5.1.6. Liquids. Many materials used in technology education laboratories come in liquid form. Solvents for printing, paints and their solvents, fuels, plastic resins,

lubricants, chemicals, adhesives, photographic developers and solutions, etchants, cleaning solutions, ceramic slips and glazes, and occasionally even consumable liquids may all be found in technology education labs. The most important safety considerations with regard to storage of liquids are labeling, containment, and flammability. Materials which are flammable or produce fumes which are flammable should be stored in approved safety cans or in metal cans inside metal safety cabinets designed for this purpose. They should never be left open, placed in glass containers, or stored where they may become ignited. Rags soaked in these materials must also be placed in safety disposal cans to prevent spontaneous combustion.

The original container should be used for storing liquids whenever possible unless specific instructions are given which contradict this. The best sources of further information on storage and use of these hazardous materials are the labels on the original containers and information sheets from manufacturers. Labeling is extremely important. If it is not practical to store liquids in their original containers, the replacement containers must be clearly marked and labeled. When possible, the entire label from the original container should be transfered to the new container so that instructions and precautionary statements from the manufacturer can be preserved. When it is necessary to maintain two forms of the same liquid--such as a stock bottle and separate working solution of photographic developer--both solutions need to be clearly marked and the directions for proper mixing should be on the containers. Make certain that the container which holds the stock and the one which has the working solution are both clearly identified accordingly. Containment means that the vessel or container is adequate to contain the solution inside. It is imperative that the liquid inside cannot eat its way through the container. The container should be large enough and strong enough that it does not burst from temperature changes or the weight of the contents. The lid should fit properly and should not leak. When venting is required, the venting system should be of the type recommended by the producer of the liquid contained. Containers which show damage, corrosion, rusting, leaks, or other potential flaws should be discarded. Containers should be of sizes commensurate with their intended uses and should not be large or heavy if they are to be transported frequently. Handles on containers must be adequate in strength and convenient for use. Liquids which are spilled must be cleaned up immediately and the area in which liquids are stored should be checked daily to detect leaks or fumes. Students must be cautioned about proper handling and storage of liquids, particularly those which are hazardous.

5.2. Hazardous Materials

In the daily activities of technology education. students are frequently exposed to hazardous materials. Any material can cause injury if it is improperly handled; however, there are many materials and situations that increase the severity of hazards. Typically, the materials or byproducts of laboratory work that are of most concern are solvents, chemicals, and airborn materials (dust, fumes, mists, gases, and vapors).

5.2.1. Solvents and Chemicals. Solvents refer to liquids commonly used to dissolve other materials. Solvents commonly used in technology education laboratories include: turpentine, gasoline, mineral spirits, acetone, lacquer thinner, printing and photographic solvents, alcohol, and others. Chemical compounds are common in plastics and

other synthetic materials, adhesives, paints and cleaning agents. There are several ways that toxic solvents and chemicals can enter the body. Liquids, gases, mists, dusts, fumes, and vapors can be inhaled. Several of these forms are often present simultaneously while working. Toxic chemicals and solvents can also be absorbed through direct contact with the skin. Some chemicals, such as paint remover, will burn or react to skin on contact. Toxic materials can also be ingested (most commonly by students eating before washing their hands), therefore it is not a good idea to allow students to eat in the laboratory.

5.2.2. Airborne Materials. There are six types of airborne materials that can cause injury.

1) Dust-- The danger to lungs and eyes of particulates depends on the composition of the patriculate material, particle size, concentration, and method of dispersion. Medical studies have shown that certain materials are associated with lung diseases. For example, respiratory diseases are associated with dust and mist from spray painting, sanding and grinding on surfaces painted red, orange or yellow, and dust from brake shoe lining. Other types of dust, such as wood dust, present a fire hazard and may cause allergic reactions for some people. The problem in dealing with these hazards is that the most harmful particles are those that are not visible to the naked eye.

2) Fumes-- Solid particles that make up fumes are very small and easily pass the upper respiratory system and enter the lungs. Fumes are created in instances when a material such as metal is condensed in cool air. Burning magnesium, welding or cutting galvanized metal, and arc welding are examples of processes that produce harmful fumes.

3) Mists-- Mists are liquid droplets suspended in air. Examples of mists commonly generated in technology education labs are oil mist from machining processes, electroplating, pickling operations and paint spray mist.

4) Gases-- Gases have fluid characteristics and often diffuse to occupy a space if proper ventilation is not provided. Welding operations commonly produce harmful fumes and, of course, internal combustion engine exhaust must be ventilated.

5) Vapors-- Vapors are produced when a liquid or solid turns into a gaseous state either by increased temperature or pressure. Solvents such as acetone will vaporize at a relatively low temperature.

6) Smoke-- Smoke results from incomplete combustion. Smoke contains particles that can be harmful when inhaled.

Solvents, chemicals, and airborn materials can have toxic effects on the human body. There are many hazardous materials that are known to cause injury. However, many materials that are now labeled as safe may prove to be hazardous in the future. Remember, asbestos was once thought to be a "safe" material. The best rule of thumb is to control exposure to all materials with proper ventilation systems and appropriate personal protective equipment. Avoid ingestion by washing hands

immediately after using toxic materials and always avoid skin contact since some chemicals and solvents can be absorbed through the skin. The best information source for toxicity is the warning label on the container. Teachers and students must be familiar with the warnings that are stated. Since the information on the label is very important, never transfer hazardous materials into an unmarked container.

5.2.3. Disposal of Hazardous Materials. The devastating effects of industrial waste on our biosphere has raised considerable concern among environmentalists. Air pollution, water pollution, soil contamination, acid rain and ozone depletion are all by-products of technology. Technology education laboratories are generators of hazardous waste. The Environmental Protection Agency (EPA) and state agencies have strict rules regarding the disposal of hazardous materials. Teachers have the responsibility to instruct students concerning the need and methods to control negative effects of improper waste disposal.

The EPA has identified four characteristics of hazardous waste:

Ignitable-- Capable of burning or causing fires.

Corrosive-- Capable of eating away materials and human tissue.

Reactive-- Capable of reacting with air or water, causing an explosion or release of poisonous fumes.

Toxic-- Capable of poisoning humans.

The most common forms of hazardous waste generated in technology education laboratories include:

1. Solvents
2. Paints containing heavy metals
3. Cleaning agents
4. Paint stripper
5. Stains
6. Wood preservatives
7. Acid solutions
8. Inks and dyes containing heavy metals
9. Photographic processing solutions--developers, hardeners, and fixer
10. Old batteries
11. Radiator coolant
12. Oil and oil products
13. Etchants
14. Resins

Waste minimization and managment should be a component of every technology education program. Following are some suggestions for managing hazardous wastes.

1. Screen all purchases of raw materials which may be potential disposal problems.

2. Label all purchases with the date received and hazard code.

3. Do not accept gifts you cannot use or which pose a difficult disposal problem.

4. Keep an inventory including names, amounts, dates, and hazard class.

5. Do not buy more than you can use in one season.

6. Take care when storing materials and wastes.

7. Keep a cover on volatile (easy to evaporate) solvents.

8. Keep absorbents and other materials handy to clean up spills.

9. Do not mix different wastes.

To properly dispose of these materials, store them in an approved container clearly labeled with the contents. Do not mix waste materials since different disposal processes are used for different materials. Every generator of hazardous material is required to obtain an EPA identification number and follow a well defined procedure for transport and disposal. To ease the burden of hazardous waste disposal, encourage your administration to establish a county-wide program for hazardous waste disposal. Remember, your laboratory is not the only generator of hazardous material in the school system. Check with your administrators. Perhaps a program is in place.

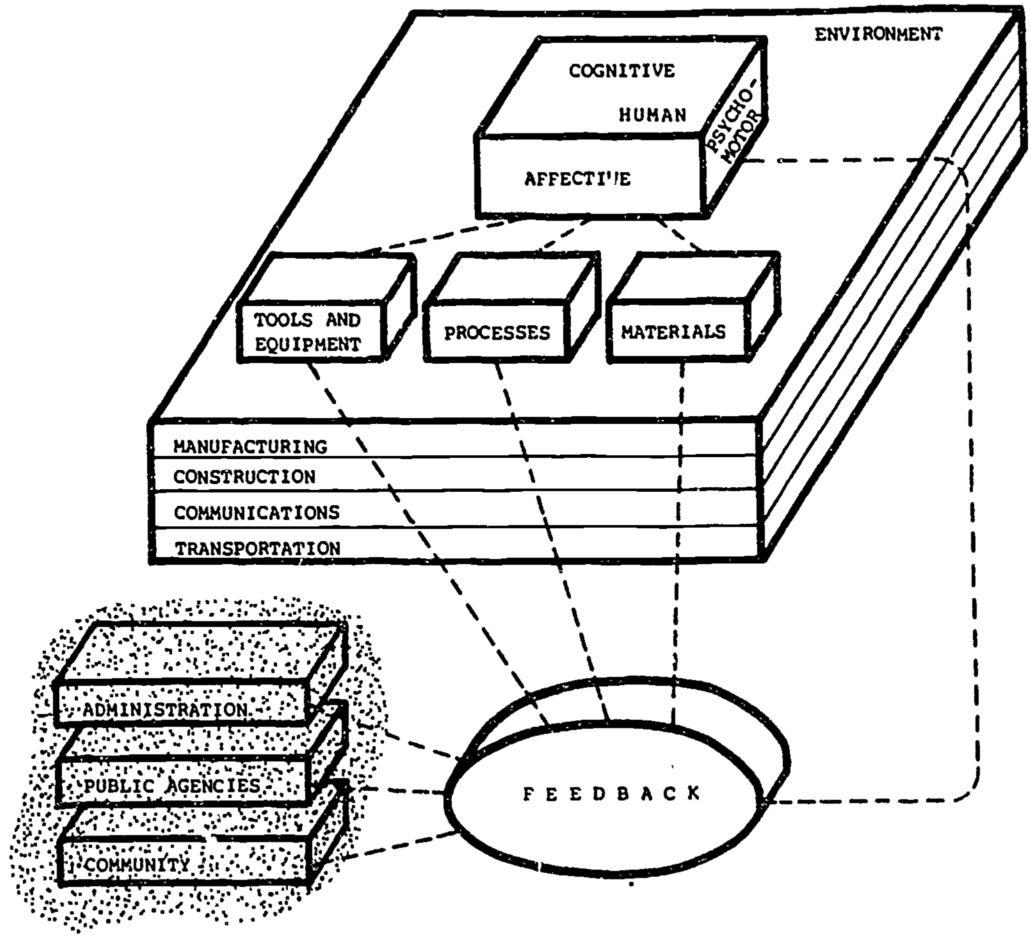
For more information on hazardous waste disposal, contact:

Hazardous Waste--

Technical Assistance Support Unit,
Haz. Waste Branch, Dept. of Human Resources,
Raleigh, NC.
(919) 733-2178

EPA Publications--

EPA Small Business Ombudsman
(800) 368-5888



6.0. Outside Influences

School administration, public agencies, and the community all play important roles in the safety system of a technology education program. These are classified here as "outside influences" because they are not under the direct control of the teacher and their actual impact on the program are frequently through indirect channels.

6.1. Public Agencies

Local, state and federal agencies all have some impact on public school facilities and programs--either indirect or direct. Sometimes these requirements vary from one local to another.

6.1.1. OSHA. In 1970 the Williams-Steiger Occupational Safety and Health Act (OSHA) was passed. It became Public Law 91-596 in 1971. It was enacted to:

> ..."assure so far as possible every working man and woman in the nation, safe and healthful working conditions and to preserve our human resources..."

OSHA standards are applied in four major categories: General industry, construction, maritime, and agriculture. States were mandated to establish their own implementation plans. At present, public schools and their employees in many states are required to comply with OSHA standards, but compliance inspections are not customarily done. The students in technology education laboratories are not employees, so they are actually not covered by OSHA regulations. However, since students and teachers (who are employees and are covered) use the same equipment and facilities, students benefit indirectly from OSHA standards. Voluntary inspections may even be requested by administrative units (i.e. the school board or a principal), but they are not mandated. Another way in which OSHA impacts schools, however, is that many other local agencies and insurance companies adopt OSHA recommendations and base their own poilicies and guidelines upon them. So, teachers should use OSHA standards as a baseline for development of their own safety procedures. Some areas in which schools can and should voluntarily attempt to comply with OSHA standards include:

Hand-tool, Machine, and Equipment Safety. The design and physical condition of every item included in a technology education laboratory must be good. Substandard items should be renovated or replaced by pieces known to be well designed and constructed.

Safety in Working with Hazardous Materials. Exposure to hazardous materials must be minimized and, if necessary, eliminated. Appropriate protective equipment should be available and its use enforced.

Training in Safety and Health Requirements. Teachers and students should be taught to recognize work hazards and potentially dangerous environmental conditions.

Fire Protection. All necessary fire protection devices and services, including fire extinguishers, sprinkler systems, and fire department assistance, should be available.

Physical Plant Design. The physical plant in which a technology education program is carried on must be planned so that it is free of safety and health hazards. Key design features of such a structure include adequate space, proper storage of materials, a good arrangement of rooms, and an effective organization of equipment.

Physical Plant Condition. The floors, walls, partitions, ceilings, windows, doors, and other parts of a laboratory must be kept in good repair.

Air Environment. Students and teachers must be able to work in air that is clean, fresh, safe, and comfortable. Effective heating, air conditioning, mechanical ventilation, and exhaust systems are necessary.

Visual Environment. Natural and artificial lighting systems must be properly designed and maintained so that people working in a laboratory can see clearly and comfortably.

Auditory Environment. Sound intensities must be reduced to a level at which hearing will not be damaged. It should be noted that hearing damage is a

factor determined by both the intensity of the sound and the duration of exposure. Since instructors cannot realistically limit lengths of exposure, it is most important that they seek preventative measures to reduce noise levels. These measures may include the use of noise absorbing materials and/or utilization of hearing protection devices that may reduce the risk of work-related hearing losses in the future.

Utility Service Systems. Electrical, water, gas, and compressed air systems must be planned and constructed so that hazards related to the use of these utilities are minimal.

Housekeeping. Laboratories must be kept clean and in good order at all times. Adequate storage of materials, especially waste products, is of major importance to laboratory safety.

Sanitary Facilities. Drinking fountains, wash facilities, and restrooms must be well designed, in good operating condition, and cleaned regularly.

First Aid and Emergency Procedures. Teachers, students, and civil service employees should be trained in basic first aid and emergency procedures.

Class Discipline. Failure to have students abide by safety rules and safe practices can promote an unsafe work environment. Teachers must require the needed classroom/laboratory discipline to ensure a safe technology education program for all students. (Pennsylvania Industrial Arts/Technology Education Safety Guide, 1988, pp15-17)

In practice, these areas should be attended to as normal parts of an ongoing safety program with or without oversight from outside agencies.

6.1.2. Other Public Agencies. State and local regulations provide other forms of support for safety programs in schools too. Fire inspections by local fire departments are common. Construction sites are inspected to ensure that work is done in the proper manner. Health inspections are also made in some areas of school buildings. These inspections may or may not include technology education laboratories--primarily depending upon local regulations and custom. Teachers who desire support for their safety programs from these and other agencies, but who are unsure about local practices, should contact their building administrators first and then, perhaps, the appropriate agency to answer their questions.

6.2. School Administration

It is actually the responsibility of the school administration to provide a safe environment and adequate instruction for students. Individual teachers do not act independently in their efforts to do this, but rather as agents of the school board and administration. However, since the technology education teacher is a specialist in the technical areas taught, and the principal generally is not, much of the weight of responsibility for maintaining safe laboratory instruction is transferred to the teacher. The administration's roles in this regard are mostly to provide or seek adequate funding for needed safety equipment, obtain inspection by specialists and

outside agencies as appropriate, monitor teachers and classes to insure that school policies and rules are observed and adequate discipline is maintained, and provide assistance to teachers in solving problems as appropriate. The principal, another administrator, or their agents may inspect a technology education laboratory at any time, but this seldom happens--most administrators depend heavily upon the judgements and care of the teachers who use technology education laboratories to insure that the labs are safe. The principal, however, is the chief administrator of a school building and the person most able to help teachers find resources and assistance in maintaining an effective safety program.

6.3. Community Support for Safety Programs

The level of support for schools varies from one local to another. This is true for all programs, including safety programs More urban and more affluent areas are more likely to require various types of inspections and formal procedures. Teachers in areas which do not require inspections and have fewer regulations with which to comply can still maximize the effectiveness of their safety programs via community support. The most readily available forms of communication with the community are through the students in the programs and their parents. Another means of reaching the community is through news media. Parents and community leaders are most likely to support programs which they perceive as timely and active--this support can be in many forms. An active TSA Chapter (formerly AIASA) which brings home honors and awards from state and national competition can bring this sort of recognition to a program. The greater the general quality and public visability of the program, the greater support the program can gain. Public service activities by the local TSA Chapter also help to give the program local visability. Still another way in which the community can support the safety system is by providing guest speakers and industrial field trips which include attention to safety and safety procedures in practice.

6.4. Professional Liability, Insurance, and Evidence

Even when effective efforts are made to maintain and promote safety, there are sometimes "freak" or unavoidable accidents. Sometimes student negligence is to blame or equipment fails at an unfortunate moment. The information and guidelines given in this section are intended to help the teacher understand professional liability and how to protect himself if the need arises.

6.4.1. What is Negligence? There is no way to predict specifically how negligence will be determined in a given lawsuit, but the following principles are applied fairly consistently. *In order to be found negligent in most situations the teacher must be found to:*

> *1. Have a duty of care.* This means that the teacher must have a duty to protect the student or look out for him in the given situation somewhat as a parent would do. For example, the teacher is responsible to see that an adequate guard is provided and properly installed on the table saw, that

general order is kept in the class, that hazardous obstructions are not present, and so on. These are part of what would be normally expected of a reasonable and prudent laboratory teacher.

2. *Breach that duty of care.* It must be proven that the teacher has failed to accomplish (adequately) a duty that he bears. If the teacher is responsible for providing a machine guard and instructing about its proper use, but he does not do one of these adequately, he could be found negligent. On the other hand, even if the teacher is responsible (bears a duty of care), a high school student who injures himself by removing the guard of his own free will may not have a claim against the teacher because the teacher did not breach his duty--the student acted improperly according to both specific instruction and normally reasonable actions.

3. *Cause the injury due to his breach of duty.* The last burden of proof for the claimant is that the injury results from the teacher's negligent breach of duty. Say, for example, a teacher fails to provide a guard on a saw. A student steps on a board with a nail in it and injures his foot while using the saw. The teacher does have a duty to provide a guard and has been grossly negligent by breaching this duty--but the injury could not possibly have been caused by this particular breach of duty, so the teacher would not be liable. In such a case, the claimant should probably have tried to prove that the teacher permitted poor housekeeping to be the norm in the lab; then there would be a more direct relationship between the duty, breach, and injury.

These are, however, only general principles. The exact application of them in a given court may vary and there are nuances of law which cannot be covered in this short section--but these principles are the general basis of most negligence decisions. States also differ in how they recognize and determine partial or participatory negligence. Generally, when partial negligence is applied, older and more highly educated children bear greater amounts of burden to act reasonably and protect themselves than do younger or less informed ones.

6.4.2. How Teachers Can Protect Themselves with Evidence. When any accident occurs, collect as much tangible evidence as possible immediately after the accident. Take photographs and statements from observers. Keep all evidence in a secure storage place. Record your own immediate thoughts and concerns in writing and keep them with the other evidence. Planning and safety inspection forms (from the Appendix) which have been completed by teachers and students may also serve as evidence in some cases--they certainly should help establish that the teacher encourages a safe environment.

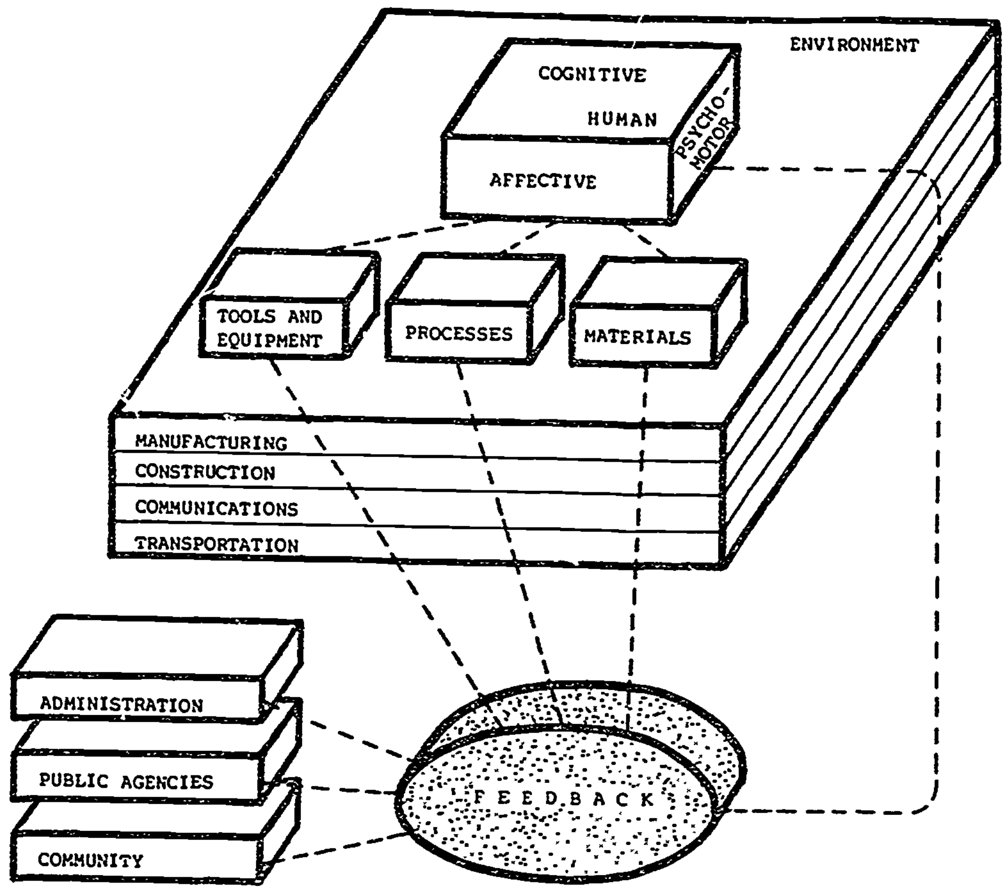
Sometimes, teachers are aware that equipment is old and becoming unsafe or that hazards and obstructions exist within their labs, but funding is not readily available to remedy the situation. A prudent teacher should inform his administration of these conditions and appropriate solutions in writing and keep a copy of all written messages in a secure storage place. Teachers must use professional judgement about how insistent they become and the way in which they approach these difficult situations, but written evidence that the teacher attempted to avoid an accident and was denied the necessary and appropriate support from the administration could shift the duty of care from the teacher to the administrator who failed to provide the support.

Still, teachers would be negligent if they permitted grossly defective equipment or hazards to remain in service regardless of actions by the administration. In such cases it would be safer to put the equipment out of service and drop topics which required it from the curriculum--perhaps this would draw increased attention to the importance of the situation. Teachers do, however, need to use careful professional judgement when determining which actions to use in a given situation. Power plays of false bravado, sniveling for the latest model of each new piece of equipment on the grounds that recently acquired ones are outdated, and threatening the administration with continuous requests for answers "in writing" reduces the effectiveness of the above tactics when they really are justified and lowers the professional image of the teacher markedly--it could even jeapordize one's career. The teacher is the "expert" in terms of the condition of the laboratory, his duty of care is increased by his level of expertise, and he deserves and should receive the support of the administration. Professionalism requires careful consideration when dealing with limited resources, but some very helpful and tangible evidence can be preserved by keeping written records of contacts with the administration and other sources.

6.4.3. Liability Insurance. Another important form of protection for teachers is liability or tort insurance. Various forms of insurance are available ranging from privately held personal policies to group policies. Many school districts have insurance covering employees--but check to be sure they protect you personally, they sometimes only protect the school. Group plans are available with membership (or as options for members) in various professional organizations. Technology teachers should make certain that their policies cover them in laboratories, that there is a high level of coverage, and that both legal fees and liability are covered.

6.5. Conclusion

There are outside agencies and forces which may come into effect in the safety system of a school technology education program. The programs are under direct or indirect influence of various regulations and agencies. School administrators and school boards also play an important supportive role in safety. Despite these factors, however, the individual teacher is the most important custodian of safety for a school technology education laboratory. Teachers should seek and utilize the forms of support which are available in their communities, and they should realize that these vary locally. Gaining visability for a program through maintaining high quality and high levels of activity is a good way to increase community support of all sorts--including support for the safety program. Self inspection forms and other aids are available for your use in the appendices of this manual. Teachers should collect various forms of evidence to support their claims and protect themselves in the event of a lawsuit.



7.0. Feedback

The Feedback subsystem is an activity based component which integrates content with student activities. The purpose of feedback is to control the hazard potential of technology education labs and to change the behavior of students so they act in a safe and responsible way. This control of the environment and behavioral change of the student can only occur if the instructional program includes safety education in every technology education activity. In this sense, safety is a "basic" that permeates every content cluster of technology at all levels.

Both students and teachers are responsible for maintaining a safe work environment. Teachers have the responsibility to design-out hazards, include safety instruction in the curriculum, manage the safety system, maintain records, and analyze records to update content. Students must have a firm knowlege of potential hazards and safe procedures; then apply this knowledge to insure the safety of everybody participating in the technology education program. Unfortunately, not all students learn what they are taught. Typically, the consequence of not learning subject matter is a failing grade; however, the consequence of not acting in a safe manner may be a disabling injury. Therefore, safety cannot be overemphasized. As stated at the beginning of this manual, safety is an attitude--an attitude developed from knowlege and experience. The activities that follow provide students with ongoing experiences which allow them to apply knowledge of safety to every aspect of laboratory work.

7.1. Student Activities

Students should be involved in designing and controlling the safety system for their class. There are seven basic activities described in this manual which involve the student in safety management. These activities are designed to be used in every content cluster of technology education and provisions are discussed to adjust the forms for grade level differences. Supplemental activities can also be included in this set of activities. Teachers can easily incorporate their standard safety activities into this system. In the optimal situation, class TSA officers would provide leadership for the various aspects of establishing and operating the safety system. The forms described below are found in Appendix A and Appendix B. Teachers should feel free to use these pages as masters for printing their own forms or as models which could be revised for specific situations.

7.1.1. Technology Education Safety Agreement. The ACT-1 form informs parents or guardians of the potential hazards of laboratory work and encourages them to discuss the importance of safety with their child.

Give students a copy of this form the first day of class. Discuss the hazards that they may encounter and their responsibilities to maintain a safe work environment. Instruct them to return the form the following day and have them pledge their agreement to observe all safety rules and procedures before they sign the form. Be sure that a signed copy of this form is on file for every student.

7.1.2. Environmental Study. Form ACT-2 requires students to analyze the laboratory or field site, identify potential hazards, and apply their knowlege of safety to minimize hazard potential.

An environmental study should be conducted by every student before they are free to work in the laboratory or at the field site. If there is a change in the work environment (rearranging machines for a mass production activity or moving to a new field site), then another environmental study should be done.

A suggested procedure for implementing this activity follows.

1. Tour the lab or field site and inform students of tools that are available for their use, safety equipment, and location of storage facilities. Specify the purpose of safety zones and the appropriate color code used to designate zones and equipment.

2. Provide instruction on standards for floor plan layout.

3. Help students lay out walls, doors, windows and stationary equipment. Depending on the grade level, teachers may wish to provide this information on the form.

4. Review the instruction on environmental factors which was presented during the tour of the lab or field site.

5. Supply students with colored pencils assign them to complete the layout using the proper standard for color coding to draw and label safety zones and

safety equipment.

7.1.3. Ergonomics Study and Job Safety. Form ACT-3 requires students to analyze machine or material handling processes to determine safe procedures.

This form should be used whenever a machine or operation is demonstrated. The heading of the form is used to record the specific operation for which the study applies. As the students complete this form, they will be recording the specific steps for performing the operation and analyzing the hazards involved with each step.

On this form, there are three columns which students should complete-- Sequence of Job Steps, Potential Hazards, and Recommended Actions.

1. Sequence of Job Steps-- Break the job down into steps which accomplish some minor task. Start first with the set of movements for preparation then determine the next logical set of movements for performing the task and terminating the task. Consider the physical demands of the task and record any concerns on the form. Depending on the student's grade level, teachers may wish to complete this column before giving the demonstration.

2. Potential Hazards-- Identify the hazards associated with each step. It is not enough to look at obvious hazards. Look at the entire environment and identify hazards such as scraps on the floor, muscle strain from lifting, or inhaling a solvent.

3. Recommended Actions-- Using the first two columns as a guide, identify the best possible actions to minimize the hazards. Possible actions may be: wear safety glasses, clear scraps, or good positioning of the body amoung others.

Teachers, use this form to prepare for your demonstations so you can instruct students of all variables that they may encounter when operating equipment. Relay the history of injury resulting when others performed similiar operations.

7.1.4. Hazardous Material Log. Form ACT-4 requires students to keep a record of hazardous materials, the hazards involved, precautions, and methods of disposal.

This form, like activity form ACT-#3, should be used whenever the use of hazardous materials is demonstrated. The four columns of this form should be completed as follows.

1. Hazardous Materials-- List the names of the materials which present the hazards. The proper names of the materials should be copied from the labels.

2. Hazards-- List the specific hazards of the materials as specified on the warning labels.

3. Precautions-- List the procedures or equipment that must be used to minimize the hazards. Ventilation, respirator, gloves, and face shield are examples of precautions.

4. Methods of Disposal-- Include the required procedures for hazardous material disposal in this column.

7.1.5. Safety Inspection. The ACT-5 form insures student compliance with safety practices and reinforces the content of safety throughout the duration of the class.

Safety inspections should be conducted on a weekly basis. The checklist is categorized into three groups that are consistent with the subsystems defined in this manual. There are several ways in which this activity can be implemented.

1. The class can be divided into four groups. One group should be designated as supervisors responsible for compiling the data and completing form ACT-6. The other three groups will then each be assigned to complete one of the categories on the inspection form.

2. The inspectors can be grouped according to their clean-up assignments. Safety supervisor's responsibilites will be assigned to the foreman or a class TSA officer.

Teachers should periodically conduct a safety inspection of their own and report findings to the class.

7.1.6. Safety Inspection Summary Sheet. Form ACT-6 provides a means to analyze the results of inspections to identify violation trends.

This form should be completed by the Safety Supervisor--a responsibility that should be rotated so every student has the opportunity to compile and analyze inspection data. Supervisors should work with the inspectors to tally the number of violations found in each category. The specific nature of the violation should be listed in the space provided. This form allows for multiple inspections to be recorded so violation trends and history can be summarized. Supervisors should analyze the information on the form and report findings to the class.

7.1.7. Design Worksheet. Form ACT-7 encourages students to consider safety when designing a new product, equipment set-up, or process. Technology educators strive to develop the student's problem-solving and creative abilities. When students develop a new procedure or design a new product, they should consider the hazards involved in using their idea. For example, a student may design speaker boxes for a car stereo system. If the design does not include a way to bolt the boxes to the car's structure, the speaker boxes will become projectiles that could seriously injure passengers in an accident.

7.1.8. Supplemental Activities. When designing the safety system for your laboratory, there are many activities that can supplement safety instruction. Following are a few ideas.

1. Take it Home-- Have students conduct an environmental study of their kitchen or a job safety analysis of mowing the lawn.

2. Children's Toys-- Use the Design Worksheet (form ACT-7) to analyze the product safety of toys. Discuss the differing safety requirements for various age groups.

3. Current events-- Have students research and present to the class current

safety issues (industrial accidents, automobile accidents, hazardous waste spills, fires, pollution, etc.). Have students report on the cause of the accident and how it could have been prevented.

4. Safety Posters-- Include safety system poster design in your curriculum. Enter your students' designs in the state's TSA competition.

5. Guest Speakers-- Invite emergency medical personnel or industrial safety engineers to speak in your class or to your TSA chapter.

7.2. Record Keeping

Compiling records of injuries and unsafe acts provides teachers with a body of information that can be used to improve the safety system. Records should be compiled and analyzed to determine the specific component of the system that is the source of the hazard. Then, action should be taken to eliminate that hazard. Records can also become valuable evidence to help teachers protect themselves in law suits. The following forms, intended for teacher use, are found in Appendix B. Again, teachers should feel free to copy them.

7.2.1. Accident Report Form. Form REC-1 should be completed whenever a student is injured, no matter how minor the injury. The information recorded on this form is useful for keeping a detailed description of accident types and causes. Some additional information concerning appropriate records and evidence to keep following an accident appears in Section 6.4.

7.2.2. Accident Report Summary. Form REC-2 provides teachers with a means to compile information from cumulative uses of form REC-1 so that they can easily analyze this data and incorporate this information in the curriculum. Near misses should also be recorded on this form.

The form has three categories under which the injury should be listed in chronological order.

1. Nature of the injury-- Describe the part of the body which was injured and the specific type of injury--cut, struck against, caught under, contact with electrical current, burns, or contact with toxic substance.

2. Source of Injury- Identify the component of the safety system which failed causing the injury-- Environmental, Human, Tools and Equipment, Processes, or Materials. In the adjacent column, identify the specific part of the component which caused the injury.

3. Hazardous Condition or Unsafe Act-- Describe the specific condition or act that caused the injury.

7.2 .3. Student Observation. Students should be observed periodically to insure that they are acting in a safe and responsible manner. The "Student Observation" sheet (form REC-3) should be completed, unannounced, to identify those students that are

not complying with the established safety standard. After the observation, teachers should discuss violations with respective students and a summary should be presented to the class. Also, use this information to improve instruction. If a trend of unsafe acts is observed, then teachers should critically review their teaching methods and alter instruction as necessary. Some teachers may choose to use these forms on a regular basis to record "daily grades" as described in Section 2.2.2.

SECTION II

EXAMPLE APPLICATIONS

8.0. Applications in Communication

The following two examples are from the Communications Systems Course (8125). They come from Module 5 (Designing & Producing Graphic Messages) and Module 6 (Designing & Producing Electronic Messages). In each case, the introduction to the modules, including objectives and activity calender, has been reproduced as it was adopted by the North Carolina State Department of Education in the original Course Guide. The text in *italic type* has been added to indicate examples of when and how to intersperse safety information and utilization of the Systems Approach to Safety along with its special features and forms.

8.1. Producing Safety Placards for Equipment in all Labs as a Class Project (First Example)

MODULE: 5 : Designing & Producing Graphic Messages

LENGTH: 18 DAYS Communication Cluster

To this point, students have participated in a variety of presentations and laboratory activities designed to introduce the area of communication technology. The next two modules expand upon this background information. Module 5 involves the design and production of several types of graphic media.

Since the days when cave dwellers first drew pictures on the walls of their caves, the creation of graphic images has been among the most important of all human communication systems. Technical drawings, paintings, photographs, rough sketches, road signs, billboards, and technical illustrations are all forms of graphic communications. This media involves exchanges of information or ideas by only visual means. *Safety information could include safe handling of sharp pointed drawing instruments, chemicals, and the effectiveness of visual communication media in relating safety precautions with particular attention to the contemporary use of icons and universally understood graphic symbols.*

There are numerous ways to produce graphic images, and the module begins with a brief explanation/demonstration of various media. The focus of this presentation should include not only printing procedures, but also the production of sketches and drawings and the visual design process. Design for graphic displays is vital to successful communication of technical information. *Students could design safety-related graphics products such as warning labels for mass production products or safety posters as projects during this study.* Building upon the students' creativity and design skills, the module then allows for the use of printing presses, photographic equipment, and related materials to develop several graphic products. *During this phase many opportunities are provided for teaching safe practices and techniques. Operation of presses and handling of darkroom chemicals are potentially very hazardous if adequate safety instruction is not given immediately before those processes are to be attempted.*

The activities in this module are fairly simple, yet hopefully illustrate the basic techniques and processes in graphic communication. The instructor may wish to use

alternative activities based on class size, facilities, equipment available, budget, or other considerations *(i.e. psychomotor and affective maturity of students from a safety standpoint!)*. Still, introductory lessons should cover the entire range of graphic concepts, then during laboratory activities the instructor should stress "why" we use certain techniques for specific situations. *These reasons "why" include safety considerations too--for example, we use machine gravure processes very rarely in technology education laboratories, partially because the inks and solvents required are extremely hazardous.* Related topics which may be covered during this module include:

1. Differences in impact vs. non-impact methods.

2. Types of print mediums (paper, cardstock, etc.).

3. Examples of commercially available graphic products and services.

4. Variety of local graphic/printing businesses.

5. Other. *(Unique safety hazards of each process and material studied and the types of safety precautions used in the real world of industry.)*

The special equipment for this unit are listed in the Appendix and most supplies should be available at local outlets. However, the instructor may need to order several items from national distributors (well in advance of the scheduled work) and should be advised of this fact.

OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Explore methods of graphic reproduction in our modern society.

2. Discover the types of businesses that produce graphic products and services.

3. Practice creating and converting graphic images by various techniques.

4. Use a variety of production equipment and supplies related to the graphic communication industry.

CALENDAR

DAY	ACTIVITY
1	Introduce concepts of graphic communication (design, media, reproduction practices, etc.). *(discuss safety with processes and the importance of graphics in transmitting safety information to the public)*
2-3	Develop a technical sketch of the floor plan of the classroom/department. *(use Form ACT-2 for this environmental study and stress the safety related factors found in the lab)*

4-5	Create a map of the local community. *(since this may require moving furniture to provide large drawing surfaces, discuss the importance of safety ergonomics and safety isles, and use Form ACT-3)*
6	Design a greeting card. *(stress safety with drawing instruments and designing for safe production)*
7-8	Produce greeting card. *(stress safety in operating the printing equipment used and in handling the inks and solvents needed)*
9	Production of cards; assemble cards in a booklet. *(safety precautions for the bindry equipment used)*
	(The whole greeting card project could alternately be replaced by a safety related product which allowed study of the same or similar technical practices--a possible suggestion is design and production of Safety Placards for equipment in all laboratories of the school or district. Examples could be "Eye Protection Required" with a graphic design or "Ask Permission Before Operating", etc. The placards could be bound and packaged for delivery to other labs to make a "complete" graphics product. Even mass printing of forms used in other aspects of the safety system could become student projects if desired.
10-11	Design a T-shirt or poster (to be screen printed). *(safety posters are a good choice here--enter in TSA competition)*
12-13	Produce T-shirt or poster. *(stress safety during printing process, ergonomics and environmental factors related to safe temporary storage of posters or shirts while they dry without obstructing safety isles, etc.)*
14	Storyboard the "frames" of a slide show which describes your school. *(or one which displays your excellent safety system in action)*
15	Complete the storyboard of the school.
16-17	Photograph scenes to match the storyboard design; have film developed at a local commercial establishment. *(discuss the imporance of the photographer keeping out of the way of the subjects involved in action shots and other temporary environmental safety impacts caused by the process of photographing events, and if developing is done at the school, include safety with darkroom processes and chemicals)*
18	Assemble slide show. *(safety concerning use of the projector and its hot bulb should be included here as well as safety in arranging a theater-style seating arrangement for viewing the show--use Form ACT-2)*

(END OF FIRST EXAMPLE)

8.2. Safety Considerations in Soldering (Second Example)

MODULE: 6 : Designing & Producing Electronic Messages

LENGTH: 18 DAYS Communication Cluster

Today's complex telecommunication systems are possible because of electronic marvels like the transistor, computer chips, and integrated circuitry. Broadcasting, hard-wired, and data processing networks help us exchange information quickly and easily across the street or around the globe. All electronic communication systems have one thing in common--electrical energy is used to transmit messages over varying distances in the form of electromagnetic signals. *This is a good place to discuss safety with electric currents and electromagnetic fields. Information on transmitted waves, such as microwaves, could also be taught now.* The ability to send information over great distances has become especially useful for business and recreational purposes.

Module six explores the interesting area of electronic communication systems. Students will have the opportunity to both design and send electronic messages or commands in various forms. *Safe methods of connecting electronic components, including soldering, will be taught in this phase.* Most electronic devices are very familiar to students; the average household in the U.S. contains many radios, telephones, at least one television set, probably a variety of remote control devices, VCR's, and electronic games. This unit describes how basic electronic equipment is used to aid the communication process.

Course activities are designed to (a) introduce the process of creating electronic messages and signals for transmission purposes, (b) describe how messages are designed/generated for electronic media, (c) cover how electronic information is transferred between remote points, and (d) the way standard hardware (like a computer or telephone switching system) manipulates data/information. Material in this course is only covered at the introductory level; more indepth coverage can be found in the specialization course on electronic communication systems.

Typically, we think all electronic communication systems involve the transmission of only radio signals (AM/FM waves, ham radio, microwaves, etc.). Using beams of visual light represents another form of electronic communication *(include safety with lenses and lasers here).* From signal fires in early times to fiber optics and lasers today, light waves are now just as important in sending electronic messages as other more traditional channels. This course would not be complete without an exploration of light-based media (especially the emerging national fiber optic network).

It is vital that each topic in this module be covered sufficiently in the suggested time-frame. The availability of key equipment or facilities should not be a factor in presenting the specified content. At the very worst, various films or video tapes may be necessary for one or two topics during the term. A guest speaker (from the local telephone company, TV or radio station, etc.) may also help in covering certain areas or systems.

OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Learn about the many and varied types of electronic devices and systems found in modern communication technology.

2. Understand the purpose and function of electronic communication devices which extend a person's ability to communicate with others.

3. Design messages that nay be transmitted via electronic media.

4. Study the means of generating and receiving electronic signals.

5. Recognize the impacts of the electronic media in daily affairs.

CALENDAR

DAY	ACTIVITY
1	Introduce electronic communication technology. *(safety with electric currents and power sources)*
2-3	Develop a bulletin/display board of various electronic communication systems. *(could include information on safe use of these in the home)*
4-7	Build a simple AM radio set. *(safe practices in soldering and the importance of good connections from a safety standpoint, complete ergonomic forms ACT-3 for safe operation of the power supply and other equipment as appropriate)*
8-9	Convert the radio to a PA system. *(stress safety aspects of circuit design during this change)*
10-13	Using computer software; write a short report or letter using word processing software; create a chart with graphics programs, etc. *(a possible assignment could be for students to design a safety form, report, or other safety-related item during this activity)*
14-16	Create an audio recording of the school's cheerleaders or marching band; reproduce several tapes for marketing the product. *(discuss the importance of safety in setting up for on-site recording where cables and microphones must be positioned to produce high quality recordings but must leave clear isles for spe ators and performers, etc.; use the environmental study form ACT-2 here)*
17-18	Duplication of tapes; design and reproduce the packaging graphics. *(no package is adequate without safety precautions for use of the product--even if this were as simple as "keep away from small children")*

(END OF SECOND EXAMPLE)

9.0. Applications in Manufacturing

The following two examples are from the Introduction to Manufacturing Course (8115). They come from Module 4 (Parts and Product Completion Process) and Module 7 (Producing Products). Like Section 8.0, the modules are reproduced as they were prepared by the North Carolina Department of Public Instruction in the adopted course guides for Industrial Arts/Technology Education. The text in *italic type* has been added to indicate examples of when and how to incorporate the Safety System Approach in this curriculum.

9.1 Equipment Safety and Hazardous Materials (First Example)

MODULE: 4: Parts and Product Completion Processes

LENGTH: 9 DAYS Manufacturing CLUSTER

Module #3 focused on the secondary processes used to manufacture parts (casting, molding, forming, and assembly). This module will focus on the secondary processes used to complete parts and products (conditioning, assembly, and finishing).

Conditioning processes change the mechanical or physical properties of a material. These changes are caused by a change of the internal structure of a material. *(Materials are often conditioned using processes that require extreme temperature, pressure or chemical reaction. Discuss the hazards involved in conditioning material)*

There are three main reasons why a manufacturing industry would change material characteristics. They are to improve machining and forming capabilities, remove internal stress, and impart desired properties of a part. *(By changing the properties of materials, parts become stronger, more reliable, and thus safer by reducing the chance of machine failure)*

Assembly processes are used to semi or permanently join (assemble) two or more materials or parts together. This module introduces assembly processes and identifies four basic techniques to assemble materials.

1. mixing
2. weaving
3. magnetic fields
4. joining

Discussion should focus on each of the techniques and the three joining methods:

1. adhesion

2. cohesion

3. mechanical

Finishing is a surface treatment which protects and/or decorates a material. Our environment has put great demands on improving and perfecting finishes. Acid rain, temperature change, moisture content, and insects tend to shorten the life expectancy of many of our materials. *(Differentiate between natural and technological conditions that deteriorate materials and finishes. What causes acid rain? Is it a safety hazard? Is the development of new finishes the best solution to this problem?)*

We also live in a world of fads and bright colors. The consumer demands not only beauty of the finish in a product, but quality of the application. Finishing involves three basic steps. First, picking the correct type of finishing material; second, preparing the part to accept the finish; finally, applying the finish.

Converted finishes and surface coatings are the two major classes of finishes. Converted finishes change the molecular structure of the surface to make a protective layer. Examples would be anodizing, oxidizing, and phosphating. Surface coatings, when applied, form a protective layer on the part. Examples of these are organic coatings (paints or lacquers) and inorganic coatings (galvanizing). *(These operations involve the use hazardous material that must be properly handled and the waste properly disposed. Discuss the environmental effects of "dumping" hazardous waste and the role of the EPA for controlling the disposal of industrial hazardous wastes)*

Industry has two basic methods of preparing the parts for finish. Mechanical cleaning requires abrasive, wire brushes, or metal shots to remove dirt and roughness. Chemical cleaning uses liquids or vapors to remove dirt and grease. *(Discuss the safe operation of tools used to clean material. Stress the proper handling of solvents and chemicals and methods to prevent the inhalation of airborne materials. Stress eye safety when performing operations with abrasives.)*

Brushing, rolling, spraying, and dipping are all methods of applying finishes to parts. To choose the right method involves evaluating the physical area *(conduct an environmental and ergonomic study using forms ACT-2 and ACT-3)* and the type of finishing material.

Include many of these techniques in the laboratory activities. Remember concepts learned in the classroom should be applied to the student's products.

OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Define and describe the secondary processes of conditioning, assembling, and finishing.

2. List and describe the basic principles of conditioning, assembling, and finishing processes.

3. Identify selected consumer and industrial goods and products that are manufactured using conditioning, assembling, and finishing processes. *(Identify hazards involved when conditioning, assembling, and finishing)*

4. Produce products using selected conditioning, assembling, and finishing processes.

5. Transfer knowledge gained from other classes or learning situations and apply that knowledge to the activities.

6. Gain skills when using tools and/or machinery related to the activities.

7. Exhibit good work habits, respect for, and cooperation with associates.

8. Identify career paths for a selected career field in materials and processes technology.

CALENDAR

DAY	ACTIVITY
1	Review secondary processes, introduce conditioning processes, and their applicable principles. Demonstrate conditioning processes to reinforce the applicable principles. *(Use form ACT-3 during your demonstrations and form ACT-4 to log hazardous materials)*
2-3	Continue demonstrations of conditioning processes. Students should review laboratory procedures, gather necessary materials and equipment, and perform laboratory activities which reinforce the principles of conditioning processes. *(Observe student performance and compliance with safety rules. Use form REC-3 to record observation data.)*
4	Continue the discussion of secondary processes. Discuss assembly processes and their applicable principles. Demonstrate assembly processes to reinforce the applicable principles. *(Discuss the use of robots and other automated equipment to assemble products and emphasize the safety hazards associated with automated equipment).*
5-6	Continue demonstrations of assembly processes. Students should review laboratory procedures, gather necessary materials and equipment, and perform laboratory activities which reinforce the principles of assembly processes. *(Use form ACT-3 during your demonstrations and form REC-3 to monitor students safe work habits).*
7	Continue the discussion of secondary processes. Discuss finishing processes and their applicable principles. Demonstrate finishing processes to reinforce the applicable principles. *(Establish a*

hazardous waste management plan and instruct students of the proper procedure for hazardous waste disposal).

8 Students should review laboratory procedures, gather necessary materials and equipment *(emphasize the use of safety equipment)*, and perform laboratory activities which reinforce the principles of finishing processes.

9 Review and discuss the concepts and processes utilized and discussed during this module. *(Conduct safety inspections and report results of inspections to the class)*

(END OF FIRST EXAMPLE)

9.2 Safety System Design in Manufacturing (Second Example)

MODULE: 7: Producing Products

LENGTH: 17 DAYS Manufacturing CLUSTER

This module is a combination of the two activity areas of production and industrial relations. Production activities include selecting a manufacturing system, designing and engineering a production facility, *(engineering a safety system)*, purchasing material resources, and establishing various control systems. Industrial relations is in charge of labor relations.

Choosing the correct type of manufacturing system is important to the efficiency of a company. The type of system is determined by the quantities and types of parts. There are three types of manufacturing systems.

1. Custom Manufacturing--few products produced according to customer's specifications.

2. Intermittent Manufacturing--several types of products or parts are produced at different periods of time.

3. Continuous Manufacturing--produces products in a steady flow.

Careful planning is needed in designing manufacturing facilities. There are five important tasks.

1. Operation Selection--Logically arranging the processes to efficiently produce products. Manufacturing engineers use three types of forms and methods: *(Safety engineering is an essential component of manufacturing system design. Include safety concerns when developing operation sheets and process flow charts.)*

    a. operation sheets

    b. flow process charts

    c. operation process charts

2. Design Tooling--devices which hold or guide parts during machining to increase speed, accuracy, and safety during production. *(Include safeguarding methods discussed in Sections 3.3. and 3.4. Have students analyze hazards when they design machine tooling)*

3. Plant Layout--planning for the location of machines, aisles, and utilities for production in the plant. Material flow is also planned at this time. *(Consider the environmental factors discussed in Section 1.0. and use form ACT-2 to synthesize safety content in plant layout design)*

4. Designing Material-Handling Systems (fixed or variable path)--Devices or

systems which move materials, parts, or products from one location to the next. *(Consider the safety aspects of the paths of material travel and safeguarding of material-handling devices and systems)*

5. Efficiency Studies--engineers are consistently reviewing and evaluating (time study) production systems to improve efficiency.

6. Include safety engineering as an industrial engineering function.

Student activities are set up to allow the students to develop their own production system. Students are to develop operations sheets, design the tooling, and plan a plant layout *(Also conduct safety inspections).* Special projects for some students could be designing and building a material handling device (conveyor, etc.) or perform a time study on a particular operation.

During production, quality control stations should be set up to limit waste, maintain tolerances, and maintain product value. Quality control gauges and tooling should be made.

A work force must be developed for the production activities. Industrial relations must first determine employment needs. Each job in the production line needs to be titled, described, and listed for potential applicants to view. Job applications should be designed, printed, passed out, and returned. Applicants should be matched with jobs and recruited. Each employee will find it necessary to move students to other areas. In small classes, students might have two or more jobs. *(Be sure to include safety personnel)*

Before pilot run and production start, stress safety procedures to the class. It is a good idea to have students in industrial relations develop a safety program. *(Safety engineering should be an independent component of the manufacturing system)*

OBJECTIVES

Upon completing this learning module, each student should be able to:

1. List and describe the characteristics of the three commonly used manufacturing systems.

2. Describe the steps used in employing production workers.

3. Describe typical purchasing procedures.

4. Describe the procedures used in selecting and sequencing operations.

5. Discuss and develop a quality control system.

6. Develop a simple manufacturing system including the selection and sequencing of operations, designing a plant layout, and material-handling system, designing tooling and quality control system.

7. List and discuss the steps in producing a product.

8. Discuss the steps in production planning.

9. Differentiate between a pilot run and a production run.

10. Develop a safety program.

11. Describe the procedure used for organizing a union.

12. Describe the procedure for settling grievances.

CALENDAR

DAY	ACTIVITY
1-2	Discuss custom, intermittent, and continuous manufacturing production systems. *(Discuss the differing requirements and methods of safety system design for each of these.)*
3	Discuss operation selection, tooling design, plant layout, material handling systems and studies, and time studies. *(Discuss each component of a safety system and safety system design)*
4-7	Discuss and develop flow process charts, operation process charts, jigs and fixtures, plant layouts, and material handling systems for the identified product. *(Include safety as an integral part of the development process. Use forms ACT-2, ACT-3, ACT-4, and ACT-7 when designing the manufacturing system)*
8	Discuss obtaining human and material resources. *(Establish a division of labor for safety personnel).*
9-11	Discuss and develop methods of controlling the resources used in the production and the quality of the identified products. *(Develop methods for managing risk--including periodic safety inspections and observation of safe work habits).*
12	Review the development of the manufacturing system. *(Include reports of the Safety Supervisor)*
13	Conduct pilot run of the manufacturing system. *(Conduct a safety inspection during pilot run).*
14-16	Review and discuss the safety program and procedures. Conduct and supervise the production line activity.
17	Complete production, run a tear-down tooling, and clean laboratory.

(END SECOND EXAMPLE)

10.0. Applications in Transportation

The following example is from the Transportation System (8126) course. Like Section 9.0, The module is reproduced as adopted by the North Carolina Department of Public Instruction. The text in *italic type* has been added to indicate examples of how to incorporate the Safety System Approach in this curriculum.

10.1. Safety and Land Vehicles

MODULE: 3: Land Transportation Systems

LENGTH: 4 DAYS Transportation CLUSTER

Transportation systems are designed to operate in specific environments. Different systems are designed to move people and cargo on land and water and in air and space. The systems most familiar to people are land transportation systems. These are used or operated by almost every citizen. *(This module provides teachers with an excellent opportunity to expand safety education beyond the classroom and teach about the hazardous aspects of technologies we use daily. Contemporary safety issues can easily be incorporated in this module by using current events as a content focuser. Commonly, automobile accidents, holiday accident statistics, and pollution indexes are reported in the daily news. Control systems including belt restraints, pollution controls, roadway improvements, and government regulations are debated in news programs. Include these issues in your curriculum and discuss the problems and the solutions).*

The common land transportation systems are:

1. Highway transportation systems
2. Rail transportation systems
3. Pipelines

Highway systems move people and cargo using cars and trucks that usually travel on fixed roadways. Rail systems use vehicles that travel on both monorail and two-track railways. Pipelines move liquids and slurries from mines and wells to manufacturing and processing plants and on to the final customers. Most homes are connected to pipelines that deliver water and natural gas, and remove waste.

This learning module will allow the students to study the three major land transportation systems and the vehicles they use. Laboratory activities will permit the students to have experience in designing vehicles for the highway and/or railroad systems and may include experiences in pipelines. *(When designing vehicles, consider safety as an integral part of vehicle design. Use Form ACT-7, Design Worksheet, to reinforce safety in vehicle design).*

Objectives

1. List and describe the three major types of land transportation systems.

2. Describe the vehicles used to transport people and cargo on rail and highway transportation systems.

3. Describe the facilities used for land transportation systems.

4. Differentiate between people and cargo-moving vehicles.

5. Discuss the impacts of land transportation systems on people and the society.

CALENDAR

DAY	ACTIVITY
1	Introduce the students to land transportation. Show a film on land transportation. *(Conduct a risk comparison of automobile, bus, and rail transportation systems.)*
2	Discuss highway transportation including routes and facilities. *(Also discuss ecological effects of various transportation systems. Discuss alternative transportation systems.)* Present land transportation laboratory activity. *(Include safety related activities such as the design of alternative systems, electric vehicles, or egg crash-test vehicles.)*
3-5	Demonstrate tools and machines to be used with the activity. *(Discuss safety in auto manufacturing, especially the use of automated equipment and robotics.)* Supervise students as they work on the land transportation assignment.
6-7	Discuss rail and pipeline transportation assignment and land transportation routing/cost assignment. *(Conduct a routing safety assessment.)*
8-10	Supervise students as they work on their land transportation assignment.
11	Have the students present the models of the transportation systems emphasizing the vehicle, pathway, and cargo/passenger compartment *(and vehicle safety system design).*

(END OF EXAMPLE)

11.0. Applications in Construction

The following example is from the Construction Systems Course (8116) as adopted in the North Carolina Curriculum. This particular unit deals with installation of mechanical systems and accesories. The safety information appears in *italic type* throughout this example.

11.1. Mechanical Systems and Accessories

MODULE: 7 : Installing Mechanical Systems

LENGTH: 9 DAYS Construction Cluster

The mechanical systems provide movement, warmth, light, information, and fresh air. With these systems, people are able to live and work in the structure. Mechanical systems include transportation, climate control, plumbing, electrical power, and communication systems. *Use of the Environmental Study (form ACT-2) and the Ergonomics Study (ACT-3) is appropriate here.*

Much of the mechanical system is placed in floors, walls, and ceilings. This part of the work is called "roughing-in". The bulky and rigid parts are roughed-in first. The most flexible last. The transportation system goes in first; and then in order, the climate control, plumbing, and finally, electrical power and communication systems. *Form ACT-7, Design Worksheet, may be useful for some of these installations. Students should be taught the safety and health functions of the systems studied with consideration to both completed systems and systems in production.*

Transportation systems use equipment to move people and supplies throughout structures. This activity is designed to provide students with a problem to solve. The solution requires considering each of the transportation modes. More than one satisfactory solution is possible. *Students must be made aware of the hidden hazards often involved with temporary or in-process transportation systems such as freight elevators, derricks, fork lifts and trucks, as well as permanent (finished) systems.*

Climate control is used to maintain air quality. This includes:

1. Heating and cooling - temperature
2. Humidifying and dehumidifying - moisture
3. Filtering - purity.

The major thrust of this activity is to provide students with an opportunity to make decisions regarding a range of climate control methods and equipment. Secondly, to give students the opportunity to work with tools and materials used in climate control distribution systems. The structure used for roughing-in the utility systems may be the one built in Module 6. *Again, both temporary ventilation and permanent air quality systems must be considered in terms of safety--Forms ACT-2 and ACT-3 (Environmental and Ergonomics Studies) could be very helpful in making these points*

"come to life" for students.

Piping systems move liquids and gases. Pipelines run between structures whereas plumbing systems are inside the structures. Plumbers and pipefitters run lines to the structure, rough-in piping, and install fixtures. The plumbing systems that are studied in this module are found inside the structure. *Safety when using torches and chemicals are naturally important aspects of the normal instruction in this unit.*

Activities are designed to give students experience with a variety of materials and processes used to rough-in plastic, copper, and steel plumbing systems. *Safety considerations required in selecting the appropriate type of system for a given application should be stressed.*

The electrical power system supplies the electrical energy needed to run the mechanical equipment, appliances, and machines used by the people who live and work in buildings.

The suggested activities provide students with experience in using a variety of materials and methods to install a service entrance and branch circuit. *Safety in handling meters, use of insulated tools, and following the "one-hand-rule" should naturally be stressed here. Safety considerations in the design and layout of circuits, following approved construction techniques, and careful inspection of work are also natural parts of this instructional unit. Forms ACT-3 (Ergonomics Study) or ACT-7 (Design Worksheet) may be used here.*

Efficient structures have efficient communication systems. Communication systems move or process information. Signs, bells, intercoms, telephones, television, and computers are common communication equipment. *This section also requires much attention to safety practices with electricity and electronics.*

In this module, many opportunities are available to direct students in safe practices and the importance of safety equipment and apparel. *Note here, that safety information was listed as an integral aspect of the original course guide.*

OBJECTIVES

Upon completion of this learning module, each student should be able to:

1. List and describe ways to move people and freight throughout a structure. *Safely!*
2. Design a transportation system for a structure.
3. Describe how heated, cooled, or cleaned air is distributed throughout a structure.
4. Install some ductwork.
5. Describe how controls monitor climate conditions.
6. Describe methods used to clean air.

7. Select climate control equipment for a specific project.

8. List and describe the kinds of plumbing systems.

9. Describe the parts and purposes of various plumbing systems.

10. List and describe the kinds of piping materials and how they are installed.

11. Rough-in piping systems that consist of a variety of materials.

12. List and describe the components of the electrical power system inside the structure.

13. Describe the procedure used to rough-in an electrical system.

14. Use a variety of methods and materials to install an electrical power system.

15. Differentiate between monitoring and interchange communication systems.

16. Install a doorbell system in a structure.

CALENDAR

DAY	ACTIVITY
1	Design and make a model of a vertical transportation plan. *Consider safety of the system and its installation.*
2	Select climate control devices for a structure. *Discuss importance of good ventilation in structures and in the technology education laboratory. Use form ACT-2.*
3	Fabricate and install some ductwork in a structure. *Be aware of safety considerations with sharp sheet metal edges.*
4	Participate in discussion of topics *including safety.*
5	Layout, cut, and solder 1/2" copper hot water lines.
	Layout, cut, and cement 1/2" CPVC cold water line.
6	Layout, cut and cement 1 1/2" PVC DWV pipe.
7	Assemble 1/2" threaded steel pipeline for water or gas. *In this study of plumbing, include information about the safety considerations involved in selecting types of piping as well as safe construction practices.*

8 Participate in discussion

Install service panel.

Install service entrance.

Rough-in octagonal box for light fixture.

Rough-in switch box.

Rough-in convenience outlet.

Report to the instructor when finished.
In this study of electrical work, stress safety practices when working on circuits, using meters, and installing components. Discuss safety considerations and electrical codes concerning selection of materials and components.

9 Attend to presentation on communication system and the demonstration.

Locate, mount, and wire push-button, transformer and mounting for the doorbell. *Discuss the safety advantages of using the low voltage transformer system and safety considerations for installation. Check all electrical and plumbing work done by students carefully for safe installation practices and have students inspect their own work with the appropriate forms.*

(END OF EXAMPLE)

12.0. Applications in Research and Development

The following example is from the Technology Research and Development Course (8195). This unit involves Module 3 (Conducting and Interpreting Industrial Research). As in earlier examples, the text is reproduced from the North Carolina Curriculum Guide (as adopted) and suggestions for integrating safety information and activities appear in *italic type*.

12.1. Selecting Materials on the Basis of Impirical Tests

MODULE: 3 : Conducting and Interpreting Industrial Research

LENGTH: 10 DAYS Field Integration Cluster

Having just designed the research project, the student (teams) should already know how the problem will be attacked and have an idea as to how the findings might be interpreted, depending on their outcome.

The significance of this module lies in the learnings which result from the student attempting meticulously to follow the plan, implementing controls, exercising care and precision in observing and recording results, and then studying the findings for clues leading to conclusions. *Students should also be aware that the "precise" way to test materials is also the safe way--many of the precautions needed to insure safety also result in greater care and accuracy of testing.*

It is important that the class understand the "team" concept of research, and that each student be involved as a team member. The teacher should look for opportunities for students to become role-players on a team. *Sometimes use of various safety officers may help to involve more students actively.*

Utilizing the "panel" approach to reporting findings (Days 8-10) requires every student to report on some aspect of the study. This also creates a chance for class interaction with a given student, but under control of the teacher. *Designated safety officers should report infractions and new procedures during these sessions. The teacher could also use these students to deliver safety messages to their peers.*

Throughout this 10-day module, the instructor must continually monitor each student's progress in identifying and developing information about his individual research efforts for Module 5. If this is not done, the instructional scheme for the last 12 weeks will be hindered.

OBJECTIVES

Upon completing this learning module, each student should be able to:

1. Explain the essence of the team's problem and discuss the variables,

treatment, and controls involved.

2. Explain the steps taken in attacking the problem undertaken by the team and the need or purpose of each step.

3. Follow a system of observing and recording data.

4. Explain relationships between conditions set forth in the design and the findings in determining interpretations of data.

CALENDAR

DAY	ACTIVITY
1-4	Advise and assist teams as they gather resources and make preparations for experiments. Also, aid them in their choice for the Module 5 activity. *Teachers should make their most concentrated effort to demonstrate the safety aspects of selected tests at this time. Help students become aware of potential hazards and ways to avoid them. The following forms are appropriate for use here as desired: Environmental Study (ACT-2), Ergonomics Study (ACT-3), Hazardous Material Log (ACT-4), and Machine or Product Design Worksheet (ACT-7).*
3-6	Supervise the students as they conduct experiments and record data. They should also begin collecting information regarding Module 5. *The teacher and student safety officers should monitor safety practices and record/report violations and new practices.*
6-7	Provide forms for teams to organize and record "raw" findings and other data in preparation for the seminar and discussion. *Safety forms may be part of this data.* They should continue gathering information for Module 5. *Have students begin to analyze safety considerations of early decisions for Module 5 at this time too.*
8-10	Assist teams in clarifying and interpreting data, then aid them in developing conclusions and recommendations. *Point out how inappropriate or unsafe operations spoil the validity of findings.*

Continue to monitor Module 5 information-gathering and have submitted at close of class.

Guide students as they report and discuss their conclusions and recommendations in the seminar. *Make sure that the safety officers are involved and give final reports along with other matters to insure that safety is seen as continuously important.*

(END OF EXAMPLE)

SECTION III

APPENDIX

APPENDIX A

STUDENT ACTIVITIES

Form ACT-1

TECHNOLOGY EDUCATION SAFETY AGREEMENT

School: ____________________ Teacher: ________________________

To: ______________________________
(Parent or Guardian)

__________________________________ is enrolled in our Technology
(Name of Student)
Education program and will have the opportunity to use various tools and equipment. Appropriate instruction in the safe operation of these tools and equipment is given and close supervision is maintained at all times. Although every precaution is taken to prevent accidents, a certain risk is involved due to the nature of the experience, the age of the student, and the learning environment.

We are asking your cooperation in impressing upon your child the importance of being careful. This we believe will back up the instruction that is given in school.

We welcome your visit in our school and in the Technology Education Department to see our program. These visits can be arranged by calling ________________.

Thank you very much for your help and assistance in providing your child with the "real world" experience of Technology Education in a safe working environment.

I have read the attached communication and I understand the type of program that ______________________________ is enrolled in.
(Student's Name)
I will stress the safety aspects of this program to my child. I encourage my child to participate fully in this Technology Education program.

______________________________________ Date: ____________
(Signature of Parent or Guardian)

Phone: ______________________ (Home) ____________________ (Work)

Please identify any health problems which may have a bearing on your child's participation in this class.

____

I agree to observe all safety rules and procedures for safe operation and conduct and I will wear approved eye protection at all times while in the laboratory.

Student Signature: ___________________________ Date: ___________

ENVIRONMENTAL STUDY

Color Code:

Red............. Fire protection equipment, emergency stops, flammable materials container.
Orange......... Machines.
Yellow......... Aisles and safety zones around machines.
Green...........First aid equipment.
Blue............ Equipment not for student use.
Black........... Housekeeping and storage areas.

ERGONOMICS STUDY
JOB SAFETY ANALYSIS

Name:______________________________ Date:__________

Tool or Machine:______________________________

Operation:______________________________

	Sequence of Job Steps:	Potential Hazards:	Recommended Actions:
	Preparation:		
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	Task Performance:		
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	Termination:		
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	Physical Demands:		
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

Form ACT-4

HAZARDOUS MATERIALS LOG

Name:______________________________ Date:____________

	Hazardous Materials:	Hazards:	Precautions:	Methods of Disposal:
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
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27.				
28.				
29.				
30.				

Form ACT-5

SAFETY INSPECTION

Person(s) Completing Report: Teacher______________ or Student Group #_______

Recorder's Name:___________________________________ Date:_______ Time:_______

	Satisfactory	Unsatisfactory	Not Applicable
Environmental Factors			
1. All lights are operable			
2. Aisles and safety zones are clear			
3. Emergency power switches are unobstructed			
4. Fire Extinguishers are: a) unobstructed			
b) in the proper locations			
c) in working order			
5. No accummulation of rubbish			
6. Trash containers are emptied			
7. First aid kit: a) in proper location			
b) well supplied			
8. Other:			
Tools and Equipment			
1. Hand tools are: a) sharp			
b) properly stored			
c) in good working order			
d) free from dirt or grease			
2. Power and Mechanics are: a) properly lubricated			
b) properly adjusted			
c) guards are in place and properly adjusted			
d) cutting edges are sharp			
e) wires, plugs, and connectors are good			
f) hoses and valves are good			
3. Automated Equipment: a) cables are neat			
b) wire is not frayed			
c) limit switches are operable			
d) emergency switch is operable			
4. Other:			
Materials and Storage			
1. Storage areas are clean and neat			
2. Racks and containers are not over filled			
3. Hazardous objects are stored on lower shelves			
4. Racks are properly designed for stored materials			
5. Other:			

Form ACT-6

SAFETY INSPECTION SUMMARY

Safety Supervisor:____ **Date:**________

Number of Violations

								Total:
Date:								
Environmental Factors:								
Equipment:								
Storage:								

List of Specific Violations:

		Date:
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		

Report results of inspection to the class.

Form ACT-7

DESIGN WORKSHEET

Name:______________________________ Date:______________

Describe the product, process, or equipment you designed or developed.

List potential hazards of this design or procedure.

Describe or sketch safeguards to minimize or eliminate the hazard.

APPENDIX B

SAFETY REPORT FORMS

Form REC-1

ACCIDENT REPORT FORM

Date of Report: ________

Name ______________________ Address ____________________

School ____________________ Sex _____ Age _____ Grade _____

Date and Time of Accident ________________

Describe the injury in detail and indicate the part of body affected.

____

____

____

What was the person doing when injured?

____

____

____

How did the accident occur?

____

____

____

Name the object substance which directly injured the student.

____

If treated, name and address of physician or hospital.

____

Date of Report __________ Prepared by ____________________

Principal ________________________

Form REC-2

ACCIDENT REPORT SUMMARY

Date:	Nature of Injury:	Source of Injury Category:	Source of Injury Part:	Hazardous Condition or Unsafe Act

Form REC-3

STUDENT OBSERVATION

Student Names:	Date:							Grade:

Code:	Description:
√)	Demonstrates good working habits and good participation
1)	Failure to wear personal protective gear
2)	Horseplay
3)	Poor house keeping practices
4)	Improper handling or disposal of hazardous materials
5)	Poor participation
6)	Using equipment without authorization

Codes 1)–6): **Unsafe acts or distractions**

APPENDIX C

EMERGENCY ACTION

EMERGENCY ACTION

1.0 First Aid Procedures

Emergency situations can occur in even the safest school environments. Therefore, each administrative unit (district or school building) should establish and publish procedural guidelines to be followed when these unfortunate events arise. The information presented here is intended to guide teachers when no other information is available at the local level and to aid local districts in establishing their own procedures. Suggested minimum contents for a laboratory first aid kit are provided in Section 1.8.

1.1. Emergency Actions Following Injury

There are two important types of actions required following an injury. These are Immediate Actions and Secondary Concerns. Immediate Actions include the actions which must be taken to aid the injured person as soon as possible after injury occurs and to prevent further injury. Secondary Concerns include the actions taken once the immediate danger is passed and the injured person has received treatment.

1.1.1 Immediate Actions. The Immediate Actions to be taken have three main functions: To preserve the life of the injured person, To seek professional help, and To prevent further injury. The amount and type of care rendered as Immediate Actions depends upon the type of injury and the training and qualifications of the person administering the care. Teachers who are not trained and qualified in first aid must ONLY do the things that will protect the injured party from further damage and immediately seek trained help. This might be limited to stopping bleeding or covering a shock victim with a blanket. It would be optimal if every teacher (and particularly every laboratory teacher, coach, or other teacher of activity intensive courses) had basic first aid training, but this is not the case at the present time. Therefore, it is important that teachers do not attempt to do more than they are formally trained to do. Serious, permanent damage and increased injury can result when untrained and possibly panic striken persons try to treat injuries. There are many persons today who have received some first aid training; the identities of such people within the school should be known by all teachers. Application of home remedies, hearsay practices, and procedures learned many years ago could prove very dangerous--some procedures which were once advocated even by professionals (such as artificial respiration by means of pumping on the back) have been found to be actually harmful and replaced by more effective methods. Here is a list of typically recommended Immediate Actions to take when injury occurs:

1. Determine the extent and type of injury. If this cannot be done, get professional help immediately.

2. Restore breathing, restore heartbeat, and stop bleeding if trained in these areas; if not, send for help.

3. Apply only the first aid that is necessary to preserve life. Do no more until trained help arrives.

4. Disperse any crowd which gathers and keep the injured person and the surrounding area as quiet as possible.

5. Notify the school nurse, principal, and immediate supervisor by sending other students to these people. Do not leave the injured person alone.

6. If the injury is minor, (a splinter or slight cut) send the student to the school nurse accompanied by another student. Do not send the injured person alone.

7. If a foreign particle has entered the eye, seek professional help. A teacher should never attempt to remove anything from a student's eye by any means. If a liquid has entered the eye (acid, etc.), immediately wash the eye in an eye wash and contact the nurse.

8. If a limb or digit has been severed, stop the bleeding of the victim's stump, wrap the severed part in gause soaked in sterile normal saline, and get transportation to the nearest trauma center or hospital as quickly as possible. Send the severed part with the victim. Sterile normal saline should be included in every modern first aid kit, but if it is not available, soak the gause in cool water. Do not try to clean either the wound or the severed part in any way, and ice is no longer recommended.

9. In the case of electrical shock, the range of possible injuries is vast. Send for helpers trained in first aid and CPR (cardiopulmonary resuscitation) at once--persons not CPR trained and currently certified should not attempt resuscitation unless there is absolutely no way to get qualified help and (even then) they take major risks of liability and increased injury into their hands if they do so. Minor shocks often need no treatment, but the victim should be taken to the school nurse for evaluation. Severe shocks can result in muscle spasms, paralysis of respiration, burns, cardiac arrest, ventricular fibrillation, or other dangerous conditions. The first task of the rescuer is to remove the victim from the source of current. This is best done by turning off the power at its source or unplugging equipment. If this is not possible, the rescuer should stand on a dry surface and use a dry insulated pole to cautiously free the victim from the source of current. If respiration or circulation are not restored spontaneously, help from someone trained in CPR is needed immediately. After any electrical shock (even very minor ones), the victim should be monitored closely for signs of physical shock induced by fear or trauma.

10. Notify parents and school officials.

It is as important for the teacher to know what not to do as it is for him to know what to do. Formal training in first aid is available from the Red Cross and through other agencies. Literature is also available. The actions taken during the first few seconds and minutes following an injury can determine the eventual severity of damage or disability, or even preserve a student's life. Technology education teachers are encouraged to obtain professional training in first aid procedures and to keep up to date on changes in technique and practices recommended.

1.1.2. Secondary Concerns. Once the injured student has been turned over to the

care of professionals (nurse, paramedics, or doctor) the teacher must return to the needs of the rest of the class. Some further actions related to the injury, however, are necessary:

1. Calm the other members of the class and restore a safe environment. If the accident was serious (involving a major cut, severance, unconciousness, or other major trauma), discontinue instruction for the remainder of the period. The student's peers will be too upset to work safely or effectively and could have spontaneous accidents of their own. The event may be used to teach an object lesson on safety, but be very sensitive to protect the injured student's privacy and self concept while doing this.

2. Complete the accident report with duplicate copies for the school nurse, the principal, your own files, and any other copies required by your district or building. Keep your own copy in a permanent file until the injured person reaches age 18 or graduates from school (records for special education students and for very serious injuries should be kept permanently).

3. Analyze the causes and effect of the accident and make written recommendations to the principal for corrective measures to be taken. Retain a copy of these communications and a record of any resulting actions.

4. Review and record safety practices, procedures, instruction, and student evaluation concerning the cognitive, psychomotor, and affective instruction that was delivered, and was intended to prevent this type of accident from happening.

5. Check on the results of the treatment received by the injured student.

6. Follow-up in your classes with a discussion and instruction regarding the safe practices that were violated and which contributed to the accident. Again, remember to safegard the privacy and self concept of the victim. Discuss the proper first aid steps which were taken and explain why it would have been dangerous to try to do more than you did.

Many of these procedures are also appropriate for "almost" and "near miss" accidents. Careful follow-up on these incidents could later prevent the real thing from happening.

1.2. Emergency Communications

Every technology education facility should have ready access to a telephone with a direct outside line (for ambulance, fire, rescue, and police emergencies). The important numbers needed for such emergencies should be posted with the phone. The phone should not be locked in an office--all persons in the laboratory, including students, should have easy access. If a direct outside line is not available immediately upon lifting the receiver, directions for obtaining one (code numbers to dial, etc.) should also be posted and made known to students. Ready communication is often more important than anything else the teacher can do for a victim in emergency situations, and the cost of a few spurious phone calls (even long distance ones) pales in comparison to the cost of loss of a single limb or a life. (Much of the information

in this section, III.C.1., came from the Pennsylvania Industrial Arts/Technology Education Safety Guide, third edition, the Pennsylvania Department of Education and the Technology Education Association of Pennsylvania, 1988. Some portions were quoted directly.)

APPENDIX D

RESOURCES

RESOURCES

Since this Safety System Design manual is intended to guide the teacher in developing an ongoing and ever evolving safety system, no lengthy list of currently available safety films, books and articles on safety, or other materials is provided here. To include such a list would immediately outdate the manual rather than fulfill its mission of helping teachers to continually update and improve their safety procedures and knowledge of safe practices. Therefore, the following brief list of sources of materials is provided, not as a comprehensive catalogue of safety materials, but to suggest a few sources of readily available materials which the teacher may contact individually as desired. In some cases addresses are given, but most of the national organizations and agencies listed have local offices in major metropolitan areas or state capitols which can respond to teachers' requests quickly. Therefore, national addresses for these sources are not provided--check the government and business sections of local telephone books first.

Local Sources --

Library/media center of local college/university

Local poison control center

Local school or school district media center

State Department media center

Technology or Vocational Education Director

National Sources --

American Association for Vocational Instruction Materials (AAVIM). 120 Driftmier Engineering Center, University of Georgia, Athens, GA 30602

American Hearing Research Foundation. 55 East Washington St., Chicago, IL 60602

American National Standards Institute, Inc. 1430 Broadway, New York, NY 10013

American Red Cross

American Society of Safety Engineers. 1800 East Oakton St., Des Plaines, IL 60018

American Technical Society

American Vocational Association (AVA). 1410 King Street, Alexandria, VA 22314

Better Hearing Institute. 5021-B Backlick Road, Annandale, VA 22003

Center for Occupational Hazards. Art Hazards Institute, 5 Beekman St., New York, NY 10038

Center for Occupational Research and Development. 601-C Lake Air Road, Waco, TX 76710

Consumer Product Safety Commission. 5401 Westbard Ave., Bethesda, MD 20861

EMC Publishing, 300 York Ave., St. Paul, MN 55101

Environmental Protection Agency

Industrial Health Foundation, Inc. 34 Penn Circle West, Pittsburgh, PA 15206

Industrial Safety Equipment Association, Inc. 1901 North Monroe St. Arlington, VA 22210

International Technology Education Association, 1914 Association Dr., Reston, VA 22091

Modern Talking Pictures Service (This and other media service organizations may be contacted through local school media centers.)

National Center for Research in Vocational Education

National Fire Protection Association

National Institute of Occupational Safety and Health, Division of Training and Manpower, Curriculum Development Branch, 4676 Columbia Parkway, Cincinnati, OH 45226

National Safety Council, School & College Department, 444 North Michigan Ave., Chicago, IL 60611

National Society to Prevent Blindness

OSHA (Occupational Safety and Health Administration)

Power Tool Institute, 501 West Algonquin Rd. Arlington Heights, IL 60005

Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062

U.S. Department of Labor