5-31-1989

A computer-aided instruction electrical safety course

Edward John Gusciora
New Jersey Institute of Technology

ABSTRACT

TITLE OF THESIS: A COMPUTER-AIDED INSTRUCTION ELECTRICAL SAFETY COURSE

Edward J. Gusciora, Master of Science in Management Engineering, Occupational Safety and Health Program, 1989

Thesis Directed by: Howard Gage, Ph.D.

It is the purpose of this thesis to show how computerized training can be used in helping to create an effective safety program. Through example, a complete electrical safety program will be developed for workers whose jobs do not pertain directly to electrical installations, but who use them through the course of their daily work activities. A computer-aided instruction module on electrical safety will be developed for presentation to workers on an IBM compatible computer.

Importance of Thesis

Too often safety factors go into the design criteria of a piece of equipment or a manufacturing process and do not extend into worker safety training. With regards to electrical safety, the Occupational Safety and Health Agency stresses proper electrical installations for safeguarding employees, but OSHA does not include a single statement on training in their section reserved for Safety-related work practices as codified in CFR1910.331-1910.360. The design

of an environment to protect workers is a sound safety decision. However, for maximum worker protection, a comprehensive approach is required. That is, good design must be coupled with proper safety related training and the use of appropriate warning labels.

Decreasing adverse effects, if not being able to prevent a potential hazard from occurring is the ultimate goal of a safety and health program. Training is not the only approach, but it does offer an effective means for helping the employee help himself. The choice of an electrical safety program presented here should serve as a model for those wanting to develop or improve similar training programs. Some key principles which all effective safety programs should contain will be analyzed. These would be beneficial in the development of other safety programs such as safe manual lifting, chemical safety, etc.. Thus, the general principles are applicable not only to electrical safety, but to many other areas of safety as well.

A COMPUTER-AIDED INSTRUCTION ELECTRICAL SAFETY COURSE

A Thesis
Presented to
The Faculty of the Graduate School
New Jersey Institute of Technology

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Management Engineering
Occupational Safety and Health Program

By
Edward Gusciora
May 1989

APPROVAL SHEET

Title of Thesis: A Computer-Aided Instruction Electrical Safety Course

Name of Candidate: Edward J. Gusciora
Master of Science in
Management Engineering, 1989
Occupational Safety and Health Program

Thesis and Abstract Approved: ______________________________
Howard Gage, Ph.D.
Associate Professor of
Industrial and Management
Engineering

Date: 5/10/89

VITA

Name: Edward John Gusciora

Permanent Address:

Degree and date to be conferred: Master of Science in Management Engineering 1989

Date of Birth:

Place of Birth:

Secondary Education: Montclair Academy
Montclair, New Jersey

College Attended	Dates	Degree	Date of Degree
Rutgers University New Brunswick, New Jersey	1982- 1985		
New Jersey Institute of Technology Newark, New Jersey	1985- 1987	BSEE	Summer 1987
	1987- 1989	MSMgtE	May 1989

Major: Occupational Safety and Health Program

Awards: National Institute of Occupational Safety and Health Fellowship

Positions Held:

IBM Corporation, Poughkeepsie, New York

Safety Engineering Internship - May 1988 to December 1988.
* Safety inspections
* Created and revised safety courses and manuals
* Audited and revised Confined Space Program
* Indutrial Hygiene sampling and monitoring
* Creating chemical labels from MSDSs
* Injury and illness recordkeeping and investigations

American Cyanamid, Wayne, New Jersey

Safety and Fire Supervisor - February 1989 to present.
* All aspects of safety supervision for the Wayne Site
* Compliance to Corporate Loss Prevention Standards and to the New Jersey Uniform Fire Codes.

TABLE OF CONTENTS

LIST OF FIGURES

Figure Page

PREFACE

This thesis attempts to correlate the development of an effective safety and health program through the use of computer-aided instruction. It is proposed specifically for workers who are indirectly involved with the use of such items as electrical equipment, and is aimed at improving worker protection by decreasing risk. The computer-aided instruction course is designed to fulfill the objectives of an effective safety program in that it concerns itself not solely with the design of the environment, but also with the education and training of all workers.

I would like to thank Dr. Howard Gage and W.F. Dalton of the New Jersey Institute of Technology for their expertise as advisors and as instructors in the safety and health curriculum. In addition, I would like to thank the IBM Poughkeepsie Safety Department, in particular, F.B. Reilly and C.J. Merando, for providing me with a graduate internship and excellent supervision. Lastly, I wish to acknowledge the support of the National Institute of Safety and Health whose funding made possible my graduate studies.

Edward J. Gusciora

May 1, 1989

CHAPTER I

SAFETY

Introduction to Safety

This thesis is divided into three main sections: the safety course and its four components, electricity and electrical injuries as a case in point, and Computer-Aided Instruction (CAI). Three separate aspects of safety are developed:

1. Warning labels
2. Worker training
3. Design factors

Warning labels can be effective, but their use is limited. Proper labeling shall include all information necessary to adequately warn a person of a potential hazard. This does not necessarily include statements for protection if that hazard cannot be avoided. For example, a do not enter sign, further reinforced by subsequent signs explaining the nature of the approaching hazard along with adequate protective measures, such as barricading, should be sufficient to warn an approaching person. But what if that person must enter the area for an acceptable reason? Then instructions on how to overcome or prevent the hazardous nature of the upcoming situation would be desirable. However, it is usually not practical to place such educational materials at every potentially hazardous location simply because one cannot expect people to read such statements in every hazardous or emergency situation. That is why training is so important.

Employees must be trained not only to recognize a hazard, but also to act accordingly to protect themselves and those around them, and to protect property as well.

A comprehensive procedure for proper training for hazardous chemical assessment is that of the National Fire Protection Association standards, "Hazardous Chemical Data, NFPA No. 49" and "Recommended System for the Identification of the Fire Hazards of Materials, NFPA No. 704M." The standards establish an emergency Hazard Identification System using a diamond shaped label that gives both the hazard and severity for a chemical at a glance, as shown below:

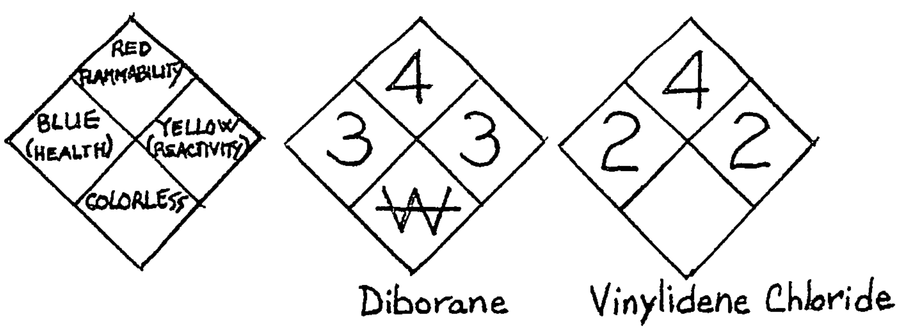


Figure 1 "Hazard Identification System" [NFPA No. 49-20].

The label identifies the severity of the health effect, flammability, and reactivity of a chemical on a scale from one (1), indicating no significant hazard, to four (4), indicating severe hazard. These classifications then become indicators of safe tactical procedures. The procedures describe precautions and protective measures as well as protective equipment that must be used by the fire fighter wherever the hazard exists.

Lastly, design factors manifest themselves as overwhelming contributors in most safety programs. Aspects of safety design factors are too broad to list but include such areas as the color coding of labels, fail safe mechanisms, disconnects, lifelines, etc.. Safety design factors can effectively reduce or even eliminate worker exposure to a specific hazard. However, safety devices or design criteria have given limitations. Therefore, training can function as a backup safety system to insure worker protection in case the physical safety hardware fails.

Design factors take into consideration the fact that workers do not always follow proper training practices. They often know better, but choose to ignore safety training thereby, increasing their risk of exposure to a known hazard. For example, pinch points are the result of a narrowing or closing of a mechanical apparatus. If a person should come in contact (fingers, hair, or limbs) with a pinch point, then there exists the potential for a bodily part to become restrained, pulled, or dismembered. A pinch point that most people are exposed to daily is an elevator door. People know that it is not wise to place a limb between the doors to prevent them from closing. The safety design factor in this case is the safety edge. The safety edge, in most cases, would be a strip along the edge of the door that has a pressure switch which when activated, will cause the door to fail safe in the open position. This is an extremely effective method of protecting a limb from getting pinched between the closing doors. However, even this system has its limitations. Briefcases, pieces of clothing, and other small compressible objects may not trigger the safety edge without fail. That the safety edge is not absolutely effective for small articles is a secondary factor in safety training while primary emphasis is placed on the continued avoidance of pinch points. Design factors include: the double closure of the doors to isolate the elevator car from the elevator shaft, time delays for door closures, an OPEN DOOR button on the inside of the car, an alarm switch, and lastly, the safety edge as a final means to assure that no one is caught between the doors.

To reinforce this point about the necessity of safety training, ask an average person if he/she ever encroached upon a yellow line at a corner curb while parking his/her car. A typical response may be "Maybe once or twice, but not if I can help it because I would be afraid of getting a ticket." However, a trained, safety minded person should recognize the fact that yellow, according to CFR 1910.144, "shall be the basic color for designating caution and for marking physical hazards such as: striking against, stumbling, falling, tripping, and 'caught in between.'" This type of learning is called "negative transfer learning." Here a possible negative response is used rather than the appropriate positive motivators. The construction worker that keeps his hard hat on only when the manager or inspector is on site and not for his own protection is reacting to a negative motivator.

Such negative motivators can often be overcome or defeated if the adverse response becomes less threatening. For example, an application for a job as a painter for water towers or any other high-structure painting might include the question "Are you afraid of heights?". One may choose to answer "No" for fear of not getting the job, or they may give a truthful answer (yes or no), or may even be indecisive and say, "Well how high is high?". But, whatever the case, if the person gets the job, he is given a lifeline or harness, and is instructed on how to use it. Then as he becomes a seasoned painter, the fear of heights decreases or is ignored to a degree so that his main concern shifts to the number of square feet that must be painted daily. This shifting of concerns can create a situation where the worker may think that he can save some time by not tying himself in except in extreme situations, or maybe not at all. This increased assumption of risk can continue until a near miss or even a serious accident occurs. Then his level of fear may increase along with a new respect for safe procedures. An ongoing cycle of increasing and decreasing adherence to safety procedures may then become a behavioral pattern for such a worker.

On the other hand, a person who is effectively trained on the safety of lifelines would more likely be tied in at all times. The word effectively is used here to emphasize the fact that passing a safety course or having taken a specific lesson does not mean that a person has benefited from the experience. The person must achieve the objective of the course or lesson in order for a permanent behavioral change to occur. Even so, that does not preclude the fact that the worker may choose not to wear his/her belt at certain times, fully aware of what is and what is not allowed. Thus, this worker is choosing to take a calculated risk. People take risks everyday. Risk is an unavoidable part of life; however, some people may not fully understand such risks, and therefore, may be unable to respond correctly to them.

That is why in industry, one key objective of management is to minimize the risks which accompany many different kinds of jobs. A first step in accomplishing this goal is the thorough training of the worker to appreciate such risks and the damage which they can cause. Hence, safety training always is a key element in virtually all risk control and hazard minimization programs.

The Safety Course

There are four basic principles to teaching an industrial safety course:

1. Background information on the topic
2. Potential hazards and injuries
3. Factors conducive to potential hazards
4. Safety methods and protective equipment/ environments

Background information on the topic is the foundation upon which the other information can be developed. It should allow the student to make an educated decision regarding unanticipated situations, or at least allow the student to better understand the implications of the safety practices discussed in the class. In other words, one cannot effectively teach electrical safety to a student who knows little to nothing about electricity. Too often a worker may be given a type of black box and told, "Don't do this or that." or "Only do this when ... or that if not." However, if he is told that the red is the hot or live wire and therefore, it must not touch the grounded case or the black grounded wire; or that the red wire may touch the ground only when the box is unplugged or when the power disconnect is in the off position, then the various safety rules offered may have some meaning. Yet, even simple instructions might be too complicated for the novice at electrical wiring and would therefore require further explanation. However, the second set of instructions obviously gives more meaning to the reasons behind the do or don't statements. This understanding can directly enhance the safety practice for preventing short circuits.

The awareness of potential hazards and injuries is also extremely important in order to understand the implications or results of an unsafe act. Severe, life threatening situations hopefully do not occur too often, so they seem so removed or unlikely, that a person may think that it could never happen to him. The less severe act can also be incorrectly perceived as minor or insignificant and therefore, may be ignored. Thus, the implications of an unsafe act can be taught through instruction as opposed to gaining such information by trial and error, or as it is often referred to as the 'school of hard knocks.' Besides teaching what could happen if an unsafe act is committed, instruction must be given to establish why certain situations or behaviors are unsafe. Teaching the reasons and implications behind safety related decision making processes can increase the probability that the worker will make the correct decision more frequently. It would not be effective to train a worker for all conceivable job situations. But teaching him how to make a correct decision, avoid risks, prevent or mitigate potential hazards, and even what to do and where to go if he is unsure of a procedure or action, is usually sufficient.

Lastly, there will always be information or methods that should be taught to the employee. Proper procedures are those steps that will allow the worker to do his job in the safest and most effective manner. Such procedures should be concise and presented with various learning aids to ease the recollection of key steps. As is presented in the electrical safety course, the Five I's of Electrical Safety can easily be remembered as: inspect, insulate, isolate, indicate, and intelligence. Some procedures by nature are more complicated requiring their inclusion in an Operations Procedure Manual (OPM) which should be reviewed as needed or annually.

Operations procedures are created in conjunction with the environmental design and processes. This is the stage where safety aspects must be developed and included to assure that such an operation can be performed in the safest manner. This may include machinery or system designs along with safe procedures to protect and safeguard the worker within the work environment or work envelope. Additionally, a more comfortable and adaptable environment can reduce worker stress and improve production.

CHAPTER II

ELECTRICITY

Introduction to Electricity

Electricity is a widely used source of power that can be used without being understood. One can plug in a kitchen appliance and use it without comprehending the theory of electricity. However, what happens if the appliance is not double insulated and/or polarized? Furthermore, what can happen if one is holding the appliance and touches the door of the stove with a bare leg? If the person involved was lucky, maybe nothing would happen, or else they might get a minor shock--one which would not be life threatening. Perhaps, more information is needed to tell the whole story. One approach is to put answering that question on hold and see if all the needed parameters can be established by the end of the lesson.

Electricity is most commonly used in two forms of current, AC (alternating current) and DC (direct current). Alternating current is what is used in most households to run a majority of the appliances, TVs, radios, etc.. The standard three prong outlet delivers 120 volts AC while some more powerful appliances require larger voltages of 208 volts AC and higher.

Voltage can be defined as a charge separation between two points. By alternating current we mean that the voltage alternates in the form of a sine wave. This is directly opposite to direct current DC source that provides a constant or relatively flat supply of voltage. For example, a typical car battery provides an average of 13.5 volts between the positive terminal and the negative terminal (also known as the chassis ground). In other words, the twelve- volt DC car battery normally provides more than twelve volts, since twelve volts is considered a minimum required voltage rather than the normal voltages.

In reference to electrical hazards, the commonly accepted saying is that 'current kills, not voltage.' Additionally, most references relate injury to electric current as shown below:

BURNS	above 200 milliamperes
VENTRICULAR FIBRILLATION	100 to 200 milliamperes
CESSATION OF BREATHING	25 to 100 milliamperes
MUSCULAR CONTRACTIONS	below 25 milliamperes

These injuries will be defined later and are included at this time to establish the relation of injury to electric current. Electric current can be expressed in numbers of amperes or AMPs. An ampere is a unit of flow of charge produced by a potential or pressure. From Ohm's Law, a basic law of electricity, the relationship between voltage and current can be expressed by the following: The force or voltage potential required to push a current through a conductor equals the rate of flow or current times the resistance of the conductor.

Consequently, when an injury is described by the amount of current passing through the body part, then it is also describing the amount of voltage applied in relation to the resistance of the circuit. If it is accepted that the minimum resistance of the body is 1000 ohms, then it should be accepted that a twelve volt battery will at most deliver 12 milliamperes = 12 volts per 1000 ohms. According to the above listing of electrical injuries, the 12 milliamperes should only cause a muscular contraction. An involuntary reaction of the affected muscles would be contraction and movement away from the electrical source.

It was quantified above the the minimum resistance of the human body was 1000 ohms. Resistance is defined as the ability of a medium to oppose the flow of charge created from a voltage potential. It can be expressed as a ratio of the constant voltage difference between ends of the medium or as a ratio of voltage per ampere, in units of ohms. Thus, the body has a minimum resistance of 1000 ohms, which is used to establish worst case, maximum current conditions. This value will increase as the length of the path increases and as the contact with the source becomes more resistive. Such is the worst case assuming a highly conductive, damp connection; this would not be the case with drier skin. Dry skin is highly resistive with 80,000 ohms being a typical value.

Insulation effectively acts as a high resistance above the mega ohms region, thus preventing current from flowing between two conductors. This is an important aspect of controlling the path of current flow in a circuit. Air, plastic, rubber, and mica are effective insulators.

The direct opposite of insulation is grounding. Grounding provides an extremely low resistance path for current to return to the source. Copper, earth, and previously aluminum were commonly used as ground conductors to control the flow of current back to the supply of power.

It is most important to understand what electrical properties or conditions lead to electrical injuries and accidents. The understanding of electrical hazards is an example of the Right to Know Law, which requires that the employee be informed of a potential hazard. An example would be a warning sign on an electrical substation door in a large building: 'DANGER --- HIGH VOLTAGE.' However, complete understanding would involve more basic items, and would answer the questions of why and how these hazards occur. Does the average employee know that if a plug is slightly out of a wall outlet exposing part of the plug, he/she can run the risk of an electrical injury if contact is made between the body and the two prongs, especially if the skin is wet or damp?

There are some basic conditions beyond the obvious which are often related to electrical accidents and which employees should know and understand. They include:

1. Damp or wet skin will improve an electrical contact, thereby increasing the current of the path.
2. Lower frequencies can resonate with natural body frequencies; higher frequencies are more steady state.
3. High temperature increases the power or energy absorbed, which can lead to a possible increase in electrical malfunctions.
4. High ambient temperature can decrease the power dissipated to the air leading to a possible increase in electrical malfunctions.
5. Decreased voltage at a constant power output means higher power loss and required input power.
6. Higher voltage means higher currents at constant resistances.
7. Non-polarized plugs can cause reversal of the hot and neutral connections making the hot exposed.

This list is not all inclusive but stresses an important facet: electrical accidents can be prevented with a thorough understanding of how electricity operates. Some points to remember for sound electrical design may include:

1. Use of explosion or spark proof equipment in possible flammable atmospheres as required by code.
2. Use of low voltage equipment in wet areas.
3. Use of ground fault circuit interrupters for personal protection.
4. Double insulated equipment as an alternative to three wire grounding.
5. Wear no jewelry or metal rimmed glasses where there is a possible electrical exposure.
6. Methods to insure that insulation is adequate.
7. Electrical injuries or illnesses may not be manifested immediately but still cause damage.
8. Never attempt to put an electrical equipment fire out with a Class A, water extinguisher.

Knowing that water is a good conductor may not always prevent a person from using a water extinguisher on an electrical fire. The person may panic and grab the wrong extinguisher, pull the pin, aim, and squeeze. By proper area layout of equipment, the area should be designed with only carbon dioxide, class BC or dry chemical, or class ABC extinguishers in the proximity. Additionally, all wet locations shall be designed with ground fault protection or even low voltage power of 24 volts. Thus, some water related electrical accidents can be prevented with the help of adequate knowledge.

More complex electrical problems can also be corrected. On occasion, the peak 120 volt AC supplied to the consumer and to industry may be varied by the electric utility company to regulate its load. For example, during the summer, when the electric power usage is peaked with an increased load from air-conditioning units, many utility companies may be forced to turn down the amount of voltage supplied to users in order to prevent an overload of their equipment. This condition is known as a brown-out. There would only be a small fluctuation from such a voltage drop, but it could adversely affect the electrical usage of sensitive equipment and increase the power losses of full load equipment. This effect combined with the addition of high ambient temperatures, which further increase the power losses and the inability of the equipment to dissipate heat, make electrical failures of equipment more common during the hotter summer months. Thus, extra precautions and inspections of equipment should be provided during hotter summer periods.

Some additional precautions may seem obvious, but failure to implement them can be detrimental. Correction of the high temperature mentioned above, may include thermo-circuit breakers. The circuit breakers installed in most houses are thermo-expansion controlled, trip units that expand with heat from excessive current or high current accompanied by a high ambient temperature. Fans are also used to lower temperatures for applications ranging from household electronic equipment to larger power utility transformers. Cooling by use of heat sinks, water, etc. may also be implemented to remove excess heat from electrical components that could cause severe damage. Alarms or automatic shutoffs may also be implemented; these could be effective in cases such as: when a unit gets too hot because the cooling water runs dry or when the fan intake is blocked by storage. Some designs may include automatic fire suppression to backup high temperature alarms and shutoffs. There also exist measures to reduce damage from thermo-expansion of electrical wiring at above normal temperatures. These design controls can help prevent electrically related accidents or injuries resulting directly from electrical malfunctions.

Electrical Injuries

Having reviewed some of the basic principles of electricity, it is now important to emphasize how electricity can act on the human body to cause injury. Following the pattern of Haddon's principles, electricity can be characterized as a source of energy with its effect on the body dependent on: the duration of exposure, the type and magnitude of electrical source, and the path of the exposure on the body. In other words, the type, magnitude, and duration of the applied electric source need to be considered along with various parameters of the body's anatomy which may be included in the circuit's path.

Basically, two types of processes are possible with electric current: The first is the release of thermal energy; the second is the inhibition or excitation of specific bodily tissues.

The amount of current passing through the body determines what will happen to the body. As the current increases, the risk of bodily injury increases. The type of injury is based upon the range of current involved. Four approximate current ranges are able to cause diverse electrical injuries for a 60 hertz AC wave with a path from head to toe. These are:

1. Frying current...above 200 milliamperes
2. Nerve block current...100 milliamperes to 200 milliamperes

3. Knock-out current...25 milliamperes to 100 milliamperes

4. Freezing current...below 25 milliamperes

Most importantly, these numbers are approximate ranges that provide a reasonable safety margin. Because of large individual differences between people with respect to exposure to electric currents, no absolute values are universally accepted. There are simply too many parameters included to obtain such absolute values.

Injury is confined to the path the current takes. Certain pathways are capable of causing death. For instance, a path from head to toe or from arm to arm, both pass through the heart and lungs.

The duration of contact is also important, not only in terms of how long the current flows, but also in terms of other physical factors which can affect the body's period of resistance.

The type of current, direct or alternating, affects the degree of injury. Generally, DC results in more electric power dissipated in the body than AC, because the time weighted average is higher for a constant peak wave than for an oscillating peak. However, an alternating current wave can have similar effects on a human as on an electrical component in reference to voltage spikes at critical instances. For example, a voltage spike during a read/write routine of a computer can cause system failure or the transfer of erroneous information. With a human, if the voltage overlays a critical electrocardial or a respiratory signal, then it could interrupt the normal functioning of the heart or lungs resulting in irreversible brain damage or even death. The result of major interruption of the normal functioning of the heart or lung without immediate medical attention can be fatal. Thus, the need for cardiopulmonary resuscitation (CPR) training has been included in the accompanying electrical safety course, and should be mandated for all electrical workers.

There is also a subjective nature to electrical injuries [Cooper, 1986]. Cooper states, "It is often believed in the electrical profession that the effect of an electric shock is much greater when either the shock is unexpeted or the person is abnormally afraid of electricity." That is, by reviewing accident and near miss reports of electrical incidents, examples of reactions to fear and instincts should also be included. For example, a worker's inability to differentiate the degree of shock can cause him to overreact to a slight tingle. On the other hand, when addressing a seasoned group of electrical workers, there will almost always be at least one worker who had a near miss exposure to a significant voltage, without any adverse reaction. Both situations typify subjective reactions to hazardous conditions. Analysis of the circuit as it relates to the worker at the time of the exposure, is therefore the only true means for determining the severity of a given electrical hazard situation.

Burns

Electricity can burn the flesh by two means: electrothermally and radiantly. Electrothermal burns are caused by electrical current passing through the body. The passing current gives off heat according to Joule's Law. Here the energy or heat generated is equal to the product of the power and time. The power is equal to the product of the applied voltage multiplied by the current through the body.

$$\begin{aligned}\text{Energy} = \text{power} \times \text{time} &= \text{voltage} \times \text{current} \times \text{time} \\ &= \text{voltage}^2 / \text{resistance} \times \text{time} \\ &= \text{current}^2 \times \text{resistance} \times \text{time}\end{aligned}$$

It can be seen that the severity of electrothermal burns is directly proportional to the magnitude of current applied. When tissue becomes sufficiently heated, damage can occur to muscle, nerves, and blood vessels. Therefore, destruction can also occur to heart and brain tissue, leading to the possibility of death.

Radiation given off by an electric arc can also cause burns. In fact, these comprise the more frequently occurring burns from electricity. In cases where thet12vp10H voltage is high, clothing can even be ignited. Radiation is also attributed to the injury of conjunctivitis (welder flash) whereby radiant heat of an electric arc can cause severe eye damage. ANSI Z87.1-1968 [American National

Standards Institute] is a consensus standard promulgated under the Occupational Safety and Health Act to impose transmission standards for radiant energy on the eyes. Although this standard is required in the case of constant arc exposures from welding, such requirements are not applicable for the radiant arc exposures that a high voltage electrical worker might encounter. Since the duration of any one exposure is very small in seconds, and the number of incidents is extremely small, the exposure is treated as an acceptable risk. However, this makes the worker susceptible when exposure does occur. The only commonly practiced rule is not to wear contact lenses, and if glasses are to be worn, they must be approved safety glasses (non-metallic).

Ventricular Fibrillation

Electric current can excite cardiac muscle and interrupt the normal rhythm of the heart. Often, low voltage alternating currents ranging from 100 milliamperes to 200 milliamperes can cause this condition to arise. This range was interpreted based on original values presented by Lee [1971] using a 99% confidence interval between 75 milliamperes and 250 milliamperes; Dalziel [1972] with a lower 0.5% limit at 51.87 milliamperes with a mean of 150 milliamperes for 5 sec.; and by OSHA 3075 [1988] which is dramatically larger, from 1 to 4.3 Amps (the fine print states that the values can be 1/10 lower for durations at or above 5 seconds). Cardiac muscle fibers contract asynchronously and excessive exposure to electric current can result in paralysis of the heart, cessation of circulation, possible brain damage, and even death.

Research by H. Antoni [1983] mentions that there is a vulnerable period which corresponds to the refractory period wherein, the heart muscles are in the early phase of recovery, also known as the T-wave on the Electrocardiogram.

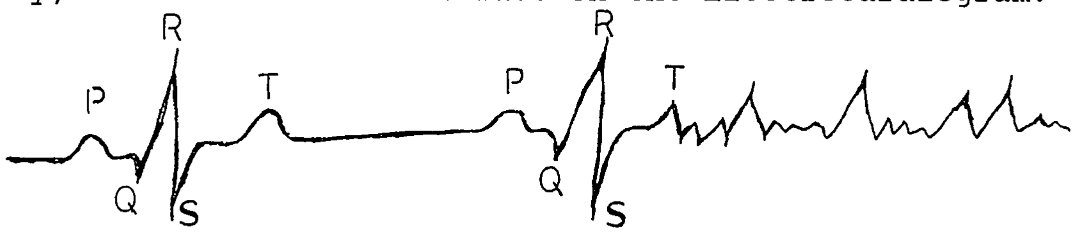


Figure 2 The electrocardiogram of the heart showing the initial T-wave and the next T-wave under electrical shock which starts to fibrillate as displayed by oscillations on the graph.

Prior to the T-wave, the heart has a natural unexcitable refractoriness which prevents the electrical stimulus from affecting it. However, during the T-wave, the heart is in its recovery phase whereby, an electrical signal can overlay the ECG tracing causing the heart to 're-enter' with successive premature heart contractions or fibrillations.

Cessation of Breathing

Electric current in the 25 to 100 milliampere range can cause inhibition of the breathing centers, hence the term 'knock-out current.' This range was lowered from the 50-150 milliamperes range as presented in OSHA Bulletin No. 3075 [1988] based on the work of Cabanes [1983] who stated that the minimum intensity necessary for prolonged contractions of the respiratory muscles is in the order of 20 to 30 milliamperes. In this case, the current affects the control transmissions for breathing from the brain. A prolonged contraction of the respiratory muscles can occur, its duration depending on the specific path which the current takes. Prolonged contractions can reduce the supply of oxygen in the blood. This condition is known as anoxaemia, and it can lead to cessation of circulation and death. However, if the current is stopped, normal breathing usually resumes in both cases.

Muscular Contractions

Small currents (below 25 milliamperes) can cause involuntary muscle contractions giving rise to various injuries, including: loss of consciousness, the so-called "freeze to the source" phenomenon, and the literal throwing of a person away from the source. These findings are based on a study conducted by the University of California Medical School which used a normal distribution and found the mean values for men and women to be 16 and 10.5 milliamperes, respectively. As compared with ranges presented in OSHA 3075 [1988], they present 6 to 25 milliamperes for women and 9 to 30 milliamperes for men. In this study, the limit of 30 milliamperes was lowered to 25 milliamperes to include the lower limits for respiratory arrest.

This range of current produces a shock that is usually less dangerous than its aftermath. The result of such an exposure is a reflexive reaction which can cause serious damage if the person hits a vital part of his body against a hard or pointed surface. For this reason, safe environmental design for the workplace is an important environmental requirement. For instance, clearances around high potential electrical enclosures should be at least as large as those specified in the National Electric Code[NEC] [these rules are also listed in NFPA 70 et seq.]

The NEC is accepted in all states as a minimum requirement for electrical installations. It includes among other things such compulsory rules as minimum working space necessary along side a panel box, the minimum working space in front of an electrical enclosure, and the minimum volume of an enclosure based on the size of the wiring and/or the equipment contained. These working space requirements help minimize the potential damage which may result from a reflexive muscular contraction. Other functional design benefits may also be derived from these space requirements. Since air is considered a good insulator, then the space requirements act to isolate various electrical systems. For example, air space can effectively isolate an emergency power panel from a standard power panel as well as isolate a standard power distribution system from sensitive communication lines.

Promotion of Cancer

Another type of exposure that can lead to a chronic illness as opposed to an acute injury is related to electromagnetic fields. There has been growing evidence that prolonged exposure to electromagnetic fields can promote cancer. Electromagnetic fields (EMF) exist around electric power transmission lines, televisions, and household electrical appliances. Studies have shown that electromagnetic radiation (EMR) affects the pineal gland, located in the brain. Such exposure causes the gland to slow down its production of melatonin, a hormone involved in the regulation of the body’s internal clock.

Scientists suspect that EMR disrupts normal cell function mainly by altering the existing electrical gradients across cells [Edwards, 1987]. As a result, signals passing between cells become modified in such a way as to cause out-of-control cellular growth. This process is believed to initiate the cancer process, but other factors, including EMR exposure may aid in the development of cancer. Experiments done on cancer-infected cells exposed to EMR, showed that the multiplication of these cells increased the normal time for development by up to 24 times [Wellborn, 1987].

The use of electrical stimulation in the medical profession for bone growth, calcification of bone, and muscle stimulation absolutely shows that the effects of electrical currents on cells are real. By altering the electrical gradient existing across cells, doctors have a new means for treating their patients which can bring them to recovery faster. However, the possible effects on specific cells not within the strict controls of medical applications present a threat to the health of exposed workers as well as to the general population. Therefore, an awareness of the possible effects of the problem coupled with training to prevent or control these effects is being researched by the Electric Power Research Institute (EPRI), utility companies, medical researchers, and environmental groups.

The regulation of electromagnetic fields would be difficult for three major reasons. EMF's could potentially affect any part of the body, as opposed to specific organs such as the lungs (lung cancer or asbestosis). There is currently no feasible engineering substitute for electricity that would be acceptable to the community. Lastly, the only feasible methods of protection used today are isolation, increased distance, or a reduction in potential.

Electrical Safety Methods: An Overview

Achieving maximum electrical safety relies upon: safe equipment (installation and function), a safe work environment, and safe work practices. Proper worker training should yield safe work practices. Employees must know when and how to inspect all electrical equipment. They should utilize a Tag-out/Lock-out Procedure with warning tags or signs and locks to designate dangerous areas and or faulty equipment being serviced. The importance of personal protective equipment in specific work areas must be appreciated by all workers. Such safe work practices insure the efficiency of other electrical safety methods discussed below.

By definition, insulating material has a very high resistance to electric current. This resistance prevents a flow of current between two separate conductors. All insulation must be inspected periodically and before each use on portable tools. A failure of the insulation, when a tool is energized could cause worker injury and/or potential equipment damage. Some commonly used insulators include glass, mica, rubber, plastic, and air.

The location of electrical equipment and the processes involved present further means for securing a safe environment. Isolation involves the closing off or enclosure of potentially dangerous areas. The use of shields and covers can be employed to protect workers while keeping unqualified personnel from entering potentially dangerous areas.

Grounding is a secondary protective device which decreases the risk of shock. A low resistance path to ground is created in order to prevent the buildup of voltage on equipment. Grounding is also useful since it offers a path of low resistance to ground. During a short circuit, trigger circuit protection devices such as fuses, breakers, or ground-fault circuit interrupters (GFCI) will be triggered. In case of a malfunction, a heavy current surge will activate one of these circuit protection devices thereby causing the flow of current to cease.

Fuses and breakers limit the amount of current flow and are designed primarily to protect equipment and wiring. However, the GFCI is known as a 'people protector.' The GFCI is a differential sensor that monitors and compares the current entering an electrical device with the current returning from that device. If the observed difference in currents is greater than say 5 milliamperes, then the circuit will trip in approximately 1/40 of a second.

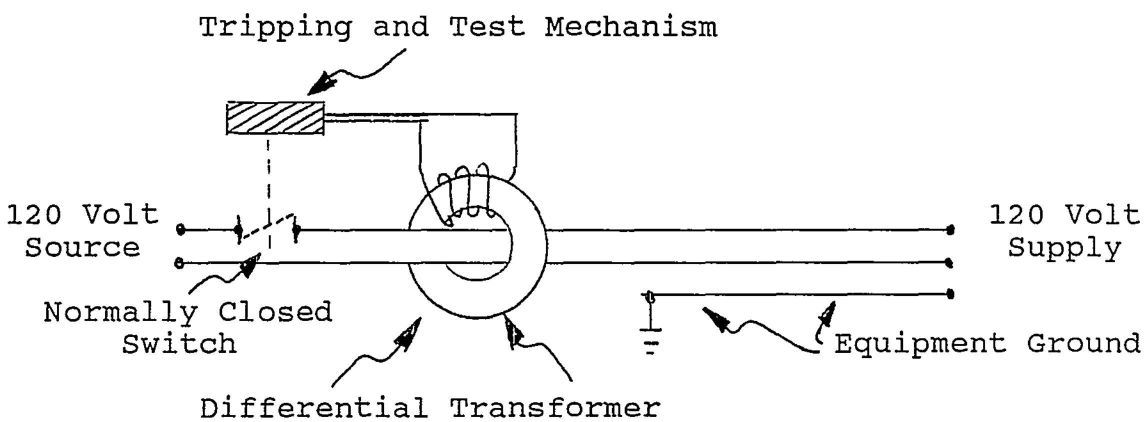


Figure 3 Circuitry of a Ground-Fault Interrupter.

Typically, GFCIs are designed to trip with low currents and in a short period of time in accordance with the applicable standard--ANSI/UL 1053-1982[R1988]. They are mostly used in high-risk and wet zones such as construction sites, bathrooms, and kitchens.

Circuit protection devices, guarding practices, insulation methods, and safe work practices are necessary for electrical safety, but there is yet one other method that should also be included as part of regularly scheduled inspections. Electrical fault testing has come of age through the use of infrared techniques as an effective testing method. Fault testing can indicate any loose connections, failed insulation, corroded wires, and so forth. Infrared testing consists of heat photographs of operating equipment. Bright spots on the photo indicate areas of high power loss and therefore a loose connection or a bad wire. Knowing beforehand where the hot spots are allows for corrections to be made in order to insure safety in the future.

Safety methods for electromagnetic radiation are difficult since the radiant energy is neither seen nor felt without the use of complex instruments. However, some states have already begun setting regulations on the strengths of fields surrounding utility transmission lines. Their primary approach is to separate or increase the distance between the source and the receiver. New Jersey is one of six states that have imposed limits on the strength of electromagnetic fields surrounding utility transmission lines. There have been several cases against various utility companies concerning electromagnetic radiation exposures and their potential for causing cancer. Even though juries have awarded millions of dollars against the utility companies, regulations have not been established because of the difficulty in quantifying the risks.

CHAPTER III

COMPUTER-AIDED INSTRUCTION

Computer aided instruction (CAI) can be used as a tool to train workers regarding safety practices. A computer terminal is used as the instructor to teach the worker selected aspects of safety that deal with his job function.

The use of the computer by the safety department frees the safety officer to perform real time safety functions while letting the computer perform the repetitive task of instruction routine. Reference to instruction as repetitive is not meant to decrease the impact of an experienced instructor, but to show that the same material may be repeated periodically or as the need arises.

A safety course should include both practical examples and rules along with instruction. The material can be formatted in a fashion similar to that contained in a book; however, the computer can take it one step further. Effective reading implies that the reader will question what is being read. This is a proven effective study habit which not everyone has adopted. The computer on the other hand can be programmed to ask the reader specific questions to insure understanding and to elicit various anticipated responses.

Some may question the ability of a computer to give an appropriate response, so here is a simple example:

QUESTION: If a reaction causes (P)pressure to decrease by two-thirds in the equation P x V = constant, then

A. The (V)olume decreases by two-thirds.
B. The (V)olume increases by three times.
C. The (V)olume increases by two-thirds.
D. The (V)olume increases by three-halves.
E. NONE OF THE ABOVE.

ANTICIPATED WRONG ANSWERS:

A — Can both variables decrease and have their product remain constant? ans> NO! --- TRY AGAIN ---

C & D — HINT: If (P)pressure decreases by 2/3, then 1/3 the (P)pressure is left after the reaction -TRY AGAIN-

E — One of the above answers is correct. - TRY AGAIN -

CORRECT ANSWER:

CORRECT

When Pressure decreases by 2/3 then 1/3(P) * 3(V) = constant
Thus, the volume increases by a factor of three.

The above question is an example of an anticipated response to a doubting reader who questioned the statement of a computer in giving an appropriate response. However, the computer would be more efficient in its presentation of such a question since it can receive feedback, whereas a hardcopy text cannot. Thus, computers can effectively branch depending on the needs and abilities of the user.

Branching may be used based on the response of the user. For example, the extreme cases of a student who knows very little or one who knows too much can both be accommodated. The student who knows very little can branch into extra help screens while a student who knows a great deal about the subject may opt not to take the entire course, choosing only to take the refresher section and the final exam. Suppose a skilled operator who works with the equipment everyday has forgotten some safety aspects while skipping to the final exam. The computer can branch him/her back to the body of the course if the answers given are inadequate.

The development of such a flexible program may entail a great deal of work to create. So an appreciation of its advantages will hopefully outweigh the start-up costs. The cost savings should increase for larger companies who will have a potentially higher use factor and increased capital investments in computers. The minimal operating margin would vary with the type of functions within a given company (i.e., the number of workers needed to make the program cost effective).

The first cost savings feature involves soft copies as opposed to hardcopy printed material. This factor implies that the users need computer access. Most larger companies have realized the merits of computers and have located them throughout various departments. However, if this is not an option, a learning center with computers may be a feasible alternative. The added advantage of a personal computer is that its usage cost is approximately $0.50 per hour while processing time of larger mainframes can accumulate to a significant figure. Yet, running such a safety program would only require fractions of a second to store information in the buffer register of the computer that the student is using. That is, the student only accesses the mainframe and does not use it as a processor. This approach makes mainframe applications more cost effective.

Computers offer a second advantage in that they can be updated easily. Once updated, the file can be saved on the system or on diskettes on personal computers. Having a permanent record of the instructional material protects the employer from the statement "I, the operator, at the time of the accident, was never told that this could happen." Various Right to Know laws assign to the employer the responsibility to educate and inform. New Jersey Statutes Annotated 34:5A-13 states that the employer must inform his employees orally and in writing of the nature of any hazardous substances or potential health risks present in the workplace. Therefore, workers should be informed about their required working spaces or clearances around high potential electrical enclosures. They should be trained for the safe handling of all potentially dangerous equipment (for example, electric arc welding equipment), and should be educated on the potential health effects of such substances as asbestos (as used in insulating material). CAI courses can be used to fulfill the requirements of Worker and Community Right to Know laws.

Limitations of CAI

Experience with CAI courses has presented some limitations that should be noted. As with any material that must be read by a worker, an employer cannot be certain that his employee has been effectively trained without some sort of test, either practical or written. If an employer, through testing, discovers that his employee has been inadequately trained, he must then retrain the worker and discontinue any related work performed by that employee until such retraining has been completed. Thus, most employers have chosen not to test the worker and prefer that the worker sign a paper indicating that he has read and comprehended all training material presented to him. While this step can reduce potential liability of an employer, it does not insure that the worker really understands the material involved. This was evident with various CAI courses where the students signed the completion certificate without a complete understanding of the course.

It is recommended that additional checks be made to insure that the worker has been effectively trained and that he is using this training in all applicable work activities. An on-site inspection of the worker at his work environment is one sure means for establishing that the worker has been effectively trained. If the worker fails to communicate the presence of a safety hazard to his supervisor, then his training has not been effective. Also, if a worker performs unsafe acts, then his training was also ineffective. Both statements are indicators that the worker needs to be retrained.

Some employees may refuse to use a computer. Others may have an aversion to non-personal training. Therefore, alternatives, such as personal instruction should be provided for such employees. Another observation is that some employees may be more receptive to personal interaction. However, students can also be observed either sleeping or not being fully attentive during a lecture, movie, or slide presentation. Therefore, it is up to the safety instructor to establish a proper medium for his workers. In many cases, alternating between CAI and personal instruction may be desirable. That is, the annual safety lectures should be supplemented with CAI. For example, the CAI course may be useful as a six month refresher between yearly safety lectures. Most importantly, this approach would meet the requirements of written and oral hazard communication as stipulated in the Right to Know Act discussed previously.

Alternatives to CAI

There are many methods available to train workers today which include video tapes, movies, manuals, models, simulators, computers, lectures, and journeymen/ apprenticeships. In deciding which method is most effective for a specific situation, one should determine the ability of the method to keep up with established regulations. Safety standards can be added or modified on a daily basis, so it is important to keep up with the latest regulations.

Designing a CAI Program

There are several factors that should be considered before attempting to create a CAI package for training workers:

1. Format and style of presentation
2. The use of subroutines
3. Means of branching within program
4. Means and ease of updating
5. Graphics/Color options
6. Speed
7. Control functions
8. Source codes
9. Word processing functions, such as spell checking

All factors were optimally achieved or used in the development of the Electrical Safety Course except for the the inclusion of advanced word processing functions--in this case, spell checking.

Format and style are important both for the end user, the student employee, and for the developer. In terms of the user, the format should allow the student to reference a screen. This is an important parameter if the student has a question about a topic because it enables him to present it to the supervisor, the safety officer, or the author. One method of identifying a screen is to label each screen with information that would include the name of the course, the lesson number, and also a screen identifier. It may also be important to include version numbers since a course may get updated with previous versions still in circulation.

Another way of allowing a student to reference a screen is to provide a print screen option. This is a control option that would allow the student to print a screen of information to hardcopy printout. This printout may then be useful in terms of pinpointing questions which require clarification by management personnel or it may be used as a method of note taking. The student can printout any useful information that he might wish to review later such as a table, a list of steps to remember, or even a test question answered incorrectly.

Another style parameter to consider is the layout of the screen. The layout should consider human factors in relation to the computer screen, such as:

1. Location coding
2. Multiple coding
3. Pictographs
4. Legibility

Some areas of the screen are more visible and legible than others. Since the screen is contoured and noncontinuous, then the edges and corners may be less legible and have a lower image quality index. Additionally, the central location of the screen to the user's line-of-sight (LOS) makes it the most visible area of the screen. Thus, the most important information should be located in the center with the less important information to the edges of the screen.

Location coding should then be established to develop consistency over each area of information to make the screen more informative and user friendly. The two top lines should be established as a space for lesson and screen labeling and for other less important information that the user need not read every time, but should still be included if the need arises. The bottom area can be used to label advancement information or control information to the user; this also is not of great importance, but is considered necessary. The side, vertical edges should be avoided except where absolutely necessary for run-on information that cannot be split. The vertical edges would serve as a buffer zone which could also be used to contain a border.

The information can further be coded by the use of colors to highlight or emphasize certain areas over others. It is best to reserve the optimal color combination for the most important and lengthy information. This should consist of the largest area being reserved for a dark color with a contrasting color that is highly visible with little glare. The reason for this scheme is to minimize the brightness on the eyes allowing for a more relaxed viewing of the information. Other color combinations can then be used to present other, less important information.

Pictographs are commonly used in the computer field. The symbol for Return is [<--']. There are also standard keys that can be used to control the flow of the program that should be used. Some useful keys may include: pg up, pg dn, end, esc, home, shift-prt sc, etc. In other words, since these are accepted use keys, then continued use of these keys will make the program more user friendly.

The use of control options should be anticipated to help the user. Advancing, reviewing, quitting, and restarting are options that should be included to allow the user to tailor the information to his needs by allowing him to review previous screens, advance, end, or even start all over. Another option is to prevent a student from getting caught in a question loop where he cannot advance until he gets the question correct. This can be overcome by offering a limited number of chances. A true or false and yes or no question should only accept one try followed by a response by the computer stating the correct answer and a reason. However, a multiple solution question may be advantageously answered with hints or helps for a limited number of responses until the student gets the correct answer or exceeds an allowable number of responses. Hints provide some helpful information if the user is unsure.

Graphics, diagrams, charts, and tables are also helpful in expressing information. They also break the flow of continuous wording making the use of the computer a more enjoyable and pleasing experience. An unattractive screen does not hold the interest of the user as does a colorful and creative screen. Speed is also important so as to not cause user disinterest because of time lags. Time spent on training is time away from production; therefore, a primary incentive is to be to the precise and concise, without the processing delays of a slow program.

Lastly, the programmer should seek a source code that can be updated quickly and with ease. By separating a lesson into parts, a section of the program would take less time to compile than if the whole program had to be compiled every time. Subroutines for questions are also very important to develop conditional flows for a question since all questions could follow a similar model. Also, any option that is repeated often should be incorporated into a subroutine to speed the program and decrease the required code. A spell check of one's work would be beneficial to correct typing errors; this can easily be done using a word processor before the program is compiled if the source code does not contain such options.

Further Applications

The use of the computer as an instructional tool can provide other applications to a safety officer. A program can even be intended to teach a safety officer or supervisor how to comply with state and federal regulations. In addition, it can then be used to log information, such as sampling and test results that will be used to generate compliance reports. This may be more apparent in larger companies, where corporate headquarters personnel may be responsible to generate safety standards for all divisions within the company.

For example, such a module may be desirable to setup corporate guidelines for an asbestos program. The main program can branch into different areas such as:

1. Description of asbestos and its uses
2. Health effects
3. Responsibility to comply, RTK, and the regulations
4. Safe work practices for the employee
5. Responsibility and procedures for management
6. Personal protective equipment
7. Housekeeping
8. Monitoring
9. Recordkeeping
10. Disposal practices
11. Medical examinations
12. Emergency procedure
13. Compliance report generator

Thus the program would branch into two major divisions: an instructional option known as a tutorial, and a report generator.

A tutorial could be used to teach the subject of asbestos and the associated regulations. Two obvious sub-divisions would be for worker training and for compliance officer training. For security purposes these two divisions may be separated completely where the workers would only get access to an individual worker training section.

A report generator would be a usefull feature to generate standardized monthly or annual reports. The advantage of such a system would be decreased time required to generate reports, at the same time providing a better report. The report generator can process data, search for trends, graph incidents over time, automatically transfer information electronically to other divisions or locations, and perform a multitude of other functions for which it was programed.

The most exhaustive use of a report generator in the safety and health field is for OSHA injury/illness reporting and recordkeeping. The are many commercially available software packages to perform injury/illness recordkeeping dependent on the type of computer system. Options are even in existence where OSHA can access a company's computer system to investigate recordkeeping of injury and illness incidents. OSHA logs can even be sent electronically.

CHAPTER IV

THE ELECTRICAL SAFETY PROGRAM

A three part electrical safety program has been completed for use on an IBM compatible computer and is listed as a hard copy in the Appendix:

EL1.exe - Lesson 1 - Introduction to Electrical Safety
EL2.exe - Lesson 2 - Electrical Health Hazards
EL3.exe - Lesson 3 - Electrical Safety Methods & Tests

The course was created and compiled using a Turbo Pascal program. The Pascal programming language was chosen for its ease in creating and updating. Additionally, the desired result of a completely executable, fast response program was achieved. Once a loop or procedure is established for the advancing, questioning, and help functions, they then can be accessed throughout the program. The advantage of such a flexible system was experienced in the development of this program. Its highlights include the following features:

1. It is a stand alone executable program. This means no copyrighted access program is needed to run the package.

2. Color options are available on the screens.

3. It offers increased speed by at least tenfold over noncompiled programs.

4. Material may be improved, added, deleted, or updated in order to keep up with changes in regulations and/or safety practices and/or the instructor's personal expertise.

5. The program is designed to be highly user friendly to the student.

6. It offers a series of improved control options.

REFERENCES

Allison, William W. "Magnetic Field Effects On Humans," Professional Safety, June 1988, 28-30.

ANSI C2-1987, "Part 4. Rules for the Operation of Electric-Supply and Communications Lines and Equipment," National Electrical Safety Code, American National Standards Institute, 1987.

ANSI C95.2 "American National Standard Radio Frequency Radiation Hazard Warning Symbol", Institute of Electrical and Electronics Engineering, New York, June 7, 1982.

Antoni, H. "Pathophysiological Basis of Ventricular Fibrillation," in Electrical Shock Safety Criteria, eds. J.E. Bridges, G.L. Ford, I.A. Sherman, and M. Vainberg. New York: Pergamon Press, 1985.

Bridges, J.E., M. Vainberg, and M.C. Wills. "Impact of Recent Developments in Biological Electrical Shock Safety Criteria," IEEE Transactions on Power Delivery, Vol. PWRD-2, No. 1, January 1987, 238-248.

Cabanes, J. "Physiological Effects of Electric Currents on Living Organisms, More Particularly Humans," in Electrical Shock Safety Criteria, eds. J.E. Bridges, G.L. Ford, I.A. Sherman, and M. Vainberg. New York: Pergamon Press, 1985.

Cooper, W.F. Electrical Safety Engineering, London: Butterworths & Co Ltd., 1986.

Dalziel, Charles F. "Electric Shock Hazard," IEEE Spectrum, February 1972, 41-50.

Dalziel, Charles F. "State of the Art--GFCIs and GFRs, Recent Developments in Ground Fault Circuit Interrupters and Ground Fault Receptacles," Professional Safety, November 1978, 31-40.

Edwards, Diane. "Cells Haywire in Electromagnetic Field?" Science News, 133: April 2, 1987, 216.

E-lab of MIT. "Electrical Injury: Understanding the Body's Response," IEEE Engineering In Medicine And Biology Magazine, 7: 1 (March 1988), 39-40.

Gallagher, John M. and L.B. McClung. "Electrical Hot Work Safety Program," IEEE, 1986, 921-927.

Kouwenhoven, W.B. "Effects of Electricity on the Human Body," Electrical Engineering, March 1949, 199-203.

Lacy, Edward A. Handbook of Electronic Safety Procedures. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1977.

Lee, Ralph H. "Electrical Safety in Industrial Plants," IEEE Spectrum, June 1971, 51-55.

Moran K.T. and A.M. Munster. "Low Voltage Electrical Injuries: The Hidden Morbidity," Journal of the Royal College of Surgeons of Edinburgh, 31: 4 (August 1986), 227-228.

NFPA 49 Hazardous Chemical Data, National Fire Protection Association, Boston, Mass., 1987.

NFPA 70 National Electrical Code, National Fire Protection Association, Boston, Mass., 1987.

NFPA 704M Recommended System for the Identification of the Fire Hazards of Materials, National Fire Protection Association, Boston, Mass., 1987.

Sances, Anthony Jr. and Joel B. Myklebust. "Electrical Injuries: Reconstruction and Analyses," Professional Safety, November 1979, 38-43.

Silva, Mike, Luciano Zaffanella, and Norm Hummon. "An Activity Systems Model for Estimating Human Exposure to 60 Hz Electric Fields," IEEE Transactions on Power Apparatus and Systems, Vol. PAS-104, No. 7, July 1985, 1923-1929.

Slesin, Louis. "Power Lines and Cancer: The Evidence Grows," Technology Review, 54: October 1987, 53-59.

Suruda, A. "Electrocution at Work," Professional Safety, July 1988, 27-32.

U.S. Department of Labor, Occupational Safety and Health Administration, "Controlling Electrical Hazards," 1988, OSHA 3075 (Wahington, D.C.: Government Printing Office, 1988), 1-10.

U.S. Department of Labor, Occupational Safety and Health Administration, "Electrical Standards for Construction," 1987, OSHA 3097 (Washington, D.C.: Government Printing Office, 1987), 1-8.

Wellborn, Stanley N. "An Electrifying New Hazard," U.S. News & World Report, March 30, 1987, 72-74.

Whorton, M. Donald, Marshall S. Levine, and Edward P. Radford. "A Preventable Death From an Electrical Hand Tool Malfunction," Journal of Occupational Medicine, 17: 9 (September 1975), 589-560.

Worker And Community Right To Know Act N.J.S.A. 34:5A-13, New Jersey Department of Labor, Trenton, N.J.

Unpublished electrical safety practices and course by Edward J. Gusciora for C.J. Merando and E. Formica, IBM Corp, 1988.

APPENDIX 62 p.

ELECTRICAL SAFETY

Created
By

Edward Gusciora

for
presentation on the
IBM Personal Computer

(May 1, 1989)

NEXT: ACKNOWLEDGEMENTS

Press <——┘ to continue.

ACKNOWLEDGEMENTS

I would like to thank the IBM Poughkeepsie Safety Department for providing me with a graduate internship, especially F. B. Reilly and C. J. Merando for their supervision. I received valuable experience in safety and health and was able to develop my background knowledge in electrical safety and in applications of computers for the safety and health professional.

The contributions of Dr. Howard Gage and W. F. Dalton of the New Jersey Institute of Technology as advisors and as instructors in the safety and health curriculum were greatly appreciated and cannot go unnoticed.

I also wish to acknowledge the support of the National Institute of Safety and Health whose funding made possible my graduate studies.

NEXT: EMPLOYER'S RESPONSIBILITY

Press <———┘ to continue.

COURSE OBJECTIVE
EMPLOYER`S RESPONSIBLITY

NJIT STUDENT USE ONLY

The Williams-Steiger Occupational Safety and Health Act of 1970, (84 Stat. 1590 et seq., 29 USC 651 et seq.) requires that those covered by the Act furnish a workplace free from recognized hazards that are causing or have potential to cause death or serious harm to employees. The employer must also comply with all standards, rules, regulations, and orders issued under the Act.

One such aspect of the OSH Act (Occupational Safety and Health Act) is electrical safety found in 46 FR 4056, Jan 16, 1981.

An understanding of the principles of electricity, the potentials for hazards, basic safety precautions, and action to be taken in the event of an accident will help YOU MAKE A SAFETY DECISION.

The bond between a safe environment and worker helps promote a healthy future for all workers.

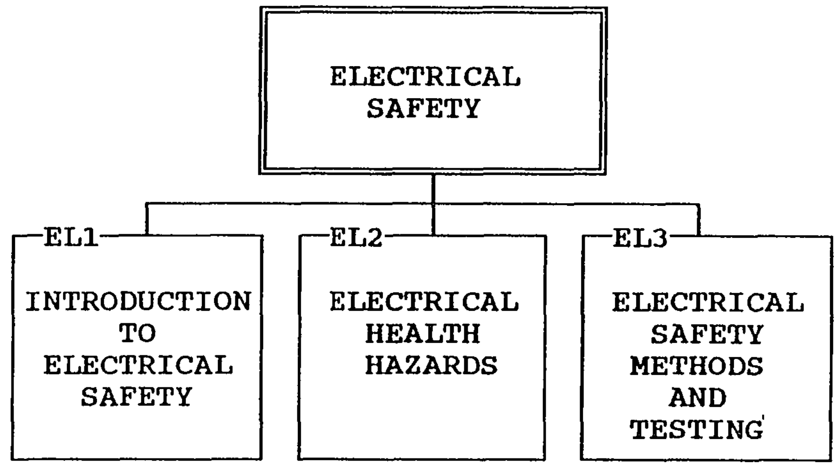
NEXT: COURSE COMPONENTS

Press <——┘ to continue.

COURSE COMPONENTS

NJIT STUDENT USE ONLY

LESSONS



NEXT: OPERATION PROCEDURES

Press <——┘ to continue.

COURSE OPERATION PROCEDURES NJIT STUDENT USE ONLY

For a description of how to perform an operation, enter the letter corresponding to one of the operations listed below.

A
- To proceed to the next screen
- To print a screen
- To get help when answering a question

B
- To review previous screens
- To stop a lesson

If you do not want any explanations, press the <——┘ key twice to continue.

NEXT: START OF LESSON 1 Press <——┘ to continue.

COURSE OPERATION PROCEDURES NJIT STUDENT USE ONLY

TO PROCEED TO THE NEXT SCREEN

Press the [<——┘] key after the [Press <——┘] symbol is displayed in the lower right-hand corner of the screen.

TO PRINT A SCREEN

Hold the [/‖\] key down and press the [PrtSc *] key.

TO GET HELP WHEN ANSWERING A QUESTION

Type the word `H`int in place of a reply to the question

Press <——┘ to continue.

COURSE OPERATION PROCEDURES NJIT STUDENT USE ONLY

TO REVIEW PREVIOUS SCREENS

Press the [Home] key to go to the start of the Lesson you are taking.

Press the [PgUp] or the [PgDn] key to go backward or forward in review.

Press the [End] key to stop a lesson and return to the main menu.

You may print this screen for your reference.
TRY THE PRINT SCREEN FUNCTION

Press <———┘ to continue.

INTRODUCTION

This lesson contains 6 topics:

1. INTRODUCTION TO ELECTRICITY
2. CURRENT FLOW
3. INSULATION
4. GROUNDING
5. OVERCURRENT PROTECTIVE DEVICES
6. GROUND FAULT INTERRUPTER

ABSTRACT

Electricity is a powerful tool, but if used carelessly, it can cause severe or fatal injuries to the human body.

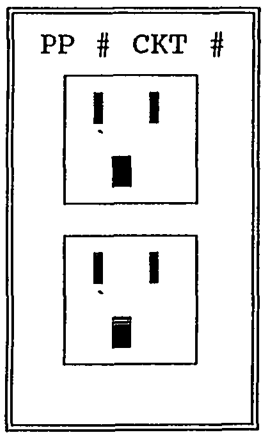
The severity of injury to human tissue from electricity is directly related to the amount type, path, and duration of current absorbed.

Electrical Currents:

1) Greater than 200 milliamperes can cause severe burns and/or death
2) Between 100 and 200 milliamperes can cause heart stoppage or ventricular fibrillation
3) Between 25 and 100 milliamperes can cause unconsciousness
4) Below 25 milliamperes are not harmful but can cause involuntary reactions

END OF LESSON 1 ABSTRACT

NEXT: ELECTRICITY Press <——┘ to continue.



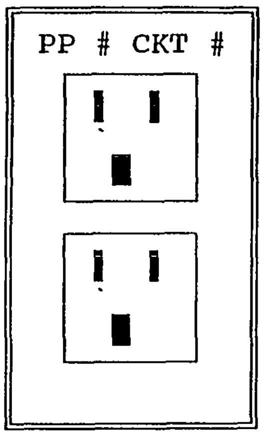
ELECTRICITY

Electric current originates from either a Direct Current (DC) source such as a battery or from an Alternating Current (AC) source such as a receptacle or wall outlet.

AC and DC voltage can both present electrical hazards if not used under control. Only AC voltage will be discussed to avoid confusion. Common appliances, lights, PCs, etc. use 120 volt supply while more powerful equipment can use 208 volts and higher. Voltage is defined as a difference in electric charge between two points.

NEXT: CURRENT FLOW

Press <——┘ to continue.



CURRENT FLOW

The hazard of electricity to the body was expressed in number of amperes (or AMPS). An ampere is a unit of the flow of charge produced by a potential or pressure(volts).

Ohm`s law describes the relationship between voltage and current: the force or potential (VOLTS) required to push a current through a conductor equals the rate of flow of current(AMPERES) times the RESISTANCE of the conductor.

VOLTS = AMPERES X RESISTANCE

Thus, increasing the resistance in a circuit will decrease the current with the voltage remaining the same. Similarly, decreasing the voltage would decrease the current given the same resistance.

NEXT: A QUESTION ON CURRENT Press <———┘ to continue.

QUESTION - The flow of current in a circuit can be reduced by:

a. Increasing the voltage
b. Increasing the resistance
c. Decreasing the voltage
d. Decreasing the resistance

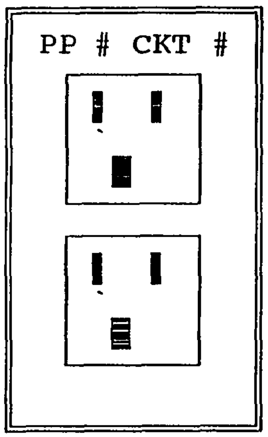
Enter the letters "a" to "d" in your answer

bc

CORRECT - Both decreasing the voltage and increasing the resistance will decrease the current.

NEXT - INSULATION Press <──┘ to continue.

INSULATION



Insulation effectively acts as a high resistance that prevents current from flowing between two conductors. However, if the insulation is broken or weak, current can start to flow between the conductors causing a short circuit. This short should trip a circuit breaker or a fuse.

Sometimes the conductors are not close enough to allow a short circuit, and the current will only bridge the gap if a conductive medium is placed in the path. A person`s hands can act as a medium for current flow which can also cause a severe injury to the person. Thus, good insulation on all conductors or wires can prevent you from becoming a path for current to travel.

If you spot a wire with failed insulation,
REPORT THE PROBLEM IMMEDIATELY TO YOUR SUPERVISOR.

QUESTION: true or false.

Insulation protects a worker from energized wires and parts.

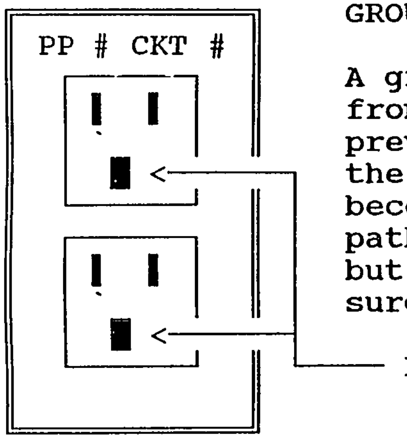
Please enter "T" for true or "F" for false.

true

CORRECT -- Insulation has a high resistance to electric current. It acts as a barrier, preventing a worker from becoming a path for electric current.

NEXT - GROUNDING

Press <——┘ to continue.



EQUIPMENT GROUND LEAD

GROUNDING

A ground is a secondary protective device that protects you from shock. It provides a low resistance path to ground that prevents a buildup of voltage on the tool or equipment. In the event of a malfunction where the case of the tool becomes energized, the ground wire serves as an alternative path to ground. A ground wire cannot eliminate all shocks, but will lessen the severity. Able to carry a heavy current surge, the ground aids in tripping the breaker or fuse.

National Electric Code Standard

All electrical equipment which has exposed metal parts or covers and which operates at a voltage that could present a shock hazard, shall be grounded through a grounding conductor. The safety ground, if insulated, shall be colored green or taped to identify as a ground.

OVERCURRENT PROTECTION DEVICES

Overcurrent Protection Devices are designed to mechanically limit or shut off the electrical power. These devices include circuit breakers, fuses, and ground-fault circuit interrupters(GFCIs).

FUSES & BREAKERS

Fuses and breakers are designed to limit the amount of current flow. The breakers are designed to trip at maximum rated currents, while the fuses are designed to melt. These circuits are designed primarily to protect equipment and wires. However, in conjunction with other safety measures, such as positive grounding, both are helpful in minimizing hazards.

NEXT - GFCIs

Press <——┘ to continue.

OVERCURRENT PROTECTION DEVICES

GROUND-FAULT CIRCUIT INTERRUPTERS (GFCI)

GFCIs monitor the current going into an electrical device with the current returning from the device. If the current in does not equal the current out, the circuit trips off. The current imbalance can occur if some current leaks to ground on a path other than the neutral wire. This circuit is designed to trip in a short period of time, dependent on the amount of current. Thus GFCIs protect workers effectively by tripping with low currents in a short period of time.

CONCLUDING INSTRUCTIONS

You have completed Lesson 1.
To complete the course satisfactorily, you must complete each of the following lessons:

```
You are here >---> EL1  -  INTRODUCTION TO ELECTRICAL SAFETY
                   EL2  -  ELECTRICAL HEALTH HAZARDS
                   EL3  -  ELECTRICAL SAFETY METHODS AND TESTING
```

You will return to DOS after this screen.

Then type EL2 and press the <——┘ to start LESSON 2

END OF INSTRUCTIONS Press <——┘ to continue.

ELECTRICAL SAFETY

Created
By

Edward Gusciora

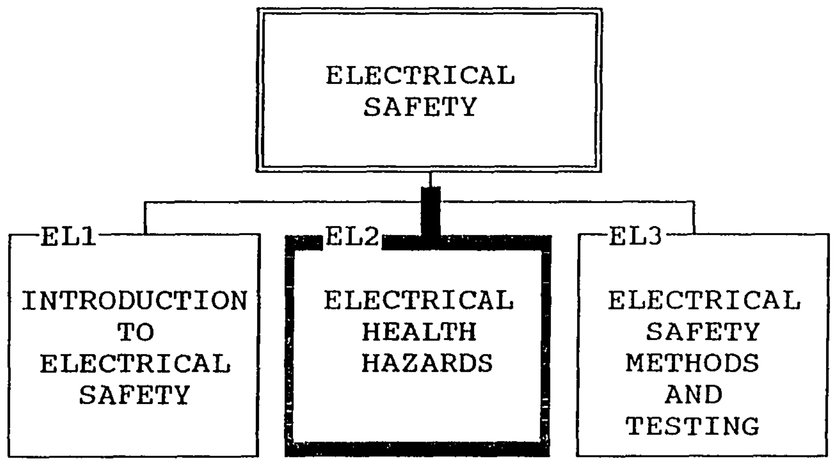
for
presentation on the
IBM Personal Computer

(May 1, 1989)

NEXT: CHART

Press <——┘ to continue.

L
E
S
S
O
N
S



NEXT: ABSTRACT

Press <——┘ to continue.

ABSTRACT

1. Electrical Injuries and Hazards

   - Burns
   - Ventricular Fibrillation
   - Cessation of Breathing
   - Muscular Contractions

2. Factors Conducive to Electrical Injuries

   - Amount of Current
   - Electrical Current Path
   - Duration of Contact
   - Type of Current

COURSE OPERATION PROCEDURES

NJIT STUDENT USE ONLY

For a description of how to perform an operation, enter the letter corresponding to one of the operations listed below.

A
- To proceed to the next screen
- To print a screen
- To get help when answering a question

B
- To review previous screens
- To stop a lesson

If you do not want any explanations, press the <——┘ key twice to continue.

END OF COURSE DESCRIPTION

Press <——┘ to continue.

ELECTRICAL INJURIES

Now that we have reviewed some of the basics of electricity, let us look at the topic of electrical injuries.

INJURIES

Electrical injuries fall into four categories, classified according to their effects on the body.

- BURNS
- VENTRICULAR FIBRILLATION
- CESSATION OF BREATHING
- MUSCULAR CONTRACTIONS

BURNS

BURNS - Electrical current passing through the body heats the tissues. If the current is large enough, the flesh is cooked, causing destruction of muscles, nerves, and blood vessels. There are numerous cases of hands and arms being burned beyond repair. If the current path is through a vital organ, the heart or brain for example, the resulting injuries could be fatal.

NEXT - VENTRICULAR FIBRILLATION Press <───┘ to continue.

VENTRICULAR FIBRILLATION

Low voltage alternating current, not large enough to cause burns, can interrupt the normal rhythm of the heart. In this condition, the fibers of the heart muscles contract separately, irregularly, and at different times resulting in virtual paralysis of the heart. Blood circulation stops. Brain damage and then death most likely occur from lack of oxygen.

Quick action with either or both of the following procedures can revive a person in this condition:

- External cardiopulmonary resuscitation (CPR).
- A defibrillation machine applied by a medical expert.

CESSATION OF BREATHING A person may stop breathing when shocked by a relatively small current. Mouth-to-mouth resuscitation given immediately may revive such a person.

MUSCULAR CONTRACTIONS Very small currents can cause muscles to contract. These involuntary reactions are the most frequent cause of injuries. A small amount of current may cause a person to lose consciousness or to freeze to the source of the current. Or, if it passes through the right combination of muscles, the person could be thrown violently from the source of the current and be seriously injured. In some cases, however, this violent reaction may be life-saving by disconnecting the person quickly from the current.

NEXT - QUESTION ON INJURIES

Press <──┘ to continue

LESSON 2 - ELECTRICAL HEALTH HAZARDS NJIT STUDENT USE ONLY

TOPIC 1 - ELECTRICAL INJURIES AND HAZARDS

QUESTION - Select from the list below the four categories of electrical injuries.

a. Cessation of breathing
b. Duration of contact
c. Ventricular fibrillation
d. Failed insulation
e. Burns
f. Muscular contractions
g. Path of current

Enter the letters "a" to "g" in your answer.

acef

- CORRECT -

1. cessation of breathing
2. ventricular fibrillation
3. burns
4. muscular contractions

END OF TOPIC 1

Press <——┘ to continue.

There are four factors that contribute to the seriousness of electrical injury. They are:

- AMOUNT OF CURRENT
- ELECTRICAL CURRENT PATH
- DURATION OF CONTACT
- TYPE OF CURRENT

Factor 1. AMOUNT OF CURRENT.

The amount of current that passes through the body determines what will happen to the body. The greater the voltage across a resistance (body resistance), the greater the current through it.

There are four general current ranges that can cause electrical injury. They are:

1. Frying current, ... above 200 milliamperes
2. Nerve block current, .. 100 milliamperes to 200 milliamperes
3. Knock-out current, ... 25 milliamperes to 100 milliamperes
4. Freezing current, ... below 25 milliamperes

NEXT - FATAL CURRENT FLOW

Press <———┘ to continue.

Current increases as voltage is increased or as resistance is decreased.

The higher the voltage contacted,
the less callus the skin,
the moister the skin,
the firmer the grip,
the greater the pressure of contact,
and
the greater the area of contact,
.
.
.
THE GREATER THE LIKELIHOOD OF FATAL CURRENT FLOW!

Factor 2. ELECTRICAL CURRENT PATH.

The amount of electrical current determines what will happen to the body. With a high current shock, the injury could be fatal if the current is between one arm and the other, or one arm and a leg. However, if the current passes from the elbow to the hand of one arm, the injury would be confined to that arm.

Factor 3. DURATION OF CONTACT.

If contact is made with 110 volts AC with sweaty hands, the current that would flow could cause blisters to form and rupture the skin. The skin resistance that was about 1500 ohms at the moment of contact may be reduced in a short period of time to a low value, making the total body resistance about 500 ohms. At this level of body resistance, the current through the body can increase enough to cause ventricular fibrillation.

NEXT - FACTOR 4 Press <——┘ to continue.

Factor 4. TYPE OF CURRENT.

With a given voltage, direct current (DC) causes a greater degree of burned flesh than alternating current (AC). This is because there is more electric power dissipated in the body with DC than with AC. However, it takes less alternating current, passing through the heart region, to cause a heart condition. The fluctuation of AC from maximum voltage to zero, causes the normal heart action to be easily upset.

NEXT - NOTES 1, 2, & 3 Press <——┘ to continue.

THREE POINTS TO REMEMBER

REMEMBER 1	Current path determines which parts of the body will be damaged.
REMEMBER 2	Length of contact time, together with the amount of current, determines the extent of the damage.
REMEMBER 3	Approved electrical gloves and other insulating devices are only as safe as their users make them. Torn rubber gloves and cracked insulation are of no value.

As a matter of fact, they are dangerous because their users are lulled into a false sense of safety.

NEXT A QUESTION ON CURRENT PATH Press <——┘ to continue.

QUESTION - Yes or No. When contacting a voltage, would a person with sweaty hands be in more danger of a fatal electrical injury than with dry hands?

Please enter the word "yes" or "no".

If your metal watch band came in contact with a voltage, the larger area of skin contact, as well as sweat under the band, would increase the current.

WEARING JEWELRY IS PROHIBITED.

yes

CORRECT - The dry resistance is approximately 100 times more than the wet resistance, therefore current would be about 100 times less for the dry hands.

NEXT: A QUESTION Press <——┘ to continue.

LESSON 2 - ELECTRICAL HEALTH HAZARDS   NJIT STUDENT USE ONLY
TOPIC 2 - FACTORS CONDUCIVE TO ELECTRICAL INJURY

QUESTION - Blisters and skin ruptures caused by contact with a high voltage decrease the body resistance by two thirds. How does this affect the amount of current flowing through the body?

a. The current decreases by two thirds.
b. The current increases by three times.
c. The current increases by two thirds.
d. The current decreases by three times.

Please choose from the statements above. Enter only the letters "a" to "d".

b

CORRECT ---
A decrease in resistance by 2/3 increases the current by 3 times.

QUESTION ON CONTRIBUTING FACTORS   Press <——┘ to continue.

QUESTION - Select from the list below the four ELECTRICAL FACTORS that contribute to electrical injuries.

a. Burns
b. Involuntary reaction
c. Amount of current
d. Duration of contact
e. Cessation of breathing
f. Type of current
g. Path of current

enter only the letters "a" to "g" in your answer.

cdfg

CORRECT ----

1. amount of current
2. duration of contact
3. type of current
4. path of current

NEXT - A QUESTION ON CURRENT RANGES

Press <——┘ to continue.

CONCLUDING INSTRUCTIONS

You have completed Lesson 2.
To complete the course satisfactorily, you must complete each of the following lessons:

```
                   EL1  -  INTRODUCTION TO ELECTRICAL SAFETY
You are here >---> EL2  -  ELECTRICAL HEALTH HAZARDS
                   EL3  -  ELECTRICAL SAFETY METHODS AND TESTING
```

You will return to DOS after this screen.

Then type EL3 and press the $\boxed{<\!\!\text{——┘}}$ to start LESSON 3

END OF INSTRUCTIONS Press <——┘ to continue.

ELECTRICAL SAFETY

Created
By

Edward Gusciora

for
presentation on the
IBM Personal Computer

(May 1, 1989)

NEXT: COURSE COMPONENTS

Press <——┘ to continue.

COURSE DESCRIPTION

NJIT STUDENT USE ONLY

ELECTRICAL SAFETY

LESSONS

EL1 INTRODUCTION TO ELECTRICITY AND HAZARDS

EL2 ELECTRICAL HEALTH HAZARDS

EL3 ELECTRICAL SAFETY METHODS and TESTING

NEXT: OPERATION PROCEDURES

Press <——┘ to continue.

For a description of how to perform an operation, enter the letter corresponding to one of the operations listed below.

A
- To proceed to the next screen
- To print a screen
- To get help when answering a question

B
- To review previous screens
- To stop a lesson

If you do not want any explanations, press the <——┘ key twice to continue.

NEXT: START OF LESSON 3 Press <——┘ to continue.

LESSON 3 - ELECTRICAL SAFETY METHODS

INTRODUCTION

NJIT STUDENT USE ONLY

This lesson contains 5 Topics.

1. THE FIVE I`S OF ELECTRICAL SAFETY
2. RULES FOR ELECTRICAL HAND TOOLS
3. ADDITIONAL SAFETY GUIDELINES
4. FOUR PERSONAL RULES OF ELECTRICAL SAFETY
5. EMERGENCY METHODS

END OF INTRODUCTION

Press <——┘ to continue.

ABSTRACT

THE 5 I`s - Inspect, Insulate, Isolate, Indicate, Intelligence.

Rules for Electrical Hand Tools

Additional Safety Guidelines

Four PERSONAL RULES of Electrical Safety

EMERGENCY PROCEDURES

THE FIVE I`s

In order to prevent electrical accidents, one should understand and know the Five I`s of Electrical Safety.

- INSPECT
- INSULATE
- ISOLATE
- INDICATE
- INTELLIGENCE

Each of these keywords will be defined on the following screens.

$\boxed{\text{INSPECT}}$ INSPECT - Inspect periodically all electrical equipment for broken or loose parts. Insulation can deteriorate and crack if flexed over a period of time. Most materials and components used in electrical circuits deteriorate with time and use.

$\boxed{\text{INSULATE}}$ INSULATE - Insulate all exposed wiring and terminals. This insures against inadvertent contact.

$\boxed{\text{ISOLATE}}$ ISOLATE - Isolate all potentially dangerous areas with covers or shields. Do not perform power-up troubleshooting on electrical equipment with exposed high voltage circuitry. One should not be able to accidentally contact dangerous voltages while working on any circuit.

NEXT: INDICATE, INTELLIGENCE

Press <——┘ to continue.

INDICATE

INDICATE - Indicate with signs and locks all danger areas. An undesignated danger area is very much like a poison kept in an unlabeled bottle.

Warning tags must be used when equipment is being serviced, to prevent other personnel from activating the equipment. The tag must be visibly attached to the primary switch or control of the equipment and should be locked OFF by a padlock or other locking device. Warning tags must have the wording "DO NOT OPERATE". The name of the person who attached the tag must also appear on the tag. The reason for the shutdown may also be included.

INTELLIGENCE

INTELLIGENCE - Intelligence is a prerequisite to working on electrical equipment. Know what you are doing and why you are doing it. Know what protective equipment should be used and what procedures are required. Do not touch it if you don`t know what it is.

NEXT: A QUESTION ABOUT WARNING TAGS Press <——┘ to continue.

QUESTION - You`ve tagged a device and later decided to bring power up for a minute to check what you have done. Since you wrote the tag, should you bring up power without first removing the tag?

Please enter "Y"es or "N"o

no

CORRECT - Devices with warning tags must not be operated at any time by anyone until the warning tag has been removed by the person who attached it.

NEXT: A QUESTION ON THE FIVE I`S Press <——┘ to continue.

QUESTION - One of the five I`s of electrical safety is INTELLIGENCE. Select from the list below, in any order, the other four I`s.

a. INACTIVATE
b. INDICATE
c. INFORM
d. INSULATE
e. INSPECT
f. ISOLATE
g. INVENT

bdef

CORRECT - The five I`s are INSPECT, INDICATE, INSULATE, INTELLIGENCE, ISOLATE

END OF TOPIC 1, LESSON 3

Press <——┘ to continue.

HAND TOOLS

HAND TOOLS - There are certain procedures concerning electrical hand tools that one should observe. They are:

- New tools must be inspected.
- All tools must be inspected periodically.
- All tools must be repaired by qualified personnel.
- Unapproved power tools may not be used.

NEXT - HAND TOOLS, RULE 1

Press <——┘ to continue.

HAND TOOLS - RULE 1. NEW TOOLS MUST BE INSPECTED

New tools must be inspected by a qualified person.

All tools must have a 3-wire, grounded plug or be double insulated. Double insulated tools must indicate on the tool that it is double insulated and bear the Underwriter`s Laboratory (UL) approval or that of another nationally recognized testing laboratory. The insulation between the motor and the exposed metal parts along with insulation of the tool housing is known as double insulated and allows the use of a 2-wire plug.

HAND TOOLS - RULE 2. TOOLS MUST BE INSPECTED PERIODICALLY

Each tool that you use must be inspected periodically and maintained by qualified personnel to insure that it is safe for it`s intended use. If a defective tool is discovered, remove it immediately from service and tag it as defective so that a qualified person can repair it.

One important item in the inspection is the ground wire which connects the tool housing to the electrical ground. This ground wire should be color coded green if it is insulated or may be uninsulated copper stranded. If a live wire in the tool shorts to the tool housing, the tool will remain at ground potential, protecting the operator from a fatal shock.

NEXT - HANDS TOOLS RULE 3 & 4 Press <——┘ to continue.

HAND TOOLS - RULE 3. TOOLS MUST BE REPAIRED BY QUALIFIED PERSONNEL

All tool repairs must be performed by qualified personnel, not the user, this will help prevent dangerous make-shift repairs that would not conform to the original quality standards.

HAND TOOLS - RULE 4. UNAPPROVED POWER TOOLS MAY NOT BE USED.

Personal electric hand tools should not be brought into work. This is to insure that no unapproved or unsafe tool is used. Do not use other`s tools; they may not maintain them with the intended cautions and care.

NEXT - A QUESTION ON SPECIAL TOOLS

Press <——┘ to continue.

QUESTION - If the need arises for a special electrical tool, can you borrow one from a contracted employee working down the hall?

Please enter "Y"es or "N"o

no

CORRECT - Hand Tool Rule #4 states: Unapproved power tools may not be used. Others may not be responsible to maintain their tools with the intended caution.

NEXT - ELECTRICAL FAULT TESTING

Press <——┘ to continue.

ELECTRICAL FAULT TESTING

Testing of electrical equipment for trouble areas is a valuable aspect of any safety or preventative maintenance program.

The use of infrared testing of equipment has now come of age as a relatively inexpensive and effective means of detecting loose connections, failed insulation, worn mechanical bearing, and bad or corroded wires.

The testing is usually contracted to a company specializing in this form of testing. The operation consists of taking a heat photograph of operating equipment. The picture produced will show bright spots indicating high heat gradients which can be equated to high resistance, a loose connection or a bad wire. All the discovered hot-spots can then be part of a preventative maintenance program to correct the warnings before they escalate into an emergency situation such as a shock or electrical fire.

REMEMBER: TO PREVENT AN ACCIDENT MAY BE THE SAME AS SAVING A LIFE!!!!

THE FOUR PERSONAL SAFETY RULES

These rules are basic rules which you should always observe and always practice. Negligence on your part could cause permanent damage to yourself and others.

The four Personal Safety Rules are:

1. Don`t work alone.

2. Know the location of the disconnect switch (EMO SWITCH).

3. Wear no jewelry.

4. Wear safety glasses.

NEXT - PERSONAL RULE 1 Press <——┘ to continue.

PERSONAL RULE 1. DON`T WORK ALONE

In case you have an accident, it`s imperative that you receive medical aid immediately! Have a fellow worker in hearing or seeing distance; then he or she is in a position to spot your predicament and lend assistance.

NEXT - PERSONAL RULE 2 Press <———┘ to continue.

PERSONAL RULE 2. KNOW THE LOCATION OF THE DISCONNECT SWITCHES

Learn the location of the power disconnect switches that control the voltage to the area in which you are working.

Another method of removing power is the Emergency Machine Off (EMO) switch that is located on most equipment. It controls the main power distribution within the unit, or in the case of a newly designd system area, an EPO switch may control all the power within the area.

You should also know the location of your fellow worker`s disconnect or EPO switch. In the event of an accident, you will know how to remove power from the immediate vicinity of the accident.

NEXT - PERSONAL RULES 3 & 4 Press <——┘ to continue.

PERSONAL RULE 3. WEAR NO JEWELRY

Don`t wear jewelry near exposed electrical equipment. In the event of contact there will be increased current flow due to the larger contact area provided by the jewelry.

PERSONAL RULE 4. WEAR SAFETY GLASSES

Safety eye protection standards state that when working on equipment where there is a possibility of flying objects, liquid, and injurious radiation safety glasses are required, especially where high voltage or current exists. Accidentally shorting a voltage bus could cause pieces of molten metal to fly into the air, possibly into your eyes. Metal rim glasses must not be worn when working around exposed hazardous voltages and currents.

NEXT: QUESTION ON PERSONAL SAFETY Press <——┘ to continue.

QUESTION - Select from the list below, in any order, the four PERSONAL RULES of electrical safety.

a. Wear no jewelry.
b. No food into the test area.
c. Don`t work alone.
d. Wear insulated gloves.
e. Know the location of the power disconnect switch.
f. Wear safety glasses.

acef

CORRECT - The four Rules are: DON`T WORK ALONE; WEAR NO JEWELRY WEAR SAFETY GLASSES; KNOW THE LOCATION OF THE DISCONNECT SWITCH

NEXT: EMERGENCY METHODS Press <——┘ to continue.

Know how to respond to an emergency, so if an accident occurs, you will be prepared to help save a life.

1. Use caution - don`t panic and become a victim yourself.
2. Know how to turn the power off by means of the Emergency Power Off switch (EPO) or disconnect switch.
3. Know how to get an emergency response team or medical help.
4. Know cardiopulmonary resuscitation (CPR) or first aid.
5. Know the proper use of fire extinguishers.

END OF
LESSON 3

TO PRINT THE ELECTRICAL SAFETY COURSE COMPLETION CERTIFICATE

Hold the key down and press the PrtSc * key.

ON THE FOLLOWING SCREEN

NEXT: COMPLETION CERTIFICATE

Press <——┘ to continue.

ELECTRICAL SAFETY COURSE COMPLETION CERTIFICATION

I hereby certify that on this date I have completed the computer instructional electrical safety course consisting of the following lessons:

1. INTRODUCTION TO ELECTRICAL SAFETY
2. ELECTRICAL HEALTH HAZARDS
3. ELECTRICAL SAFETY METHODS AND TESTING

Student`s name (please print)   Social Security #   Date

Student`s Signature ______________________________

Version 5/1989

NEXT: COMPLETION CERTIFICATE   Press <——┘ to continue.

END OF COURSE

M A K E   A   S A F E T Y   D E C I S I O N   T O D A Y

THE END

Press <──┘ to continue.