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# Development of an expert system for the safety of workers from electrical hazards at work place

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# ABSTRACT

**Title of Thesis:** Development of an expert system for the safety of workers from electrical hazards at workplace.

**Faizul Islam,** Master of Science in Manufacturing Engineering, 1991

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This thesis presents the development of an expert system for the safety of workers from electrical hazards at work place.

The objective of this work is to show how an expert system within the workplace can be used in helping to create an effective safety program.

An effective expert system for electrical safety have been developed for the workers to prevent accidents from electrical hazards using the safety regulations of Occupational Safety and Health Administration.

The regulations developed by OSHA have been incorporated in rule based expert system which can be accessed by any non computer professional and the system acts like a consultant in helping out to follow the required regulations.

The system developed cover rules for all the equipments and installations used to provide electric power and light for employee workplace.

# DEVELOPMENT OF AN EXPERT SYSTEM FOR THE SAFETY OF WORKERS FROM ELECTRICAL HAZARDS AT WORK PLACE.

by

Faizul Islam

Thesis submitted to the faculty of the Graduate School of the New Jersey Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Manufacturing Engineering 1991.

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**Dedicated to my parents**

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# CHAPTER 1

# INTRODUCTION TO THE CONCEPT OF SAFETY

## 1. Introduction:

In this chapter, different terminologies used by the safety professionals have been discussed and defined.

In the beginning of the chapter an attempt has been made to give a brief background of the nature of accidents, the number of people involved and the causes of most of the disasters. The objective of the chapter is to familiarize' the readers with the idea and concept of industrial safety.

## 1.1 PROBLEM OF SAFETY:

This era of science and technology has provided human beings with many blessings but with it came some associated complexities and problems as well. These complexities might have been from the very beginning but had never been recognized or were being overlooked. The problem of safety is one of them and it has always been there but now the effect of any failure to normal operation is more drastic, severe and mostly non compensatable.

The world has recognized the importance of this aspect now and there are statues and laws to take care of any mismanagement and non fulfillment of required facilities and procedures.

People are working since the beginning of human race and sometime it is the test of physical endurance and on occasions it has drag the human being to its full mental exhaustion. There is no way to avoid it because work is necessary for survival but it could be made less exhausting, more relaxing, comfortable and enjoyable.

It is hard to remove the perils completely out of the work place but the chance of catastrophic disasters could be made lesser if not completely eliminated. The statistics of accidents show that over 14,000 persons are killed and 2.2 million are injured seriously enough every year in USA that they cannot go to work. This only

covers the figure that are in records of Bureau of Statistics and does not take any account of those which remained unreported or unnoticed.

Similarly, according to statistics published each year by National Safety Council, United States is caught up in a repeating accident syndrome that is really painful and alarming [1]. According to these figures, the number of deaths and disabling injuries have reached 9 million annually and is still escalating and the cost associated with these accidents is around $130 million. Again, these statistics which are the results of different studies have not counted unreported and over-looked accidents or their associated costs or the after-effects and consequences resulting from long term, low level exposure to hazardous working environment.

Most of these figures in these statistics only account for those who die violently or injured by physical accidents such as electric shock, fires or fall from high places.

No considerations have been made for those who are prematurely aged, or suffered crippled bodies and minds while working in hazardous environment for their livelihood.

Keeping in view the above point, it is important to disregard presently available figures when considering the hazards of modern industrial work.

So the above discussion highlights the fact that the state of working conditions are even worse than the figures actually show and there is a need for the development of logically based system safety program. Also, the developments and accomplishments in space and defence technology, automotive industry, computer and nuclear technology, all have emphasized the importance and need for having a comprehensive safety program.

There has never been more need than now for hazard identification, management and hazard control, and the recent disasters such as Chernobyl and Bhopal nuclear and chemical incidents, recent train collisions (Amtrak/Conrail 87), Three mile island incidents and Challenger space shuttle O.ring destruction, all of these

incidents should be enough to make the management and government authorities realize the fact that it is the time to give the safety affair the due importance and take safety issues very seriously.

Before describing different terminologies used in the field of safety, it is necessary to give the infra-structure of different safety agencies which are monitoring different laws and their enforcement, and are also responsible for formulating different safety laws.

It all started in December 1970 when the occupational safety and health act was passed and signed by President Richard M. Nixon. The Congress of the United States declared that the purpose of this piece of legislation is " to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources."

Before this act, there were few federal laws but their applicability was limited to only a small number of employers.

**1.2. ADMINISTRATION [2]**

Administration and enforcement of the OSHAct are vested primarily with the Secretary of Labor and the Occupational Safety and Health Review Commission. With respect to the enforcement function, the Secretary of Labor performs the investigation and prosecutions aspects of the enforcement process and the Review Commission performs the adjudication portion of the enforcement process.

Research and related functions and certain educational functions are vested in the Secretary of Health, Education, and Welfare and are, for the most part, carried out by the National Institute for Occupational Safety and Health established within the Department of Health and Human Services. Compiling injury and illness statistical data is handled by the Bureau of Labor Statistics, U.S. Department of Labor. to assist the Secretary of Labor, the Act authorizes the appointment of an Assistant Secretary of Labor for Occupational Safety and Health. The Assistant Secretary is

the chief of the Occupational Safety and Health Administration (OSHA) established within the Department of Labor. The Assistant Secretary acts on the behalf of the Secretary of Labor.

### 1.3 Occupational Safety and Health Administration

The Occupational Safety and Health Administration came into existence officially on April 28, 1971.

The responsibilities included :

1. To promulgate, modify, and revoke safety and health standards.
2. To conduct inspections and investigations and to issue citations including proposed penalties.
3. To require employers to keep records of safety and health data.
4. To petition the courts to restrain imminent danger situations.
5. To approve or reject state plans for programs under the act.

The act also authorizes OSHA

1. To provide training and education to employers and employees.
2. To consult with employers, employees, and organizations regarding prevention of injuries and illnesses.
3. To grant funds to the states for identification of program needs and plan development, experiments, demonstrations, administration and operation of programs.
4.. To develop and maintain a statistics program for occupational safety and health.

### 1.4 Occupational Safety and Health Review Commission

The principal function of the Commission is to adjudicate cases resulting from an enforcement action initiated against an employer by OSHA when any such action is contested by the employer or by his employees or their representatives.

### 1.5 National Institute for Occupational Safety and Health

It was established through the provisions of the OSHAct. Originally NIOSH came under the direction of the HEW, which has since evolved to become the Department of Health and Human Services.

The responsibilities of NIOSH are as follows:

1. Research and related functions to determine new occupational safety and health standards.

2. Educating and training to assure qualified safety and health professionals and informational programs to educate individuals on the adequate use of safety and health equipment.

3. Employee and employer services, including hazard evaluations, technical information exchange, accident prevention, industrial hygiene, and medical services.

### 1.6 Bureau of Labor Statistics

This department is responsible for doing surveys and establishing techniques and methodologies for analyzing the data gathered.

Having mentioned about the agencies which run this safety business it is also necessary to mention that the approach for solving and dealing with safety hazards need a scientific handling and thats why identification and control of hazards require a systematic approach and methodology and could be studied under a relatively recent term "System Safety".

### 1.7 SYSTEM SAFETY TERMINOLOGIES

Few of the definition pertinent to System Safety are described below [3].

#### 1.7.1 THE HAZARD:

The word hazard has many definitions listed in the dictionary; among them are:

1. risk, peril, jeopardy
2. a source of danger
3. chance or a chance event or accident

4. mistake

5. something risked

The safety person sees a hazard as an implied threat or danger of possible harm. It is a potential condition waiting to become a loss. A stimulus is required to cause the hazard to transfer from the potential state to the loss. The stimulus could be component failure, a condition of the system (pressure, temperature, switching condition i.e. out of tolerance, a maintenance failure, operator failure, or a combination of other events and conditions.

The following is more technical definition of hazard:

A potential condition, or set of conditions, either internal and/or external to a system, product, facility, or operation, which when activated transforms the hazard into a series of events that culminate in a loss (an accident). A simpler and more fundamental definition of hazard is a condition that can cause injury or death, damage to or loss of equipment or property or environmental harm.

**1.7.2 THE SYSTEM:**

A group of interacting, interrelated, or interdependent elements forming or regarded as forming a collective unity. A more direct definition of system is a composite set of people, procedures and equipment that are integrated to perform a specific operational task or function within a specific environment. A subsystem represents an element of a system that may constitute a system in itself.

**1.7.3 THE STIMULUS:**

The normal system has a hierarchy of subsystems, assemblies, subassemblies, and components. The number of these elements in the hierarchy will vary with the type of system and its complexity. Naturally, the components are interconnected in such a manner that they perform specific function when input is provided from a source, such as component or human operator. Thus an action of component will create

output. This series of interconnected events cause a sequential, logical action in the system .

**1.7.4 THE ACCIDENT:**

We normally think of accident as the loss of a system or part of a system, the injury to or fatality of the operators or personnel in near proximity, and property damage of related equipment or hardware. An accident is usually a dynamic event since it results from the activation of a hazard and culminates in a flow of sequential and concurrent events until the system is out of control and a loss is produced. Although we think in terms of the events proceeding logically, we should remember that environmental influences are part of these logical relationships. Accident events may be fire, explosion, high energy release, destruction of parts, separation of parts of the system, and so on. We must focus on the set of events that occurs and leads to the accident resulting in a loss, thus the accident can be defined as a dynamic mechanism that begins with the activation of a hazard and flows through the system as a series of events, in a logical sequence, to produce a loss. A simpler statement from another point of view is that an accident is an undesired an unplanned event that results in death, injury or property damage. An accident is closely related with a definition of an unforeseen event or occurrence that does not result in death, injury or property damage. This is commonly called a 'near miss'. The word mishap is commonly used in place of accident. Damage is partial or total loss of system hardware, the environment, or closely related property due to the occurrence of the accident.

**1.7.5 SAFETY:**

If we return to the dictionary, we find safety defined as "the condition of being free from undergoing or causing hurt, injury or loss". Put another way, total safety is freedom from potential harm. The system safety professional may use such terms as increased safety, improved safety, and safer.

These characteristics are an integral part of a system (and a certain confidence in the system functions may be attributed to them by their designers and operators). Safety in a system may be defined as a quality of a system that allows the system to function under predetermined conditions with an acceptable minimum of accidental loss.

**OTHER HAZARD DEFINITIONS:**

**1.7.6 HAZARDOUS EVENT:**

An occurrence that may lead to an accident.

**1.7.7 HAZARDOUS EVENT PROBABILITY:**

The likelihood, expressed in quantitative or qualitative terms, that a hazardous event will occur.

**1.7.8 HAZARD PROBABILITY:**

The aggregate probability of occurrence of the individual hazardous events that create a specific hazard.

**1.7.9 HAZARD SEVERITY:**

An assessment of harm that could be caused by a specific hazard.

**1.7.10 WHAT IS SYSTEM SAFETY?**

The system safety concept is the application of special technical and managerial skills to the systematic, forward looking identification and control hazards throughout the life cycle of a project, program or activity. The concept calls for safety analyses and hazard control actions, beginning with the conceptual phase of a system and continuing through the design, production, testing, use and disposal phases, until the activity is retired.

**1.7.11 SYSTEM SAFETY OBJECTIVE:**

A safety objective such that each person will live and work under conditions in which hazards are known and controlled to an acceptable level of potential harm .

# CHAPTER 2

# ELECTRICAL HAZARDS AT WORK-PLACE

## 2.1 Introduction:

In this chapter, the possible electrical hazards, their causes and their preventions have been discussed at length. In the beginning, the effect of current and voltage at different amperage and frequency on the human body have been discussed along with the resistance offered by human body under dry and wet conditions.

The possible failure effect of different electrical equipments and appliances have also been discussed. The effects of natural lightning and static electricity have also been dealt.

The purpose of this chapter is to make the reader familiar with the effect of electrical operations on human body and to give a brief idea of what possible hazards could be faced in the industry setup and what could be the consequences in case of any accident or disaster.

## 2.2 ELECTRICAL HAZARDS:

The source of energy most widely used to supply power whether to industrial environment or to domestic use, has always been electricity and will continue to be like that and associated with it comes the hazards due to its extensive use.

Common use of high tech instruments in the industry or the domestic appliances at home has resulted in failure of recognition of hazards involved by a very large volume of population.

The different categories in which these electrical hazards can be divided are [4]:

1. Shock to Personnel and flash burns
2. Ignition of Combustible materials
3. Overheating and damage to equipments and burns

4. Electrical Explosions

5. Inadvertent activation of equipment

**2.2.1 ELECTRIC SHOCK AND FLASH BURNS:**

When the electric current flows through the human body, it can cause shock and injury.

Shock can be described as sudden and accidental stimulation of human beings nervous system by the flow of electric current. The flow of current through the human body depends on the resistance of body and the potential difference associated with the electric current. If this potential difference is powerful enough to overcome the resistance offered by the body then there will always be a flow of current.

The intensity and severity of the injury depends on the following factors:

1. The magnitude of current flowing.

2. Nature of current i.e. whether it is direct or alternating current.

3. If it is alternating current, what is the magnitude of frequency.

4. The duration of current flow through the body.

Most fatal accidents occurs when the current flows from hands to feet through the body near the heart. Relatively large currents can pass from one leg to other with only contact burns. Contrary to it, similar current from arm to arm or arm to leg may clamp the heart or paralyze the respiratory muscles.

As stated before, the flow of current through the body depends on the resistance of body and additional resistance between it and earth. The resistance of human body is high when the skin is dry as compare to the resistance offered by wet skin. The human skin has been divided into two layers. The outer layer has a very high resistance when dry and is composed of dead, scally cells. When it is dry, clean and unbroken, it offers very good resistance and its range vary from 100,000 to 600,000 ohms of resistance depending upon the thickness of the layer.

When the layer is wet and broken, the resistance it offers reduce drastically to just 500 ohms or even less. The reason for it is that the current can pass to the inner skin layer, which has less resistance. The cause of this lower resistance is the presence of body fluids which makes the inner layer moist. Dry skin offers a resistance to flow of current 10 times that of wet skin. Similarly resistance of a person drops to 50% when the person has washed his hands as compared to before it. The resistance offered by man's body is much more than that offered by feminine sex and the same effects are said to be produced with about 60% of the current required in a man. Most common injuries which are faced by human to flow of electric current are [5]:

| | |
|---|---|
| 1. Burns | Above 200 milliamperes |
| 2. Ventricular Fibrillation | 100 to 200 milliamperes |
| 3. Cessation of Breathing | 25 to 100 milliamperes |
| 4. Muscular Contraction | Below 25 milliamperes |

Effect of electric current on a man's body at different alternating or direct current can be seen by the following table:

| **Current in Milliamperes** | | | **Effect** |
|---|---|---|---|
| **a.c 50 Hz** | **d.c** | **a.c. 1000 Hz** | |
| 0-1 | 0-5 | 0-9 | No sensation |
| 1-8 | 6-55 | 10-55 | Mild shock |
| 9-15 | 60-80 | 60-80 | Painful shock |
| 16-20 | 80-100 | 80-100 | Some loss of muscular control |
| 20-45 | 100-350 | | Severe shock of loss of muscular control |
| 50-100 | 400-800 | | Possible hear failure |
| over 100 | over 800 | | Usually fatal |

The effect of any amperage varies with the frequency. Alternating currents with as low potential as 18 volts or direct currents upto 140 volts have never been fatal.

As compared to alternating currents, direct currents required 3 to 5 times intensity to produce the same effects as that of alternating current.

Currents with frequencies of 20 to 100 hertz are the most hazardous. In most commercial systems 60-hertz current is used which is hazardous because it is close to the frequency range at which ventricular fibrillation exist. It probably decreases inversely with the increase in frequency so at 100 hertz the chances of fibrillation is less. A high frequency current flows over the surface of body and not through the inner portion. So currents with high frequency will cause less internal problems than do lower frequencies.

Dry skin is considered to possess great resistance but this resistance is very easily broken down by a high voltage. High voltage frequency current causes violent muscular contraction, often so severe that the victim is thrown clear. Lower voltage may cause less violent contraction but even then prevent the victim from freeing himself, so the effect is no different.

Human body can be injured in the following ways by electric shocks.

1. Temporary paralysis of the nerve center leading to breathing failure. This failure may continue for a considerable time after the current has been removed. During this time the victim must be kept alive by artificial respiration.
2. Contraction of chest muscles causing interference with breathing, leading eventually to asphyxiation.
3. Irregular movement of heart muscles – known as ventricular fibrillation – which causes blood circulation to stop. The heart cannot spontaneously recover, and death usually follows.
4. Suspension of heart action by muscular contraction, from which the heart may recover when the flow of current ceases.

5. Haemorrhage and destruction of nerves, tissues and muscles, caused mainly by heat. Flash burns can be caused by operating switches, removing fuses from energized circuits or by shorting cables. These burns may be deep and slow to heal.

Welding flashes cause eye pain to personnel exposed to them even at considerable distances.

The pain, due to ultra-violet light, is often not immediate but is felt after two or three days.

Electric welding operations should be screened so that the eyes of personnel not involved with them are not exposed to the flashes.

The use of specialized electrical equipment have introduced new hazards. The equipments use ultra violet, infra-red or other light source. In addition to it there are different X-ray machines and high frequency heating installations. All these equipments have made the hazards more prominent and need trained and professional personnels for installation, maintenance and protection of equipments.

Painful burns can also be caused by coming in contact with high frequency power supply and these high frequency transmission lines, generators, heaters and other equipments require safety interlocks and shieldings to prevent any possible injury or damage.

Normally there are five principle ways by which a person can be shocked :

1. Contact with a normally bare energized conductor.

2. Contact with an energized conductor on which the insulation has deteriorated or has been damaged so that it has lost its protective value.

3. Equipment failure which causes an open or short- circuit.

4. Static electricity discharge.

5. Lightning strike.

### 2.2.2 Bare Energized Conductor:

There are lots of electrocution cases in which energized bare conductors are used. The most common example of such cases are overhead electrical line. Mostly people working in construction industry, electrical corporations or persons working on rooftops are subject to this type of hazard.

Most of the fatalities from this sort of hazard occurs due to failure in following the safety codes.

### 2.2.3 Electric Insulation Failures:

A person could be shocked and seriously injured because of deterioration or damage in the condition of insulations used.

The insulation can get defective because of numerous reasons.

One of the cause is that insulation material is not uniform through out and as a result resistance and specific heat is not same at every place, so the heat due to power loss in the conductor causes the temperature in high specific heat areas to increase more than in other and deteriorate sooner.

There are several other causes of deterioration of insulations, few of them are due to:

1. Moisture and humidity
2. Heat and elevated temperatures
3. Radiation
4. Oxidation
5. Biological factors
6. High voltages
7. Mechanical damage
8. Chemical incompatibility

**2.2.4 Equipment failures:**

There could be problems when there are failures of equipment. For example, faults in electrical, especially portable tools cause the housing to be energized. The appliance may have a broken connection or wrongly replaced internal wiring which touches the tool or appliance housing. When the device is turned on, the user receives a shock when the person touches the housing.

Similarly if the tool is not ground and the person who touches the equipment is not insulated, the person may form connection to ground through which current will pass.

Three wire systems are being used to overcome and minimize the problem.

Out of three wires, the third wire in it is used for grounding purpose (the other two being positive and negative respectively) but sometimes the outlets are not grounded properly so the ground wire becomes useless.

Thus a strict observation and following of OSHA regulations and requirements are necessary for safe operation of equipment and appliances.

**2.2.5 Static Electricity:**

It consists of an excess or deficiency of electrons on the surface of a material and it discharges because of its capacitive nature which can cause repeated sparking.

There are several means by which static electricity problem can be controlled :

**Selection of Suitable Materials:**

Selection of such material which do not generate static electricity.

**Making a material suitable:**

Sprays and coatings are available to make the surface conductive thus reducing the problems of static electric.

**Bounding and Grounding:**

Surface are bounded to provide a path by which neutralization can occur.

Similarly grounding can be done to provide a path by which electrons can be discharged.

**Humidification:**

If relative humidity can be raised above 65%, charges will be able to leak off and dissipate.

### 2.2.6 Lightning:

It is one of the major source of static electricity and a natural discharge of very high potentials and current takes place.

It mostly causes problems at elevated structures because it is always looking for easiest path to earth.

To be protected from its effects lightning rods are used at higher positions then any nearby structures.

Certain material structures are more subject to lightning strikes then others because of the path they provide to ground.

## 2.3 IGNITION OF COMBUSTIBLE MATERIALS:

Electrical installations in majority of the cases are not designed to eliminate sparking or local hot spots which might ignite an explosive mixture of a flammable gas, vapor or powder and air.

Normally ignition by contact with an electrically heated surface generally requires the expenditure of considerable power to cause the heating. On the other hand, arc or spark involves little energy but is discharged rapidly in limited space where it is adequate to cause the ignition of an extremely small volume of flammable mixture. Energy released from this combustion is good enough to cause further propagation of fire.

The use of electrical equipments and circuits in flammable atmospheres possess few questions which have to be answered before allowing any equipments, if at all in the hazardous area.

The questions could be:

1. Is it easy to ignite the flammable material.

2. How far does the hazard extend.

3. What amount of hazardous material is liable to be ignited and what will be total impact.

What actually happens in industry is that a policy of safeguard is adopted against the effects of relatively small escapes by allowing no possible source of ignition within 7.5 meters of likely source of emission.

Large emissions in an industrial complex are almost certain to reach a source of ignition before being diluted by air to harmless concentration. At sea or in open space, the chances of large emission to disperse harmlessly are more.

## 2.4 OVER HEATING AND DAMAGE TO CIRCUITS, EQUIPMENTS OR BURNS:

Whenever we are using electricity as a source of power, there will always be generation of heat which could be either as designed or expected, or could be unavailable and unproductive loss because of resistance to flow of conductor.

As a result of electrical heating, the most principal effect is the cause of accidental fires.

It can:

1. Raise a flammable mixture to a temperature where it ignites easily.

2. Raise the mixture to its ignition temperature where it ignites.

3. Cause insulation, wood and other organic materials to melt or burn.

4. Cause rapid evaporations of liquid fuels so flammable concentrations are created.

5. Cause breakdown of noncombustible polymeric materials to produce less complex but combustible compounds.

6. Cause burnouts of operating equipment raising its temperatures so high that the equipment fails and sometimes ignites.

7. Cause the material surface to become so hot that any person who touches it inadvertently may get burned.

The safety law requires effective measures to avoid any damage from the possibility of over heating. Almost all circuit protection is to guard against overloads of currents. Similarly protective devices ensure that current flow does not produce heat which causes temperatures to rise to dangerous levels.

## 2.5 ELECTRICAL EXPLOSIONS:

If a very heavy current flows from a conductor which is inadequate for it either because of its size or material, there are chances that it may explode. Circuit breakers, fuses, switches and other equipments may explode due to rapid over heating caused by overcurrents either because of short circuits or current surges.

This type of thing is sometime done purposely, for example in a electro explosive device but if it happens unintentionally it causes lot of problems.

## 2.6 INADVERTENT ACTIVATION:

This inadvertent activation of equipments mostly at work places have caused lots of deaths and injuries. There have been so many instances where people have been injured or killed, when they crawled inside to repair or clean electrically operated equipments.

Precautionary measures to lower the probability of any unintentional activation is very essential and every possible step as required by the department of Occupational Safety and Health Administration should be taken to avoid any possibility of loss or damage due to it.

# CHAPTER 3

# INTRODUCTION TO ARTIFICIAL INTELLIGENCE

## 3.1 Introduction:

The objective of this chapter is to introduce some of the basic concepts of artificial intelligence i.e. how it works, where it is being applied and in which applicable areas it has potential to grow.

For presenting the knowledge like a consultant, expert system has been used in this thesis because of its ability to behave like a specialist and the ability in it to store, access and update large amount of text and data.

Expert System has been discussed at length in the second part of this chapter, so that the reader could understand, what is it and how it works.

Last portion of this chapter covers a description of VP EXPERT, the software on which all the electrical regulations for the safety of workers have been programmed.

## 3.2 ARTIFICIAL INTELLIGENCE:

Artificial intelligence is an attempt to utilize formal and informal human knowledge in a structured way [6].

The potential of this rapid growing new concept is based on increasing the availability and usefulness of expert knowledge.

Further, it is being used to enhance the understanding of human thought processes and is facilitating the generation of new knowledge.

### 3.2.1 A Definition of Artificial Intelligence :

According to Donald Knuth "The difference between art and science is that, science is what we can program into a computer, all else is art" [7].

Artificial intelligence covers so much intellectual ground that it can be difficult to define it much more precisely than that.

To William Taylor, the author of "What every engineer should know about Artificial Intelligence", it is two unrelated things:

1. Human emulation that does not work
2. Software techniques that are ready for use

According to him, Artificial Intelligence is a programming style, where programs operate on data according to rules in order to accomplish goals.

This programming style corresponds to applied engineering practices. Data is supplied in the statement of problem. Rules are the properties of materials, design experience, contents of technology manuals, the accumulated wisdom of profession.

The goal is to solve a problem -- build a dam, make a circuit, do something a customer wants badly enough to allocate resources to acquire it, etc. etc.

Artificial Intelligence fall into three basic categories:

1. Expert (knowledge base) systems
2. Natural Language (every day native language) System
3. Perception System for vision, speed and touch.

Of the above, natural language systems encompasses programs that understand the native language for the user such as English.

The most popular of such systems are those that act as interfaces to databases.

These interfaces allow database users to query databases in fairly unconstrained English instead of formal query languages. This make database information accessible to non computer professionals.

The perception systems for vision, speech, and touch can interpret visual scenes and decide if objects meet inspection standards and quality control criteria, or move a robot to grasp a part for manufacturing. Currently these vision systems have fairly

limited capabilities. In addition to this most vision systems analyze numeric and pattern recognition techniques and few have any Artificial Intelligence context.

The most popular and rapidly growing field in Artificial Intelligence is the Expert Systems which is discussed in the following pages.

### 3.2.2 Types of Applications:

Artificial intelligence is still in its development stage and it will need more experience before it becomes as pervasive as other computer technologies even then there are already many examples of its practical applications.

Various companies and organizations have reported useful results from using AI technology based systems and the overall performance efficiency and effectiveness have shown improvement by the utilization of this concept.

The following list gives a broad range of its current applications:

* Manufacturing
* Education
* Law
* Medicine
* Accounting and Finance
* Software development
* Weapon systems
* Data processing
* Planning
* Design systems

There are many other interesting applications of Artificial Intelligence and the number of in use systems is increasing very rapidly and is bound to make its impressions on nearly all aspects of life.

## 3.3 EXPERT SYSTEM

An expert system is a computer program designed to represent knowledge of a

particular subject as provided by a human expert or other source of information. This system also includes procedures for utilizing this knowledge to arrive at a solution to a problem of the type which would normally require human expertise.

A computerized model of expert's reasoning and problem solving abilities is first formed and then that knowledge is used to solve the problems in a human like fashion.

Expert system is the most popular version of Artificial Intelligence in engineering.

It can be divided into four basic parts:

1. User Interface
2. Inference Engine
3. Knowledge base
4. Data base

**User Interface:**

This is the component that makes the computer seem intelligent.

It asks the user questions, strikes up a conversation and presents the results.

**Inference Engine:**

In it the logical procedure for finding solutions is incorporated. It could be called "central processing unit" of the expert system. The inference engine conducts the dialog with the user, asking for information and applying it. It uses the knowledge base to draw conclusions for each situation.

The structure of the inference engine depends on the nature of the problem and the way knowledge is represented in the expert system. The inference engine represents both the knowledge base and the procedures to be used for a particular application.

**Knowledge Base:**

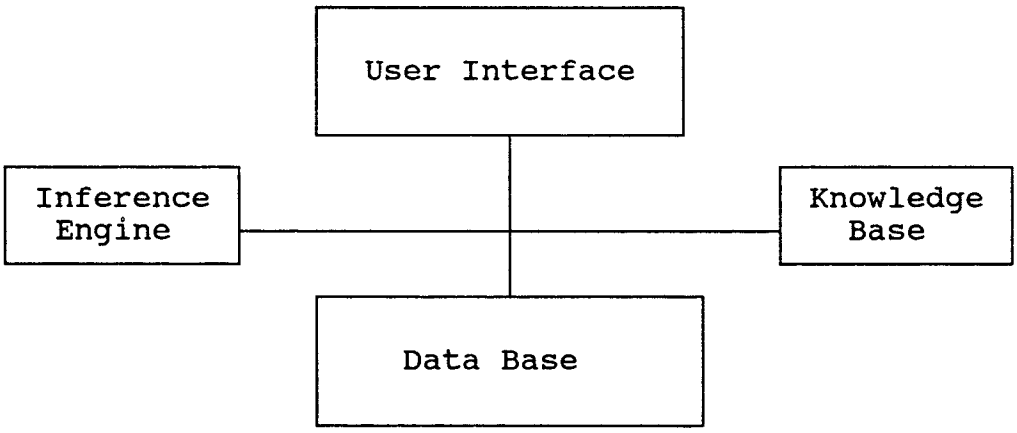
Here all the information required to solve any problem is programmed i.e it contains all the information and the rules of thumb that the expert system uses to make decisions.

This information should represent high level expertise gained from top experts in the field.

**Data base:**

Any information that does not belong to knowledge base but are required to provide the necessary knowledge is stored in

a database which can always be updated.




To reason like a human being, expert systems rely not only on factual knowledge as do conventional programs, but also on uncertain knowledge and observations based on experience and intuition which is collectively called heuristics. The facts and heuristics are extracted from experts in a specialized subject area.

They are then coupled with methods of analyzing, manipulating and applying the encoded knowledge so that the program can make inferences and explain the actions.

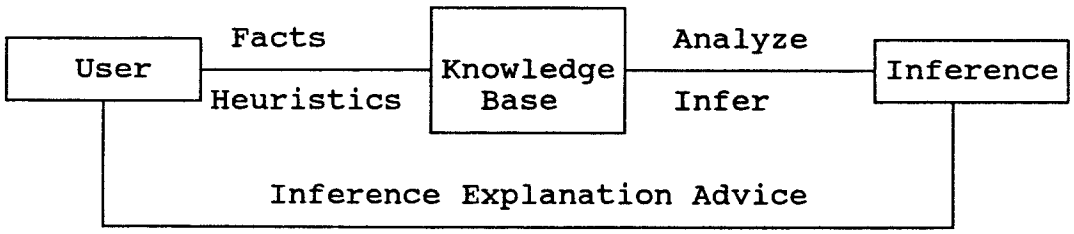
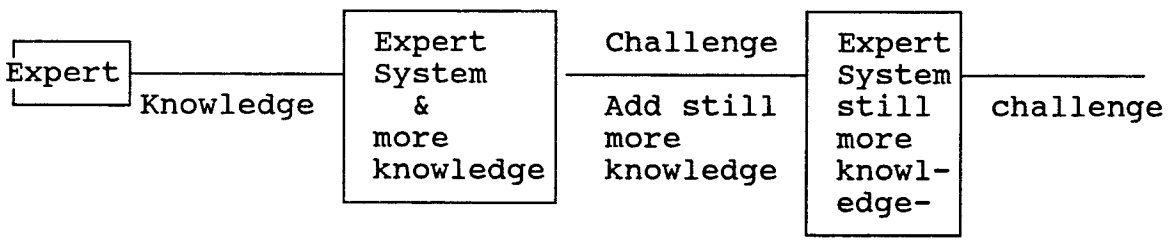



Figure: Expert System infer and advise based on interpreting human expert's knowledge.

Expert systems differ from computer programs because their reasoning is not straight forward.

Their tasks have no practical algorithmic solutions and they must often make conclusions based on incomplete, judgmental, speculative, uncertain or fuzzy information [8].




To build an expert system, the developer chooses a form to represent the experts knowledge.

The developer and the expert together challenge the expert system with lot of problems and cases. As the fledgling expert system makes mistakes, its developers add more knowledge and thus try to improve on the model of expert.

**3.3.1 Characteristics of an Expert System:**

An expert system should have the following characteristics:

1. Designed for solving complex problems which ordinarily require human intelligence.

2. Embodying both expert knowledge and expert inferencing means.

3. Capable of achieving high performance in narrowly specified domains, incremental development, of dealing with incomplete or uncertain data, of handling unforeseen situations and of explaining or justifying its results.

The more of the listed characteristic a program exhibits, the more readily it will be recognized as being an expert system.

**3.3.2 Application of Knowledge Based Expert System :**

The range of these expert system applications are wide and is gaining popularity with time. These expert systems can be used to help solve problems at any stage of the project, process and design, and is of great help in reducing the intensity of the problem and in rectifying the faults.Its application is not just restricted to the engineering related industries but its scope is very wide and it is being used even in treatment of human beings. Bio-medicine, human resources, operation research, management science, business related activities are the few areas where knowledge base expert system is being considered as a great tool and great help to solve the problems. In the field of engineering, it can be used nearly at all steps, whether it is to analyze or interpret the problem or looking for some sort of diagnosis of a problem. There have been several expert systems developed by different organizations for different engineering applications.

For example, Ingersall Rond developed an expert system to design pressure vessels. United Technologies developed CMPP system to develop instructions for manufacturing parts, Digital Equipment developed an expert system called XCON to meet consumer demands for its products.

Carnigie Mellon University developed expert system for efficient allocations of people and equipment to produce a product.

There are few knowledge base expert systems specifically for process industry e.g.

* Heuristic Dendral written in INTERISP.
* CONPHYDE,
* HEATEX,
* PICON (Process Intelligent Control)

Some other examples of application of different commercial expert systems can be seen on the attached table in the next page.

**Table 1. Examples of Expert Systems**

| Area | Type | Name | Purpose |
|---|---|---|---|
| Electronics | Diagnosis | ACE | Diagnosis faults in telephone networks. |
| Medicine | Diagnosis | MYCIN | Helps diagnose & treat bacterial infections. |
| Medicine | Interpretation | PUFF | Diagnosis lung diseases. |
| Geology | Interpretation | DIPMETER ADVISOR | Helps geologists determine geological structure. |

**3.3.4 How Expert Systems Are Developed:**

The initial step in the development of an expert system is the selection of a project that represents a good opportunity. First a recognized expert must be found. This expert should be ten times better than an amateur problem solver in the particular area. The task involved should be primarily cognitive and must be narrowly defined, so that the specialized knowledge can be used. In addition, the task should be one that really needs an expert consultation i.e it should not be so simple that it hardly needs 10 rules to come to the conclusion because in that case it would be much better to solve the problem manually.

Finally, the project should have a potentially high utilization and payoff so that the investment in development is justified.

The development of expert system involves the process of knowledge engineering, which means the creation of knowledge base. The knowledge engineer builds the pieces of knowledge base. This involves working with an expert who uses his or her experience to develop rules applying to a problem.

Expert system development entails the acquisition of knowledge, and several factors related to knowledge acquisition apply to their development. First of all, knowledge is inexact. No one has perfect knowledge, including the expert. Second, Knowledge is incomplete. Knowledge is acquired in pieces, a little at a time and through trial and error.

Expert system development is also incremental. In the initial development phase, a preliminary set of rules are defined and applied to a simple problem. However, as experience with the system grows, new rules are incorporated into the knowledge base. An expert system ultimately requires a great deal of knowledge.

**3.3.5 Advantages of Expert Systems:**

1. Expert system can be replicated for very small money whereas human experts require educational costs which runs in thousands of dollars.

2. Salaries of human experts continue to rise, while the cost of expert systems continue to drop.

3. Human experts develop, then flourish and finally fadeaway, making errors along the way whereas the expert systems once developed can live for years.

4. An expert system can be used for consultation and training in numerous locations, simply by duplicating the necessary hardware, software, and data disks. Once the expert system is constructed, it can be documented. This prevents losing the valuable expertise of experienced technical experts who may retire.

**3.3.6 Disadvantages of Expert Systems:**

1. It has got less breadth of scope and flexibility then human experts, so on occasions the level and range of its expertise is doubtful and unrealistic.

2. It might cost people their jobs.

3. The importance of human intelligence and experience may be underrated due to the evaluation and growth of expert system.

4. It sometime create misunderstanding in the sense that few of the persons in the industry consider it to be more reliable and authentic, and under estimate the capability and experience of the person at the shop floor.

## 3.4 VP EXPERT

Expert system technology involves the creation of computer software that emulates the way people solve the problems.

An expert system like a human expert uses its storage of knowledge to give advices to specific problem.

This knowledge is usually stored in IF - THEN rule formulation.

VP Expert is an "expert system developmental tool" that allows virtually anyone to build an expert system because of its relative simplicity to use, though on occasions it is the test of ones endurance and patience.

It does not require any sophisticated programming skills. What it actually need is dedication and concentration to develop an effective expert system.

Once you get through the different example modules provided in the software, the problem is relatively easy to handle.

Good analytical ability, problem solving attitude and flavor of patience are the few pre-requisite to work on it effectively.

As mentioned before it is a developmental tool, so what it needs from the user is encoding and developing a knowledge base logically and intelligently, and formulating a IF & THEN rule scheme so that inference engine can work efficiently and give out the right results to the users satisfaction.

### 3.4.1 System Requirements [9]:

It works on IBM personal computers with 384K or more Random Access Memory on which the size of knowledge base is dependent. It is recommended to use hard disk but can run on two double side disk drives.It can run on any of the following DOS versions i.e. on 2.xx, 3.xx, or 4.xx. This development tool have been tested positively to work efficient on IBM PC, PC-XT, PC-AT and most compatible systems. When required to use graphical features of VP Expert, an IBM CGA, EGA or VGA, a Hercules monochrome graphics adopter, or a compatible video adopter is required.

**Some Features of VP Expert:**

It is one of the best micro-computer based expert system available in the market with such a powerful combination of features that it is the ultimate choice & preferred over development tools that costs in thousands of dollars.

Some of the worth mentioning features are:

* The ability to exchange data with VP-Info or dBASE database files, VP-Planner, VP-Planner Plus, Lotus 1-2-3, or Symphony worksheet files and ASCII text files.

* Simple English like rule construction.

* Commands that allow VP Expert to explain its actions during a consultation.

* Knowledge base chaining which lets create knowledge bases that would otherwise be too large to fit in memory.

* The ability to record and graphically display the rule by rule search pattern used behind the scenes during a consultation.

**Information Base:**

One of the most significant capabilities of this expert tool is its ability to exchange data with database, worksheets and text files. Using these files as information base, large amount of data can be stored into knowledge base without making IF - THEN rule structure complex.

Using such a information base allows to create a drastically reduced and simplified "rule base" with the option that data be stored outside and be modified, updated and corrected externally which is also much simpler.

**3.4.4 What Else It Can Do:**

No doubt its an expert system developmental tool but its options are not only limited to the expert systems.

It has certain additional features also and can be used to :

1. Design tests and procedural guidance systems.

2. Index text files for quick access.

3. Create custom front ends for compatible worksheet and database files.

### 3.4.5 Where It Has Been Successfully Used:

VP Expert has been used successfully in the following areaa) medicine, b) engineering, c) business, d) geology,

e) tax analysis, f) law , g) insurance, h) real estates

It has proved its effectiveness in the above mentioned areas and was successfully utilized to diagnose illness, analyze structures, train personnel, recommend strategies, evaluate tax assessments and returns etc.

# CHAPTER 4

# IMPLEMENTATION OF THE PROGRAM DEVELOPED

## 4.1 Description of the approach:

In this thesis, the rules and regulations which addresses electrical safety requirements that are necessary for the practical safeguarding of employees in their workplaces have been gathered in the form of an expert system where the knowledge of engineering has been used to make the applicable rules easily accessible after answering a series of questions.

Now the first thing that comes to mind is why electrical hazards have been addressed and not any other field.

The answer to this question is, that there are so many different areas which provide different hazards in the industry and all of them could not be addressed together, or to be more precise it will not be practical or feasible to address all of them together. There are two reasons for them.

1. This will be beyond the capability of an individual to develop a system that will accumulate rules concerning all the industrial hazards because of the amount of regulations involved may run in millions.

2. This is the era of segregation and specialization, and people work in the form of different segregated groups of specialized field and mostly they are only concerned with the applications in their particular area and their interest and knowledge in other areas is very limited. I have chosen and addressed regulations concerning electrical hazards because they are one of the major fields where rules are needed to be followed more strictly.

Therefore this is an attempt to make those rules readily accessible so that people in the industry do not have to run after different agencies or experts, or at least they

can design, install or maintain different instruments which do not posses much of a threat and they do not need to spend time and money searching for the exact rules and their interpretations, and looking for appointments with the consultants.

A brief picture can be perceived about the effects of electrical hazards by looking at the table which has been taken from the studies resulted from the survey of Occupational injuries and illness 1989 conducted by U.S. Department of Labor, Bureau of Labor Statistics and released in January 1991.

From the statistics shown in the table we can see that the range of accidents as a result of any form of electrical hazard are showing variation from 7.4% to 19.7% and with them are lost work days ranging from 51.9 days to 176.5 days. The rest of accidents from electrical hazards fall in between these figures.

The picture which I got from these figures with my limited knowledge is that the state of affairs need immediate remedial step. It requires the attention of experts and specialists to sit together and take effective measures so that the work place can be a safe place.

In my attempt to contribute my share towards the safety of work place, I have tried to include all the regulations which are currently applicable for safety from electrical hazards. The problem with the expert system is that, it is never complete because it stores the knowledge of expert and knowledge is a continuous generative process and it is hard to say, when this generation of knowledge flow will stop. Same has happened with my attempt of making a complete comprehensive system. The rules and regulations, I have accumulated are subject to continuous change and they can never be final as it is necessary to keep them changing as per requirements of the system, so that they are effective and keep playing the part and fulfilling the objective they have been formulated for. Similarly in some of the areas, rules are still in formulating stages and when these rules are finalized, the system needs to be

updated in order to keep the pace with time, so that the expert system is still applicable.

Expert Systems can have different behavior, objective and approach to problem solving, and no one method or strategy is final or correct. An attitude of compromise and collaboration is required for successful implementation of any system and this also apply to my humble attempt.

In this system, an attempt has been made to present as many regulations as possible so that the system is covering a wide range and the effort is not waisted by just restricting it to one or two areas. The areas which I have attempted to cover include the following:

* Design safety standard for electrical system
* Electrical utilization system
* General requirements
* Wiring design and protection
* Wiring methods, components, and equipment for general use
* Specific purpose equipment and installations
* Hazardous locations
* Safety related work practices
* Safety related maintenance requirements
* Safety requirements for special equipment

I don't claim that my system is very comprehensive and complete. I am still going through my learning phase and have attempted within my capabilities to make it as informative as possible.

Totally this system involves 59 files including the database stored in the text files.

Most of the programming have been done using the RULE based programming method. I have also used WHILETRUE based programming method in one of the files just to see the difference between the two methods. From these changes I came

to know that this sort of programming technique is just a conventional mode of programming and cannot be termed as expert system. So on the advise and guidance of my advisor, I have shifted to RULE based programming which is a correct and much more effective way of doing the programming and developing any expert system.

The biggest problem which was faced during the development phase of the system was errors in programming which was overcome with more effort and concentration. Another tough part was to accommodate all the rules and few of them were very lengthy and it was a hectic job to store them in the text files. Few problems were also faced due to some shortcomings in the software used and which made the task, tough and tiring.

In the end, it would be appropriate to mention that I have attempted to utilize maximum of the tools available in my programming and it has given me the confidence and courage to go for more sophisticated models in the years to come.

I am enclosing a series of flow charts which tell the path to follow when looking for a specific area.

The first flow chart (figure 4.1) gives a complete picture of the expert system for safety of all electrical equipment and installations used to provide electric power and light for employee work places.

It is showing how different modules or specific areas are related to each other and how the chaining has been done. For example, there are three main areas in the system:

1. Design safety requirements
2. Safety related work
3. Safety related maintenance

For Safety related work and Safety related maintenance, the messages are displayed in the screen. In Design safety requirements, we can see the further subdivisions. It divides into two areas, namely

1. Design Standard Utilization
2. Future Design Safety

If choice # 1 is selected, then the system will ask to select from the following choices:

1. General Requirements
2. Wiring design and protection
3. Wiring methods: Components and equipments for general use
4. Specific purpose equipment
5. Hazard location
6. Special system
7. Electrical utilization

The flow chart of figure 4.1 is clearly showing that which of the above mentioned choices are connected through chaining to which file.

When the user will select any of the above choices, the corresponding chained file will be automatically loaded and from selecting the right choices in the newly loaded file, the required regulations can be accessed.

In figure # 4.2, General requirements of government regulations and its subdivision can be seen. There are eight specific areas about which the requirements can be seen by selecting the correct choices. The flow chart in this figure is showing, how each of the areas are further divided and if the user is selecting any specific choice by looking at the figure, he can immediately know what will be the next question and which specific area will be displayed. In this figure, it can be seen that in few boxes "DISPLAY RULE" is mentioned which means that the rule is displayed directly at the screen. Few boxes also display "IN TEXT" which means that the rules are stored

in a text file and will be displayed through the text file.

In figure # 4.3, the flow chart is showing what choices are available when looking for "Wiring Design & Protection". If this file is loaded, the system will ask to select from the thirteen choices available. These are different areas as shown in the flow chart and regulations can be seen for any specific area by pressing "Enter" at that choice. Except for two of the choices, rules in this file as can be seen from the boxes in the flow chart are either displayed directly or from a text file.

The two choices, Overcurrent protection and Services, if selected are not directly displayed but are chained to different files and those files are first loaded to see about them.

If user wants to access "Requirements for wiring methods" he should look at the figure # 4.4. Here in the first series of choices, it will ask to select from the following four choices:

1. General Requirements
2. Open Wiring on Insulators
3. Cable trays
4. Temporary wiring

Except choice # 2, all the other three will display the regulations directly at the screen. If choice # 2 is selected, it will load a new file 1.kbs as shown in the flow chart. Once this file is loaded, the user will be asked to select from five choices. Once again the boxes in the flow chart is showing that four of them will directly display the requirements. But one of these five options i.e when "Protection from physical damage" is selected, it will load another file named 2.kbs. This file i.e. 2nd.kbs have eleven choices as can be seen from the boxes in the flow chart. Of these, ten choices are displaying the rules for each specific area directly. The user can select any of these and see the government regulations. The eleventh choice

loads another file 3.kbs. Similarly from here the user can access the required rules by following the flow chart carefully. If the user needs to see certain specific areas and he is following the flow charts, he might end up in either file 4.kbs or 5.kbs.

Figure # 4.6 deals with hazardous locations and have three boxes in it. The user can select any of the three regarding which the requirements are needed.

In figure # 4.7, the flow charts are for Special Systems and the program for it is stored in file 40.kbs. In it there are seven choices and the flow chart is showing seven boxes for them. Of these choices, if the option chosen is "Tunnel installations" then file named as 41.kbs is chained through it and will be loaded. The user can go into this file and see the options.

If "Fire protective signalling system" is selected, then the options in file 42.kbs can be seen.

Lastly if "Communication System" is chosen, the flow chart gives a very clear picture about the linkage or chaining with file 43.kbs and the available options.

For figure # 4.8, the program is stored in file RR6.kbs. It has three choices. By selecting option 1, the user can have access to the "Requirements for electric installation and utilization" regardless when they were installed or designed. When the user selects this option, the program is so written that it will bring the required text from the text file "Law 1". Similarly option 2 receive the requirements from text file "Law 2". This text file shows the requirements for "Electrical utilization system and equipments" installed, repaired or modified after March 15, 1972. Third option shows the same requirements but only for installations which are installed, modified or repaired after April 16, 1981 and are stored in text file "Law 3".

Figure # 4.9 and 4.10 are showing the flow charts for " Services" and "Over current protection requirements". They are programmed in file Riz.kbs and Choice.kbs respectively. The boxes in the flow chart for them are very clear and easy to follow.

The purpose of all these attached flow charts is to help the user to select the right module, so that he can access to requirements in the minimum of time without any difficulty.

**How To Run The Program:**

After the flow charts, screen view of one of the program is attached. The purpose of it is to make the user familiar with it before actually running the program.

Initially when the VP Expert Program is loaded, the user will be required to give a path i.e. in which drive your program disk is placed [figure 11.].

The next choice is to select from "FILE NAME" and finally he has to press "CONSULT" option, and the user will be in the required program file.

It can be seen from the screen view prints attached that there is a rectangular border within which, there are text or questions which have to be first answered or chosen to proceed further. The user has to select, one of the options, take the cursor over there and hit "Enter" key followed by pressing "End" key. If their are any further questions, it is necessary to select the right choices, so that the required options can be seen. If it is required to use any of the options outside the rectangular boundary, just take the cursor over there, highlight your choice and press "Enter". For example if you want to "RUN" a program, take the cursor to choice "GO" in the main menu and press "Enter". Similarly to edit or to see any RULE or any other option there, just take the cursor to your choice and hit any key. It is possible to get out of the program any time by just pressing "/" and followed by "Q". This option can only be used when the program is being run as can be seen from one of the screen view prints.

The screen view of one of the expert program files is attached so that the reader can follow what is actually happening and what is the end result.

At the end of this chapter, all the program files are attached in the Appendix, so that if the user wants to see how the programming has been done, he can go through them.

**Table 4.1. Occupational injury and illness incidence rates for the years 1988 and 1989.**

| INDUSTRY | 1989 ANN. AVG. EMPLOYMENT (THOUSANDS) | TOTAL CASES 1988 | TOTAL CASES 1989 | LOST WORKDAYS 1988 | LOST WORKDAYS 1989 |
|---|---|---|---|---|---|
| Electronic & other electrical equipments | 1753 | 8.7 | 9.1 | 68.3 | 77.5 |
| Electrical distribution equipment | 100.2 | 10.6 | 12.0 | 84.7 | 92.0 |
| Transformers except electronics | 50.8 | 11.1 | 13.0 | - 87.1 | 90.9 |
| Switchgear & switchboard apparatus | 49.4 | 10.0 | 10.9 | 82.1 | 93.2 |
| Electrical industrial apparatus | 177.4 | 10.6 | 11.1 | 91.6 | 98.4 |
| Motors & generators | 89.1 | 12.9 | 13.9 | 112.5 | 121.6 |
| Carbon & graphite products | n.a. | 9.6 | 8.9 | 89.1 | 85.0 |
| Relays & industrial controls | 68.2 | 7.4 | 8.0 | 67.5 | 76.6 |
| Electrical lightning & wiring equipment | 196.3 | 11.1 | 10.8 | 98.8 | 100.8 |
| Electric Lamps | 26.0 | 7.8 | 8.6 | 61.5 | 88.8 |
| Current carrying wiring devices | 76.1 | 9.3 | 9.1 | 96.9 | 90.1 |

| | | | | | |
|---|---|---|---|---|---|
| Non current carrying wiring devices | 16.4 | 16.6 | 14.2 | 143 | 135.1 |
| Residential lighting fixtures | 26.0 | 11.8 | 13.0 | 102 | 108.8 |
| Miscellaneous components and accessories | 169.8 | 11.8 | 12.1 | 97.8 | 109.3 |
| Storage batteries | 28.7 | 16.6 | 19.7 | 176.5 | 232.8 |
| Engine electric equipment | 71.5 | 14.2 | 13.4 | 109.1 | 104.4 |
| Primary batteries | 25.3 | 9.1 | 9.3 | 49.7 | 90.7 |
| Construction electric work | 553.7 | 13.3 | 13.1 | 106.5 | 105.6 |

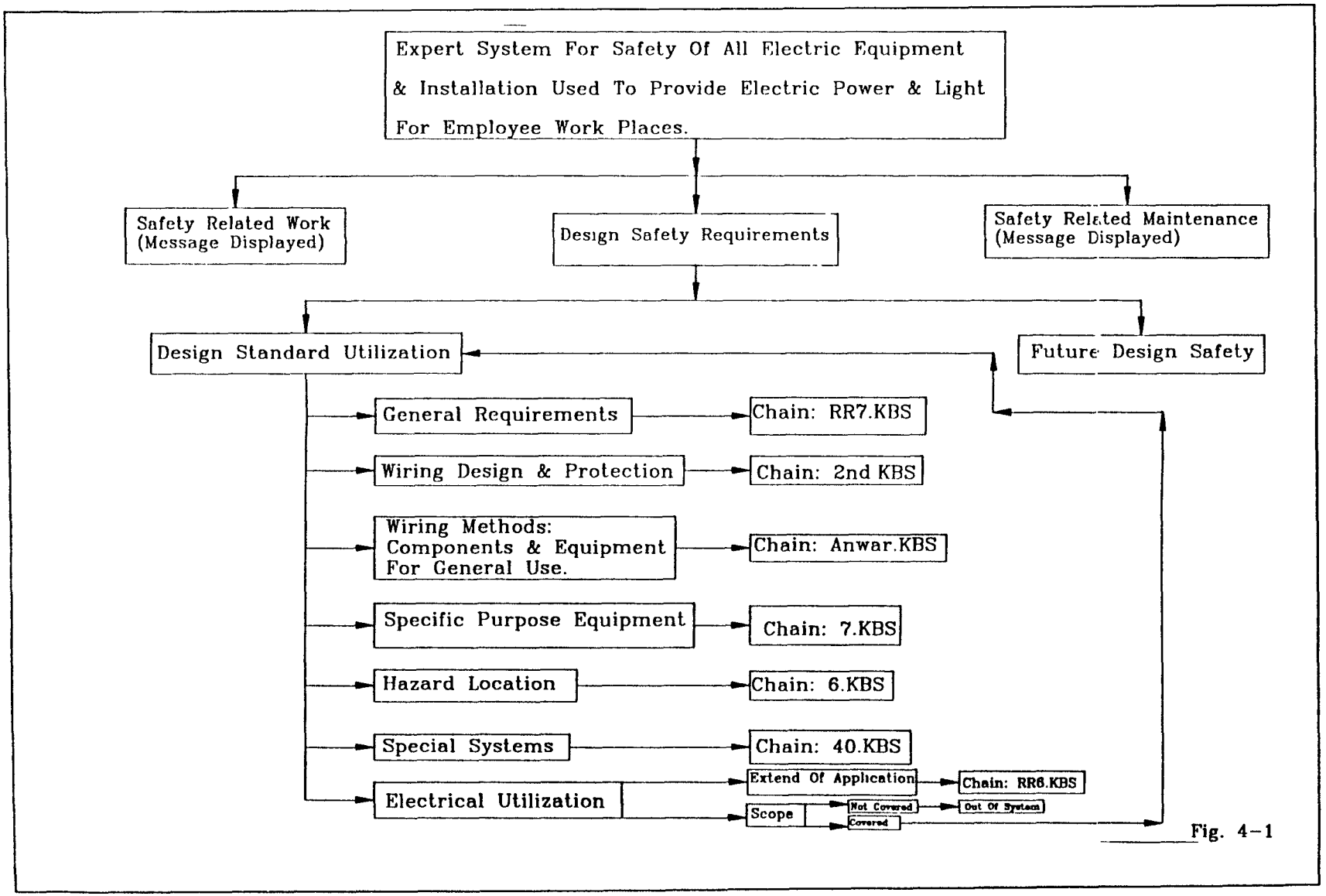

Expert System For Safety Of All Electric Equipment & Installation Used To Provide Electric Power & Light For Employee Work Places.
Safety Related Work (Message Displayed)
Design Safety Requirements
Safety Related Maintenance (Message Displayed)
Design Standard Utilization
Future Design Safety
General Requirements
Chain: RR7.KBS
Wiring Design & Protection
Chain: 2nd KBS
Wiring Methods: Components & Equipment For General Use.
Chain: Anwar.KBS
Specific Purpose Equipment
Chain: 7.KBS
Hazard Location
Chain: 6.KBS
Special Systems
Chain: 40.KBS
Electrical Utilization
Extend Of Application
Chain: RR6.KBS
Scope
Not Covered
Out Of System
Covered

Fig. 4-1

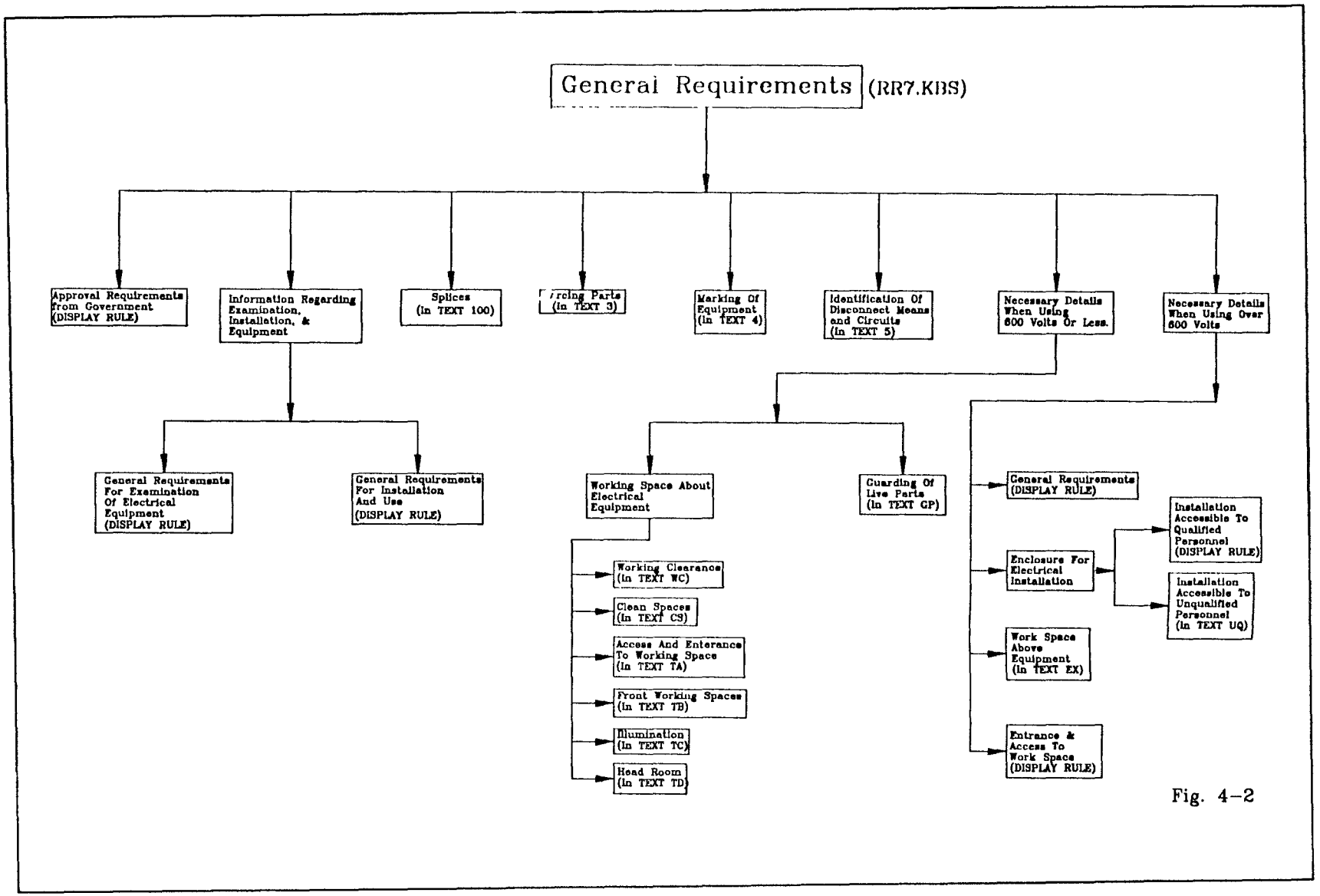

General Requirements (RR7.KBS)
Approval Requirements from Government (DISPLAY RULE)
Information Regarding Examination, Installation, & Equipment
Splices (In TEXT 100)
Wiring Parts (In TEXT 3)
Marking Of Equipment (In TEXT 4)
Identification Of Disconnect Means and Circuits (In TEXT 5)
Necessary Details When Using 600 Volts Or Less.
Necessary Details When Using Over 600 Volts
General Requirements For Examination Of Electrical Equipment (DISPLAY RULE)
General Requirements For Installation And Use (DISPLAY RULE)
Working Space About Electrical Equipment
Guarding Of Live Parts (In TEXT GP)
Working Clearance (In TEXT WC)
Clean Spaces (In TEXT CS)
Access And Enterance To Working Space (In TEXT TA)
Front Working Spaces (In TEXT TB)
Illumination (In TEXT TC)
Head Room (In TEXT TD)
General Requirements (DISPLAY RULE)
Enclosure For Electrical Installation
Installation Accessible To Qualified Personnel (DISPLAY RULE)
Installation Accessible To Unqualified Personnel (In TEXT UQ)
Work Space Above Equipment (In TEXT EX)
Entrance & Access To Work Space (DISPLAY RULE)

Fig. 4-2

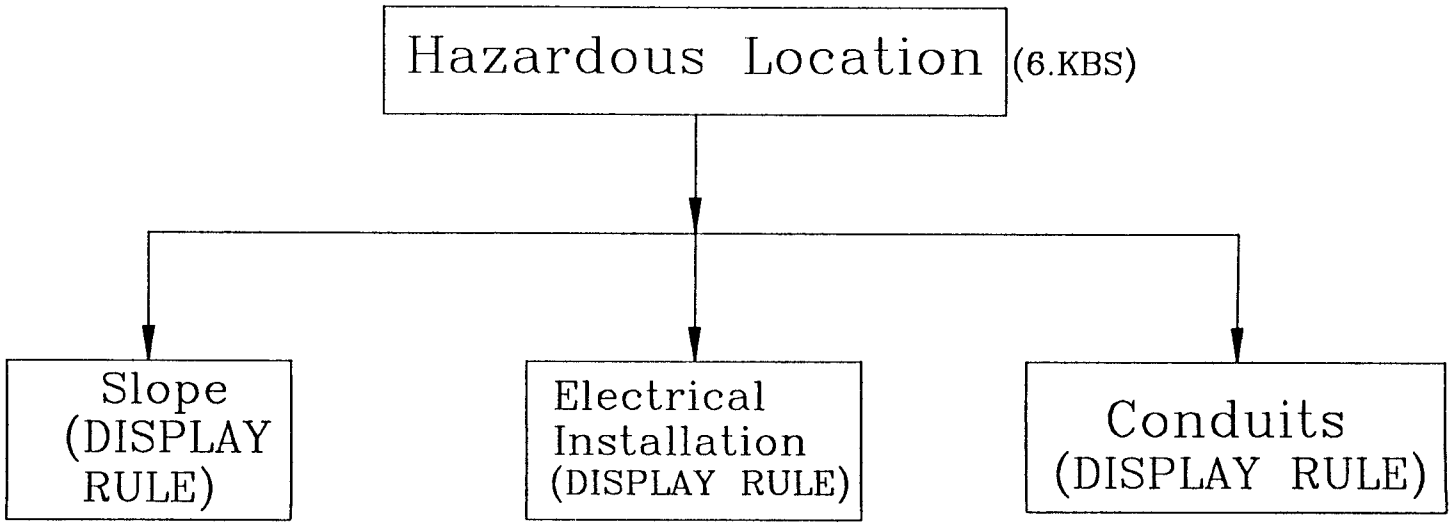

Hazardous Location
(6.KBS)
Slope
(DISPLAY
RULE)
Electrical
Installation
(DISPLAY RULE)
Conduits
(DISPLAY RULE)

Fig. 4-3

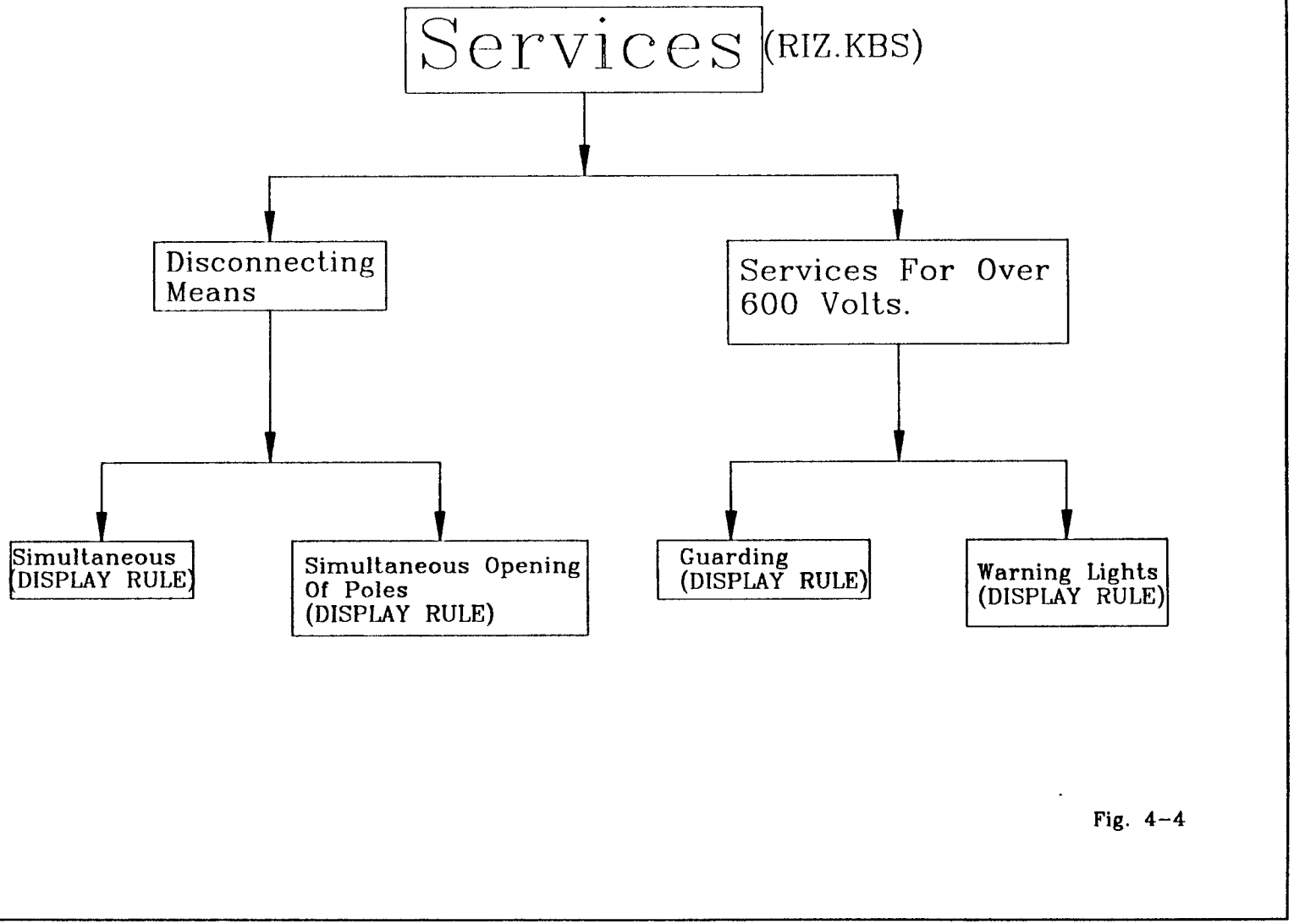

Services (RIZ.KBS)
Disconnecting Means
Services For Over 600 Volts.
Simultaneous (DISPLAY RULE)
Simultaneous Opening Of Poles (DISPLAY RULE)
Guarding (DISPLAY RULE)
Warning Lights (DISPLAY RULE)

Fig. 4-4

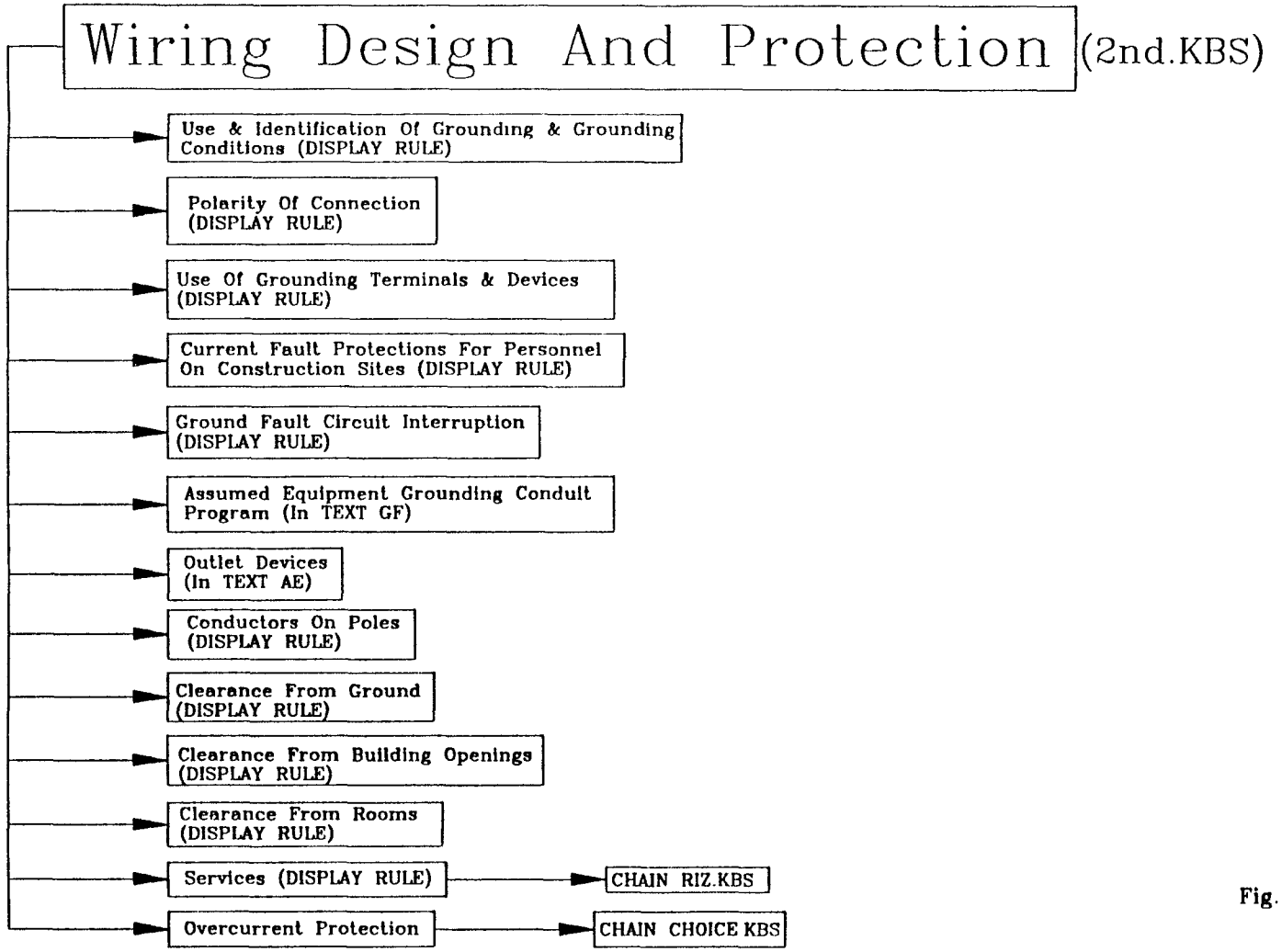

Wiring Design And Protection (2nd.KBS)
Use & Identification Of Grounding & Grounding Conditions (DISPLAY RULE)
Polarity Of Connection (DISPLAY RULE)
Use Of Grounding Terminals & Devices (DISPLAY RULE)
Current Fault Protections For Personnel On Construction Sites (DISPLAY RULE)
Ground Fault Circuit Interruption (DISPLAY RULE)
Assumed Equipment Grounding Conduit Program (In TEXT GF)
Outlet Devices (In TEXT AE)
Conductors On Poles (DISPLAY RULE)
Clearance From Ground (DISPLAY RULE)
Clearance From Building Openings (DISPLAY RULE)
Clearance From Rooms (DISPLAY RULE)
Services (DISPLAY RULE)
CHAIN RIZ.KBS
Overcurrent Protection
CHAIN CHOICE KBS

Fig. 4-5

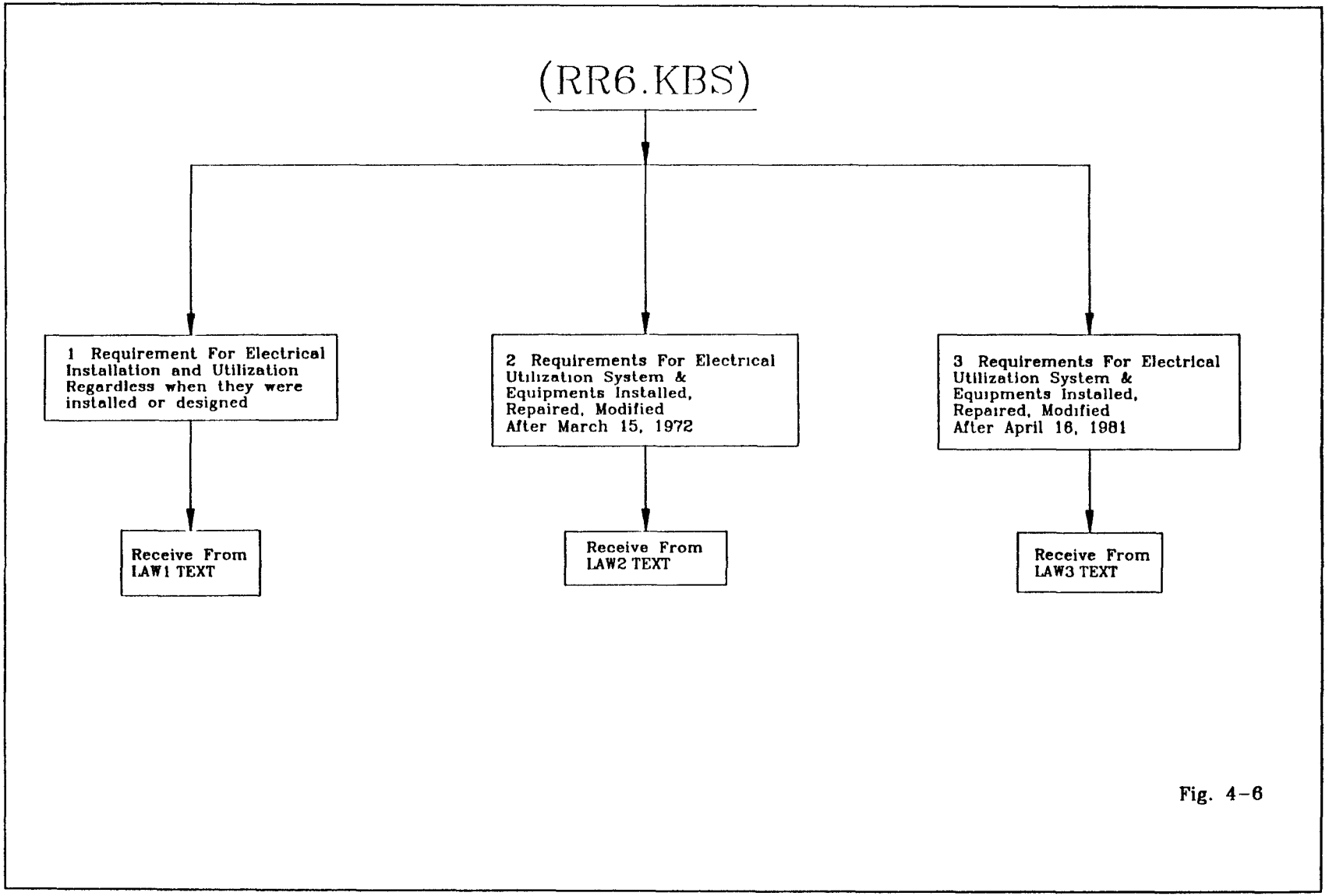

(RR6.KBS)
1 Requirement For Electrical Installation and Utilization Regardless when they were installed or designed
2 Requirements For Electrical Utilization System & Equipments Installed, Repaired, Modified After March 15, 1972
3 Requirements For Electrical Utilization System & Equipments Installed, Repaired, Modified After April 16, 1981
Receive From LAW1 TEXT
Receive From LAW2 TEXT
Receive From LAW3 TEXT

Fig. 4-6

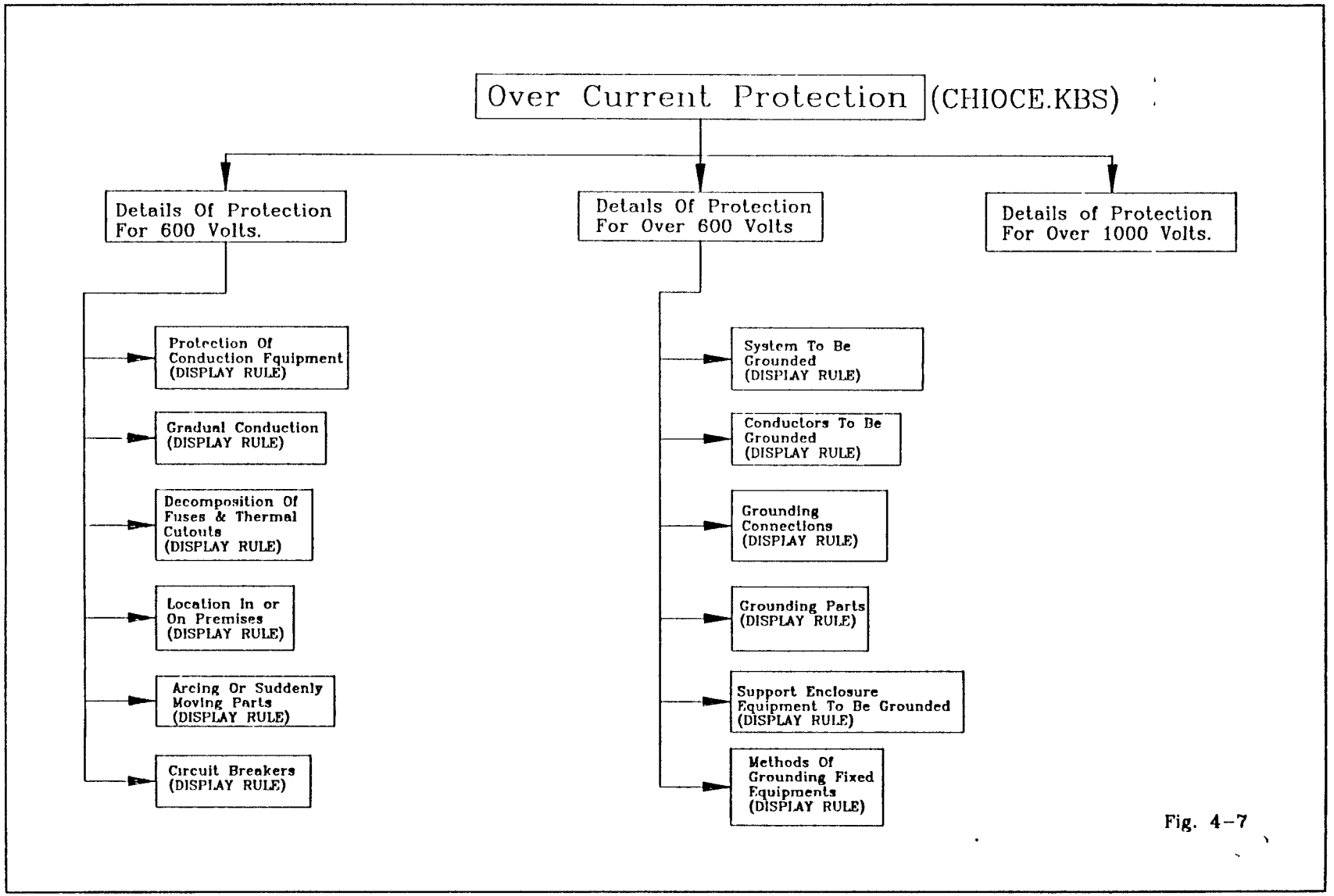

Over Current Protection (CHIOCE.KBS)
Details Of Protection For 600 Volts.
Details Of Protection For Over 600 Volts
Details of Protection For Over 1000 Volts.
Protection Of Conduction Equipment (DISPLAY RULE)
Gradual Conduction (DISPLAY RULE)
Decomposition Of Fuses & Thermal Cutouts (DISPLAY RULE)
Location In or On Premises (DISPLAY RULE)
Arcing Or Suddenly Moving Parts (DISPLAY RULE)
Circuit Breakers (DISPLAY RULE)
System To Be Grounded (DISPLAY RULE)
Conductors To Be Grounded (DISPLAY RULE)
Grounding Connections (DISPLAY RULE)
Grounding Parts (DISPLAY RULE)
Support Enclosure Equipment To Be Grounded (DISPLAY RULE)
Methods Of Grounding Fixed Equipments (DISPLAY RULE)

Fig. 4-7

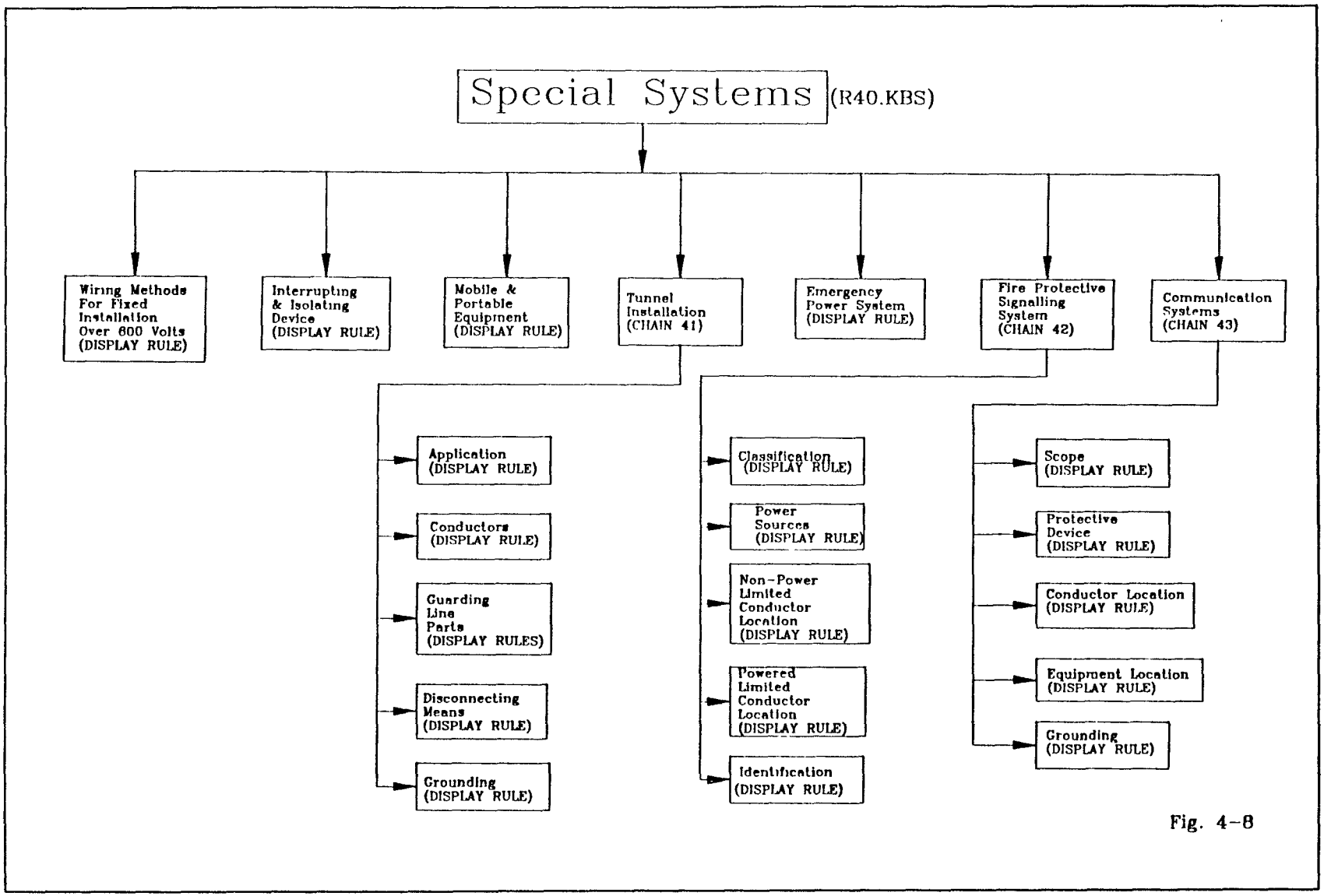

Special Systems (R40.KBS)
Wiring Methods For Fixed Installation Over 600 Volts (DISPLAY RULE)
Interrupting & Isolating Device (DISPLAY RULE)
Mobile & Portable Equipment (DISPLAY RULE)
Tunnel Installation (CHAIN 41)
Emergency Power System (DISPLAY RULE)
Fire Protective Signalling System (CHAIN 42)
Communication Systems (CHAIN 43)
Application (DISPLAY RULE)
Conductors (DISPLAY RULE)
Guarding Line Parts (DISPLAY RULES)
Disconnecting Means (DISPLAY RULE)
Grounding (DISPLAY RULE)
Classification (DISPLAY RULE)
Power Sources (DISPLAY RULE)
Non-Power Limited Conductor Location (DISPLAY RULE)
Powered Limited Conductor Location (DISPLAY RULE)
Identification (DISPLAY RULE)
Scope (DISPLAY RULE)
Protective Device (DISPLAY RULE)
Conductor Location (DISPLAY RULE)
Equipment Location (DISPLAY RULE)
Grounding (DISPLAY RULE)

Fig. 4-8

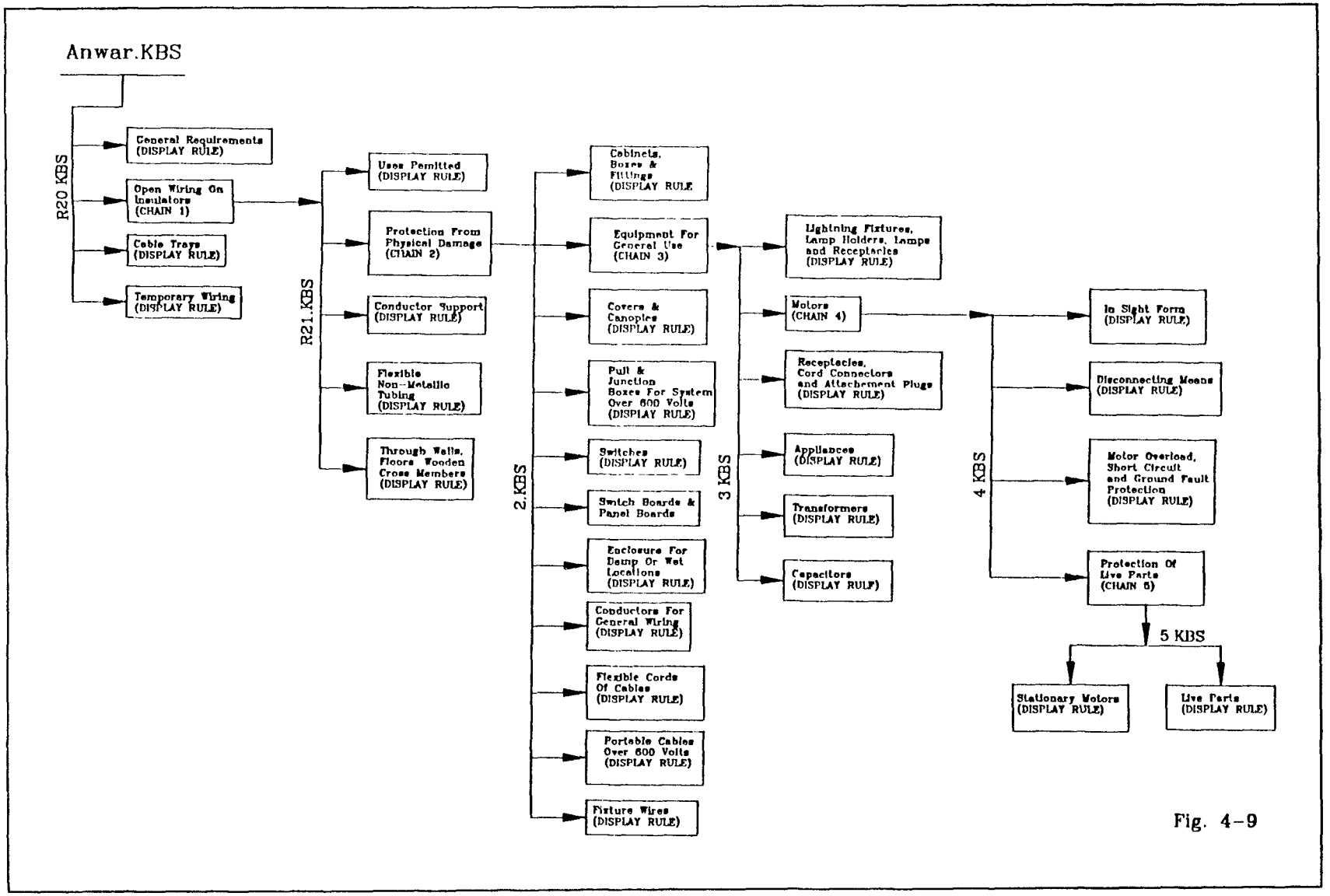

Anwar.KBS
R20 KBS
General Requirements (DISPLAY RULE)
Open Wiring On Insulators (CHAIN 1)
Cable Trays (DISPLAY RULE)
Temporary Wiring (DISPLAY RULE)
R21.KBS
Uses Permitted (DISPLAY RULE)
Protection From Physical Damage (CHAIN 2)
Conductor Support (DISPLAY RULE)
Flexible Non-Metallic Tubing (DISPLAY RULE)
Through Walls, Floors Wooden Cross Members (DISPLAY RULE)
2.KBS
Cabinets, Boxes & Fittings (DISPLAY RULE
Equipment For General Use (CHAIN 3)
Covers & Canopies (DISPLAY RULE)
Pull & Junction Boxes For System Over 600 Volts (DISPLAY RULE)
Switches (DISPLAY RULE)
Switch Boards & Panel Boards
Enclosure For Damp Or Wet Locations (DISPLAY RULE)
Conductors For General Wiring (DISPLAY RULE)
Flexible Cords Of Cables (DISPLAY RULE)
Portable Cables Over 600 Volts (DISPLAY RULE)
Fixture Wires (DISPLAY RULE)
3 KBS
Lightning Fixtures, Lamp Holders, Lamps and Receptacles (DISPLAY RULE)
Motors (CHAIN 4)
Receptacles, Cord Connectors and Attachement Plugs (DISPLAY RULE)
Appliances (DISPLAY RULE)
Transformers (DISPLAY RULE)
Capacitors (DISPLAY RULE)
4 KBS
In Sight Form (DISPLAY RULE)
Disconnecting Means (DISPLAY RULE)
Motor Overload, Short Circuit and Ground Fault Protection (DISPLAY RULE)
Protection Of Live Parts (CHAIN 5)
5 KBS
Stationary Motors (DISPLAY RULE)
Live Parts (DISPLAY RULE)

Fig. 4-9

SCREEN VIEW OF THE PROGRAM FILE AMB.KBS

THIS EXPERT SYSTEM ADVISES YOU ON FEDRAL REQUIREMENTS
AND REGULATIONS REGARDING WORKERS SAFETY FOR ELECTRICAL
INSTALLATIONS AND MAINTENANCE IN AN INDUSTRIAL ENVIROMENT.

INCLUDED IN THIS EXPERT SYSTEM ARE ALL ELECTRICAL EQUIPMENT
AND INSTALLATIONS USED TO PROVIDE ELECTRIC POWER AND LIGHT
FOR EMPLOYEE WORKPLACES.

IT CAN BE USED AS REFERENCE BY THE MANUFACTURERS OF ELECTRICAL
EQUIPMENTS, PRACTICING ENGINEERS, ELECTRICAL CONTRACTORS AND
TECHNICIANS.

Press Enter To Continue

1Help 2Go 3WhatIf 4Variable 5Rule 6Set 7Edit 8Quit
1Help 2How? 3Why? 4Slow 5Fast 6Quit

THESE ARE THE THREE MAJOR AREAS FOR WHICH YOU CAN HAVE
RULES AND BY SELECTING THE ONE WHICH FITS YOUR NEEDS,
YOU CAN SEE THE EXACT REQUIREMENT IF YOU ARE SELECTING
THE RIGHT CHOICES AND THE EXPERT SYSTEM WILL GIVE YOU
THE APPROPRIATE LAWS WHICH CONCERNS YOU

Which of the three major divisions you want to go?
Design Safety Requir ◄ Safety Related Work Safety Related Maint

↑ ↓ → ← Enter to select END to complete /Q to Quit ? for Unknown

OF THE FOLLOWING TWO, DESIGN STANDARD FOR UTILIZATION CONCERNS WITH THE EXISTING REQUIREMENTS FOR ANY DESIGN, INSTALLATION AND MAINTENANCE OR INSTALLING A NEW SYSTEM OR DOING MAINTENANCE OF AN EXISTING SETUP, WHILE THE FUTURE DESIGN SAFETY STANDARDS CONCERNS WITH THE REGULATIONS FOR THE DEVELOPING TECHNOLOGY LIKE ROBOTICS AND FMS, AND THESE RULES HAVE YET TO BE COMPLETELY FINALIZED BY THE DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION AND THESE RULES ARE CONSTANTLY SUBJECTED TO CHANGES BECAUSE OF NEW DEVELOPMENT IN THESE FIELDS

Which of the following you want to go?
Design Std for Utili ◄ Future Design Safety

↑ ↓ → ← Enter to select END to complete /Q to Quit ? for Unknown

THE FOLLOWING CHOICES TELLS YOU ABOUT THE LAWS IN THEIR PARTICULAR AREAS.
ELECTRICLA UTILIZATION TELLS ABOUT WHAT ARE EXACTLY COVERED WITHIN THE JURISDICTION OF OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION AND WHAT ARE THE EXTEND OF APPLICATION.
GENERAL REQUIREMENT GIVES YOU THE DETAILS ABOUT DIFFERNT REQUIREMENTS WHICH ARE REQUIRED IN DIFFERENT AREAS AS PRE-REQUISITES BEFORE YOU CAN EXACTLY START A WORK.
OTHER CHOICES GIVES THE DETAILS OF THE INDIVIDUAL AREAS.

Which of the following you want to go?

| | | |
|---|---|---|
| Electrical Utilizati ◄ | General Requirements | Wiring Design And Pr |
| Wiring Methods Comp | Specific Purpose Equ | Hazardous Locations |
| Special Systems | | |

↑ ↓ → ←  Enter to select  END to complete  /Q to Quit  ? for Unknown

BY CHOOSING NO1, YOU WILL BE ABLE TO KNOW
ABOUT THE AREAS OR FIELDS WHICH FALL UNDER
THE LAWS OF OCCUPATIONAL SAFETY AND HEALTH .

CHOOSING THE SECOND WILL TELL YOU ABOUT
THE DETAILS OF THE APPLICATIONS OF THE
LAWS WHICH ARE FORMED FOR THE SAFETY OF
WORKERS IN MIND WHILE DOING ANY ELECTRICAL WORK.

Which of the two you want to look at?
Scope ◄ Extend of Applicatio

↑ ↓ → ←  Enter to select  END to complete  /Q to Quit  ? for Unknown

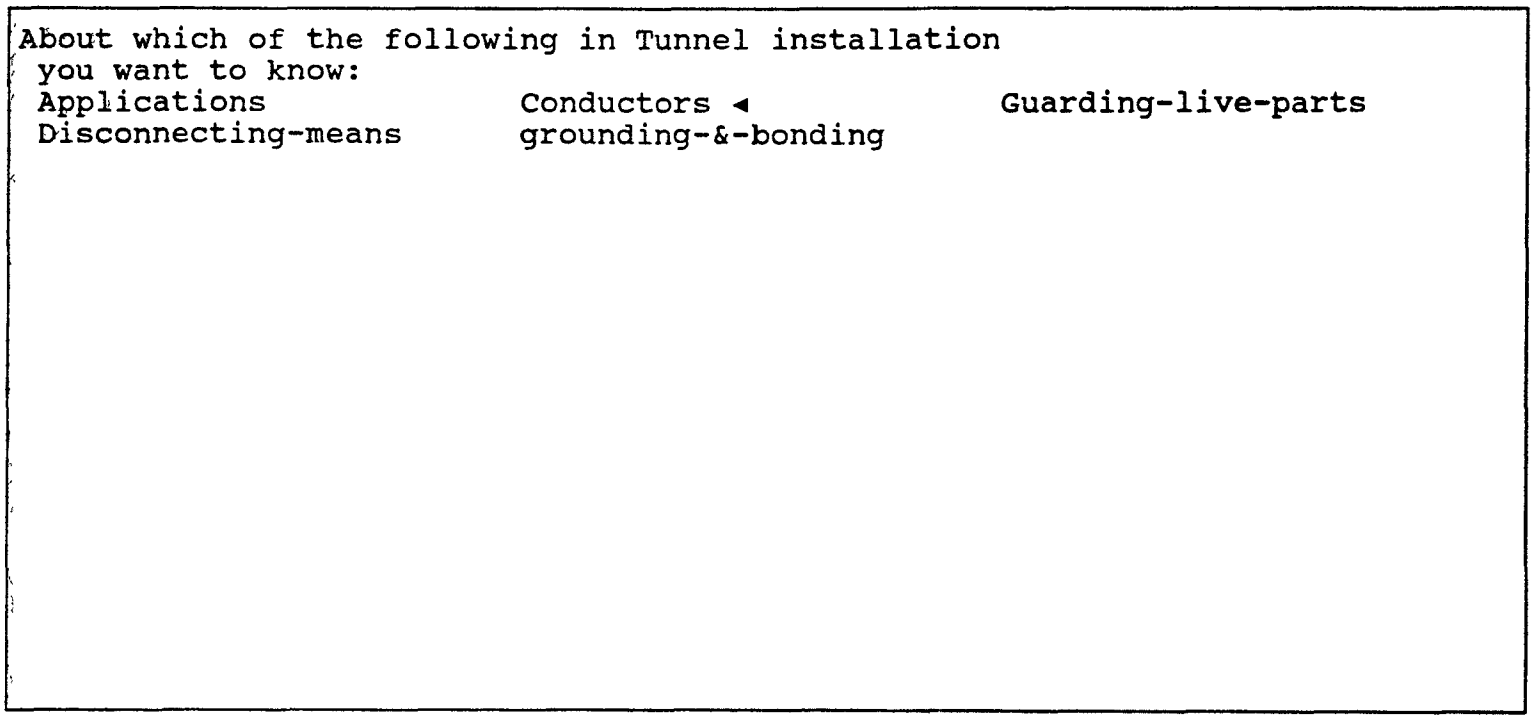
```
Electrical installations and utilization equipment
installed or used within or outside buildings, structures,
and other premisse including :
1) Yards
2) Carnivals
3) Parking and other lots
4) Mobile homes
5) Recreational Vehicles
6) Industrial Substation
7) Conductors that connect the installations to
   a supply of electricity, and
8) Other outside conductors on premises,
ARE COVERED IN THIS EXPERT SYTEM AND SAFETY REQUIREMENTS
FROM WORKERS POINT OF VIEW ARE ONLY FOR THESE AREAS,SO IF YOU
ARE COVERED AMONG THIS LIST, THEN CHOOSE COVERED AND LOOK FOR
OPTIONS YOU WANT TO SEE THERE ARE NO OTHER REQUIREMENTS FOR ANY
OTHER AREAS FOR WORKERS' SAFETY IN ELECTRICAL INSTALLATIONS AND,
UTILIZATION EQUIPMENT, AND IF YOU ARE AMONG SO, CHOOSE NOT COVERED AND
GO OUT OF THE SYSTEM
Which of the following you want to choose?
 Covered ◄                Not covered

↑ ↓ → ←   Enter to select   END to complete    /Q to Quit   ? for Unknown
```

A) WIRING METHODS OF FIXED INSTALLATIONS
B) INTERRUPTING AND ISOLATING DEVICE
C) MOBILE AND PORTABLE EQUIPMENT
D) TUNNEL INSTALLATIONS
E) EMERGENCY POWER SYSTEMS
F) FIRE PROTECTION SIGNALLING SYSTEM
G) COMMUNICATION SYSTEMS

About which of the following you want to see
the requirements

| | | |
|---|---|---|
| A | B | C |
| D ◄ | E | F |
| G | | |

↓ → ←  Enter to select  END to complete  /Q to Quit  ? for Unknown




↑ ↓ → ←  Enter to select  END to complete  /Q to Quit  ? for Unknown

About which of the following in Tunnel installation you want to know:
Applications Conductors ◄ Guarding-live-parts
Disconnecting-means grounding-&-bonding

Conductors in tunnels shall be installed in in one or more of the following:

A) Metal conduit or other metal raceway,
B) Type MC Cable, or
C) Other approved multiconductor cable

Conductors shall also be located or guarded as to protect them from physical damage. Multiconductor portable cable may supply mobile equipment.
An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor may be insulated or bare.

# APPENDIX

**FILE NAME <AMB.KBS>**

This is the main program of expert system for safety of all electric equipment and installations used to provide electric power and light for employee workplaces.

ELECTRICAL SAFETY REQUIREMENTS

```
  RUNTIME;
  ACTIONS
  COLOR =5
  DISPLAY "
          THIS EXPERT SYSTEM ADVISES YOU ON FEDERAL
          REQUIREMENTS AND REGULATIONS REGARDING
          WORKERS SAFETY FOR ELECTRICAL INSTALLATIONS
          AND MAINTENANCE IN AN INDUSTRIAL
          ENVIRONMENT.
          INCLUDED IN THIS EXPERT SYSTEM ARE ALL
          ELECTRICAL EQUIPMENT AND INSTALLATIONS USED
          TO PROVIDE ELECTRIC POWER AND LIGHT EMPLOYEE
          WORKPLACES.
          IT CAN BE USED AS REFERENCE BY THE
          MANUFACTURERS OF ELECTRICAL EQUIPMENTS,
          PRACTICING ENGINEERS, ELECTRICAL CONTRACTORS
          AND TECHNICIANS.


       Press Enter To Continue
~"
FIND message
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
!COLOR=1
CLS;
RULE 1
IF R1=DESIGN_SAFETY_REQUIREMENTS AND
R2=DESIGN_STD_FOR_UTILI AND
R3=Electrical_Utilizati AND
R4=SCOPE AND
R5=COVERED
THEN message=Yes
RESET R3
FIND R3
WHILETRUE R2=DESIGN_STD_FOR_UTILI AND
R3=General_Requirements AND
R4=SCOPE AND
R5=COVERED
THEN CHAIN A:RR7;

RULE 2
IF R1=DESIGN_SAFETY_REQUIREMENTS AND
R2=DESIGN_STD_FOR_UTILI AND
R3=Electrical_Utilizati AND
R4=Extend_of_Application
THEN message=chain

CHAIN A:RR6;
```

```
RULE 3
IF R1= DESIGN_SAFETY_REQUIREMENTS AND
R2= DESIGN_STD_FOR_UTILI AND
R3= GENERAL_REQUIREMENTS
THEN message=chain
CHAIN A:RR7;
RULE 4
IF R1= DESIGN_SAFETY_REQUIREMENTS AND
R2= DESIGN_STD_FOR_UTILI AND
R3= WIRING_DESIGN_AND_PROTECTION
THEN message =chain
CHAIN A:2ND;
RULE 5
IF R1=SAFETY_RELATED_WORK_PRACTICES
THEN message=displayed
DISPLAY"
Laws and Regulations for safety related work practices
are still in its formulation stage and the details
about it can be found out by writing at US Department
of Labor Occupational Safety and Health Administration,
201 Varick Street,
Room No 670,
New York, NY 10014
Telephone: (212) 337-2378";
RULE 6
IF R1 = SAFETY_RELATED_MAINTENENCE
THEN message=displayed
DISPLAY "
The rules and regulations for this area of safety
maintenance is still in its formulating stage and US
Department of Labor, Occupational Safety and Health
Administration is evaluating all the aspects in
consultation with different agencies like National
Institute for Occupational Safety and Health, and is
trying to constitute a very comprehensive regulations
for the workers safety in this field.
Since the rule for this area is still to be finalized,
therefore more details about it can be found by
looking at section 51A, Series 29 of Codes of Fedral
Regulations.
~"
CLS;
RULE 7
IF R1= DESIGN_SAFETY_REQUIREMENTS AND
R2= DESIGN_STD_FOR_UTILI AND
R3= WIRING_METHODS_COMP_EQUIPTS_FOR_GEN_USE
THEN message = chain
CHAIN A:anwar;
RULE 8
```

```
IF R1=DESIGN_SAFETY_REQUIREMENTS AND
R2=DESIGN_STD_FOR_UTILI AND
R3=SPECIAL_SYSTEMS
THEN message = chain
CHAIN A:40;



RULE 8
IF R1= DESIGN_SAFETY_REQUIREMENTS AND
R2= DESIGN_STD_FOR_UTILI AND
R3= HAZARDOUS_LOCATIONS
THEN message = chain
CHAIN A:6;
! ********INPUT STATEMENTS*******
 ASK R3 : "
 THE FOLLOWING CHOICES TELLS YOU ABOUT THE LAWS IN
 THEIR PARTICULAR AREAS.ELECTRICAL UTILIZATION TELLS
 ABOUT WHAT ARE EXACTLY COVERED WITHIN THE
 JURISDICTION OF OCCUPATIONAL SAFETY AND HEALTH
 ADMINISTRATION AND WHAT ARE THE EXTEND OF
 APPLICATION.
 GENERAL REQUIREMENT GIVES YOU THE DETAILS ABOUT
 DIFFERENT REQUIREMENTS WHICH ARE REQUIRED IN DIFFERENT
 AREAS AS PRE-REQUISITES BEFORE YOU CAN EXACTLY START
 A WORK. OTHER CHOICES GIVES THE DETAILS OF THE
 INDIVIDUAL AREAS.

  Which of the following you want to go?";
  CHOICES R3:    Electrical_Utilizati,
                 General_Requirements,
                 Wiring_Design_And_Protection,
           Wiring_Methods_Comp_Equipts_For_Gen_Use,
             Specific_Purpose_Equipts_&_Install,
             Hazardous_Locations,
             Special_Systems;
    ASK R1 :"
    THESE ARE THE THREE MAJOR AREAS FOR WHICH YOU CAN
    HAVE RULES AND BY SELECTING THE ONE WHICH FITS
    YOUR NEEDS, YOU CAN SEE THE EXACT REQUIREMENT IF
    YOU ARE SELECTING THE RIGHT CHOICES AND THE EXPERT
    SYSTEM WILL GIVE YOU THE APPROPRIATE LAWS WHICH
    CONCERNS YOU

    Which of the three major divisions you want to
    go?";
    CHOICES R1: Design_Safety_Requirements,
                Safety_Related_Work_Practices,
                Safety_Related_Maintenence;

    ASK R2:"
    OF THE FOLLOWING TWO, DESIGN STANDARD FOR
    UTILIZATION CONCERNS WITH THE EXISTING
```

REQUIREMENTS FOR ANY DESIGN, INSTALLATION AND MAINTENANCE OR INSTALLING A NEW SYSTEM OR DOING MAINTENANCE OF AN EXISTING SETUP,
WHILE THE FUTURE DESIGN SAFETY STANDARDS CONCERNS WITH THE REGULATIONS FOR THE DEVELOPING TECHNOLOGY LIKE ROBOTICS AND FMS, AND THESE RULES HAVE YET TO BE COMPLETELY FINALIZED BY THE DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION AND THESE RULES ARE CONSTANTLY SUBJECTED TO CHANGES BECAUSE OF NEW DEVELOPMENT IN THESE FIELDS

Which of the following you want to go?";
CHOICES R2: Design_Std_for_Utili,
Future_Design_Safety_Standards;
ASK R4: "

BY CHOOSING NO1, YOU WILL BE ABLE TO KNOW ABOUT THE AREAS OR FIELDS WHICH FALL UNDER THE LAWS OF OCCUPATIONAL SAFETY AND HEALTH . CHOOSING THE SECOND WILL TELL YOU ABOUT THE DETAILS OF THE APPLICATIONS OF THE LAWS WHICH ARE FORMED FOR THE SAFETY OF WORKERS IN MIND WHILE DOING ANY ELECTRICAL WORK.

Which of the two you want to look at?";
CHOICES R4: Scope,
Extend_of_Application;

ASK R5:"
Electrical installations and utilization equipment installed or used within or outside buildings, structures, and other premisse including :

1) Yards
2) Carnivals
3) Parking and other lots
4) Mobile homes
5) Recreational Vehicles
6) Industrial Substation
7) Conductors that connect the installations to a supply of electricity, and
8) Other outside conductors on premises,

ARE COVERED IN THIS EXPERT SYSTEM AND SAFETY REQUIREMENTS FROM WORKERS POINT OF VIEW ARE ONLY FOR THESE AREAS, SO IF YOU ARE COVERED AMONG THIS LIST, THEN CHOOSE COVERED AND LOOK FOR OPTIONS YOU WANT TO SEE THERE ARE NO OTHER

```
REQUIREMENTS FOR ANY OTHER AREAS FOR WORKERS'
SAFETY IN ELECTRICAL INSTALLATIONS AND,
UTILIZATION EQUIPMENT, AND IF YOU ARE AMONG
SO, CHOOSE NOT COVERED AND GO OUT OF THE
SYSTEM



Which of the following you want to choose?";
 CHOICES R5: Covered, Not_covered;


 ASK R6 : "FOR WHICH OF THE FOLLOWING THREE YOU
           WANT TO SEE APPLICABLE LAWS?";
 CHOICES R6: 1, 2, 3;
```

```
RUNTIME;
ACTIONS
COLOR =14
FIND message
LOCATE 20,20
COLOR=20
DISPLAY "
         press any key to do the consultation~";

RULE 1
IF R20=GENERAL-REQUIREMENTS
THEN message = displayed
DISPLAY "

ELECTRICAL CONTINUITY OF METAL RACEWAYS AND ENCLOSURES

Cable, armor and other metal enclosures for conductors shall
be
metallically joined together into a continuous electric
conductor
and shall be so connected to all boxes, fittings, and
cabinets as to
provide effective electrical continuity.

PLEASE PRESS ENTER TO CONTINUE
~"
DISPLAY "
WIRING IN DUCTS

No wiring system of any type shall be installed in ducts
used to transport dust, loose stock or flammable vapors.
No wiring system of any type may be installed in any duct
used
for vapor removal or for ventilation of commercial type
cooking
equipment, or in any shaft containing only such ducts.

~"

BECAUSE "When they are joined in this manner, they will
provide effectiveelectric continuity and the chances of any
mishappening will be minimized

Law also requires that there should be no wiring in those
ducts which are
used to transport ducts, flammable vapors, loose stock, or
for vapor removal orventilation . This all has been done to
reduce the possibility of any accidents.

";
```

```
RULE 2
IF R20= TEMPORARY-WIRING
THEN message= displayed

DISPLAY "
Temporary electrical power and lightning wiring methods may
be of a class less than would be required for a permanent
installation.
Except as specifically modified here, all other requirements
for permanent wiring shall apply to temporary wiring
installation.

(i) Uses permitted, 600 volts, nominal or less:

a) During and for remodeling, maintenance, repair, or
   demolition of buildings, structures, or equipment, and
   similar activities.
b) For experimental and development work
c) For a period not to exceed 90 days for Christmas
   decorative lighting, carnivals and similar purposes.

  PLEASE PRESS ENTER TO CONTINUE
~"

DISPLAY "

ii) Uses permitted, over 600 volts, nominal.

Temporary wiring over 600 volts, nominal, may be used only
during periods of tests, experiments, or emergencies.

 PLEASE PRESS ENTER TO CONTINUE ~"

DISPLAY "

iii) General Requirements for Temporary wiring

A) Feeders shall originate in an approved distribution
   center. The conductors shall be run as multiconductor
   cord or cable assemblies or where not subject to physical
   damage, they may run as open conductors on insulators not
   more than 10 feet apart.

B) Branch circuits shall originate in an approved power
   outlet or panel board. Conductors shall be multiconductor
   cord or cable  assemblies or open conductors. If run as
   open conductors they shall be fastened at ceiling height
   every 10 feet. No branch circuit conductor may be laid on
   the floor.
```

```
 PLEASE PRESS ENTER TO CONTINUE~"

DISPLAY "

C) Receptacles shall be of the grounding type.

D) No bare conductors nor earth returns may be used for the
   wiring of any temporary circuit.

E) Suitable disconnecting switches or plug connectors shall
   be installed to permit the disconnection of all
   ungrounded conductors of each temporary circuit.

F) Lamps for general illumination shall be protected from
   accidental contact or breakage. Protection shall be
   provided by elevation of at least 7 feet from normal
   working surface or by a suitable fixture or lampholder
   with a guard.

G) Flexible cords and cables shall be protected from
   accidental damage. Sharp corners and projections shall be
   avoided.
~";

RULE 3

IF R20 = CABLE-TRAYS
THEN message = displayed

DISPLAY "

Only the following may be installed in cable tray systems:

1. Mineral insulated metal sheeted cable (Type MI)
2. Armored cable (Type AC)
3. Metal-clad cable (Type MC)
4. Power limited tray cable (Type PLTC)
5. Shielded nonmetallic-sheated cable (Type SNM)
6. Multiconductor service-entrance cable (Type SE or USE)
7. Nonmetallic-sheated cable (Type NM or NMC)
8. Multiconductor underground feeder and branch-circuit
   cable
9. Power and control tray cable (Type TC)
10.Other factory assembled, multiconductor control, signal,
   or power cables which are specifically approved for
   installation in cable trays.
11.Any approved conduit or raceway with its contained
   conductors.
                          ~"
```

```
BECAUSE "
All these cable types have been recommended to use and have
been made part of the law because they are considered to be
safest for use in this specific application."
;

RULE 4
IF R20 = OPEN-WIRING-INSULATORS
THEN message = YES
CHAIN A:1
END;


ASK R20: "

About which of the following topics you want to know the
law requirements


";
CHOICES R20: GENERAL-REQUIREMENTS,
             TEMPORARY-WIRING,
             CABLE-TRAYS,
             OPEN-WIRING-INSULATORS;
```

## FILE NAME <RR7.KBS>

This file covers the Gerneral Requirements needed to be fulfilled at any workplace.

The topics included in it are :

1. Approval Requirements from government agencies.the expert
2. Information regarding Examination, Installation and equipments of electrical components.
3. Splices
4. Marking of equipment
5. Identification of disconnect means and circuirts
6. Necessary details when using 600 Volts or less.
7. Necessary details when using over 600 volts
8. Arcing parts

```
RUNTIME;
ACTIONS
COLOR=14
DISPLAY"
      (A)  YOU CAN HAVE THE INFORMATION REGARDING THE
           APPROVAL REQUIREMENTS OF THE GOVERNMENT.
      (B)  GIVES INFORMATION REGARDING
           EXAMINATION,INSTALLATION AND USE OF EQUIPMENT
      (C)  WILL GIVE INFORMATION REGARDING SPLICES.
      (D)  GIVES THE INFORMATION ABOUT ARCING PARTS
      (E)  IS CHOOSED, WE CAN FIND THE REQUIREMENTS ABOUT
           MARKING OF THE EQUIPMENT  i.e. INFORMATION
           SUCH AS MANUFACTURERS NAME,TRADEMARK, OR OTHER
           DESCRIPTIVE DETAILS REQUIREMENTS.
      (F)  GIVES THE DETAILS ABOUT IDENTIFICATION OF
           DISCONNECTING MEANS And CIRCUITS.
      (G)  ALL THE NECESSARY DETAILS WHEN USING 600
           VOLTS, NOMINAL, OR LESS CAN BE FOUND.
      (H)  DETAILS WHEN USING OVER 600 VOLTS CAN BE
           FOUND. "
LOCATE 20,20
COLOR=20
DISPLAY"Press First Letter to Select~"
CLS
COLOR=1
FIND R7
CLS
RR=(R7)
WHILETRUE  RR=A THEN
COLOR=0
CLS
DISPLAY"
APPROVAL:
The conductors and equipment required and permitted by this
section of
of the law shall be acceptable only if approved."
COLOR=0
RR=UNKNOWN
END
RR=(R7)
WHILETRUE RR=A THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=0
RR=(R7)
WHILETRUE RR=B THEN
DISPLAY"  1 = General requirements for examination of
              electrical equipment
          2 = General requirement for installation and
              use."
```

```
LOCATE 15,0
COLOR=1
FIND R8
CLS
RR=UNKNOWN
END
COLOR=4
RR=(R7)
WHILETRUE RR=C  THEN
WHILEKNOWN SAM
RECEIVE TEXT100, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R7)
WHILETRUE RR=C THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4
RR=(R7)
WHILETRUE RR=D THEN
WHILEKNOWN SAM
RECEIVE TEXT3, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R7)
WHILETRUE RR=D THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4
RR=(R7)
WHILETRUE RR=E THEN
WHILEKNOWN SAM
RECEIVE TEXT4,SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R7)
WHILETRUE RR=E THEN
LOCATE 20,25
```

```
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4

RR=(R7)
WHILETRUE RR=F THEN
WHILEKNOWN SAM
RECEIVE TEXT5,SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R7)
WHILETRUE RR=F THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
RR=(R7)
WHILETRUE RR=G THEN
COLOR=0
DISPLAY"
          1 = Working space about electric equipment
          2 = Guarding of live Parts"
LOCATE 15,0
FIND R9
RR=UNKNOWN
END
CLS

RR=(R7)
WHILETRUE RR=H THEN
COLOR=4
DISPLAY "
         1 = GENERAL REQUIREMENTS
         2 = ENCLOSURE FOR ELECTRIC INSTALLATIONS
         3 = WORK SPACE ABOUT EQUIPMENT
         4 = ENTRANCE AND ACCESS TO WORKSPACE"
LOCATE 15,0
FIND R11
RR=UNKNOWN
END
CLS
RR=(R11)
```

```
WHILETRUE RR=1 THEN
COLOR=4

DISPLAY "Conductors and equipment used on circuits
         exceeding 600 volts, nominal, shall comply with
         all applicable provisions provided in the
         section 1910.303 (a) through (g) that can be
         seen in Codes of Federal Regulations series 29
         for labors and can be obtain from any of the
         regional offices of Occupational Safety and
         Health Administration."
COLOR=20
LOCATE 20,25
DISPLAY"Press Any key to Continue"
COLOR=1
RR=UNKNOWN
END
RR=(R11)
WHILETRUE RR=1 THEN
DISPLAY"~"
RR=UNKNOWN
END
CLS
RR=(R11)
WHILETRUE RR=2 THEN
COLOR=4
DISPLAY "
        i = Installation Accessible to Qualified Person
       ii = Installation Accessible to Unqualified Person"
COLOR=1
LOCATE 15,0
FIND R12
CLS
RR=UNKNOWN
END
CLS
RR=(R12)
WHILETRUE RR = i THEN
COLOR=0
DISPLAY "
 Electrical installations having exposed live parts
 shall be accessible to qualified persons only and shall
 comply with all the other applicable provisions .
 Qualified person is one, who is familiar with the
 construction and operation of the equipment and hazards
 involved.  "
LOCATE 20,25
COLOR = 20
DISPLAY "Press Any Key to Continue"
RR=UNKNOWN
END
RR=(R12)
```

```
WHILETRUE RR=i THEN
DISPLAY"~"
RR=UNKNOWN

END
CLS
COLOR = 4
RR=(R12)
WHILETRUE RR=ii THEN
WHILEKNOWN SAM
RECEIVE UQ,SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R12)
WHILETRUE RR=ii THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4
RR=(R11)
WHILETRUE RR=3 THEN
WHILEKNOWN SAM
RECEIVE EX, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R11)
WHILETRUE RR=3 THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR = 14
RR=(R11)
WHILETRUE RR=4 THEN
DISPLAY "
1) Atleast one entrance not less then 24 inches wide and
   6 feet 6 inches high shall be provided to give access
   to the working space about electric equipment. On
   switch board and control panels exceeding 48 inches in
   width, there shall be one entrance at  each of such
   board where practicable.
   Where bare energized parts at any voltage or insulated
   energized parts above 600 volts are located adjacent
   to such entrance, they shall be suitably guarded.
```

2) Permanent ladders or stairways shall be provided to give safe access to the working space around electric equipment installed on platforms, balconies, mezzanine floors, or in attic or roof rooms or spaces. "

```
COLOR = 20
LOCATE 20,25
COLOR = 0
RR=UNKNOWN
END
RR=(R11)
WHILETRUE RR=4 THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
RR=(R8)
WHILETRUE RR=1 THEN
COLOR =14
DISPLAY "

EXAMINATION:
Electrical equipment shall be free from recognized hazards
that are likely to cause death or serious physical harm to
employees. Safety of equipment shall be determined using the
following considerations:
i) Suitability for installation and use in conformity with
the provisions of this sub-part. Suitability of equipment
for an identified purpose may be evidenced by listing or
labelling for that identified purpose.
ii) Mechanical strength and durability, including , for
parts designed to enclose and protect other equipment, the
adequacy of the equipment thus provided.
iii) Electric insulation.
iv)  Heating effects under conditions of use.
v)   Arcing effects.
vi)  Classification by type, size, voltage, current
     capacity, specific use.
vii) Other factors which contribute to the practical
     safeguarding of the employees using or likely to
     come in contact with the equipment."
COLOR = 0
LOCATE 20,25
DISPLAY "Press Any Key to Continue"
COLOR = 0
RR=UNKNOWN
END
RR=(R8)
WHILETRUE RR=1 THEN
DISPLAY"~"
RR=UNKNOWN
```

```
END
CLS
RR=(R8)
WHILETRUE RR=2 THEN
COLOR =14


DISPLAY "
INSTALLATION AND USE:
Listed or labeled equipment shall be used or installed in
accordance with any instructions included in the listing or
labeling."
COLOR = 20
LOCATE 20,25
DISPLAY "Press Any Key to Continue"
COLOR =0
RR=UNKNOWN
END
RR=(R8)
WHILETRUE RR=2 THEN
DISPLAY"~"
RR=UNKNOWN
END
CLS
RR=(R9)
WHILETRUE RR=1 THEN
COLOR =14
DISPLAY "
          i = Working clearance
         ii = Clear spaces
        iii = Access and entrance to working spaces
         iv = Front working spaces
          v = Illumination
         vi = Head Room"
COLOR = 20
COLOR =1
LOCATE 15,0
FIND R10
RR=UNKNOWN
END
RR=UNKNOWN
WHILETRUE RR=1 THEN
DISPLAY "~"
END
CLS
COLOR =4
RR=(R10)
WHILETRUE RR=i    THEN
WHILEKNOWN SAM
RECEIVE WC, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
```

```
RR=(R10)
WHILETRUE RR=i THEN
LOCATE 20,25
COLOR=4
DISPLAY "Press Any Key to Continue~"


RR=UNKNOWN
END
CLS
COLOR=4

RR=(R10)
WHILETRUE RR=ii THEN
WHILEKNOWN SAM
RECEIVE CS, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R10)
WHILETRUE RR=ii THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue ~"
RR=UNKNOWN
END
CLS
COLOR=4

RR=(R10)
WHILETRUE RR=iii THEN
WHILEKNOWN SAM
RECEIVE TA, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R10)
WHILETRUE RR=iii THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue ~"
RR=UNKNOWN
END
CLS
COLOR=4

RR=(R10)
WHILETRUE RR=iv THEN
WHILEKNOWN SAM
RECEIVE TB, SAM
DISPLAY "{SAM}"
END
```

```
RR=UNKNOWN
END
RR=(R10)
WHILETRUE RR=iv THEN
LOCATE 20,25
COLOR=20

DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4

RR=(R10)
WHILETRUE RR=v THEN
WHILEKNOWN SAM
RECEIVE TC, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R10)
WHILETRUE RR=v THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4
RR=(R10)
WHILETRUE RR=vi THEN
WHILEKNOWN SAM
RECEIVE TD, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWM
END
RR=(R10)
WHILETRUE RR=vi THEN
LOCATE 20,25
COLOR=20
DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS
COLOR=4
RR=(R9)
WHILETRUE RR=2 THEN
WHILEKNOWN SAM
RECEIVE GP, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
```

```
END
RR=(R9)
WHILETRUE RR=2 THEN
LOCATE 20,25
COLOR=20

DISPLAY"Press Any Key to Continue~"
RR=UNKNOWN
END
CLS;

! ******* INPUT STATEMENTS ******

ASK R6 : "
FOR WHICH OF THE FOLLOWING THREE YOU WANT TO SEE APPLICABLE
LAWS?";
CHOICES R6: 1, 2, 3;

ASK R7:" Which of the following you want to select ? ";
CHOICES R7: A,B,C,D,E,F,G,H;

ASK R8:
"About which of the following topics you want to see the law
requirements to be fulfilled ? ";
CHOICES R8: 1,2;

ASK R9: "
About which of the following you want to see the
applicable law?";
CHOICES R9: 1,2;

ASK R11: "
About which of the following you want to have law
requirements?";
CHOICES R11: 1,2,3,4;

ASK R12: "
Whether you want to see installation accessible to qualified
person or for unqualified person";
CHOICES R12: i,ii;

ASK R10: "
Of the following topics which you want to look at";
CHOICES R10: i,ii,iii,iv,v,vi;
```

## FILE NAME <2ND.KBS>

In this file, the requirements regarding Wiring Design & Protection can be seen.

Totally there are eleven topic which are covered in this file.

```
RUNTIME;
ACTIONS
COLOR = 1
FIND R13
CLS
RR=(R13)
WHILETRUE RR=a THEN
COLOR = 14
DISPLAY"
A conductor used as a grounded conductor shall be
identifiable and distinguishable from all other conductors."
COLOR=0
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=a THEN
LOCATE 20,20
COLOR = 20
DISPLAY" Press any key to continue~"
RR=UNKNOWN
END
CLS
COLOR=0
RR=(R13)
WHILETRUE RR=b THEN
COLOR = 14
DISPLAY"
 No grounded conductor may be attached to any terminal or
 lead so as to reverse deignated polarity."
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=b THEN
LOCATE 20,20
COLOR =20
DISPLAY "Press Any Key to continue~"
COLOR=0
RR=UNKNOWN
END
CLS
RR=(R13)
WHILETRUE RR=c THEN
COLOR=14
CLS
DISPLAY
"A grounding terminal or grounding type devices on a
 receptable, cord connector, or attachmenet plug may not  be
used for purposes other than grounding."
COLOR=0
RR=UNKNOWN
END
```

```
RR=(R13)
WHILETRUE RR=c THEN
LOCATE 20,20
COLOR = 20
DISPLAY "Press Any key to continue~"
RR=UNKNOWN
END
CLS
RR=(R13)
WHILETRUE RR=d THEN
COLOR=14
DISPLAY
"The employer shall use either ground fault circuit
 interrupters (can be seen by choosing 'e') or an assured
 equipment grounding  conductor program (can be seen by
 choosing 'f')."
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=d THEN
LOCATE 20,20
COLOR = 20
DISPLAY" Press Any Key to continue~"
COLOR=0
RR=UNKNOWN
END
CLS
COLOR =4
RR=(R13)
WHILETRUE RR=e THEN
WHILEKNOWN SAM
RECEIVE GF, SAM
DISPLAY "{SAM}"
END
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=e THEN
LOCATE 20,25
COLOR = 20
DISPLAY "Press Any Key to continue~"
RR=UNKNOWN
END
CLS
COLOR=4
RR=(R13)
WHILETRUE RR=f THEN
WHILEKNOWN SAM
RECEIVE AE, SAM
DISPLAY "{SAM}"
```

```
END
RR=UNKNOWN
END

RR=(R13)
WHILETRUE RR=f THEN
LOCATE 20,25
COLOR=20
DISPLAY "Press Any Key to continue~"
RR=UNKNOWN
END
CLS
RR=(R13)
WHILETRUE RR=g THEN
COLOR=0
DISPLAY
"Outlet devices shall have an ampere rating not less
 than the load to be served."
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=g THEN
LOCATE 20,20
COLOR=20
DISPLAY"Press Any Key To Select Other Options~"
RR=UNKNOWN
END
CLS
RR=(R13)
WHILETRUE RR=h THEN
COLOR=4
CLS
DISPLAY
"Conductors supported on poles shall provide a horizontal
 climbing space not less than the following:
1) Power conductors below communication conductors-30
   inches
2) Power conductors alone or above communication
   conductors :
    300 volts or less   -- 24inches
    more than 300 volts -- 30 inches
3) Communication conductors below power conductors with
   power conductors 300 volts or less -- 24 inches
                    more than 300 volts -- 30 inches"
COLOR=0
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=h THEN
LOCATE 20,20
```

```
COLOR=20
DISPLAY "Press Any key to see other sections~"
RR=UNKNOWN
END
CLS


RR=(R13)
WHILETRUE RR=i THEN
COLOR=14
CLS
DISPLAY
"Open conductors shall conform to the following
 minimum clearences :
 (i)      10 feet -- above finished grade, sidewalks, or
          from any platform or projection from which they
          might be reached.
 (ii)     12 feet -- over areas subject to vehicular
          traffic other than truck traffic.
 (iii)    15 feet -- over areas other than those specified
          in the above cases.
 (iv)     18 feet -- over public streets, alleys, roads.
          and driveways."
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=i THEN
LOCATE 20,20
COLOR=20
DISPLAY "Press Any key to see other sections~"
RR=UNKNOWN
END
CLS
RR=(R13)
WHILETRUE RR=j THEN
COLOR=14
CLS
DISPLAY
"Conductors shall have a clearence of at least 3 feet  from
 windows doors, porches, fire escapes, or similar
 locations.
 Conductors run above the top level of a window are
 considered to  be out of reach from that window and,
 therefore, do not have to be 3 feet away."
COLOR = 0
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=j THEN
LOCATE 20,20
```

```
COLOR=20
DISPLAY"Press Esc KEY To See Other Sections~"
RR=UNKNOWN
END
CLS


RR=(R13)
WHILETRUE RR=k THEN
COLOR =14
CLS

DISPLAY

"Conductors shall bave a clearence of not less than 8  feet
from the highest point of roofs over which they  pass,
 except that:

 1. Where the voltage between conductors in 300 volts or
    less and the roof has a slope of not less than 4
    inches in 12, the clearence from roofs shall be at
    least 3 feet, or

 2. Where the voltage between conductors in 300 volts or
    less and the conductors do not pass over more than 4
    feet of the overhang portion of the roof and they are
    terminated at a through the roof raceway or approved
    support, the clearence from roofs shall be at least
    18 inches."

COLOR=0
RR=UNKNOWN
END
RR=(R13)
WHILETRUE RR=k THEN
LOCATE 20,20
COLOR=20
DISPLAY "Please Press Any Key to see other sections~"
RR=UNKNOWN
END
CLS
RR=(R13)
WHILETRUE RR=l THEN
CHAIN RIZ
RR=UNKNOWN
END
CLS
```

```
!ACTIONS

RR = (R13)
WHILETRUE RR=m THEN

DISPLAY

"WHAT DO YOU WANT TO DISPLAY~"
RR = UNKNOWN
CHAIN CHOICE
RR=UNKNOWN
END;



ASK R13: " BY SELECTING THE APPROPRIATE CHOICES OF THE
           FOLLOWING YOU CAN HAVE THE EXACT REQUIREMENTS
           OF THE APPLICABLE LAWS
         a) Use and identification of ground and
            grounding conditions.
         b) Polarity of connections
         c) Use of grounding terminals and devices
         d) Current fault protection for personnel on
            construction sites.
         e) Ground fault circuit interruption.
         f) Assured equipment grounding conductor
            program
         g) Outlet devices
         h) Conductors on poles
         i) Clearence from ground
         j) Clearence from building openings
         k) Clearence from roofs
         l) Services
         m) Over current protection";



CHOICES R13: a,b,c,d,e,f,g,h,i,j,k,l,m;

ASK R14: "
            1) DISCONNECTING MEANS: Gives details about
               how shall means be provided to disconnect
               conductors
            2) SERVICES OVER 600 VOLTS : Tells about the
               additional requirements applicable to
               services over this range.";

CHOICES R14: 1,2;

ASK R15: "  1. GENERAL : It gives the general information
                         for disconnecting the
                         conductors.
            2. SIMULTANEOUS OPENING OF POLES ";
```

## FILE NAME <RR6.KBS>

This file in the expert system covers:

1. Requirements for Electrical Installations and Utilization regardless when they were installed.
2. Requirements for Electrical Utilization Systems and Equipments installed, repaired or modified after March 15, 1972.
3. Requirements for Electrical Utilization Systems and Equipments installed, repaired or modified after April 16, 1981.

```
RUNTIME;
ACTIONS
COLOR = 14
DISPLAY"
        REMARKS:

      1=REQUIREMENTS FOR ALL ELECTRIC INSTALLATIONS AND
        UTILIZATION REGARDLESS OF WHEN THEY WERE INSTALLED
        OR DESIGNED.
      2=REQUIREMENTS FOR ELECTRIC UTILIZATION SYSTEMS AND
        EQUIPMENTS INSTALLED, REPAIRED, MODIFIES AFTER
        MARCH 15, 1972.
      3=REQUIREMENTS FOR ELECTRIC UTILIZATION SYSTEMS AND
        EQUIPMENT INSTALLED AFTER APRIL 16, 1981. "
FIND message
LOCATE 20,20
COLOR=20
DISPLAY"Please hit enter to select~"
CLS;

RULE 1
IF R6 =1
THEN message = received
WHILEKNOWN SAM
RECEIVE a:LAW1,SAM
DISPLAY "{SAM}"
END
CLS;


RULE 2
IF R6=2
THEN message = received
WHILEKNOWN SAM
RECEIVE LAW2,SAM
DISPLAY "{SAM}"
END
CLS;


RULE 3
IF R6 = 3
THEN message =received
! chain
WHILEKNOWN SAM
RECEIVE LAW3, SAM
DISPLAY "{SAM}"
END
CHAIN A:AMB;
```

```
ASK R6:"FOR WHICH OF THE FOLLOWING THREE YOU WANT TO SEE
APPLICABLE LAWS?";
CHOICES R6: 1, 2, 3;
ASK R3:"WHICH OF THE FOLLOWING YOU WANT TO GO?";
CHOICES R3: Electrical_Utilizati,
            General_Requirements,
            Wiring_Design_And_Protection,
            Wiring_Methods_Comp_Equipts_For_Gen_Use,
            Specific_Purpose_Equipts_&_Install,
            Hazardous_Locations,
            Special_Systems;
```

**FILE NAME <40.KBS>**

This file of the expert system covers the requirements for Special Systems.

It includes:

1. Wiring Method for fixed installation over 600 volts.
2. Interrupting and isolation of device
3. Mobile portable equipment
4. Tunnel Installations
5. Emergency power System
6. Fire protective signalling system
7. Communication system

```
RUNTIME;
ACTIONS
COLOR=5
DISPLAY "

              A) WIRING METHODS OF FIXED INSTALLATIONS
              B) INTERRUPTING AND ISOLATING DEVICE
              C) MOBILE AND PORTABLE EQUIPMENT
              D) TUNNEL INSTALLATIONS
              E) EMERGENCY POWER SYSTEMS
              F) FIRE PROTECTION SIGNALLING SYSTEM
              G) COMMUNICATION SYSTEMS ~"
FIND work
LOCATE 20,20
COLOR=20
DISPLAY "Press any key to continue consultation";
RULE 1
IF R40= A
THEN work= displayed
DISPLAY "
1. Above ground conductors shall be installed in rigid
   metal conduit, in intermediate metal conduit, in cable
   trays, in cable bus, in other suitable raceways, or as
   open runs of metal-clad cable suitable for the use and
   purpose.
   However open runs of non metallic-sheeted cable or of
   bare  conductors or busbars may be installed in
   locations accessible only to qualified persons.
   Metallic shielding components, such as tapes, wires,
   or braids for conductors, shall be grounded. Open runs
   of insulated wires and cables having a bare lead
   sheath or a braided outer covering shall be supported
   in a manner designed to prevent physical damage to the
   braid or sheath.
2. Conductors emerging from the ground shell be enclosed
   in approved raceways.~";

RULE 2
IF R40= B
THEN work = displayed
DISPLAY "
i)  Circuit breakers installations located indoors shall
    consist of metal enclosed units or fire resistant
    cell mounted units. In locations accessible only to
    qualified personnel, open mounting of circuit
    breakers is permitted. A means of indicating the open
    and closed position of circuit breakers shall be
    provided.
PLEASE PRESS 'ENTER' TO CONTINUE ~"
DISPLAY "
```

```
ii) Fused cutouts installed in  buildings or transformer
    vaults shall be of a type approved for the purpose.
    They shall be readily accessible for fuse
    replacement.

PLEASE PRESS 'ENTER' TO CONTINUE~"

DISPLAY "
111) A means shall be provided to completely isolate
     equipment for inspection and repairs. Isolating
     means which are not designed to interrupt the load
     current of the circuit shall be either interlocked
     with an approved circuit interrupter or provided
with a sign warning against opening them under load. ~";
RULE 3
IF R40 = C
THEN work = displayed
DISPLAY "

a) POWER CABLE CONNECTIONS TO MOBILE MACHINES

   A metallic enclosure shall be provided on the mobile
   machine for enclosing the terminals of the power
   cable. The enclosures shall include provisions for a
   solid connection for the ground wire terminal to
   effectively ground the machine frame. The method of
   cable termination used shall prevent any strain or
   pull on the cable from stressing the electrical
   connections.
   The enclosure shall have provision for locking so only
   authorized qualified persons may open it and shall be
   marked with a sign warning of the presence of
   energized parts
PLEASE PRESS 'ENTER' TO CONTINUE~"
DISPLAY "
GUARDING LIVE PARTS

All energized switching and control parts shall be enclosed
in effectively grounded metal cabinets or enclosures.
Circuit breakers and protective equipment shall have the
operating means projecting through the metal cabinet or
enclosure so these units can be reset
without locked doors being opened. Enclosures and metal
cabinets  shall be locked so that only authorized
qualified persons have access and shall be marked with a
sign warning of the presence of energized parts.
Collector ring assemblies on revolving type machines like
shovels, draglines, etc. shall be guarded.
```

```
~";
RULE 4
IF R40 = D
THEN work = chain
CHAIN A:41;

RULE 5
IF R40= E
THEN work = displayed
DISPLAY "
SCOPE
The provisions for emergency systems apply to circuits,
systems, and equipment intended to supply power for
illumination and special loads, in the event of failure of
the normal supply.
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION
                                                    ~"
DISPLAY "
WIRING METHODS
Emergency  circuit wiring shall be kept entirely independent
of all other wiring and equipment and may not enter the same
raceway, cable, box, or cabinet or other wiring except
either where common circuit elements suitable for the
purpose are required, or for transferring power from the
normal to the emergency source.
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION
~"
DISPLAY "
EMERGENCY ILLUMINATION
Where emergency lighting is necessary, the system shall be
so arranged that the failure of any individual lighting
element, such as the burning out of a light bulb, cannot
leave any space in total darkness.~";

RULE 6
IF R40= F
THEN work = chain
CHAIN A: 42;

RULE 7
IF R40 = G
THEN work = chain
CHAIN A: 43;

ASK R40: "
About which of the following you want to see the
requirements ";

CHOICES R40: A,B,C,D,E,F,G;
```

**FILE NAME <41.KBS>**

This file of the expert system covers the topic of Tunnel Installations. Within it, the following topics are included:

1. Application requirements
2. Conductors
3. Guarding Live parts
4. Disconnecting means
5. Grounding of wiring

```
RUNTIME;
ACTIONS
COLOR=5
!DISPLAY "";
FIND message
LOCATE 20,20
COLOR = 20
DISPLAY "Press any key to continue consultation";
RULE 1
IF R41= Applications
THEN message =displayed
DISPLAY "
The provisions of this law apply to installation and use of
high voltage power distribution and utilization equipment
which is portable and/or mobile, such as substations,
trailers, cars, mobile shovels, draglines, hoists, drills,
dredges, compressors, pumps,conveyors, and underground
excavators.~";
RULE 2
IF R41=Conductors
THEN message = displayed
DISPLAY "
Conductors in tunnels shall be installed in one or more of
the following:
A) Metal conduit or other metal raceway,
B) Type MC Cable, or
C) Other approved multiconductor cable

Conductors shall also be located or guarded as to protect
them from physical damage. Multiconductor portable cable may
supply mobile equipment.
An equipment grounding conductor shall be run with circuit
conductors inside the metal raceway or inside the
multiconductor cable jacket. The equipment grounding
conductor may be insulated or bare.~";
RULE 3
IF R41= Guarding-live-parts
THEN message = displayed
DISPLAY "
Bare terminals of transformers, switches, motor controllers,
and other equipment shall be enclosed to prevent accidental
contact with energized parts. Enclosures for use in tunnels
shall be drip proof,
weatherproof, or submersible as required by the
environmental conditions.~";
RULE 4
IF R41 = Disconnecting-means
THEN message = displayed
DISPLAY "
A disconnecting means that simultaneously opens all
ungrounded conductors shall be installed at each transformer
or motor location.~";
```

```
RULE 5
IF R41 = Grounding-&-bonding
THEN message = displayed
DISPLAY "
All non-energized metal parts of electric equipment and
metal raceways and cable sheaths shall be effectively
grounded and bonded to all metal pipes and rails at the
portal and at intervals not exceeding 1000 feet throughout
the tunnel.~";

ASK R41:

 "About which of the following in Tunnel installation
 you want to know:";



CHOICES R41: Applications, Conductors, Guarding-live-
             parts,
             Disconnecting-means, grounding-&-bonding;
```

FILE NAME <42.KBS>

In this file, Fire Protective Signalling System has been addressed. Within it the following topics arec covered:

1. Classifications
2. Power sources
3. Non power limited conductor location
4. Power limited conductor location
5. Identification

```
RUNTIME;
ACTIONS
COLOR=5
DISPLAY "
                A) Classification
                B) Power sources
                C) Non Power limited conductor location
                D) Power limited conductor location
                E) Identification~"
FIND work
LOCATE 20,20
COLOR = 20
DISPLAY " Press any key to continue consultation ";

RULE 1
IF R42 = A
THEN work = displayed
DISPLAY "
Fire protective signalling circuits shall be classified
either as non-power limited or power limited. ~";
RULE 2
IF R42 = B
THEN work = displayed
DISPLAY "
The power sources for use with fire protective signaling
circuits shall be either power limited or nonlimited as
follows:

i) The power supply of non-power-limited fire protective
signalling circuits shall have an output voltage not in
excess of 600 volts.
ii) The power for power limited fire protective signaling
circuits shall be either inherently limited, in which no
overcurrent protection is required, or limited by a
combination of a power source and overcurrent protection.
~";
RULE 3
IF R42 = C
THEN work = displayed
DISPLAY "
Non-power-limited fire protective signalling circuits and
Class 1 circuits may occupy the same enclosure, cable, or
raceway provided all conductors are insulated for maximum
voltage of any conductor within the enclosure, cable, or
raceway. Power supply and fire protective signalling circuit
conductors are permitted in the same enclosure, cable, or
raceway only if connected to the same equipment.
~";
```

```
RULE 4
IF R42 = D
THEN work = displayed
DISPLAY "
Where open conductors are installed, power limited fire
protective signaling circuits shall be separated at least 2
inches from conductors of any light, power, and non-power-
limited fire protective signalling circuits unless a special
and equally protective method of conductor separation is
employed. Cables and conductors of two or more power-limited
fire protective signaling circuits are permitted in the same
cable, enclosure or raceway.
~";
RULE 5
IF R42 = E
THEN work = displayed
DISPLAY "
Fire protective signaling circuits shall be identified at
terminal and junction locations in a manner which will
prevent unintentional interferences with the signaling
circuit during testing and servicing. Power-limited fire
protective signaling circuits shall be durably marked as
such where plainly visible at terminations.

~";

ASK R42 : "
Which of the following in Fire Protective signalling
circuits  you want to know about";


CHOICES R42 : A,B,C,D,E;
```

**FILE NAME <43.KBS>**

The expert system of this file covers the topic of Communication Systems. The following areas in it are addressed:

1. Scope of the regulations
2. Protective Device
3. Conductor Location
4. Equipment Location
5. Grounding

```
RUNTIME;
ACTIONS
COLOR =5
FIND message
LOCATE 20,20
COLOR = 20
DISPLAY "
Please press any key to continue consultation ~";

RULE 1
IF R43 = Scope
THEN message = displayed
DISPLAY "
The provisions for communication systems apply to such
system as central-station-connected and non central-station-
connected telephone circuits, radio and television receiving
and transmitting equipment, including community antenna
television and radio distribution systems, telegraph,
district messenger, and outside wiring for fire and burglar
system, and similar central station systems.~";
RULE 2
IF R43 = Protective-device
THEN message = displayed
DISPLAY "
i) Communication circuits so located as to be exposed to
accidental contact with light or power conductors operating
at over 300 volts shall have each circuit so exposed
provided with a protector approved for the purpose.

ii) Each conductor of a lead-in from an outdoor antenna
shall be provided with an antenna discharge unit or other
suitable means that will drain static charges from the
antenna system.~";

RULE 3
IF R43= Conductor-location
THEN message = displayed
DISPLAY "
OUTSIDE OF BUILDINGS

a) Receiving distribution lead-in or aerial-drop cables
attached to buildings and lead-in conductors to radio
transmitters shall be so installed as to avoid the
possibility of accidentally contact  with electric light or
power conductors.
b) The clearance between lead-in conductors and any
lightning protection conductors may not be less than 6 feet.
PRESS 'ENTER' TO CONTINUE ~"
```

```
COLOR =5
DISPLAY "
ON POLES

Where practicable , communication conductors on poles shall
be located below the light or power conductors.
Communications conductors may not be attached to a cross arm
that carries light or power conductors.
PRESS 'ENTER' TO CONTINUE ~"

COLOR=5
DISPLAY "
INSIDE OF BUILDINGS

Indoor antennas, lead-ins, and other communication
conductors attached as open conductors to the inside of
buildings shall be located at least 2 inches from conductors
of any light or power or circuits unless a special and
equally protective method of conductor separation, approved
for the purpose is employed.~";
RULE 4
IF R43 = Equipment-location
THEN message = displayed
COLOR =14

DISPLAY "
Outdoor metal structures supporting antennas, as well as
self supporting antennas such as vertical rods or dipole
structures, shall be located as far away from overhead
conductors of electric light and power circuits of over 150
volts to ground as necessary to avoid the possibility of the
antenna or structure falling into or making accidental
contact with such circuits.~";

RULE 5
IF R43 = Grounding
THEN message = displayed
DISPLAY "

i)   LEAD-IN CONDUCTORS

If exposed to contact with electric light and power
conductors, the metal shealth of aerial cables entering
buildings shall be grounded or shall be interrupted close to
the entrance to the building by an insulating joint or
equivalent device. Where protective devices are used, they
shall be grounded in an approved manner.

PLEASE PRESS 'ENTER' TO CONTINUE~"
```

```
DISPLAY "

ii)    ANTENNA STRUCTURES

Masts and metal structures supporting antennas shall be
permanently and effectively grounded without splice or
connection in the grounding conductor.

PLEASE PRESS 'ENTER' TO CONTINUE
~"
DISPLAY "
iii) EQUIPMENT ENCLOSURES

Transmitters shall be enclosed in a metal frame or grill or
separated from the operating space by a barrier, all
metallic parts of which are effectively grounded.
Unpowered equipment and enclosures shall be considered
grounded where connected to an attached coaxial cable with
an effectively grounded metallic shield.
~";

ASK R43: "
About which of the areas in communication systems
you want to see the laws to be followed

 ";


CHOICES R43: Scope,
             Protective-device,
             Conductor-location,
             Equipment-location,
             Grounding;
```

FILE NAME <RIZ.KBS>

The following topics are covered in the expert system of this file:

1. Disconnecting Means
2. General Regulations
3. Simultaneous opening of the poles
4. Services for over 600 volts
5. Guarding
6. Warning lights

```
RUNTIME ;
ACTIONS
!COLOR=1
FIND R14
RR=(R14)
WHILETRUE RR=1 THEN
COLOR = 1
FIND R15
RR=UNKNOWN
END
CLS
RR=(R14)
WHILETRUE RR=2 THEN
COLOR = 1
FIND R16
RR=UNKNOWN
END
CLS
RR=(R15)
WHILETRUE RR=1 THEN
COLOR =14
DISPLAY
"Means shall be provided to disconnect all conductors in  a
building or other structure from the service entrance
 conductors. The disconnecting means shall plainly  indicate
whether it is in the open or closed position  and shall be
installed at a readily accessible location  nearest the
point of entrance of the service entrance  conductors."
RR=UNKNOWN
END
RR=(R15)
WHILETRUE RR=1 THEN
LOCATE 20,20
COLOR=20
DISPLAY "Press Any Key to continue~"
CLS
RR=UNKNOWN
END
CLS
RR=(R15)
WHILETRUE RR=2 THEN
COLOR = 14
DISPLAY"
 Each service disconnecting means shall simultaneously
 disconnect all ungrounded conductors."
RR=UNKNOWN
END
RR=(R15)
WHILETRUE RR=2 THEN
LOCATE 20,20
COLOR=20
```

```
DISPLAY "Press Any Key to continue~"
RR=UNKNOWN
END
CLS
RR=(R16)
WHILETRUE RR=1 THEN

COLOR=14
DISPLAY "
 Service entrance conductors installed as open wires  shall
be guarded to make them accessible only to  qualified
persons."
RR=UNKNOWN
END
RR=(R16)
WHILETRUE RR=1 THEN
LOCATE 20,20
COLOR=20
DISPLAY "Press Any Key to see other sections~"
RR=UNKNOWN
END
CLS
RR=(R16)
WHILETRUE RR=2 THEN
COLOR=0
DISPLAY"
 Signs warning of high voltage shall be posted where  other
than qualified employs might come in contact with  live
parts."
RR=UNKNOWN
END
RR=(R16)
WHILETRUE RR=2 THEN
LOCATE 20,20
COLOR = 20
DISPLAY "Press Any key to continue~"
RR=UNKNOWN
END
CLS;
!INPUT STATEMENTS
ASK R14: "
WHICH OF THESE YOU WANT TO KNOW ABOUT

1) DISCONNECTING MEANS:

Gives details about how shall means be provided to
disconnect conductors.

2) SERVICES OVER 600 VOLTS :
```

```
Tells about the additional requirements applicable to
services over this range.";



CHOICES R14: 1,2;

ASK R15: "
WHICH OF THESE YOU WOULD LIKE TO SEE

1. GENERAL : It gives the general information for
   disconnecting the conductors.

2. SIMULTANEOUS OPENING OF POLES

";


CHOICES R15: 1,2;

ASK R16:"

WHICH OF THE FOLLOWING YOU WANT TO SEE

1. GUARDING,

2. WARNING SIGNS

";

CHOICES R16: 1,2;
```

**FILE NAME <CHOICE.KBS>**

In this file "Over current protection" regulations have been addressed in the expert system. Following subtopics can be seen in this file:

1. Details of protection for 600 volts
2. Details of protection over 600 volts
3. Details of protection over 1000 volts

```
RUNTIME;
ACTIONS
FIND R17

RR=(R17)
WHILETRUE RR=1 THEN
COLOR = 1
FIND R18
RR=UNKNOWN
END
CLS
RR=(R17)
WHILETRUE RR=2 THEN
COLOR =1
FIND R19
RR=UNKNOWN
END
CLS

RR=(R18)
WHILETRUE RR=1 THEN
COLOR=4
DISPLAY "
Conductors and equipment shall be protected from overcurrent
in accordance with their ability to safely conduct current."
LOCATE 20,20
COLOR=20
DISPLAY "PRESS ESC KEY TO SEE OTHER SECTIONS~"
CLS
RR=UNKNOWN
END

RR=(R18)
WHILETRUE RR=2 THEN
COLOR=0
DISPLAY"
Except for motor running overload protection, overcurrent
devices may not interrupt the continuity of the grounded
conductor unless all conductors of the circuit are opened
simultaneously. "
LOCATE 20,20

COLOR =20
DISPLAY "Please press escape to see other sections~"
CLS
RR=UNKNOWN
END

RR=(R18)
WHILETRUE RR=3 THEN
COLOR=14
```

```
DISPLAY "
 Except for services fuses, all cartridge fuses which are
 accessible to other than qualified persons and all fuses
 and thermal cutouts on circuits over 150 volts to ground
 shall be provided with disconnecting means. This
 disconnecting means shall be installed so that the fuse  or
thermal cutout can be disconnected from its supply  without
disrupting service to equipment and circuits  unrelated to
those protected by overcurrent device."
LOCATE 20,20
COLOR =20
DISPLAY "Please press Escape to see other sections~"
CLS
RR=UNKNOWN
END
RR=(R18)
WHILETRUE RR=4 THEN
COLOR = 0
DISPLAY"
Overcurrent devices shall be readily accessible to each
employee or authorized building management personnel.
These overcurrent devices may not be located where they will
be exposed to physical damage nor in the vicinity of easily
ignitible material."
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER  SECTIONS~"
CLS
RR=UNKNOWN
END
RR=(R18)
WHILETRUE RR=5 THEN
COLOR=14
DISPLAY "
ARCING OR SUDDENLY MOVING PARTS:
Fuses and circuit breakers shall be so located or shielded
that employees will not be burned or otherwise injurd by
their operation."
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS~"
CLS
RR=UNKNOWN
END
CLS
RR=(R18)
WHILETRUE RR=6 THEN
COLOR=4
DISPLAY "
```

A) Circuit breakers shall clearly indicate whether they are in the open (OFF) or closed (ON) position.

B) Where circuit breakers handles on switch boards are operated vertically rather than horizontally or rotainally, the up position of the handle shall be closed (ON) position.

C) If used as switches in 120 volts, fluorescent lighting circuits, circuit breakers shall be approved for the purpose. "

```
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS~"
CLS
RR=UNKNOWN
END
CLS
RR=(R19)
WHILETRUE RR=A THEN
COLOR =14
DISPLAY"
```

The following systems which supply premises wiring shall be grounded:

1. All 3-wire DC systems shall have their nertral conductor grounded.
2. Two wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless:

A) They supply only industrial equipment in limited areas and are equiped with a ground detector.~"

```
DISPLAY"
```

C) They are fire protective signaling circuits having a maximum current of 0.03 amperes.

d) AC circuits of less than 50 volts shall be grounded if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.~"

```
DISPLAY"
```

e) AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions:

1. If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts.
2. If the system is nominally rated 480 Y/277 volt, 3 phase, 4-wire in which the neutral is used as a circuit conductor.
3. If the system is nominally rated 240/120 volt, 3 phase,

4- wire in which the nertral is used as circuit conductor.
4. If the system is nominally rated 240/120 volt, 3 phase, 4-wire in which the midpoint of one phase is used as a circuit conductor.
5. If a service conductor is uninsulated."

```
LOCATE 20,20
COLOR =20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS~"
CLS
RR=UNKNOWN
END
CLS
RR=(R19)
WHILETRUE RR=B THEN
COLOR=4
DISPLAY "
For AC premises wiring systems the idetified conductor shall
be grounded."
LOCATE 20,20
COLOR=20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS~"
CLS
RR=UNKNOWN
END
CLS
RR=(R19)
WHILETRUE RR=C THEN
COLOR=14
DISPLAY"
For a grounded system, a grounding electrode conductor shall
be used to connect both the equipment grounding conductor
and the grounded circuit conductor to the grounding
electrode.Both the equipment grounding conductor and
grounding electrode shall be connected to the grounded
circuit conductor on the supply side of the system
disconnecting means or over current devices if the system is
separately derived. ~"
DISPLAY  "For an ungrounded service supplied system, the
equipment grounding conductor shall be connected to the
grounding electrode conductor at the service equipment."
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER  SECTIONS~"
CLS
RR=UNKNOWN
END
```

```
CLS
RR=(R19)
WHILETRUE RR= D THEN
COLOR=4
DISPLAY " The path to ground from circuits, equipment, and
enclosures shall be permanent and continous."
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS~"
CLS
RR=UNKNOWN
END
```

```
CLS
RR=(R19)
WHILETRUE  RR=E THEN
COLOR =0
DISPLAY"
SUPPORTS AND ENCLOSURES FOR CONDUCTORS
Metal cable trays, metal raceways, and metal enclosures for
conductors shall be grounded except that:
A) Metal enclosures such as sleeves that are used to
   protect cable assemblies from physical damage need not
   be grounded. ~"
DISPLAY"
B) Metal enclosures for conductors added to existing
installations of open wire, knob and tube wiring, and non-
metallic sheated cable need not be grounded if all of the
following conditions are met :
   1. Runs are less than 25 feet.
   2. Enclosures are free from probable contact with
      ground, grounded metal, metal laths, or other
      conductive materials
   3. Enclosures are guarded against employee contact.~"
DISPLAY "
SERVICE EQUIPMENT ENCLOSURES
Metal enclosures for service equipment shall be grounded.~"
DISPLAY"
FRAMES OF RANGES AND CLOTHES DRYERS
Frames of electric ranges, wall mounted ovens, counter
mounted cooking units, clothes deyers, and metal outlet or
junction boxes which are part of the circuit for these
appliaces shall be grounded.~"
DISPLAY "
Exposed non current carrying metal parts of fixed equipment
which may become energized shall be grounded under any of
the following conditions:
A. If within 8 feet vertically or 5 feet horizontally of
ground or grounding metal objects and subject to employee
contact.
```

```
B. If located in a wet or damp location and not isolated.
C. If in electric contact with metal.
D. If in a hazardous location.
E. If supplied by a metal-clad, metal-sheathed, or grounded
metal raceway wiring method.~"
DISPLAY"
EQUIPMENT CONNECTED BY CORD AND PLUG
They shall be grounded under following conditions:
1. If in hazardous locations.
2. If operated at over 150 volts to ground, except for
   guarded motors and metal frames of electrically heated
   appliances if the appliances if the appliance frames
   are permanently and effectively insulated from ground.

3. If the equipment is of the following types:
   1. Refrigerators, freezers, and air conditioners;
   2. Clothes-washing, clothes-drying and dishwashing
      machines, sump pumps, and electrical acquarium
      equipment.
   3. Hand held motor operated tools.
   4. Motor operated appliances of the following types:
      hedge, clippers, lawn mowers, snow blowers, and wet
      scrubbers.
   5. Portable and mobile X-ray and associated equipment.
   6. Tools likey to be used in wet and conductive
      locations.
   7. Portable hand lamps.~"
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS ~"
CLS
RR=UNKNOWN
END
CLS
RR=(R19)
WHILETRUE RR=F THEN
COLOR = 14
DISPLAY"
NON CURRENT CARRYING METAL PARTS OF FIXED EQUIPMENT
If required to be grounded, shall be grounded by an
equipment which is contained within the same raceway, cable,
or cord, or runs with or encloses the circuit conductors.For
DC circuits only, the equipment grounding conductor may be
run separately from the circuit conductors."
LOCATE 20,20
COLOR = 20
DISPLAY "HIT ESC KEY TO SEE OTHER SECTIONS~"
CLS
```

**FILE NAME <1.KBS>**

The program on this file covers the topic of "Open wiring on insulators".

Within it are the following topics:

1. Uses permitted
2. Protection from physical damage
3. Conductor support
4. Flexible non metallic tubing
5. Wiring through walls, floors and wooden cross members

```
RUNTIME;
ACTIONS
COLOR =14
DISPLAY "
              A) Users permitted
              B) Conductor supports
              C) Flexible non metallic tubing
              D) Through walls, floors, wood cross
                 members
              E) Protection from physical damage~"
FIND message
COLOR = 20
LOCATE 20,20
DISPLAY "
         Press any key to continue consultation~";

RULE 1
IF R21 = A
THEN message = displayed
DISPLAY "
Open wiring on insulators is only permitted on systems of
600 volts, nominal, or less for industrial or agriculture
establishments and for services. ~ "
BECAUSE "
If open wiring is allowed for more than this range, than
there could be problems and chances of disasters and
dangerous accidents will increase.";
RULE 2
IF R21=B
THEN message = displayed
DISPLAY "
Conductors shall be rigidly supported on noncombustible,
nonabsorbent insulating materials and may not contact any
other objects."
BECAUSE"
This is because if the conductors touch any combustible or
any absorbent materials or any other object, there could be
incidents of any short-circuit which can ultimately lead to
fire and other losses.~";
RULE 3
IF R21 = C
THEN message = displayed
DISPLAY "
In dry locations where not exposed to severe physical
damage, conductors may be separately enclosed in flexible
nonmetallic tubing. The tubing shall be in continues lengths
not exceeding 15 feet and secured to the surface by straps
at intervals not exceeding 4 feet.~ "
BECAUSE "
This is for the safety of the workers and have been made law
on the recommendations of experienced safety personnels and
as a result of safety analysis done by different safety
agencies.";
```

```
RULE 4
IF R21 = D

THEN message= displayed
DISPLAY "
Open conductors shall be separated from contact with walls,
floors, wood cross members, or partitions through which they
pass by tubes or bushings of noncombustible, nonabsorbent
insulating material. If the bushing is shorter than the
hole, a waterproof sleeve of nonconductive material shall be
inserted in the hole and an insulating bushing slipped into
the sleeve at each end in such a manner as to keep the
conductors absolutely out of contact with the sleeve. Each
conductor shall be carried through a separate tube or
sleeve. ~"
BECAUSE"
All these requirements are required to be fulfilled so that
there are minimum of problems at the workplace. The details
of these laws has been made by using the experience of
specialized safety consultants and the ultimate objective of
all these precautions is to provide a hazard free
workplace."
;


RULE 5
IF R21 = E
THEN message = yes
CHAIN A:2
END;


ASK R21: "
Which of these you want to see when you are dealing with
open wiring on insulators
";

CHOICES R21: A,B,C,D,E;
```

**FILE NAME <2.KBS>**

The program on this file covers the "Regulation requirements for protection from physical damage. Topics included in it are:

1. Pull and Junction boxes for system over 600 volts.
2. Switch board and panel board
3. Cabinet boxes and fittings
4. Switches
5. Equipment and General use
6. Covers and Canopies
7. Enclosure for Damp or wet locations
8. Conductors for General Wiring
9. Flexible cords of cables
10. Portable cables over 600 volts
11. Fixture wires

```
RUNTIME;
ACTIONS
COLOR= 5
DISPLAY "

   i.  Conductors entering cabinets, boxes or fittings
  ii.  Covers and Canopies
 iii.  Pull and Junction boxes for system over 600 volts
       nominal
  iv.  Switches
   v.  Switch board and Panel board
  vi.  Enclosures for dump or wet location
 vii.  Conductors for general wiring
viii.  Flexible cords and cables
  ix.  Portable cables over 600 volts, nominal
   x.  Fixture wires
  xi.  Equipment for general use~"
FIND regulation
COLOR =20
LOCATE 20,20
DISPLAY "
          Press any key to continue the consultation ~";
RULE 1
IF R22 = i
THEN regulation = displayed
DISPLAY "
Conductors entering boxes, cabinets or fittings shall also
be protected from abrasion, and openings through which
conductors enter shall be effectively closed.
Unused openings in cabinets, boxes and fittings shall be
effectively closed.~ "
BECAUSE "
The law requires conductors be protected from abrasion and
the closing of any unused openings in cabinets, boxes and
other fittings so that the chances or probability of any
mishappening is made very low."
;
RULE 2
IF R22 =ii
THEN regulation = displayed
DISPLAY "
All pull boxes, junction boxes and fittings shall be
provided with covers approved for the purpose.
If metal covers are used they shall be grounded. In
completed installations each outlet boxes shall have a
cover, faceplate, or fixture canopy. Covers of the outlet
boxes having holes through which flexible cord pendants pass
shall be provided with bushings designed for the purpose or
shall have smooth, well rounded surfaces on which the cords
may bear.
~ "
```

```
BECAUSE  "
Junction boxes, pull boxes and other fittings should never
be left alone and shall properly covered as required by this
law, so that there is minimum of problems from any
unintentional touch, similarly if metal covers are used,
they should be properly grounded so to make them safer. The
purpose of all these steps are to minimize the chances of
any accidents and to make the workplace a safe place to be
in."
;
RULE 3
IF R22 = iii
THEN regulation = displayed
DISPLAY "
     Following  requirements must be fulfilled:

     1. Boxes shall provide a complete enclosure for the
        contained conductors or cables.

     2. Boxes shall be closed by suitable covers securely
        fastened in place.
        Ungrounded box covers that weigh over 100 pounds
        must meet this requirement. Covers for boxes
        shall be permanently marked 'HIGH VOLTAGE'. The
        marking shall be on the outside  of the box cover
        and shall readily visible and legible.
~"
BECAUSE "
All the requirements in this law is for the safety of
workers at workplace and the objective is to minimize the
possibility of any accident for this hazard."
;
RULE 4
IF R22 = iv
THEN regulation = displayed
DISPLAY "
KNIFE SWITCHES
Single throw knife switches shall be so connected that the
blades are dead when the switch is in the open position and
it should be so placed that gravity will not tend to close
them. Such switches approved for use in the inverted
position shall be provided with a locking device that will
ensure that the blades are remain in the open position when
so set. Double throw knife switches may be mounted so that
the throw will be either vertical or horizontal. However, if
the throw is vertical a locking device shall be provided to
ensure that the blades remain in the open position when so
set.
PLEASE ENTER TO CONTINUE
```

~"

DISPLAY "
FACEPLATES FOR FLUSH MOUNTED SNAP SWITCHES

These switches when are mounted in underground metal boxes and located within reach of conducting floors or other conducting surfaces shall be provided with faceplates of nonconducting, noncombustible material. ~"
BECAUSE "
The law requirement here are to prevent any unintentional opening of switches and to do proper locking of different types of switches so that accidents from this type of accidents could be minimized";

RULE 5
IF R22 =v
THEN regulation = displayed
DISPLAY "
Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible to only qualified persons. Panel boards shall be mounted in cabinets, cutout boxes, or enclosures approved for the purpose and shall be dead front. However panel boards other than the dead front externally operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.~ "
BECAUSE "
Switch boards, panel boards should be located in dry locations and mounted in cabinets and other enclosures, so that there are no accidents and there are certain type of panel boards as mentioned in the law that is only accessible by qualified persons and this is again for
the safety of workers and for a safe work place. ";
RULE 6
IF R22 = vi
THEN regulation = displayed
DISPLAY "
1. Cabinets, cutout boxes, fittings, boxes, and panel board enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weather proof. 2. Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.~ "
BECAUSE"

```
They should be well protected as mentioned in law, so that
there are no problems due to moisture or wet locations
because moisture or wet location could be very hazardous at
places where there is flow of current."
;



RULE 7
IF R22 = vii
THEN regulation = displayed
DISPLAY "
All conductors used for general wiring shall be insulated
unless permitted in some other regulation.
The conductor insulation shall be of a type that is approved
for the voltage, operating temperature, and location of use.
Insulated conductors shall be distinguishable by appropriate
color or other suitable means as being grounded conductors,
ungrounded conductors or equipment grounding conductors.
~ "
BECAUSE
"Insulation of conductors is very necessary otherwise there
could be serious electrical accidents and the prevention as
required in this law is very necessary and will help in
removing the hazards."

;
RULE 8
IF R22 = viii
THEN regulation = displayed
DISPLAY "
Flexible cords and cables shall be approved and suitable for
conditions of use and location. They shall be only used for
:
A) Pendants
B) Wiring of fixtures
C) Connection of portable lamps or appliances
D) Elevator cables
E) Wiring of cranes and hoists
F) Connection of stationary equipment to facilitate their
frequent interchange
G) Prevention of the transmission of noise or vibration
H) Appliances where the fastening means and mechanical
connections are designed to permit removal for maintenance
and repair.
PLEASE PRESS ANY KEY TO CONTINUE    ~ "
DISPLAY "
Flexible cords and cables may not be used for the following:

1. As a substitute for the fixed wiring of a structure.
2. Where run through holes in walls, ceilings or floors.
```

```
3. Where run through doorways, windows, or similar openings.
4. Where attached to building surfaces.
5. Where concealed behind building walls, ceiling or floors.
PLEASE PRESS ANY KEY TO CONTINUE   ~"



DISPLAY "
IDENTIFICATION, SPLICES, AND TERMINATIONS

1. A conductor of a flexible cord or cable that is used as a
grounded conductor or an equipment shall be distinguishable
from other conductors.
Types SJ, SJO, SJTO, S, SO, ST, and STO  shall be durably
marked on the surface with the type designation, size, and
number of conductors.

2. Flexible cords shall be used only in continuous lengths
without splice or tap.

3. Flexible cords shall be connected to devices and fittings
so that strain relief is provided which will prevent pull
from being directly transmitted to joints or terminal
screws.
~";

RULE 9
IF R22= ix
THEN regulation = displayed
DISPLAY "
Multiconductor portable cable for use in supplying power to
portable or mobile equipment at over 600 volts, nominal,
shall consist of NO 8 or larger conductors employing
flexible stranding. Cables operated at over 2000 volts shall
be shielded for the purpose of confining the voltage
stresses to insulation. Grounding conductors shall be
provided.
                PLEASE PRESS ANY KEY TO CONTINUE~"
DISPLAY "
Connectors for these cables shall be of a locking type with
provisions to prevent their opening or closing while
energized.
Strain relief shall be provided at connections and
terminations.
Portable cables may not be operated with splices unless the
splices are of permanent molded, vulcanized, or other
approved type.
Termination enclosures shall be suitably marked with a high
voltage hazard warning, and terminations shall be accessible
only to authorized and qualified personnel~ ";
```

```
RULE 10
IF R22 = x
THEN regulation = displayed
DISPLAY "

1. GENERAL
Fixture shall be approved for the voltage, temperature, and
location of use. A fixture wire which is used as a grounded
conductor shall be identified.~"




DISPLAY "
2. USES PERMITTED
Fixture wires may be used:

i) For installation in lighting fixtures and in similar
equipment where enclosed or protected and not subject to
bending or twisting in use.

ii) For connecting lighting fixtures to the branch-circuit
conductors supplying the fixtures.
3. USES NOT PERMITTED

Fixture wires may not be used as branch-circuit conductors
except as permitted for Class 1 power limited circuits.

 ";
RULE 11
IF R22 = xi
THEN regulation = chain
CHAIN A:3
END;

ASK R22: "
About which of the following you want to see the
requirements for protection from any physical damage";

CHOICES R22: i,ii,iii,iv,v,vi,vii,viii,ix,x,xi;
```

**FILE NAME <3.KBS>**

This program in the expert system covers "Equipment for General Use".

It has covered the following topics:

1. Lightning fixtures, Lamp holders, Lamps and receptacles.
2. Motors
3. Receptacles, Cord connectors and Attachment plugs
4. Appliances
5. Transformers
6. Capacitors

```
RUNTIME;
ACTIONS
COLOR = 14
DISPLAY "
                1)  Lightining fixtures, Lamp holders,
                    Lamps and Receptacles.
                2)  Receptacles, cord connectors and
                    attachment plugs
                3)  Appliances
                4)  Motors
                5)  Transformers
                6)  Capacitors
                7)  Storage Batteries

~"
FIND work
LOCATE 20,20
COLOR=20
DISPLAY " Press any key to continue consultation";

RULE 1
IF R23=1
THEN work = displayed
DISPLAY "
i. Fixtures, lampholders, lamps, rosettes, and receptacles
may have no live parts normally exposed to employee contact.
However, rosettes and cleat type lampholders and receptacles
located at least 8 feet above the floor may have exposed
parts.
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION ~"

DISPLAY "
ii. Handlamps of the portable type supplied through flexible
cords shall be equipped with a handle of molded composition
or other material approved for the purpose, and a
substantial guard shall be attached to the lampholder or the
handle.
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION ~"

DISPLAY "
iii. Lampholders of the screw-shell type shall be installed
for use as lampholders only. Lampholders installed in wet or
damp locations shall be of the weatherproof type
iv.  Fixtures installed in wet or damp locations shall be
     approved for the purpose and shall be so constructed
     or installed that water cannot enter or accumulate
     in wireways, lampholders, or other electrical parts.
 ";
RULE 2
IF R23 = 2
THEN work = displayed
```

```
DISPLAY "
A) Receptacles, cord connectors, and attachment plugs shall
be constructed so that no receptacle or cord connector will
accept an attachment plug with a different voltage or
current rating than that for which the device is intended.
However, a 20 ampere T-slot receptacle or cord connector may
accept a 15 ampere attachment plug of the same voltage
rating.

B) A receptacle installed in a wet or damp location shall be
suitable for the location
 "
BECAUSE "
This law requirement is to prevent any accident from
different of voltage, which could cause disastrous results
in case of any technical problems."

;
RULE 3
IF R23 = 3
THEN work = displayed
DISPLAY "
i.   Appliances other than those in which the current
carrying parts at high temperatures are necessarily exposed
to employee contact.
ii.  A means shall be provided to disconnect each appliance.
iii. Each appliance shall be marked with its rating in volts
and amperes or volts and watts.
"
BECAUSE "
This will reduce the chances of any accident because if
means are provided to disconnect appliances or if there are
proper marking about the rating of voltage or amperage, then
naturally the user has a low probability of making any wrong
connections and chances of accidents will be minimized."
;
RULE 4
IF R23 = 4
THEN work = chain
CHAIN A:4;
RULE 5
IF R23 = 5
THEN work = displayed
DISPLAY "
a)   The operating voltage of exposed live parts of
transformer installations shall be indicated by warning
signs or visible markings on the equipment or structure.
b)   Dry-type, high fire point liquid insulated, and
askarel-insulated transformers installed indoors and rated
over 35 KV shall be in a vault.
```

```
c) If they present a fire hazard to employees, oil insulated
transformers installed indoors shall be in a vault.

 Please press 'ENTER' to continue the consultation ~"
DISPLAY "
d) Combustible material, combustible buildings and parts of
buildings, fire escapes, and doors and window openings shall
be safeguarded from fires which may originate in oil
insulated transformers attached to or adjacent to a building
or combustible material.

Please press 'ENTER' to continue the consultation ~"
DISPLAY "
e) Transformer vaults shall be constructed so as to contain
fire and combustible liquids within the vault and to prevent
unauthorized access. Locks and latches shall be so arranged
that a vault door can readily opened from the inside.

f) Any pipe or duct system foreign to the vault installation
may not enter or pass through a transformer vault.

g) Materials may not be stored in transformer vaults.
 " ;
RULE 6
IF R23 = 6
THEN work = displayed
DISPLAY "
1) All capacitors except surge capacitors or capacitors
included as a component part of other apparatus, shall be
provided with an automatic means of draining the stored
charge after the capacitor is disconnected from its source
of supply.
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION ~"
DISPLAY "
2) Capacitors rated over 600 volts, nominal, shall comply
with the following additional requirements:

a) Isolating or disconnecting switches shall be interlocked
with the load interrupting device or shall be provided with
prominently displayed caution signs to prevent switching
load current
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION ~"
DISPLAY "
For series capacitors, the proper switching shall be assured
by use of atleast one of the following:
i.   Mechanically sequenced isolating and bypass
     switches.
ii.  Interlocks or
```

```
iii. Switching procedure prominently displayed at the
     switching location " ;



RULE 7
IF R23= 7
THEN work = displayed
DISPLAY "
Provisions shall be made for sufficient diffusion and
ventilation of gases from storage batteries to prevent the
accumulation of explosive mixtures.                    ~"
BECAUSE "
This is very necessary because in case of no proper
ventilation path for gases to exhaust, there could be
chances of chemical reaction which could result in great
explosions."
;

ASK R23: "
 About which of the following equipments you want to know";
CHOICES R23: 1,2,3,4,5,6,7;
```

**FILE NAME <4.KBS>**

In this file we will be able to see the requirements for Protection from any physical damage by malfunctioning of motors.

```
RUNTIME;
ACTIONS
COLOR=5
DISPLAY "
          i)    In sight form
         ii)    Disconnecting mean
        iii)    Motor overload, short circuit and ground
                fault protection
         iv)    Protectection of live parts~"

FIND message
LOCATE 20,20
COLOR=20
DISPLAY "
Press any key to continue the consultation ~";

RULE 1
IF R24=i
THEN message= displayed
DISPLAY "
If specified that one piece of equipment shall be 'in sight
from' another piece of equipment, one shall be visible and
not more than 50 feet from the other
~"

BECAUSE "
This has also been made for the purpose of safety from any
unforeseen accidents."

;

RULE 2
IF R24 = ii
THEN message = displayed

DISPLAY "

A)  A disconnecting means shall be located in sight from the
controller location. However, a single disconnecting means
may be located adjacent to a group of coordinated
controllers mounted adjacent to each other on a multi-motor
continues process machine. The controller disconnecting
means for motor branch circuits over 600 volts may be out of
sight of the controller, if the controller is marked with a
warning label giving the location and identification of the
disconnecting means which is to be locked in the open
position.

PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION
~"
```

```
DISPLAY "
B) The disconnecting means shall disconnect the motor and
the controller from all ungrounded supply conductors and
shall be so designed that no pole can be operated
independently.
PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION
~"
DISPLAY "

C) If the motor and the driven machinery are not in sight
from the controller location, the installation shall comply
with one of the following conditions:

1. The controller disconnecting means shall be capable of
being locked in the open position.

2. A manually operable switch that will disconnect the motor
from its source of supply shall be placed in sight from the
motor location.


PLEASE PRESS 'ENTER' TO CONTINUE CONSULTATION

~"
DISPLAY "
D) The disconnecting means shall plainly indicate whether it
is in the open (off) or closed (on) position.
E) The disconnecting means shall be readily accessible. If
more than one disconnect is provided for the same equipment,
only one need be readily accessible.
PLEASE PRESS 'ENTER' TO CONTINUE THE CONSULTATION ~"

DISPLAY "

F) An individual disconnecting means shall be provided for
each motor, but a single disconnecting means may be used for
a group of motors under any one of the following conditions:

1. If a number of motors drive special parts of a single
machine or piece of apparatus, such as a metal or wood
working machine, crane or hoist.

2. If a group of motors is under the protection of one set
of branch-circuit protective devices.

3. If a group of motors is in a single room in sight from
the location of the disconnecting means.
~";
```

```
RULE 3
IF R24 = iii
THEN message = displayed
DISPLAY "
Motors, motor control apparatus, and motor branch circuit
shall be protected against overheating due to motor
overloads or failure to start, and against short circuits or
ground faults.
These provisions shall not require overload protection that
will stop a motor where a shutdown is likely to introduce
additional or increased hazards, as in the case of fire
pumps, or where continued operation of a motor is necessary
for a safe shutdown of the equipment or process and motor
overload sensing devices are connected to a supervised alarm

~"
BECAUSE "
This is done to prevent motors and its other attachments
from the consequences of any short circuits or ground faults
as a result of overheating because of any sort of
overheating or due to some other reasons."
;

RULE 4
IF R24 = iv
THEN message = chain
CHAIN A:5;

ASK R24:"
         This section deals with motor, motor circuits, and
controllers. Which of the following, you want to know so
that it can help you for the measures necessary to prevent
accidents";

CHOICES R24: i,ii,iii,iv;
```

**FILE NAME <5.KBS>**

This file covers the requirements for protection of live parts.

```
RUNTIME;
ACTIONS
COLOR =5
!DISPLAY "FAIZI~"
FIND message
LOCATE 20,20
COLOR =20

DISPLAY"
Press any key to continue consultation ";
RULE 1
IF R25 = Stationary-motors
THEN message = displayed
DISPLAY "
Stationary motors having commutators, collectors, and brush
rigging located inside of motor end brackets and not
conductively connected to supply circuits operating at more
than 150 volts to ground need not have such parts guarded.
Exposed live parts of motors and controllers operating at 50
volts or more between terminals shall be guarded against
accidental contact by any of the following:

1. By installation in a room or enclosure that is accessible
only to qualified persons.

2. By installation on a suitable balcony, gallery, or
platform, so elevated and arranged as to exclude unqualified
persons.

3. By elevation 8 feet or more above the floor.~";

RULE 2
IF R25 = Live-parts
THEN message =displayed
DISPLAY "

Where live parts of motors or controllers operating at over
150 volts to ground are guarded against accidental contact
only by location, and where adjustment or other attendance
may be necessary during the operation of the apparatus,
suitable insulating mats or platforms shall be provided so
that the attendant cannot readily touch live parts unless
standing on the mats or platforms.~";


ASK R25:"
Which of the two you want to see, so that you can take
necessary action for preventing any damage or accident";

CHOICES R25: Stationary-motors, Live-parts;
```

**FILE NAME <6.KBS>**

```
RUNTIME;
ACTIONS
COLOR=5
FIND message
LOCATE 20,20
COLOR=20
DISPLAY" Please press any key to continue~";
RULE 1

IF R50= SCOPE
THEN message = displayed
DISPLAY "
This section covers the requirements for electric equipment
and wiring in locations which are classified depending on
the properties of the flammable vapors, liquids or gases, or
combustible dusts or fibers which may be present therein and
the likelihood that a flammable or combustible concentration
or quantity is present.

PLEASE PRESS 'ENTER' TO CONTINUE
~"
DISPLAY "
Hazardous locations may be found in occupancies such as, but
not  limited to the following:
* Aircraft hangars
* Gasoline dispensing and service stations
* Bulk storage plants for gasoline or other volatile
flammable liquids.
* Paint finishing process plants
* Health care facilities
* Agriculture or other facilities where excessive
combustible dusts may be present.
* Marinas
* Boat yards
* Petroleum or chemical plants
                    ~";
RULE 2
IF R50 = ELECT-INSTALLATIONS
THEN message = displayed
DISPLAY "
Equipment, wirnig methods, and installations of equipment in
hazardous locations shall be instrinsically safe, approved
for the hazardous or safe or for the hazardous location.
Requirements for each of these options are as follows:
1. INTRINSICALLY SAFE
Equipment and associated wiring approved as intrinsically
safe shall be permitted in any hazardous location for which
it is approved.

PLEASE PRESS 'ENTER' TO CONTINUE
~"
```

```
DISPLAY
"
2. APPROVED FOR THE HAZARDOUS LOCATION

i)  Equipment shall be approved not only for the class of
location but also for ignitable or combustible properties of
the specific gas, vapor, dust, or fiber that will be
present.
ii) Equipment shall be marked to show the class, group and
operating temperature or temperature range, based on
operation in a 40 degrees C ambient, for which it is
approved. The temperature marking may not exceed the
ignition temperature of the specific gas or vapor to be
encountered.
                                                        ~";
RULE 3
IF R50 = CONDUITS
THEN message = displayed
DISPLAY "
All conduits shall be threaded and shall be made wrench-
tight. Where it is impractical to make a threaded joint
tight, a bonding jumper shall be utilized.~"
BECAUSE"
Conduits shall be tightly joint by either a wrench tight or
through a bonding bumper, so that every thing remain working
perfectly.
";

ASK R50 : "
Which of these three in 'hazardous locations' you want to
look at?


";

CHOICES R50 : Scope,
              Elect-Installations,
              Conduits;
```

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