Report of Committee on Electrical Equipment Maintenance

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This Committee Report is essentially the Recommended Practice for Electrical Equipment Maintenance, NFPA No. 70B-T, which is proposed for tentative adoption.

The document has been submitted to letter ballot of the Committee which consists of 26 voting members and two alternates. Final comments and suggestions were invited. Of the 26 voting members, 25 have voted affirmatively. There were no negative ballots. Mr. Schaad did not return his ballot.

Since this Committee reports to the Association through the National Electrical Code Correlating Committee, this report was also submitted to them for letter ballot.

Over a period of many years, the need for guidance to promote the safety of persons and property through effective electrical equipment maintenance has been increasingly evident. In the fall of 1967 the Board of Directors of the National Fire Protection Association authorized the formation of an Ad Hoc Committee on Electrical Equipment Maintenance to determine the need for the development of a suitable document on this subject. In reaching its affirmative decision early in 1968, the Ad Hoc Committee pointed out many reasons why it believed the National Electrical Code was not the proper document in which to cover the maintenance of electrical equipment. However, the high frequency of electrical accidents attributed to lack of maintenance, which results annually in numerous fatalities and serious injury as well as high monetary losses of property, caused the Committee to advise that it was a subject requiring prompt attention.

In June 1968 the Board of Directors authorized the formation of a new NFPA Committee on Electrical Equipment Maintenance having the following scope:

"To develop suitable texts relating to preventive maintenance of electrical systems and equipment used in industrial-type applications with the view of reducing loss of life and property. The purpose is to correlate generally applicable procedures for preventive maintenance that have broad application to the more common classes of industrial electrical systems and equipment without duplicating or superseding instructions which manufacturers normally provide. Reports to the Association through the Correlating Committee of the National Electrical Code Committee."

With this background the Committee was organized in December 1968. Its large and very active membership has seen few changes in personnel since its inception. It should be pointed out that the members are individually highly qualified and collectively the committee representation includes equipment manufacturers; installers; inspectors; safety, labor, and insurance organizations; users of the equipment; maintenance contractors and engineers; representatives of the National Electrical Code Committee and other NFPA Committees; and specialists. All committee members have made a fine contribution to this endeavor.

Recommended Practice for

ELECTRICAL EQUIPMENT MAINTENANCE

NFPA No. 70B-T, 1973

HISTORY

The Board of Directors of the National Fire Protection Association in the fall of 1967 authorized the formation of an Ad Hoc Committee on Electrical Equipment Maintenance to determine the need for the development of a suitable document on this subject. The purpose of the document would be to give recommendations on the maintenance of various types of electrical installations, apparatus, and equipment usually found in industrial and large commercial type installations. Various highly diversified interests and organizations were invited to participate.

At a meeting of the Ad Hoc Committee held January 10, 1968, in New York, with 31 representatives attending, it was pointed out that several requests had been made to the National Electrical Code Committee to include maintenance recommendations in the NEC. The subject had been discussed by the Correlating Committee of the National Electrical Code Committee and the decision was made that the Code was not the proper document in which to cover the maintenance of electrical equipment. However, the high frequency of electrical accidents attributed to lack of maintenance, which result annually in numerous fatalities and serious injuries as well as high monetary losses of property, caused the committee to recognize that it was a subject requiring attention.

It was noted that electrical safety information breaks down logically into four main subdivisions: (1) design or product standards; (2) installation standards (as covered by the National Electrical Code and the National Electrical Safety Code; (3) maintenance recommendations; and (4) use instructions. The problem was to explore whether something more should be done in the interest of electrical safety on the maintenance of electrical equipment and what form activity in this field should take.

It was recognized that much has been done to enunciate maintenance needs for specific types of equipment by the equipment manufacturers, and that guidance is available on the general subject from a number of sources. However, it was also felt desirable to bring together some of the general guidelines in a single document under the NFPA procedure. The stature of the document would also be enhanced if it could in some way become associated with the National Electrical Code. To this end, a tentative scope was drafted for presentation to the Board of Directors of the National Fire Protection Association with a recommendation that an NFPA Committee on Electrical Equipment Maintenance be authorized.

On June 27, 1968 the NFPA Board of Directors authorized the establishment of an NFPA Committee on Electrical Equipment Maintenance with the scope statement indicated below (which was subsequently amended to include the last sentence): "To develop suitable texts relating to preventive maintenance of electrical systems and equipment used in industrial-type applications with the view of reducing loss of life and property. The purpose is to correlate generally applicable procedures for preventive maintenance that have broad application to the more common classes of industrial electrical systems and equipment without duplicating or superseding instructions which manufacturers normally provide. Reports to the Association through the Correlating Committee of the National Electrical Code Committee."

The committee was formed and an organizational meeting was held December 12, 1968 in Boston. Twenty-nine members or representatives attended. This Recommended Practice on Electrical Equipment Maintenance represents the cumulative effort of the entire Committee.

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CHAPTER 1 — GENERAL.

110. Purpose.

1110. The purpose of this recommended practice is to reduce hazard to life and property that can result from failure or malfunction of industrial-type electrical systems and equipment. The first three chapters of these recommendations for an effective Electrical Preventive Maintenance (EPM) program have been prepared with the intent of providing a better understanding of benefits, both direct and intangible, that can be derived from a well-administered EPM program. This practice explains the function, requirements, and economic considerations that can be used to establish such a program.

120. Scope.

1210. This recommended practice is confined to preventive maintenance for industrial-type electrical systems and equipment, and is not intended to duplicate or supersede instructions that electrical manufacturers normally provide. Systems and equipment covered are those operating at 15 kV and below and are typical of those installed in industrial plants, institutional and commercial buildings, and large multifamily residential complexes. Consumer appliances and equipment intended primarily for use in the home are not included.

130. Definitions.

1310. Electrical Preventive Maintenance (EPM) is the practice of conducting routine inspections, tests, and the servicing of electrical equipment so that impending troubles can be detected and reduced, or eliminated.

1320. Electrical equipment is a general term applied to material, fittings, devices, fixtures, and apparatus that are part of, or are used in connection with, an electrical installation. This includes the electrical power generating system, substations, distribution systems, utilization equipment, and associated control, protective, and monitoring devices.

CHAPTER 2 — WHY AN EPM PROGRAM PAYS DIVIDENDS

210. Why EPM?

2110. Electrical equipment deterioration is normal, but equipment failure is not inevitable. As soon as new equipment is installed, a process of normal deterioration begins. Unchecked, the deterioration process can cause malfunction or an electrical failure. Deterioration can be accelerated by factors such as a hostile environment, overload, or severe duty cycle. An effective EPM program identifies and recognizes these factors and provides measures for coping with them.

2120. In addition to normal deterioration, there are other potential causes of equipment failure that may be detected and corrected through EPM. Among these are load changes or additions, circuit alterations, improperly set or improperly selected protective devices, and changing voltage conditions.

2130. Without an EPM program, management assumes a much greater risk of a serious electrical failure and its consequences.

220. Value and Benefits of a Properly Administered EPM Program.

2210. A well-administered program will reduce accidents, save lives, and minimize costly breakdowns and unplanned shutdowns of production equipment. Impending troubles can be identified — and solutions applied — before they become major problems requiring more expensive, time-consuming solutions.

2220. Benefits of an effective EPM program fall in two general categories. Direct, measurable, economic benefits are derived by reduced cost of repairs and reduced equipment downtime. Less measurable but very real benefits result from improved safety. To understand fully how personnel and equipment safety are served by an EPM program, the mechanics of the program — inspection, testing and repair procedures — should be understood. Such an understanding explains other intangible benefits such as improved employee morale, better workmanship and increased productivity, less absenteeism, reduced interruption of production, and improved insurance considerations. Improved morale will come with employee awareness of a conscious management effort to promote safety by reducing likelihood of electrical injuries or fatalities, electrical explosions, and fires. Reduced personal injuries and property loss claims can help keep insurance premiums at favorable rates.

Table I

Losses Associated with Electrical Failures
Includes Electrical and Fire Damage*

1967 & 1968

Class of Equipment	*No. of Losses All Causes Incl. Unknown*	*Dollar Loss All Causes Incl. Unknown*	*Number Cause Unknown*	*Dollar Loss Due Cause Unknown*	*Number of Losses of Known Causes due to Defective Maintenance*	*Dollar Loss of Known Causes due to Defective Maintenance*
Generators	51	$ 367,690	20	$ 117,300	25	$ 233,000
Motors	420	1,627,530	109	560,000	256	924,000
Transformers	87	1,814,900	38	445,000	38	721,000
Circuit Breakers	27	199,700	11	117,000	14	74,600
Cables	73	580,010	21	140,000	45	406,000
Controllers	37	321,770	14	152,500	18	132,000
Switchgear	44	578,100	17	254,000	23	308,000
Switch Bds.	23	1,041,640	9	181,500	11	791,000
Switches Air & Oil	4	17,250	1	11,000	3	6,250
TOTAL	766	$6,548,590	240	$1,978,300	433	$3,595,850

*Statistics compiled by only one of the major insurance groups (Factory Mutual) which specialize in industrial fire and machinery insurance.

2230. While benefits resulting from improved safety are difficult to measure; direct, measurable, economic benefits can be documented by equipment repair cost and equipment downtime records after an EPM program has been placed in operation.

2231. Dependability can be engineered and built into equipment, but effective maintenance is required to keep it that way. Experience shows that equipment lasts longer and performs better when covered by an EPM program. In many cases, the investment in EPM is small compared to the cost of equipment repair and production losses associated with an unexpected equipment shutdown.

2232. Careful planning is the key to economic success of an EPM program. With proper planning, maintenance costs will be held to a practical minimum, while production is maintained at a practical maximum.

2240. Electrical preventive maintenance requires the support of top management, because it is top management who must provide funds to initiate and maintain the program. Maintenance of industrial electrical equipment is essentially a matter of business economics. Maintenance costs can be placed in either of two basic categories: (1) preventive maintenance; or (2) breakdown repairs. Money spent for preventive maintenance will be reflected as less money required for breakdown repairs. An effective EPM program holds the sum of these two expenditures to a minimum. Figure 1 is a typical curve illustrating this principle.

2250. Electrical preventive maintenance is a form of protection against accidents, lost production and loss of profit. EPM enables management to place a dollar value on the cost of such protection. An effective EPM program satisfies an important part of management's responsibility for keeping costs down and production up.

2260. Insurance statistics document the high cost of inadequate electrical maintenance (see Table I). This table represents results of a study performed by only one of the major insurance groups (Factory Mutual) which specializes in industrial fire and machinery insurance. The table indicates that in a two-year period (1967–68), one-half of the losses associated with electrical equipment failures might have been prevented by an effective EPM program.

230. Case Histories: They Gambled and Lost.

2310. A total plant shutdown resulted from the failure of a transformer in an industrial plant. Cause of the failure was contamination of the transformer insulating oil. The contamination

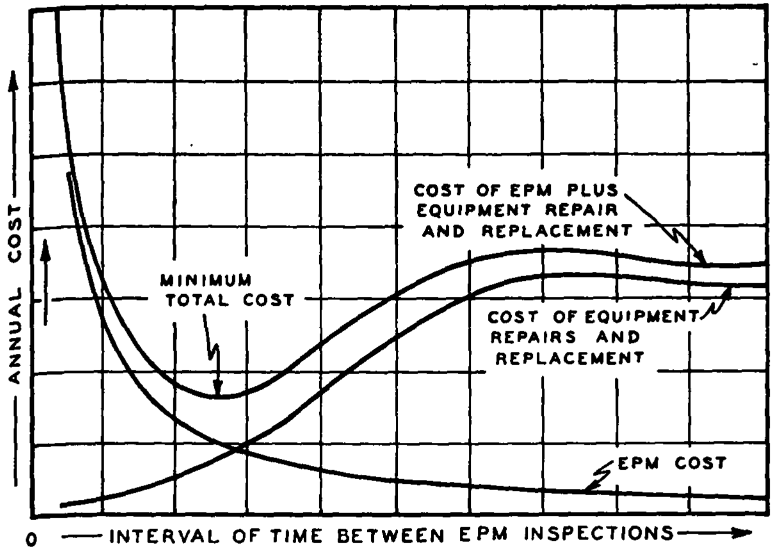

Fig. 1. Effect of EPM Inspection Frequency on Overall Costs

NOTE: As the interval of time between EPM inspections is increased, cost of EPM will diminish and cost of breakdown repairs and replacement of failed equipment will increase. The lowest total annual expense is realized by maintaining an inspection frequency that will keep the sum of repair/replacement and EPM costs at a minimum.

went undetected because the oil had not been tested for several years. Fire damage and equipment replacement costs amounted to $50,000, exclusive of the cost of plant downtime. This amount would have paid for the cost of operating an EPM program covering the entire plant electrical distribution system for several years.

2320. Damage amounting to $100,000 was attributed to the failure of the main switchgear in an industrial plant. The failure was caused from fouling by dirt, gummy deposits, and iron filings. The cost of this failure would have supported a comprehensive EPM program covering all of the plant's electrical distribution system for several years.

2330. McCormick Place, a large exhibition hall in Chicago, was destroyed by a fire believed to have been started because of a defective extension cord serving a display booth. Direct property loss was $60 million, and loss of the facility cost an additional

$100 million to the economy in the Chicago area. This fire might have been prevented if a program had been in effect to ensure: that worn cords were replaced; that only heavy-duty cords were used; and that cords and their supply circuits were not overloaded.

2340. Failure of a large motor shut down an entire industrial plant for 12 days. Cause of the failure was overheating resulting from dust-plugged cooling ducts. An EPM inspection would have detected the clogged ducts and averted the failure and accompanying plant outage.

CHAPTER 3 —
WHAT IS AN EFFECTIVE EPM PROGRAM?

310. General.

3110. An effective electrical preventive maintenance program is one which enhances safety and also reduces equipment failure to a minimum consistent with good economic judgment. Basic ingredients of such a program are men qualified to carry out the program, and regularly scheduled inspection, testing, and servicing of equipment. Equally important to the success of the program are (1) the application of sound judgment in evaluating and interpreting results of inspections and tests, and (2) the keeping of concise, but complete records.

320. Planning an EPM Program.

3210. The following basic factors should be considered when planning an EPM program:

(1) *Personnel Safety.* Will an equipment failure endanger or threaten the safety of any personnel? What can be done to ensure personnel safety?

(2) *Equipment Loss.* Is installed equipment — both electrical and mechanical — complex or so unique that required repairs would be unusually expensive?

(3) *Production Economics.* Will breakdown repairs or replacement of failed equipment require extensive downtime? How many production dollars will be lost in event of an equipment failure? Which equipment is most vital to production?

330. Main Parts of an EPM Program.

3310. Essential ingredients of an EPM program are:

(1) Responsible and qualified personnel.

(2) Survey and analysis of electrical equipment and systems to determine maintenance requirements and priorities.

(3) Programmed routine inspections and suitable tests.

(4) Accurate analysis of inspection and test reports so that proper corrective measures can be prescribed.

(5) Performance of necessary work.

(6) Complete, but concise records.

3320. A well-qualified individual should be in charge of the program. Men assigned to inspection and testing duties should be selected from the best maintenance men in the plant. Where in-plant personnel are not qualified, a maintenance contractor should be engaged.

3330. Survey and analysis should cover equipment and systems that have been previously determined to be essential in accordance with a priority plan. Regardless of the size of the program being contemplated, the EPM supervisor must determine the extent of the work to be done and where to begin. Therefore, all electrical equipment — motors, transformers, circuit breakers, controls and the like — should receive a thorough inspection and evaluation. Evaluating equipment condition and the operating environment will permit the EPM supervisor to make a qualified judgment as to how, where, and when each piece of equipment should be fitted into the program.

3331. In addition to determining physical condition, the survey should determine if the equipment is operating within its rating. In the course of the survey, it is imperative that the condition of electrical protective devices be checked. Such devices include fuses, circuit breakers, protective relays, and motor overload relays. These devices are the safety valves of an electrical system. They should be in proper operating condition to ensure safety of personnel, protection of equipment, and reduction of economic loss.

3332. After the survey has been completed, data should be evaluated to determine equipment condition. Equipment condition will reveal repair work to be done, as well as the nature and frequency of required inspections and tests.

3340. Inspection and testing procedures should be carefully tailored to requirements. In some plants, regularly scheduled tests will call for scheduled outages of production or process equipment. In such cases, close coordination is required between maintenance and production personnel.

3350. Analysis of inspection and test reports should be followed by implementation of appropriate corrective measures. Follow-through with necessary repairs, replacement, and adjustment is in fact the end purpose of an effective EPM program.

3360. Records should be accurate, and contain all vital information. Care should be taken to ensure that extraneous information does not become part of the record because excessive record keeping may hamper the program.

340. EPM Support Procedures.

3410. Design for Ease of Maintenance. Effective electrical preventive maintenance begins with good design. In design of new facilities, conscious effort is required to ensure optimum maintainability. Dual circuits, tie circuits, auxiliary power sources, and drawout protective devices make it easier to schedule maintenance and to perform maintenance work with minimum interruption of production. Other effective design techniques include equipment rooms to provide environmental protection, grouping of equipment for more convenience and accessibility and standardization of equipment and components.

3420. Training for Technical Skills and Safety. Training programs will help ensure continuing availability of qualified manpower. Instruction, both in and out of the plant, will provide a solid foundation in technical fundamentals and safe work procedures that are necessary to work on today's sophisticated equipment.

3430. Outside Service Agencies. Some maintenance and testing operations, such as relay and circuit breaker inspection and testing, require specialized skills and special equipment. In small organizations, it may be impractical to develop the skills and acquire the equipment needed for this type of work. In such cases, it might be advisable to contract the work to firms that specialize in providing such services.

3440. Tools and Instruments. Proper tools and instruments are an important part of an EPM program, and safety protective gear is an essential part of the necessary equipment. Proper tools, instruments, and other equipment will ensure maximum safety and productivity from the maintenance crew. Where specialized instruments and test equipment are needed only occasionally, they can be rented from a variety of sources.

CHAPTER 4 — PLANNING AND DEVELOPING AN ELECTRICAL PREVENTIVE MAINTENANCE PROGRAM

410. Introduction.

4110. The purpose of an EPM program is to reduce hazard to life and property that can result from failure or malfunction of industrial type electrical systems and equipment. The first part of these recommendations for an effective electrical preventive maintenance (EPM) program has been prepared with the intent of providing a better understanding of benefits — both direct and intangible — that can be derived from a well-administered EPM program. This chapter explains the function, requirements, and economic considerations that can be used to establish such a program.

4111. There are four basic steps to be taken in the planning and development of an electrical preventive maintenance program. In their simplest form, they are:

(1) Compile a listing of all plant equipment and systems.

(2) Determine what equipment and/or systems are most critical and most important.

(3) Develop a system for keeping up with what needs to be done.

(4) Train people for the work that needs to be done, or contract for the special services that are needed.

4112. Success of an EPM program is dependent on the caliber of personnel responsible for its implementation. Primary responsibility for program implementation and its success should lie with a single individual. This individual should be given the authority to do the job and he should have the cooperation of management, production, and other departments whose operations might affect the EPM program. Ideally, the person designated to head the EPM program should have the following qualifications:

(1) *Technical Competence.* He should, by education, training and experience, be well-rounded in all aspects of electrical maintenance.

(2) *Administrative and Supervisory Skills.* He should be skilled in planning, development of long-range objectives to achieve specific results, and should be able to command respect and solicit the cooperation of all persons involved in the program.

4113. The maintenance supervisor should have open lines of communication with design supervision. Frequently an unsafe installation or one requiring excessive maintenance can be traced to improper design or construction methods or misapplication of hardware.

4114. The work center of each maintenance work group, whether it be a zone or total plant, should be conveniently located. This work center should contain all of the inspection and testing procedures for that zone, copies of previous reports, single-line diagrams, schematic diagrams, record of complete nameplate data, vendors' catalogs, plant stores catalogs, and supplies of report forms. There should be adequate storage facilities for the tools and test equipment that are common to the group.

4115. In a continuously operating plant, running inspections (inspections made with equipment operating)play a very vital role in the continuity of service. The development of running inspection procedures varies with the type of operation. However, they should be as thorough as practicable within the limits of safety and the skill of the craftsman. These procedures should be reviewed regularly in order to keep them current. Each failure of electrical equipment, be it an electrical or mechanical failure, should be reviewed against the running inspection procedure to determine if some other inspection technique would have indicated the impending failure. If so, the procedure should be modified to reflect the findings.

4116. Handling the results of running inspections is the area that gives supervisors their best motivational opportunities. When the electrical maintenance supervisor initiates corrective action the craftsman should be so informed; the craftsman who found the condition will then feel that his job was worthwhile and will be motivated to try even harder. However, if nothing is done, individual motivation may be adversely affected.

4117. Trends in failure rates are hard to change and take a long time to reverse. For this reason, the inspection should continue and resulting work orders written, even though the work force may have been reduced. Using the backlog of work orders as an indicator, the electrical maintenance supervisor can predict trends before they develop. With the accumulation of a sizable backlog of work orders, an increase of electrical failures and production downtime may be expected.

420. Survey of Electrical Installation.

4210. Definition. The survey may be defined as the collection of accurate data on the plant electrical system and the evaluation of this data to obtain the necessary information for developing the

EPM program. The systems and equipment covered in specific parts of the survey should be based on logical divisions of the overall plant, either on an electrical system or plant process basis. In some cases a combination of the two is the most suitable.

4220. Data Collection.

(1) The first step in organizing a survey is to take a look at the total "package." Will the available manpower permit the survey of an entire system, process or building, or must it be divided into segments?

(2) Next, a priority should be assigned to each segment. Some segments may be found to be sequential, so they should be identified before the actual work commences.

(3) The third step is the assembling of all documentation. This may necessitate a search of desks, cabinets, etc., in the plant area, and may also require that manufacturers be contacted in order to replace lost documents. All of these documents should be brought to a central location and marked immediately with some form of effective identification.

4230. Diagrams and Data. The availability of up-to-date, accurate, and complete diagrams is the foundation of a successful EPM program. No EPM program can operate without them, and their importance cannot be overemphasized. The following diagrams are some of those in common use:

4231. Single-line diagrams trace the flow of electrical power. They should show all electrical equipment in the system and give all pertinent ratings. In making this type of diagram it is basic that voltage, frequency, phase, and normal operating position should be included. No less important, but perhaps less obvious, are items such as transformer impedance, available short-circuit current, and equipment continuous and interrupting ratings. Other items include current and potential transformers and their ratios, surge capacitors, and protective relays. Where one diagram cannot cover all of the equipment involved, additional diagrams, appropriately noted on the main diagram, should be drawn.

4232. Short-circuit and coordination study is very important. Many have the misconception that this engineering study is part of the initial plant design, after which the subject can be forgotten. However, a number of factors can affect the available short-circuit current in an electrical system. Among these are changes in the supply capacity of the utility company, changes in size or percent impedance of transformers, changes in conductor size, addition of motors, and system operating conditions.

(1) In the course of periodic maintenance testing of protective equipment such as relays and series or shunt-trip devices, their settings should be evaluated. Along with the proper sizing of fuses this is part of the coordination study.

(2) In a small plant — one receiving electrical energy at utilization voltage, or from a single step-down transformer — the short-circuit study is very simple. The available incoming short-circuit current can be obtained from the utility company sales engineer.

(3) In a larger system, it may be desirable to develop a computerized short-circuit study to improve accuracy and reduce engineering time. Should facilities not be available within the plant organization, the short-circuit study can be performed on a contract basis. The short-circuit data are used to determine the required momentary and interrupting ratings of circuit breakers, fuses and other equipment.

(4) Fuses are rated on the basis of their current-carrying and interrupting capacities. These ratings should be determined and recorded. Other protective devices are usually adjustable as to pickup point and time-current characteristics. Settings of such protective devices should be determined, verified by electrical tests, and recorded for future reference.

(5) Personnel performing the tests should be trained in proper test procedures. Several manufacturers of switchgear or test equipment have set up regularly scheduled seminars where participants are taught the principles of maintenance and testing of electrical protective devices.

4233. Circuit routing diagrams, cable maps, or raceway layouts show the physical location of conductor runs. In addition to voltage, such diagrams should also indicate the type of raceway, the number and size of conductors, and type of insulation. Where control conductors or conductors of different systems are contained within the same raceway, the coding appropriate to each conductor should be noted. Vertical and horizontal runs, with the location of taps, headers and pull boxes, should be shown. Access points should be noted where raceways pass through tunnels or shafts with limited access.

4234. Layout diagrams, plot plans, equipment location plans, or plant maps show the physical layout (and in some cases, the elevations) of the plant with all equipment in place. Switching equipment, transformers, control panels, mains, and feeders should be identified. Voltage and current ratings should be shown for each piece of equipment.

4235. Schematic diagrams are arranged for simplicity and ease of understanding circuits without regard for the actual physical location of any components. The schematic is always drawn with switches and contacts shown in a de-energized position.

4236. Wiring diagrams, like schematics, should show all components in the circuit, but they are arranged in their actual physical location. Electro-mechanical components and strictly mechanical components interacting with electrical components are shown. Of particular value is the designation of terminals and terminal strips with their appropriate numbers, letters, and/or colors.

4237. Diagrams should identify all equipment parts and devices by standard methods, symbols, and markings.

4240. System diagrams generally are needed to complete the data being assembled. The importance of the system determines the extent of information shown, or for a small plant, whether it is even needed. The information may be shown on the most appropriate type of diagram, but should include the same basic information, source and type of power, conductor and raceway information, and switching and protective devices with their physical locations. It is vital to show where the system may interface with another, such as with emergency power; hydraulic, pneumatic, or mechanical systems; security and fire alarm systems; and monitoring and control systems. Some of the more common of these are described in subsections 4241 through 4244.

4241. Lighting system diagrams (normal and emergency) may terminate at the branch-circuit panelboard, listing the number of fixtures, type and lamp size for each area, and the design lighting level. It should show watchman lights and probably an automatic transfer switch to the emergency power system.

4242. Ventilation systems normally comprise the heating, cooling, and air-filtering system. Exceptions include furnace, dryer, oven, casting, and similar areas where process heat is excessive and air conditioning is not practical. Numerous fans are used to exhaust the heated and possibly foul air. In some industries, such as chemical plants and those using large amounts of flammable solvents, large volumes of air are needed to remove the hazardous vapors. Basic information, including motor and fan sizes, motor or pneumatically operated dampers, etc., should be shown. Additionally, many safety features may be involved to ensure starting of fans before the process — airflow switches to shut down an operation on loss of ventilation — and other interlocks of similar nature. Each of these should be identified with respect to type, function, physical location, and its operating limits.

4243. Heating and air conditioning systems are usually manufactured and installed as a unit — furnished with diagrams, operating and maintenance manuals. This information should be updated as the system may be changed or modified. Because these systems are often critical to plant operation, additional equipment may have been incorporated — humidity, lint, and dust control for textile, electronic, and similar processes; corrosive and flammable vapor control for chemical and related industries, etc. Invariably these interface with other electrical or nonelectrical systems: pneumatic, or electro-mechanical operation of dampers, valves, etc.; electric operation for normal and abnormal temperature control; manual control stations for emergency smoke removal, are just a few. There may be others, but all should be shown and complete information given for each.

4244. Control and monitoring system diagrams are necessary to understand how these complicated systems function. They usually are in the form of a schematic diagram and may refer to specific wiring diagrams. Maximum benefit can only be obtained when every switching device is shown, its function indicated, and identified for ease in finding a replacement. These often involve interfaces with other systems, whether electro-mechanical (heating or cooling medium) pumps and valves; electro-pneumatic temperature and damper control; safety and emergency operations. A sequence-of-operation chart and list of safety precautions should be included to promote safety of personnel and equipment. Understanding these complex circuits is best accomplished by breaking down the circuits into their natural functions, such as heating, cooling, process, or humidity controls. The knowledge of how each function relates to another enables the craftsman to have a better concept of the entire system and thus perform his assignment more efficiently.

4250. Emergency procedures should list, step by step, the action to be taken in case of emergency, or for the safe shutdown or start-up of equipment or systems. Optimum use of these procedures is made when they are bound for quick reference and posted in the area of the equipment or systems. Some possible items to consider for inclusion in the emergency procedures are interlock types and locations, interconnections with other systems, and tagging procedures of the equipment or systems. Accurate single-line diagrams posted in strategic places are particularly helpful in emergency situations. The production of such diagrams in anticipation of an emergency is essential to a complete EPM program. Diagrams are a particularly important training tool in developing a state of preparedness. Complete and up-to-date diagrams provide quick review of emergency plan. During an actual emergency they provide a simple, quick-reference guide when time is at a premium.

4260. Test and Maintenance Equipment. All maintenance work requires the use of proper tools and equipment to properly perform the task to be done. In addition to their ordinary tools, each craftsman (such as carpenters, pipe fitters, and machinists) uses some special tools or equipment based on the nature of the work to be performed. The electrician is no exception, but for EPM, additional equipment not found in his toolbox should be readily available. The size of the plant; nature of its operations; extent of its maintenance, repair, and test facilities; are all factors which determine the use-frequency of the equipment. Economics seldom justify purchasing an infrequently used expensive tool when it can be rented. However, a corporation having a number of plants in the area may well justify common ownership of the same device for joint use, making it quickly available at any time to any plant. Typical examples might be high-current or DC high-potential test equipment, or a ground-fault locator.

4261. A certain amount of mechanical maintenance is often a part of the EPM program being conducted on associated equipment. The electrical craftsman should have ready access to such items as assorted lubrication tools and equipment; various types and sizes of wrenches; nonmetallic hammers and blocks to protect against injury to machined surfaces; wheel pullers; feeler gauges; inside- and outside-diameter measuring gauges; intruments for measuring torque, tension, compression, vibration, and speed; standard and special mirrors with light sources for visual inspection; portable blowers and vacuums of industrial type having insulated nozzles for removal of dust and foreign matter; nontoxic, nonflammable cleaning solvents; and clean lint-free wiping cloths.

4262. The use of well-maintained safety equipment is essential and should be mandatory when working on or near live electrical equipment. Some of the more important articles needed are heavy leather gloves; insulating gloves, mats, blankets, baskets, boots, jackets and coats; insulated hand tools such as screw drivers and pliers; nonmetallic hard hats with clear insulating face shields for protection against arcs; poles with hooks and hot sticks to safely open isolating switches. A statiscope is desirable to indicate the presence of high voltage on certain types of equipment.

4263. Portable electric lighting is often necessary particularly in emergencies involving the plant power supply. Portable electric lighting used for maintenance areas which are normally wet or where personnel will be working within grounded metal structures such as drums, tanks, and vessels should be operated at a maximum of 12 volts supplied from an isolating transformer or other isolated source. Ample supply of battery lanterns should be available with extra batteries. Suitable extension cords are usually necessary.

4264. Portable meters and instruments are necessary for testing and troubleshooting, especially on circuits of 600 volts or less. These include general-purpose volt meters, volt-ohmmeters, and clip-on-type ammeters with multiscale ranges. In addition to these conventional instruments, recording meters are useful for measuring magnitudes and fluctuations of current, voltage, power factor, watts and volt-amperes versus time values. These are a definite aid in defining specific electrical problems and to determine if equipment malfunction is due to abnormal electrical conditions. Other valuable test equipment includes devices to measure insulation resistance of motors and similar equipment in the megohm range and similar instruments in the low range for determining ground resistance, lightning protection systems, and grounding systems. Continuity testers are particularly valuable for checking control circuits and for circuit identification.

4265. A ground-loop tester is an important part of the EPM equipment. It is used to check the continuity of the equipment grounding circuit regardless of its location, including the grounding slot of receptacles. It can also be used to check the equipment grounding circuit of portable electric tools.

4266. Insulation-resistance measuring equipment should be used to indicate insulation values at the time equipment is put in service. Later measurements may indicate any deterioration trend of the insulation values of the equipment. High-potential AC and DC testers are used effectively to indicate dielectric strength and insulation resistance of the insulation respectively. It should be recognized that the possibility of breakdown under test due to concealed weakness is always present. High-potential testing should be performed with caution and only by qualified operators.

4267. Portable ground-fault locators can be used to test ungrounded power systems. Such devices will indicate ground location while the power system is energized. They are thus a valuable aid for safe operation by indicating where to take corrective steps before an insulation breakdown occurs on another phase.

430. Identification of Critical Equipment.

4310. Equipment (electrical or otherwise) is considered critical if its failure to operate normally and under complete control will cause a serious threat to people, property, or the product. Electric power, like process steam, water, etc., may be essential to the operation of a machine, but unless loss of one or more of these supplies causes the machine to become hazardous to people, property or production, that machine may not be critical. The combined knowledge and experience of several people may be needed to make this determination. In a small plant this can probably be done by the plant engineer or master mechanic working with the operating superintendent. A large operation may need a "team" comprising the following qualified people: (1) the electrical foreman or superintendent; (2) a production man or men thoroughly familiar with the operation capabilities of the equipment and the effect its loss will have on final production; (3) the senior maintenance man who is generally familiar with the maintenance and repair history of the equipment or process; (4) a technical man knowledgeable in the theoretical fundamentals of the process and its hazards (in a chemical plant he should be a chemist, in a mine a geologist, etc); and (5) a safety engineer or one responsible for the overall security of the plant and its people against fire and accidents of all kinds. They should go over the entire plant or each of its operating segments in detail, considering each unit of equipment as related to the entire operation, and the effect of its loss on safety and production.

4311. There are entire systems that may be critical by their very nature. Depending on the size of the plant and the complexity of the operation, it may contain any or all of the examples listed: emergency power, emergency lighting, fire alarm systems, fire pumps, and certain communication systems. There should be no problem in establishing whether or not any of these systems is critical, and in having the proper amount of emphasis placed on its maintenance.

4312. More difficult to identify are the parts of a system which are critical because of the function of the utilization equipment and its associated hardware. Some examples are:

(1) The agitator drive motor for a kettle-type reactor may be extremely critical in that, if it fails to run for some period of time, when the charge materials are added to the reactor the catalyst stratifies. If the motor is then started, rather than a slow, controlled reaction, a rapid reaction could result that may run away, overpressurize, and destroy the reactor.

(2) The cooling water source of an exothermic reactor may have associated with it some electrical equipment such as a drive motor, solenoid valves, controls or the like. The failure of this cooling water may allow the exothermic reaction to go beyond the stable point and overpressurize and destroy the vessel.

(3) A process furnace recirculating fan drive motor or fan may fail, nullifying the effects of temperature sensing points allowing hot spots to develop with serious side reaction.

(4) The failure of gas analysis equipment and interlocks in a drying oven or annealing furnace may allow the atmosphere in the drying oven or furnace to become flammable with the possibility of an explosion.

(5) The failure of any of the safety combustion controls on a large fire box, such as a boiler or incinerator, may cause a serious explosion.

(6) Two paralleled pump motors may be needed to provide the total requirements of a continuous process. Failure of either of these motors may cause a complete shutdown, rather than simply reduce production.

4313. There are parts of the system that are critical because they reduce the widespread effect of a fault in electrical equipment. The determination of these is primarily the responsibility of the electrical man on the team. Among the things that fall in this category are:

(1) Some overcurrent protective devices, such as circuit breakers or fuses. This includes the relays and control circuits. It also includes the coordination of trip characteristics of the devices.

(2) Automatic bus transfer switches or other transfer switches that would supply critical loads with power from the emergency power source if the primary source failed. This includes instrument power supplies as well as load power supplies.

4314. Parts of the control system are critical because they monitor the process and automatically shut down equipment or take other action to prevent catastrophe. These items are the interlocks, cutout devices, or shutdown devices installed throughout the plant or operation. Each of these interlocks or shutdown devices should be carefully considered by the entire team to establish whether or not they are critical shutdowns or whether they are "convenience" shutdowns. It should be thoroughly understood by the maintenance group which shutdowns are critical and which are convenience. The critical shutdown devices are normally characterized by having a sensing device separate from the normal control device. It probably has a separate, final, or end device that causes action to take place. Once the critical shutdown systems are recognized, they should be distinctly identified on drawings, on records, and on the hardware itself. Some examples of critical shutdown devices are: overspeed trips, high or low temperature, pressure, flow or level trips, low lube oil pressure trips, pressure relief valves, overcurrent trips, and low-voltage trips.

4315. There are parts of the system that are critical because they alert operating personnel to dangerous or out-of-control conditions. These are normally referred to as alarms. Like shutdown devices, alarms fall into at least three categories: (1) those that signify a true pending catastrophe; (2) those that indicate out-of-control conditions; and (3) those that indicate the end of an operation or similar condition. The entire team should consider each alarm in the system with the same thoroughness with which they have considered the shutdown circuits. The truly critical alarm should be characterized by having a separate sensing device, a separate readout device, and preferably separate circuitry and power source. The maintenance department should thoroughly understand the critical level of each of the alarms. The critical alarms and the significance should be distinctly marked on drawings, in records, and on the operating unit. For an alarm to be critical does not necessarily mean that it is complex or related to complex action. A simple valve position indicator may be one of the most critical alarms in an operating unit.

440. Establishment of a Systematic Program.

4410. The purpose of any inspection and testing program is to establish the condition of equipment to determine what work should be done and to verify that it will continue to function until the next scheduled servicing occurs. Inspection and testing is best done in conjunction with routine maintenance. In this way, many minor items that require no special tools, training, or equipment can be corrected as they are found. The inspection and testing program is probably the most important function of a maintenance department in that it establishes what needs to be done to keep the system in service to perform the function for which it is required.

4420. The atmosphere or environment in which electrical equipment is located has a definite effect on its operating capabilities and the degree of maintenance required. An ideal environment is one in which the air is: (1) clean or filtered to remove dust, harmful vapor, excess moisture, etc.; (2) the temperature is maintained in the range of 60°F to 85°F; and, (3) the humidity in the range of 40–70 percent. Under such conditions the need for maintenance will be minimized. Where these conditions are not maintained, the performance of electrical equipment will be adversly affected. Good housekeeping contributes to a good environment and reduced maintenance.

4421. Dust can foul cooling passages and thus reduce the capabilities of motors, transformers, switchgear, etc., by raising their operating temperatures above rated limits, decreasing operating efficiencies, and increasing fire hazard. Similarly, chemicals and vapors can coat and reduce the heat transfer capabilities of heating and cooling equipment. Chemicals, dusts, and vapors can be highly flammable, explosive, or conductive, increasing the hazard of fire, explosion, ground faults, and short circuits. Chemicals and corrosive vapors can cause high contact resistance, which will decrease contact life and increase contact power losses with possible fire hazard or false overload conditions due to excess heat. Large temperature changes combined with high humidity can cause condensation problems, malfunction of operating and safety devices, and lubrication problems. High ambient temperatures in areas where thermally sensitive protective equipment is located can cause such protective equipment to operate below its intended operating point. Ideally, both the electrical apparatus and its protective equipment should be located within the same ambient. Where the ambient temperature difference between equipment and its protective device is extreme, compensation in the protective equipment should be made.

4430. Equipment is designed and rated to perform satisfactorily when subjected to specific operating and load conditions. A motor designed for safe continuous operation at rated load may not be satisfactory for frequent intermittent operation, which can produce excessive winding temperatures or mechanical trouble. The resistance grid or transformer of a reduced-voltage starter will overheat if left in the starting position. So-called "jogging" or "inching" service imposes severe demands on equipment such as motors, starters, and controls. Each type of duty influences the type of equipment used and the extent of maintenance required. The five most common types of duty are defined in the National Electrical Code, and they are repeated in subsection 4431 below.

4431. Duty is defined as:

CONTINUOUS: Operation at a substantially constant load for an indefinitely long time.

INTERMITTENT: Operation for alternate intervals of (1) load and no load; (2) load and rest; (3) load, no load, and rest.

PERIODIC: Intermittent operation in which the load conditions are regularly recurrent.

SHORT-TIME: Operation at a substantially constant load for a short and definitely specified time.

VARYING: Operation at loads, and for intervals of time, both of which may be subject to wide variation.

4432. Some devices that may be of use in establishing a proper maintenance period are: running time meters (to measure total "on" or "use" time); counters to measure number of starts, stops or load on, load off and rest periods; and recording ammeters to record graphically load and no-load conditions. These devices can be applied to any system or equipment and will help classify the duty. This will help establish a proper frequency of preventive maintenance.

4433. Safety and limit controls are devices whose sole function is to assure that values remain within the safe design level of the system. Each device should be periodically and carefully inspected, checked, and tested to be certain that it is in reliable operating condition because it functions only during an abnormal situation when an undesirable or unsafe condition is reached.

4440. Wherever practical, a history of each electrical system should be developed for all equipment or parts of a system vital to a plant's operation, production or process. The record should include all pertinent information for proper operation and maintenance. This information is useful in developing repair cost trends, items replaced, design changes or modifications, significant trouble or failure patterns, and replacement parts or devices that should be stocked. System and equipment information should include:

(1) Types of electrical equipment — motors, starters, contactors, heaters, relays.

(2) Types of mechanical equipment — valves, controls, etc., and driven equipment such as pumps, compressors, fans — and whether they are direct, geared, or belt driven.

(3) Nameplate data.

(4) Equipment use.

(5) Installation date.

(6) Available replacement parts.

(7) Maintenance test and inspection date — type and frequency of lubrication; electrical inspections, test, and repair; mechanical inspection, test, and repair; replacement parts list with manufacturer's identification; electrical and mechanical drawings for assembly, repair and operation.

4450. **Inspection Frequency.** Those pieces of equipment found to be critical should require the most frequent inspections and tests. Depending on the degree of reliability required, other items may be inspected and tested much less frequently.

4451. Manufacturers' service manuals should have a recommended frequency of inspection. The frequency given is based on "standard" or "usual" operating conditions and environments. It would be impossible for the manufacturer to list all combinations of environment and operating conditions. However, this is a good basis from which to begin considering the frequency for inspection and testing.

4452. There are several points to consider in establishing the initial frequency of inspections and tests. Electrical equipment located in a separate air-conditioned control room or switch room certainly would not be considered normal, so the inspection interval might be extended 30 percent. However, if the equipment is located near another unit or operating plant that discharges dust or corrosive vapors, it might reduce this time as much as 50 percent.

4453. Continuously operating units with steady loads or with less than the rated full load would tend to operate much longer, and more reliably, than intermittently operated or standby units. For this reason, the interval between inspections might be extended 10 to 20 percent for continuously operating equipment and possibly reduced by 20 to 40 percent for standby or infrequently operated equipment.

4454. Once the initial frequency for inspection and tests has been established, this frequency should be adhered to for at least four maintenance cycles unless undue failures occur. For equipment that has unexpected failures, the interval between inspections should be reduced by 50 percent as soon as the trouble occurs. On the other hand, after four cycles of inspections have been completed, a pattern should have developed. If equipment consistently goes through more than two inspections without requiring service, the inspection period may be extended by 50 percent. Loss of production due to an emergency shutdown is almost always more expensive than loss of production due to a planned shutdown. Accordingly, the interval between inspections should be planned to avoid the diminishing returns of either too long or too short an interval.

4455. This adjustment in the interval between inspections will continue until the optimum interval is reached. This adjustment time can be minimized and the optimum interval approximated more closely initially by providing the person responsible for establishing the first interval with as much pertinent history and technology as possible.

4456. The frequency of inspection for similar equipment operating under different conditions may need to be widely different.

Typical examples illustrating this are:

(1) In a continuously operating plant having a good load factor and located in a favorable environment, the high-voltage oil circuit breakers may only need an inspection every two years. On the other hand, an electrolytic process plant using similar oil circuit breakers for controlling furnaces may find it necessary to inspect and service them as frequently as every 7 to 10 days.

(2) An emergency generator to provide power for noncritical loads may be tested on a monthly basis. Yet the same generator in another plant having processes sensitive to explosion on loss of power may need to be tested each shift.

450. Methods and Procedures.

4510. If a system is to operate without failure, not only should the discrete components of the system be maintained, but the connections between these components should also be covered by a thorough set of methods and procedures. Overlooking this important link in the system causes many companies to suffer high losses every year.

4511. Other areas where the maintenance department should develop their own procedures are shutdown safeguards, interlocks, and alarms. Although the individual pieces of equipment may have testing and calibrating procedures furnished by the manufacturer, the application is probably unique, so that the system, per se, should have an inspection and testing procedure developed for it.

4520. A variety of forms may go along with the inspection, testing, and repair (I T & R) procedure. They should be detailed and direct, yet simple and durable enough to be used in the field. Field notes taken should be legibly transcribed. One copy of reports should go in the working file of the piece of equipment and one in the master file maintained by first line supervision. These forms should be used by the electrical maintenance people. They are not for general distribution. If reports to production or engineering are needed, they should be separate, and inspection reports should not be used.

4521. The I T & R procedure folder for a piece of equipment should have listed in it:

(1) All the special tools, materials, and equipment necessary to do the job.

(2) The estimated or actual average time to do the job.

(3) Approriate references to technical manuals.

(4) Previous work done on the equipment.

(5) Points for special attention indicated by previous I T & R. If major work was predicted at the last I T & R, the procedure folder should contain a copy of the purchase order and receiving reports for the parts to do the work. It should contain references to unusual incidents reported by production that may be associated with the equipment.

4522. Special precautions relative to operation should be part of the I T & R document. What other equipment is affected and in what way? Who has to be informed that the I T & R is going to be done? How long will the equipment be out of service if all goes well and also if major problems are uncovered?

453. Planning.

4531. Having developed the I T & R procedures and having the frequency established (even though preliminary) now comes the task of scheduling. Scheduling in a continuous process plant (as opposed to a batch-process plant) is most critically affected by availability of equipment in blocks consistent with maintenance manpower capabilities. In general, plants will be shut down on some regular basis for overall maintenance and repair. Some of the electrical maintenance items should be done at this time. I T & R that could be done while equipment is in service should be done prior to shutdown. Only work that need be done during shutdown should be scheduled at that time — to level out manpower requirements and to limit downtime.

4532. The very exercise of scheduling I T & R will point out design weaknesses that require excessive manpower during critical shutdown periods or require excessive downtime to do the job with the men available. Once these weaknesses have been uncovered, consideration can be given to rectifying them. For example, the addition of one circuit breaker and a little cable may change a shutdown from three days to one day.

4533. Availability of spare equipment affects scheduling in many ways. Older plants may have installed spares for a major part of the equipment, or the plant may be made up of many parallel lines so that they may be shut down, one at a time, without seriously curtailing production. This concept is particularly adaptable to electrical distribution. Use of a circuit breaker and a transfer bus may extend the interval between total shutdown on a main transformer station from once a year to once in 5 years or more.

4534. In many continuous process plants, particularly the newer ones, the trend is toward a large single-process line with no installed spares. This method of operation will require running inspections and running tests since there will be a natural desire to extend the time between maintenance shutdowns. Downtime in such plants will be particularly costly, so it is desirable to build as much monitoring into the electrical systems as possible.

4535. Planning running inspections can vary from a simple desk calendar to a computer program. Any program for scheduling should have four facets: (1) a reminder to order parts and equipment with sufficient lead time to have them on the job when needed; (2) the date and man-hours to do the job; (3) a check to see that the job has been completed; and (4) noticing if parts are needed for the next I T & R and when they should be ordered.

4536. Planning shutdown I T & R is governed by the time between shutdowns established by the limitations of the process or production units involved. Reliability of electrical equipment can and should be built in to correspond to almost any length of time.

4537. Small plants will want to utilize, in a much abbreviated form, the following shutdown recommendations of a large plant I T & R:

(1) Know how many man-shifts the work will take.

(2) Know how many men will be available.

(3) Inform production how many shifts the electrical maintenance will require.

(4) Have all the tools, materials, and spare parts that will be required assembled on the job site. Overage is better than shortage.

(5) Plan the work so that each man is used to best suit his skills.

(6) Plan what each man will be doing each hour of the shutdown. Allow sufficient off time so that if a job is not finished as scheduled, the men working on that job can be held over without overtiring them for the next shift. This will allow the schedule to be kept.

(7) Additional clerical people during shutdown I T & R will make the job go smoother, help prevent missing some important function, and allow an easier transition back to normal.

(8) Supply copies of the electrical group plan to the overall shutdown coordinator so that it can be incorporated into the overall plan. The overall plan should be presented in a form that is easy to use by all levels of supervision. In a large complex operation, a critical path program, or some similar program, should be used.

4538. Automatic shutdown systems and alarm systems that have been determined as critical should be so designed and maintained that nuisance tripping does not destroy operator confidence. Loss of operator confidence can and will cause these systems to be by-passed and the intended safety lost. Maintenance should prove that each operation was valid and caused by an unsafe condition.

4539. A good electrical preventive maintenance program should identify the less critical jobs, so it will be clear to first-line supervision which EPM can be delayed to make men available for emergency breakdown repair.

455. Analysis of Safety Procedures.

4551. It is beyond the scope of this recommended practice to cover details of safety procedures for each of the I T & R activities. Manufacturers' instructions contain safety procedures required in using their test equipment.

4552. The test equipment (high voltage, high current, or other uses) should be inspected in accordance with vendor recommendations before the job is started. Any unsafe condition should be corrected before proceeding.

4553. The people doing the I T & R should be briefed to be sure that all facets of safety before, during, and after the I T & R are understood. It is important that all protective equipment is in good condition and is on the job.

4554. Screens, ropes, guards, and signs needed to protect people other than the I T & R team should be provided and used.

4555. A procedure should be developed, understood, and used for leaving the test site in a safe condition when unattended. These times may include a smoke break, a lunch break, or even overnight.

4556. A procedure should be developed, understood, and used to ensure safety to and from the process before, during, and after the I T & R. The process or other operation should be put in a safe condition for the I T & R by the operating people before the work is started. The procedure should include such checks as are necessary to ensure that the unit is ready for operation after the I T & R is completed and before the operation is restarted.

456. Records.

4561. Sufficient records should be kept by maintenance management to evaluate results. Analysis of the records should guide the spending level for EPM and breakdown repair.

4562. Figures should be kept to show the total cost of each breakdown. This should be the actual cost plus an estimated cost of the business interruption. This figure is a powerful indicator for the guidance of expenditures for EPM.

4563. **Records Kept by First Line Supervisor of EPM.** Of the many approaches to this phase of the program, the following is a typical set that fulfills the minimum requirements:

(1) *Inspection Schedule.* The first line supervisor should maintain, in some easy to use form, a schedule of inspections so that he can plan manpower requirements.

(2) *Work Order Log.* An active log should be kept of unfinished work orders. A greater susceptibility to imminent breakdown is indicated by a large number of outstanding work orders resulting from the inspection function.

(3) *Unusual Event Log.* As the name implies, this lists unusual events that affect the electrical system in any way. This record is derived from reports of operating and other personnel. This is a good tool for finding likely problems after the supervisor has learned to interpret and evaluate the reports he gets. This is the place where near misses can be recorded and credit given for averting trouble.

457. Emergency Procedures.

4571. It should be recognized that properly trained electrical maintenance personnel have the potential to make a very important contribution in emergency situations that are most likely to occur. However, most such situations will also involve other crafts and disciplines, such as operating personnel, pipe-fitters, and mechanics. An overall emergency procedure for each anticipated emergency situation should be cooperatively developed by qualified personnel of each discipline involved, detailing steps to be followed, sequence of steps, and assignment of responsibility. The total procedure should then be run periodically as an emergency drill to assure that all involved personnel are kept thoroughly familiar with the part they must perform.

CHAPTER 5. BIBLIOGRAPHY

510. Introduction.

5110. This bibliography lists some of the more widely recognized sources of maintenance and testing information. There are many excellent text books by individual authors that are not listed because they are too numerous and information on them is available from the various publishers.

5111. For those who are interested in implementing an effective EPM program or improving an existing one, a suitable reference library should be readily available. Size of the plant and the extent of its maintenance and servicing operations will determine the desired publications for the reference library.

5112. The need to use manufacturers' service manuals and instructions furnished with specific equipment or apparatus has been previously mentioned and cannot be overemphasized. Additionally, there are many sources of helpful information on general and specific maintenance, troubleshooting, test methods, test instruments and their use. Some of these are available without cost, but most entail a nominal charge. Publishers of technical and trade magazines are another important source of pertinent literature. Some can provide, without charge, reprints of specific articles, or for a nominal fee, a compilation of reprints of articles on a particular subject.

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McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020.

National Electrical Manufacturers Association (NEMA), 155 E. 44th St., New York, NY 10017.

National Fire Protection Association (NFPA), 60 Batterymarch St., Boston, MA 02110.

National Safety Council (NSC), 425 N. Michigan Ave., Chicago, IL 60611.

Prentice-Hall, Inc., Inglewood Cliffs, NJ 07632.

Reinhold Publishing Co., 430 Park Ave., New York, NY 10022.

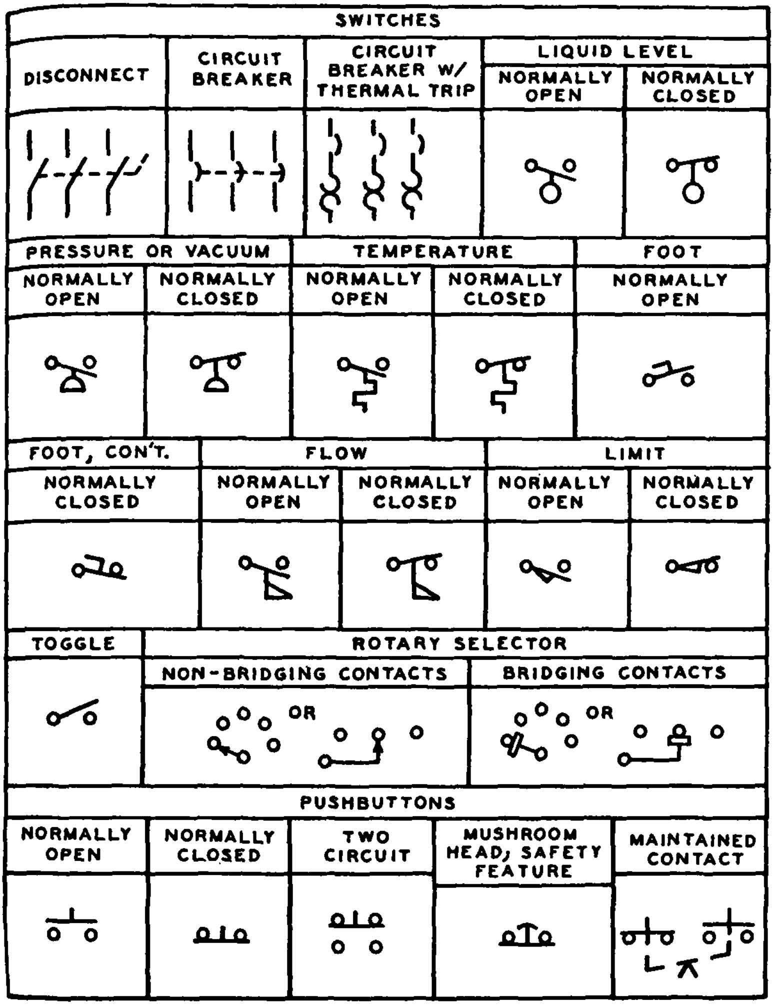
TAB Books, Blue Ridge Summit, PA 17214.

Technical Publishing Co., 1301 South Grove Ave., Barrington, IL 60010.

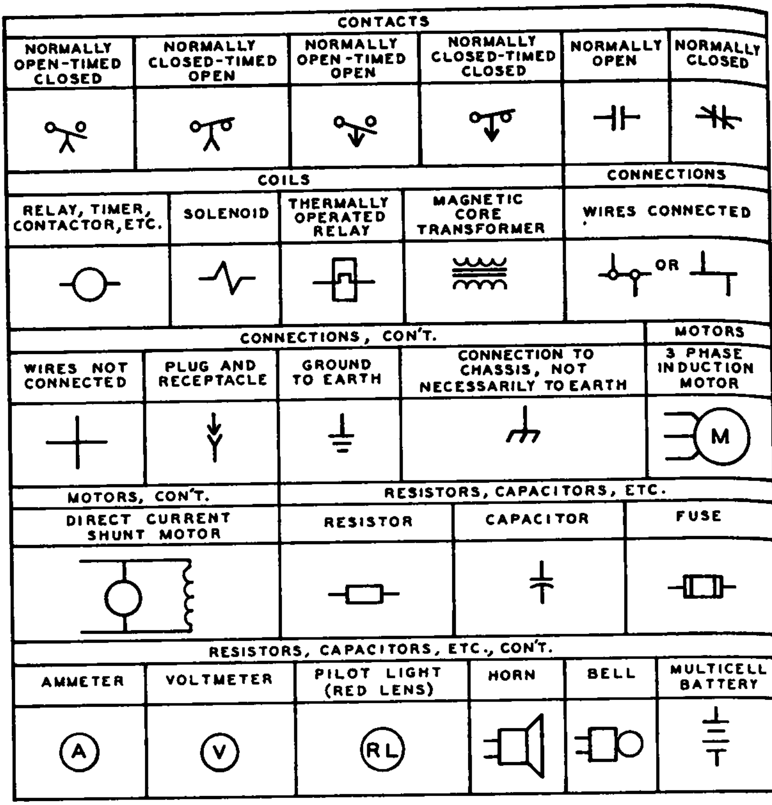
Westinghouse Electric Corp., Apparatus Repair Division, Pittsburgh, PA.

APPENDICES

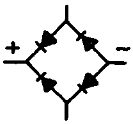
Appendix A-1 Some Typical Electrical Symbols — ANSI Y32.2 — 1970



Appendix A-2 Some Typical Electrical Symbols



Appendix A-3 Some Typical Electrical Symbols

SEMICONDUCTORS			MISCELLANEOUS
RECTIFIER DIODE	RECTIFIER BRIDGE	THERMISTOR	TERMINAL BLOCK
			

MISCELLANEOUS, CON'T.

TABLE OF CONTACT OPERATION FOR CONTROL SWITCH

DETACHED CONTACTS SHOWN ELSEWHERE ON DIAGRAM

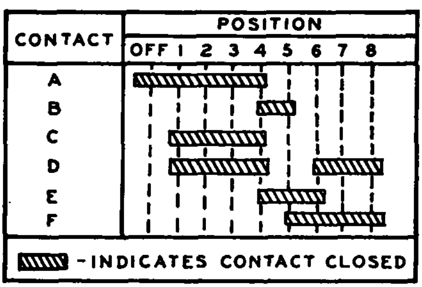
CONTACT	POSITION		
	1	2	3
A	X		
B		X	
C			X

X - INDICATES CONTACT CLOSED

MISCELLANEOUS, CON'T.

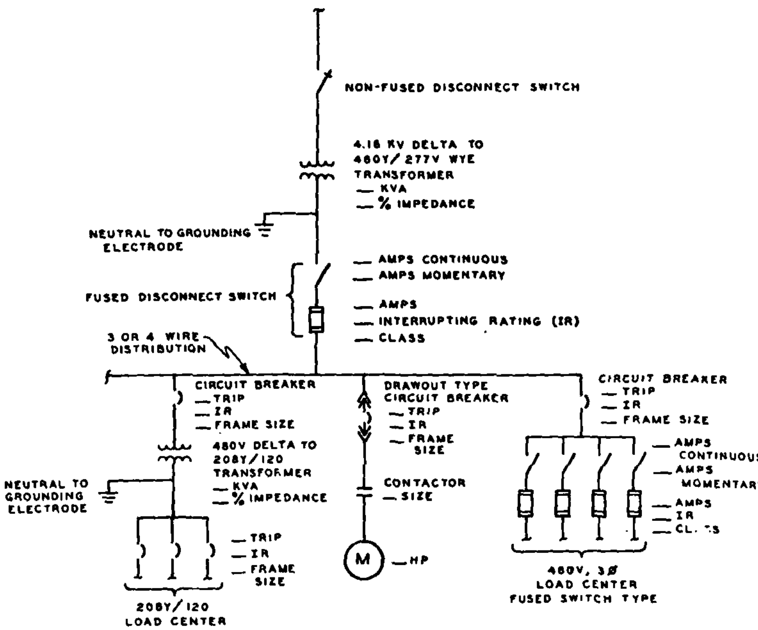
TABLE OF CONTACT OPERATION FOR DRUM SWITCH (SLIDING CONTACT TYPE)

DETACHED CONTACTS SHOWN ELSEWHERE ON DIAGRAM



Appendix B-1 Typical Use of Symbols in a Single-Line Power Distribution Diagram

NOTE: This is presented to show use of symbols and not to be construed to indicate recommendations.



Appendix B-2 Typical Wiring Diagram

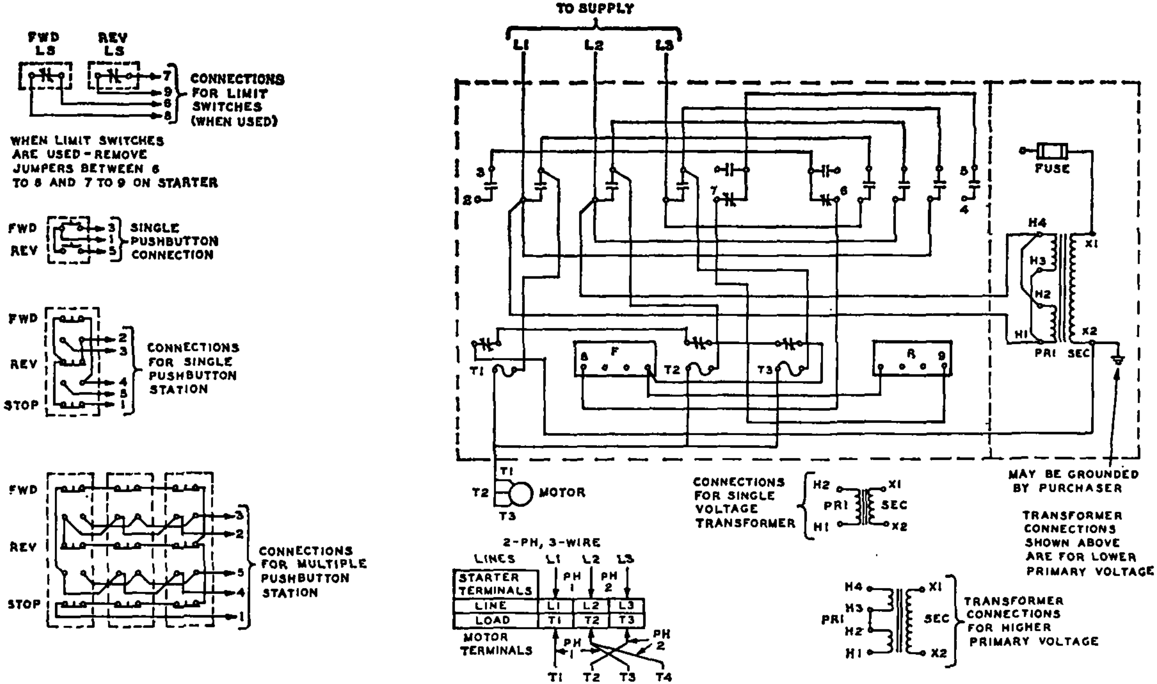
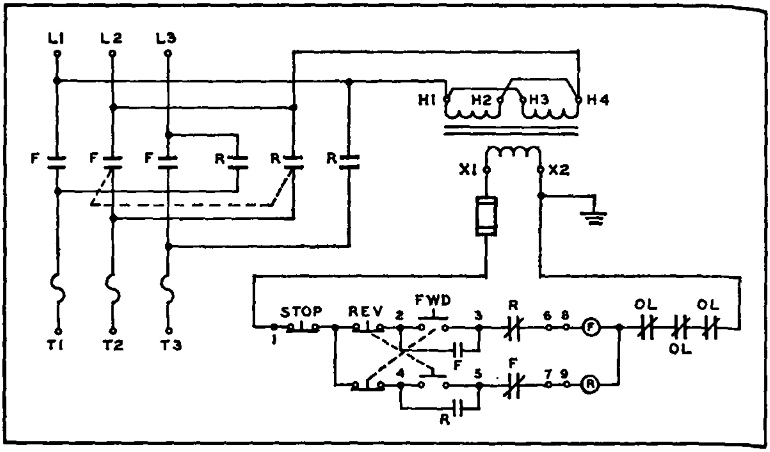


Diagram shows wiring for reversing starter with control transformer.

Appendix B-3 Typical Schematic Diagram



Power and control schematic for reversing starter with low-voltage remote pushbuttons. Forward, reverse, stop connections are shown.

Appendix C-1
Typical Work Order Request Form

Work Order Request

WORK ORDER NO.	CRAFT

PLANT DEPARTMENT

DIRECTIONS TO REQUESTER: Complete Section I ONLY. Submit four copies to the Plant Department. Maintain last copy for your files. Prepare a separate request for each job. This request will be returned to you and becomes a work order only when approved and assigned a work order number by the Plant Department. Allow sufficient time for completion. Please TYPE your request.

I. TO BE COMPLETED BY REQUESTER: Date ..../........../..........

Summary of work request..........

Location of work: Room(s) .... Building ....

Details of work request..........

....

Typical work order request form consists of five parts — includes copies for plant department (or plant engineer), data processing, receiving stores, requester, and requester's department. Work to be done is spelled out in detail.

....

Special time requirement — Date needed........../........../..........Indicate reason..........

Department..........Tel. Ext.......... ☐ Plan attached ☐ Info. attached

Authorized signature..........Title..........Approval if required..........

II. FOR PLANT DEPARTMENT USE ONLY: Date Received........../........../..........

A. Your request has been ☐ Approved ☐ Disapproved ☐ Forwarded to ....

for action. Use the assigned work order number when referring to this request.

B. Instructions: ....

....

JOB ESTIMATES	Craft	Total Hours	Total Labor	Material	Grand Total
	Hours		$	$	$

Assigned to .... Craft .... ☐ Day ☐ Night

Foreman —

C. Completed per Plant instructions? ☐ Yes ☐ No

Can recurrence be prevented? ☐ Yes ☐ No

If yes, indicate ....

ACTUAL HOURS USED	Tot. Reg.	Tot. O/T	Tot. Equiv. Hrs.

Requester —

Completed per your request? ☐ Yes ☐ No

Plant and Requester note variations ....

....

....

Date .... Foreman's Signature .... Requester's Signature ....

III. FOR DATA PROCESSING USE ONLY

Dept.	Bldg.	Class	Category	Cause	Pay	O/T $

Total Labor $	+	Total Material $	=	Total $

Work Description (Alphabetic)

WORK ORDER NO.

CRAFT

FARMS

96

70B-45

Appendix D-1

Suggestions for Inclusion in A Walk-Through Inspection Check List

These suggested items are directed toward minimizing the day-to-day electrical hazards. The list is not complete, nor do the items necessarily appear in order of importance. It is presented as a guide for the preparation of a check list that should be developed for each plant. Because of the similarity to the plant fire prevention inspection, both inspections may be carried out by the same personnel.

Flexible Cords (Including Those on Appliances). Heater-type cords are required for portable heating appliances, such as toasters, grills, and coffee makers. Check condition for badly worn or frayed spots, splices (not permitted), improper type, current-carrying capacity too small.

Plugs and Connectors. Check for stray strands and loose terminals. Are they grounding type where required for specific appliances? Green conductor must be connected to grounding pin.

Extension Cords. Are they used in place of permanent wiring, of excessive length, of proper type? They should not pass through walls, partitions, or doors.

Multiple Current-Tap's. Are they used because of too few receptacles? Note particularly such areas as canteens, lunchrooms, and offices.

Appliances: Grills, toasters, and similar equipment should be permanently spaced from combustible material.

Heating Appliances: Where used with combustible material such appliances generally require a signal light to indicate when "On."

Hot Water Heaters. Check for proper electrical protection. Manually operate the combination temperature and pressure relief valve to be sure it is free and the drainline is clear. Visually check setting.

Office Equipment. Check condition of flexible cords, plugs, and connectors. Look for excessive use of extension cords and multiple current taps.

Receptacle Outlets. Three-pole grounding-type receptacles are generally required. Check each receptacle for continuity of grounding connection, using suitable test instrument. Are special receptacle configurations used for those supplying unusual voltages, frequencies, etc. Are they well-marked or identified? Note particularly missing faceplates, receptacles showing signs of severe arcing, loose mounting, etc.

Portable Equipment (Tools, Extension Lamps and Extension Cords). In shop or tool room after each use, check for isolation between live parts and frame. Note condition of cord and plug. Is continuity maintained between frame and grounding pin of plug? The green conductor should connect only to the plug grounding pin. On lamps check condition of guards, shields, etc. See the National Electrical Code, NFPA No. 70, for portable hand lamps; metal-shell, paper-lined lampholders for hand lamps are not permitted.

Lighting Fixtures. All lighting fixtures should be labeled and grounded. See the National Electrical Code, NFPA No. 70, for connection of electric-discharge lighting fixtures. These may be connected by suitable, 3-conductor flexible cord where visible for its entire length and terminated at outer end in a grounding-type attachment plug or busway plug. No fixtures should be located close to highly combustible material. Note location of fixtures having burned out bulbs or tubes; where fixtures are heavily coated with dust, dirt, or other material; and where the reflectors are in need of cleaning.

Equipment Grounding: Where machinery and/or wiring enclosures are grounded through the conduit system, look for broken or loose connections at boxes and fittings, flexible connections, and exposed ground straps. Multiple bonding of conduit and other metallic enclosures to interior water piping systems including sprinkler systems, is sometimes used as a precaution where building vibration is severe, even though a separate equipment grounding conductor is run with the circuit conductors inside of the conduit.

Yard Transformer Stations. Note condition of transformers, fence, gates, and locks. Yard and equipment should be free of storage of combustible material, weeds, grass, vines, birds' nests, etc. Watch for indication of localized overheating indicated by conductor discoloration. Indication of excessive transformer temperature, pressure or oil leakage should be noted.

Services. Visually check condition of weatherheads and weatherhoods to determine that they remain in good condition. Eliminate birds' and rats' nests, etc. At the same time determine the apparent condition of lightning arresters, surge capacitors, grounding conductors, and grounds. Are switches safely and readily accessible?

Switchrooms and Motor Control Centers. Check to see that they are clean and used for no other purpose. They should be free of storage of any kind, especially combustible material. Ventilation equipment should be in working condition and unobstructed.

Notice and promptly report any unusual noises or odors. Metering equipment should be checked for high or low voltage and current, and any indication of accidental grounding (ungrounded systems). Are switches and motor controllers properly identified as to function; are fire extinguishers in place, of suitable type and charged?

Grouped Electrical Control Equipment (Such As May Be Mounted on Walls, Etc.). Are they protected from physical damage and readily accessible? Are any equipment enclosures damaged or have missing or open covers? Are any live parts exposed? Report any condition preventing quick or ready access.

Enclosures of Electrical Parts (Motor Control Equipment, Junction Boxes, Switches, Etc.). Are covers secured in place? Report location of broken or loose conduit, wiring gutters, etc. Missing dust caps should be replaced.

Hazardous Location Equipment. All cover bolts should be in place and tight. Permanent markings should not be obstructed by paint. Examine joints between cover and case for signs of having been pried open in removing cover. This may have damaged the mating surfaces of the joints. Excessive accumulations of dust and dirt should be noted for removal from all enclosures, including motors, which also should be examined for obstructed ventilation. Note and report the use of nonexplosion-proof electric equipment, including lighting, which may have been installed in the hazardous location area.

Emergency Equipment.

(1) Exit lights should all be functioning properly.

(2) Emergency lights should all be in working condition. Periodic tests are recommended to be sure that they function when normal lighting is lost.

(3) Emergency power supplies such as batteries, engine driven generators, etc., normally receive scheduled tests. Check records of periodic tests. Are fuel and cooling supplies for engine drives adequate? Are fire extinguishers in place, of proper type and charged?

(4) Alarm systems, such as for fire, intrusion, smoke detection, sprinkler waterflow and fire pumps, also receive periodic tests. Check records of these tests to be sure that all signals are properly transmitted and equipment is in good working condition.

Report of Committee on Electrical Metalworking Machine Tools

Swaffield Cowan,† *Chairman,*
Factory Insurance Assn., 131 Providence Rd., Charlotte, N. C. 28207

E. J. Loeffler, *Secretary,*
National Machine Tool Builders' Assn., 7901 Westpark Dr., McLean, VA 22101

Randall L. Antrobus, Cincinnati Milacron, Inc.

A. T. Bacheler, Westinghouse Electric Corp.

R. H. Butterfield, Caterpillar Tractor Co.

E. E. Carlton, California Div. of Industrial Safety.

J. I. Ehrhardt, Ex-Cell-O Corp.

W. F. Huette, Allen-Bradley Co.

R. D. Jordan, The Minster Machine Co.

H. B. Love, City of Detroit, Bureau of Electrical Inspection.

J. E. Menzies, Delco Products Div., General Motors Corp.

R. W. Nelson, Nelcor, Inc.

G. B. Newbold, Middle Department Assn. of Fire Underwriters.

S. F. Newman, General Motors Corp.

Robert W. Seelbach, Underwriters' Laboratories, Inc.

R. E. L. Shirley, Georgia Power Co.

Dale C. Walker, Square D Co.

John H. Watt,* National Fire Protection Assn.

Alternate.

Norbert J. Patek, Factory Insurance Assn. (Alternate to Swaffield Cowan.)

†Mr. Swaffield Cowan retired on December 1, 1972 and Mr. Robert W. Seelbach is the new committee chairman.

*Nonvoting.

The revisions covered by this report have been submitted to letter ballot of this Committee which consisted of seventeen voting members, all of whom have voted in the affirmative.

Since the Electrical Metalworking Machine Tools Committee reports to the Association through the Correlating Committee of the National Electrical Code Committee, the report and revisions were submitted to letter ballot of the Correlating Committee which consists of nine voting members, all of whom voted affirmatively.

Proposed Amendments to Electrical Standard for

Metalworking Machine Tools

NFPA No. 79 — 1971

1. *Page 4 — Preface. Delete last paragraph.*

2. *100–1 (b). Replace the phrase* "the art of electrical or mechanical engineering" *with* "the state of the art."

3. *100–7. Delete entire Section.*

4. *100–8. Add new Section:*

100-8. Official Interpretations. The procedure for requesting and processing an Official Interpretation shall be given as in Chapter 110 of NFPA Regulations Governing Technical Committees — 1972, as shown in Appendix C.

5. *100-11. Add new Section:*

100-11. Nominal Voltages. All voltages mentioned in this standard are nominal.

6. *110-5. (a). First Paragraph. Delete parenthetical expression in second line* "(see Note 1)." *Also, change Note 1 to a second full print paragraph and add* "shown on the nameplate" *to follow the word* "current" *in first line. Also change Note 2 to a third full print paragraph.*

7. *120-9. Delete* "It is recommended that the," *and add* "shall" *following* "conductors" *in second line, to read:* "Incoming supply line conductors shall terminate . . ."

8. *120-13 (a). Begin second sentence* "The disconnecting means shall be . . ." *instead of* "It is recommended that it be . . ."

9. *120-13 (b). In first line, change* "more than one" *to* "two or more" *and change* "is" *to* "are."

10. *120-15. Change first word from* "The" *to* "Each." *Delete parenthetical cross references.*

11. 120-17 (b). End sentence after "floor" *in third line. Add new sentence* "A permanent operating platform, readily accessible by means of a permanent stair or ladder, shall be considered as the floor for the purpose of this requirement."

12. TYPICAL DIAGRAMS. Identify as "Diagram 130-1."

13. 130-1. In first line replace "Figures I, II, III and IV show" *with* "Diagram 130-1 shows." *Delete parenthetical cross reference.*

14. 130-3. In second and third lines change "Typical Diagrams" *to* "Diagram 130-1."

15. 130-5. Second line. Change "the Typical Diagrams" *to* "Diagram 130-1."

16. 130-7. Third line. Add period after "supply" *and delete* "except as follows."

17. Note to Table 130-D. Change "refer to" *to* "see the."

18. 130-13. Delete last sentence.

19. 130-19. (a). In last sentence add period after "side" *and delete parenthetical cross reference.*

20. 130-20. Revise former Note to Section 130-19 (b) and make new Section to read:

130-20. Common Overcurrent Device. The use of the same overcurrent device to provide the protection called for in Sections 130-15, 130-17, and 130-19 shall be permitted.

21. 130-21. In second line change "a hazardous" *to* "an unsafe."

22. 140-3 (a). Exception No. 1. In first line, change "may be used" *to* "shall be permitted."

23. 140-3 (a). Exception No. 2. In first line change "may be used" *to* "shall be permitted;" *also in fourth line delete parenthetical cross reference.*

24. 140-3 (a). Exception No. 3. In second and third lines, change "may be energized" *to* "shall be permitted to be energized."

25. 140-3 (b). Exception. In first line change "may" *to* "shall be permitted to."

26. 140-4. Completely revise to read:

140-4. Grounding of Control Circuits. Grounded or ungrounded control circuits shall be permitted as provided for in Section 240-1.

27. 140-7. In fourth line delete "protective;" *and in last line change* "a hazardous" *to* "an unsafe."

28. In second line change "create a hazardous condition" *to* "cause a malfunction;" *also in last line change* "insure" *to* "ensure."

29. 150-1. Delete this Section.

30. 150-3. Revise to make former recommendation mandatory as follows:

150-3. Connections. Convenient means for making conductor connections shall be provided on or adjacent to all control devices mounted in the control enclosure.

31. 150-5. Revise to make former recommendation mandatory as follows:

150-5. Subpanels. Subpanels with concealed or inaccessible internal wiring or components shall be mounted and wired so as to be removable.

32. 150-7 (a). In first line add "motor" *ahead of* "controller."

33. 160-1. Exception. In first and second lines change "may be" *to* "shall be permitted to be;" *also at end of last line delete* "and without hazard," *placing a period after* "satisfactorily."

34. 160-2. Completely revise to read:

160-2. Nonmetallic Enclosures. Nonmetallic enclosures approved for the purpose shall be permitted. For grounding provisions see Section 240-5.

35. 160-9. Revise last line to read "The width of doors shall not exceed 36 inches."

36. 160-13. Delete parenthetical cross reference.

37. 160-13. Exception. Change to "Exception No. 1."

38. 160-13. Revise note following former Exception and change to Exception 2 as follows:

Exception No. 2. It shall be permitted to provide means for qualified persons to gain access without removing power. The interlocking shall be reactivated automatically when the door(s) is closed.

39. 170-1 (b). Delete this former recommendation.

40. 170-3 (a). Delete this former recommendation.

41. 170-5 (a). Delete paragraph designation, making this paragraph the sole requirement of this Section.

42. 170-5 (b). Delete this former recommendation.

43. 180-1 (a). Delete this Exception.

44. 180-1 (b). Delete this former recommendation.

45. 180-11 (a), (b) and (c). Revise to read:

(a) Pendent operator control station enclosures shall be oiltight.

(b) A wobble stick or rod operator at the bottom of the station shall be permitted for 'Emergency Stop' controls.

(c) Grounding and bonding shall comply with Sections 240-7 and 240-9 (c).

46. 190-1 (c). Change second phrase from recommendation to requirement. Section to read:

(c) They shall be provided with gaskets to prevent entrance of oil or moisture when in operating position, and means shall be provided to cover the receptacle when the plug is removed.

47. 190-2 (a). In first line change "may" *to* "internal to control enclosure shall."

48. 190-2 (b). In first line delete "nominal."

49. 190-2 (c). In first line change "should" *to* "shall."

50. 190-3 (b) (2). In first line change "The" *to* "A grounded;" *also delete parenthetical cross reference.*

51. 190-3 (e). Change to read:

(e) Grounding shall comply with the provisions of Section 240-3.

52. 190-3 (f). Delete parenthetical cross reference.

53. 200-1. In first line delete parenthesis marks only.

54. 200-1 (a) (1) (c). Add new Exception No. 1 to read:

Exception No. 1: Wire Nos. 14-10 with 45 mils insulation and wire No. 8 with 60 mils insulation shall be permitted.

55. 200-1 (a) (1) (c). Add new Exception No. 2 to read:

Exception No. 2: Where subjected to normal temperatures exceeding the limits for Type MTW, conductors having suitable insulation shall be used.

56. 200-1 (a) (1) (c). Fine print note. Relocate without change ahead of new Exception No. 1.

57. 200-1 (a) (1) (d). Exception. In third line change "may be used" *to* "shall be permitted."

58. 200-1 (a) (3). Exception. In second line change "may be located" *to* "shall be permitted."

59. 200-1 (b). Delete "AWG" *from tabulation.*

60. 200-1 (b) (2) Exception. Delete "AWG" *and change* "may be used" *to* "shall be permitted."

61. 200-1 (b) (4). Combine into one statement as follows:

(4) For electronic, precision, and static control as in Section 200-3.

62. Table 200-A. In fourth column change next to bottom line to "37[a] (19[d])" *and bottom line to* "61[a] (37[d])." *Also in explanations: c) change* "may be used" *to* "shall be permitted;" *and in d) change* "recommended" *to* "Shall be permitted."

63. *200-3 (a) (2). Exception: change to read:*

Exception: Solid conductors No. 24-30, within the control enclosure and not subject to flexing shall be permitted.

64. *200-3 (a) (3). Change* "may be used" *to* "shall be permitted."

65. *200-3 (b) (1). Delete* "AWG."

66. *200-3 (b) (1). Exception. In second line delete* "AWG" *and change* "may be used" *to* "shall be permitted."

67. *200-3 (b) (2). Delete* "AWG."

68. *200-3 (b) (2). Exception. Delete* "AWG" *and change* "may be used" *to* "shall be permitted."

69. *210-1 (a). Delete italicized statement* "Exceptions to the above may be made only as follows:"

70. *210-1 (b). Exception. Change to read:*

Exception: Splices shall be permitted to leads attached to electrical equipment, such as motors and solenoids, and shall be insulated with oil-resistant electrical tape.

71. *210-1 (d). Delete.*

72. *210-3 (a). In second line change* "may be used" *to* "shall be permitted."

73. *210-3 (b). Delete first sentence. In second line insert* "control" *ahead of* "panels."

74. *210-3 (c). In first line delete* "It is recommended that," *capitalize* "Multiple," *and insert* "shall" *to follow* "panels."

75. *210-5 (e). In second line delete parenthetical marks and change* "see" *to* "as shown in."

76. *210-5 (e). Exception. Change* "may be used" *to* "shall be permitted."

77. *210-5 (g). Insert* "A.C. power" *ahead of* "circuit."

78. *210-5 (g). Exception. Delete.*

79. *210-5 (h). In second line change* "may occupy" *to* "shall be permitted in."

80. *210-5 (i). Rephrase first sentence. Section to read:*

(**i**) Connection through a polarized grounding-type attachment plug and receptacle shall be permitted where equipment is removable. The male plug shall be connected to the load circuit.

81. *220-1 (b). Change* "may be provided with" *to* "shall be permitted in," *and rephrase to read:*

(**b**) Drain holes of ¼ inch shall be permitted in raceways, junction boxes and pull boxes subject to accumulations of oil or moisture.

82. *220-1 (c). Delete.*

83. *220-5. Title. Correct spelling of* "Fittings."

84. *220-5 (a). Delete last sentence.*

85. *220-9 (d). Insert* "nominal" *ahead of* "dimensions," *and change* "near as practicable to the values given" *to* "shown."

86. *220-11 (a). In first line change* "may be used" *to* "shall be permitted."

87. *220-13. In second and third lines change* "may be used" *to* "shall be permitted."

88. *220-15. Delete second sentence.*

89. *220-17. In second line delete* "general purpose;" *and change beginning of second sentence to read* "The connection of terminals . . ." *and change* "may be connected" *to* "shall be permitted."

90. *230-3. In second, third and fifth lines delete* "easily."

91. *230-5. In second and third lines change* "cause injury to the operator or damage to property" *to* "produce an unsafe condition."

92. 240-1. In second line change "When" *to* "Where;" *in fourth line delete* "(see Section 140-5)" *and end the sentence after* "transformer;" *and rewrite fifth line. Changed requirement now reads:*

240-1. Control Circuits. Control circuits may be grounded or ungrounded as determined by local operating conditions. Where grounding is provided, that side of the circuit common to the coils shall be grounded at the control transformer. For color coding of conductors see Section 210-1 (a).

93. 240-1. Exception. Rephrase to read:

Exception: Exposed control circuits as permitted by Section 140-3 (a) Exception No. 2 shall be grounded.

94. 240-3 (a). In first line change "fed" *to* "supplied."

95. 240-3 (b). In first line change "fed" *to* "supplied."

96. 240-7. In second line change "or" *to* "and."

97. 240-9 (a). In first line delete "or other corrosion-resistant;" *also delete entire second sentence.*

98. 240-9 (b). In last sentence change "are" *to* "shall not be considered as."

99. 240-11 (a). In first line change "may" *to* "shall."

100. Appendix A. Glossary of Terms. Add definition of "Readily Accessible" *as follows:*

READILY ACCESSIBLE: Capable of being reached quickly, for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (NEC-NFPA 70–1971, ANSI Cl–1971).

101. Appendix B. References to Other Codes and Standards. Change address of both National Machine Tool Builders' Association and Joint Industrial Council to "7901 Westpark Drive, McLean, Va. 22101."

102. Appendix C (New). Official Interpretations. Exact copy of Section 110 of NFPA Regulations Governing Technical Committees — 1972.