Westinghouse Electrical Maintenance Hints

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How to Use This Book:

"Westinghouse Electrical Maintenance Hints"

This book has been designed to provide quick and easy reference to acceptable maintenance practices on the most commonly used types of industrial electrical apparatus, particularly that manufactured by Westinghouse Electric Corporation.

It is arranged in a manner which will help you to quickly locate any particular subject covered by the book. There is a general contents which will refer the reader to a specific chapter and the type of apparatus of particular interest at the moment. Each chapter is indexed to show, in topical order and by sub topics, all information contained in each chapter. For example, to obtain information on the subject of commutation on dc machines, refer to Chapter 16. The chapter index provides a further breakdown of the significant areas of maintenance of commutators and what to look for if commutation is not satisfactory. Hints on probable causes and corrective measures appear as topical subjects. This eliminates the need to completely read or review the entire chapter to obtain information on solving commutation problems.

Warning

This book is not intended as a substitute for engineering or other expert assistance or for the data set forth in instruction manuals or other literature issued by the manufacturers of specific items of apparatus. It is understood that the reader assumes all risks in using this book and that Westinghouse hereby disclaims any and all responsibility arising out of such use.

The Purpose of this Revision

Westinghouse "Maintenance Hints" has been an enduring and authoritative guide to acceptable maintenance practices for many years although it is not a text book. Some of its basic material, including theory and practices, has not been affected by technological advancements in the electrical industry. Many of the methods and procedures recommended in earlier printings are still valid and in use because a better method has not been developed to perform them. Certain tests are still being performed as they were 20 or more years ago but, in other areas there have been significant changes. Many portions of the original text were found to be outdated and revision was necessary. All of the chapters have been rewritten and the book has been considerably expanded to provide modern viewpoints on more types of apparatus and techniques.

Over 20 years experience in using the original text as a guide for Westinghouse Field Service Engineers has shown it would be advisable to devote more time, and place more emphasis, on the care of modern electrical apparatus. Also, we appreciate there is still considerable vintage equipment in service; and this apparatus will still have to be maintained but, it will ultimately be phased out or replaced. Today, it is more important for maintenance personnel to be informed and progressively knowledgeable. Technological advancements, coupled with the use of new and better insulating materials are changing long established practices as well as maintenance requirements. New viewpoints are being adopted as a result of more than a decade of study by technological societies, insurance underwriters and electrical equipment manufacturers. The cause of most electro/mechanical failures has invariably been traced to some aspect of maintenance, either the lack of it, ignoring requirements or, improper care of equipment once it has been installed.

Installation practices play a major role; many factors are involved which can affect performance of equipment. Failures, some of them occurring at start-up, have resulted in total destruction of new and valuable equipment. They could have been avoided if more care had been exercised when equipment was being installed. It is extremely important, as this revision will point out, to maintain, service, inspect and test electrical apparatus at regular intervals. This may involve a change in the frequency for maintenance than that specified by the manufacturer, depending on environment and application.

Please keep in mind, the information and recommendations contained in this revision of Westinghouse "Electrical Maintenance Hints" are based on Westinghouse Electric Corporation procedures and authorized Field Service practices. Manufacturers have many common view points pertaining to maintenance of electrical equipment but, there is not as yet, a maintenance standard for the industry. Nothing contained in Westinghouse "Electrical Maintenance Hints" is to be construed, or interpreted, as applying universally to the equipment manufactured by others.

When used as a guide, you can follow Westinghouse recommendations and satisfy the maintenance requirements of most manufacturers. When you are working on Westinghouse apparatus, observe the time tested procedures and factory methods endorsed by Westinghouse Electric Corporation. You will find that good maintenance pays off. You should experience fewer unexpected power and equipment failures and have less unproductive downtime attributable to electrical problems.

Of greater significance is the factor that apparatus condition and reliability are directly related. To obtain maximum life from electrical equipment, maintain reliability, and minimize repair costs, it is necessary to service it; the quality of maintenance is extremely important.

It is possible to keep mechanical apparatus running by improvised methods, patch work and temporary repairs but, electrical equipment can be irreparably damaged by keeping it "on line" when there is evidence of trouble. Throughout this book, the reader will be constantly reminded of the Do's and Don'ts applying to the maintenance of electrical apparatus.

Adherence to "acceptable" practices can have direct bearing on the M.T.B.F. (mean time between failure) ratio associated with a plants operation. Regular shutdowns for maintenance are necessary. These shutdown periods should be utilized, whenever possible, to thoroughly inspect and recondition normally energized electrical equipment.

Electrically powered process machinery which is maintained in perfect condition is worthless unless the motors, generators, control, and other components of the plants electrical system are equally reliable. It is the responsibility of the maintenance department and its personnel to maintain and assure the reliability of all Plant equipment. Neglect by this group jeopardizes the entire Plant operation. For this reason, Plant Management is becoming more cognizant, and concerned, about the rising cost of maintenance; in many plants it is developing into a profit detractor.

A new attitude toward maintenance is developing and spreading throughout industry. Many plants rely very heavily on electrically powered equipment. Preventive Maintenance, instead of "necessary" maintenance, is now being highlighted and the doctrine is spreading. Attitudes are changing; it is no longer true that maintenance is something industry must tolerate and learn to live with. Studies have shown that when production has priority over maintenance requirements it reflects on maintenance costs. Poorly maintained equipment deteriorates much faster, gives more trouble and ultimately requires more extensive and costly repairs. Whenever maintenance becomes "subordinate" to production there is no valid reason to condemn the apparatus or its supplier. Failure to maintain equipment constitutes abuse. Hopefully, Westinghouse "Electrical Maintenance Hints," in this expanded and updated version, will become a valuable source of information on "how not to abuse equipment" and result in improved maintenance practices.

The Energy Crisis

There appears to be a correlation between the interest in changing maintenance practices and the energy crisis. Manufacturing processes and raw materials processing requires tremendous amounts of electricity which, over the years, has been generated mainly by coal, oil and gas-fired turbine generators. These fuels, once considered virtually unlimited are now becoming scarce, particularly fuel oils and gas. It has been recently estimated that this nation has coal reserves for hundreds of years but, much research is needed to make coal a suitable replacement for critically short oil supplies.

As this book is being written, stringent measures are being proposed to conserve existing reserves of fossil fuel, natural gas, and oil deposits. Unless new, untapped deposits of oil and gas are located and developed, we will have to revert to coal as the basic fuel to operate the steam turbine generating plants. This represents a backward step from an ecological viewpoint and will require a revision in present laws controlling air pollution. Even if we were to return to coal fired boilers in every power house in the country, our continuing growth rate in population and energy consumption will require development and conversion to other forms of energy to keep us a progressive nation.

Even with the greatest scientific minds in the world desperately trying to find other alternate sources of non-polluting energy, *the fact remains that there is a serious energy crisis.* We can only hope that our industrial and economic structure will survive the present crisis. We have become very dependent on the conveniences provided by electricity, oil, natural gas, and coal. Each of these fuels plays a vital part in our everyday life. Many manufactured and commonly used products, including clothing, gasoline, oil, tires, plastics, synthetic fibers, building materials, and an almost endless list of new products developed in recent years, are derived from our diminishing natural resources. Many medicines, drugs, anesthetics, chemicals, acids, and other commodities including food preservatives, dyes, lubricants and gasoline are by-products obtained from crude oil and coal. The manufacture and extraction of these by-products would not be possible without electrical energy to run the machines or maintain the chemical conversion processes which produce either raw materials or distillates which industry then converts to consumer products. Today, electricity plays a vital role in practically every facet of our economy, providing more advantages and conveniences than mankind has ever known.

Americans are very resourceful and, unquestionably, the most advanced and technologically oriented people in the world. We will find some means individually, or through world co-operation, to pull out of this crisis, but the immediate future presents many challenges....chiefly that of continuing to be an affluent society without sacrificing many of the luxuries or comforts to which we have become accustomed. Even in our homes we have increased the demand for electricity since we, as consumers, have demanded and represent an expanding market for electrical appliances. However, industry is still the greatest user of electricity and will continue to be. Statistical data compiled over a period of many years indicates that on a national basis, the demand for electricity has been doubling every ten years.

As new and more efficient electrical apparatus is developed, there should be a commensurate drop in power requirements to maintain the same level of productivity. Unfortunately, the cost of electrical energy is going to go up unless there is a break-through and some new energy source is discovered. As of now, nuclear powered generating stations appear to be the most logical, long range, solution but, they are expensive and take a long time to complete. Even then, the cost of the power they produce will probably become an economic factor since construction costs must be passed on to the consumer and more plants will have to be constructed at intervals to satisfy the demand for more and more electricity, if the present trend continues.

This book offers no solution to the energy crisis, nor do we wish to discuss it further. It is factual, and we will either have to live with it or solve it. But, we do have a valid opinion that it can be alleviated appreciably by maintaining all electrical apparatus in good operating condition at all times, with original performance characteristics and efficiencies. The electrical losses associated with poorly maintained apparatus are hard to determine.

There may be occasions when the reader has a need for more technical information, fundamental theory or training in basic electricity. He should refer to specific manuals or publications devoted to these subjects. It is assumed that the reader's background and experience in electrical maintenance is relatively advanced; at least to the point where basic theory and the fundamentals pertaining to any topic in this book are not necessary. If help is required to resolve a unique or reoccurring type of maintenance problem, not covered by apparatus instruction books, the manufacturer or his nearest Service Agency should be contacted.

If time does not permit this type of action or, the Manufacturer does not service or repair equipment on a local basis, please contact the nearest Westinghouse Apparatus Service Department or Apparatus Repair Plant. The Service Engineers employed by Westinghouse are experienced and knowledgeable individuals. They are trained and equipped for diagnostic trouble shooting. Their familiarity with all types of electrical equipment, including other manufacturers apparatus, can be invaluable to you when emergency situations arise and you need engineering assistance or repairs to resume plant operations.

Dedication

This book is dedicated to the vast number of individuals employed as electrical maintenance personnel. Without their skills, knowledge and ability to keep equipment operating under very adverse and seemingly impossible situations, production goals can be forgotten. *They,* more than anyone else, in Plant Operations are responsible for productive and safe operation of Plant equipment.

Electrical Systems–Plan for Reliability and Maintenance

DESPITE THE NEED for higher reliability, electrical distribution systems being installed today are deteriorating in quality due to poor system planning during initial planning stages.

System layouts are poorer than they were 20 years ago, even though there are better methods and equipment now available. In a nationwide analysis of several hundred plants in the past several years, only 10% of them revealed any ingenuity in the design of their power systems.

Electrical equipment today constitutes 2 to 10% of the overall cost of a new plant. This means that the additional cost required to design a good system is very small.

This cost would be returned by eliminating just one unnecessary plant shutdown.

(1) Problems In Poor Designs

Shortcomings many plant systems have, which can result in electrical system failure and halt production are:

Inadequate spare capacity.

No alternate feed for critical loads.

Uncoordinated protective devices.

Too many loads on individual circuit breakers.

No metering to monitor loads.

Power centers too far from the load.

Having defined the inadequacies of plant design, let's review the guide posts to good system design.

Load Determination – This is one of the first problems that confronts the electrical design engineer and later presents problems to the maintenance technician who must trouble-shoot the system.

Plant distribution (load determination) usually must be designed before all loads are known. This is at a time when the equipment layout itself is only in the formative stage.

In the established plant the process may be changing as production schedules change and new equipment which has greater power demands is fitted into the production line.

Such production tools as electric powered drills, heat guns, etc. affect the utility load in some manner. Unless circuits have been originally designed for sufficient overload, problems will immediately begin to occur. Circuits will be over-loaded, breakers will be kicked out and power will be lost to an entire area. Production stops until plant maintenance can re-establish the power.

It's for these reasons that load estimates should be employed to influence major decisions in planning the demands and distribution system. In most cases, it's better to consider the lighting and power loads separately, then combine them later to determine demands in any one area, since present practice is to supply these loads from a centrally located substation.

(2) Factors Frequently Used to Determine Distribution System Loads are:

Demand factor, which is defined as the ratio of the maximum demand on a system to the total connected load of the system. The maximum demand is usually the integrated maximum kilowatt demand over a 15 to 30 minute interval rather than the instantaneous or peak demand.

Diversity factor is the ratio of the sum of the individual maximum demands of the various parts of a system to the maximum demand of the whole system.

Load density estimates are especially useful for equipment operated at 600 volts or below. In any plant, the density may vary from 0 in storage areas to 35 or more volt-amperes per square foot.

Lighting loads are not difficult to estimate. Known factors must be the area of the building and the illumination level desired. However, for more accurate estimates, the general types of construction must be known as well as mounting height and spacing and location of roof trestles and columns, to enable optimum arrangement to be checked against physical requirements.

For quick estimates of lighting with the most efficient fluorescent units, approximately 3 watts per square foot will provide 50 foot-candle illumination. If incandescents are used, the wattage will be approximately twice as much.

(3) New Department Or Plant Layout

These factors should be considered when creating a new department or plant layout.

With the emphasis on decentralized manufacturing areas, meters should be installed on each feeder to provide management with a record of each department's power cost.

Place equipment as close to the load as possible to reduce unnecessary losses in voltage drop. Use discretion in placing equipment too close to the load as environmental problems may occur.

Consider equipment and motor rooms where concentrated blocks of power are required. These rooms sometimes air conditioned, provide optimum environment, which often pay off in savings in equipment and maintenance cost.

(4) Planning a New System

When planning a new system, make a study to determine the advisability of purchasing electric power from the utility versus generating your own.

Advantages of using utility power are possible better voltage regulation, greater reliability of a larger system and absence of operation problems associated with power generation.

The trend today is to purchase power instead of generating your own, but this "buy or generate decision" depends largely upon local conditions. In some industries, where process steam is a requirement, gas or steam turbines may serve a twofold purpose, thus making in-plant generation more desirable.

If power is purchased, make a study to determine whether the outdoor parts of the main plant substation is to be owned by you or the utility. Economics including initial, operational and maintenance costs must be compared with local utility rates at different voltages to determine ownership of the outdoor substation.

(5) The Need for Reliable Power

Excluding economics, plant ownership of the substation has the advantage of you selecting the equipment and arrangement which best suits your needs. On the other hand, utility ownership may enable quicker restoration of power because they generally stock spare parts and equipment.

In your dealings with the utility, have them establish their range of voltage and frequency regulation, and their average outage rate. Have them define their interpretation of "outage," which is a non-technical term that has a different interpretation for almost every industry.

For a computer manufacturer, a 10% dip in voltage may cause and be defined as an outage, but for a factory without a critical load, a number of cycles or seconds is not disastrous. To a power company, an outage is a loss of power for longer than a minute. They also use the term "interruption," which is a loss of power for only a few cycles and is restored automatically with devices on the system. How long of an interruption can your plant tolerate?

You might have to provide an alternate power source for critical loads (high frequency welders, particle accelerators, computers). This power source could be a full capacity transmission line or a small capacity line at some lower voltage, standby generator, or some combination of these.

Allow for margin in substation capacity. At least 25% extra kva capacity over that needed for present operation is desirable in the initial substation installation. Circuit breakers should allow for anticipated increase in utility short circuit capacity, and overall consideration should be given to providing features in the substation to facilitate subsequent expansion.

(6) Selection of System Voltage

The selection of utilization, distribution and subtransmission levels is one of the most important considerations in power system design. System voltages usually affect the economics of equipment selection and plant expansion more than any other single factor.

Factors affecting system voltage section are:

Service voltages available from the utility.

The best distribution voltage to use within a plant may not be one of the service voltages available from the utility. If this is the case, the design engineer must determine the relative cost of using the available service for distribution or providing sufficient substation transformer capacity to obtain the desired distribution voltage.

Load magnitude. This is usually the determining factor for selecting distribution voltages when the plant is compact and where the load is concentrated in one area. The utilization equipment voltage rating and voltage limitations are almost the entire governing factor.

Distance power is to be carried. Distance does not usually affect selection of voltages in the 600 volt class, but it is important in the selection of distribution and subtransmission voltages. It is particularly important when sizable loads are located at quite a distance from the main plant.

Rating of utilization devices. Certain types of commonly used equipment, such as small fractional horsepower motors, hand tools, business machines etc., are generally available with 110 to 120 volt ratings. Therefore, in these cases, a 120-volt single-phase supply must be available. Three-phase motors are readily available from 208 to 13,200 volts. The most desirable voltage for a given motor from both the design and system cost standpoint varies with the horsepower rating.

(7) Safety Criteria

Safety is a major factor in selecting system voltage in the area of 120 volt, or below, where appliances and portable tools are used.

For example, where there is a possibility of contact with energized parts, such as in ungrounded frame portable tools, voltages on the order of 32 volts have been selected because it has been shown that voltages above 50 to ground can be lethal. This practice, in general, conforms to NEC. The grounding of all portable tools is recommended. On circuits above 120 volts, there seems to be little evidence that voltage selection from a safety standpoint is a major consideration.

Codes and standards. NEC places limitations on the voltage ratings of equipment and distribution circuits within buildings and should be consulted to assure conformance.

(8) Power Factor Considerations

Don't overlook power factor correction. Since the rate structures of many utility companies include power factor clauses which result in increased power cost when the power factor is below a specified level, consideration should be given to a power factor correction.

Benefits provided by power factor improvements are:

Lower purchased power cost.

Increased system capacity.

Voltage improvement.

Lower system losses.

Maximum benefits are obtained when capacitors or synchronous motors are located at the load where the low power factor exists.

(9) Guide to Good System Design

Define all load requirements.

Prepare a plant layout. Mark it with the major loads at various locations. From this determine total plant load requirements.

Establish a motor list.

Determine critical loads.

Understand process requirements.

Determine lighting, air conditioning and other load requirements.

Determine Applicable Codes and Standards:

NEMA, NEC, ANSI, local codes and OSHA Regulations.

System Design Considerations:

Reliability – Many manufacturing processes are on a production line basis. A line shutdown may hold up an entire plant, therefore, considerations should be given to:

Reliability of power supply from utility and/or local generation source.

Plant distribution system arrangement.

Reliability of equipment and installation.

Flexibility – For load growth and change: Plants change manufacturing processes from time to time. Where castings are used today, welding may be used tomorrow. The electrical distribution system should be flexible enough so that complete new process layouts can be made without requiring major changes in the distribution system.

Expansion – The system design should permit reasonable expansion with minimum investments and minimum downtime to existing production.

Safety – To personnel and equipment: Safety to personnel involves no compromise. Only the safest system can be considered. Safety to material may involve some compromise when safety to personnel is not jeopardized.

Review complete design:

Potential equipment overload.

Interrupting capability.

Critical loads.

Codes and standards.

(10) Maintenance Considerations

A one-line diagram is a very useful tool and should become part of plant maintenance records to assist technicians in troubleshooting the system and in uncovering other operational problems which might occur.

These diagrams should include:

Available short circuit currents of the source.

Size, type and number of incoming and outgoing cables.

Rating, reactances and connections of the transformers.

Circuit breaker continuous and interrupting ratings.

Motor ratings and type, horse power and whether squirrel cage, wound rotor or synchronous.

Size, type and setting of all protective devices, such as relays, circuit breakers and fuses.

An essential requirement for a good maintenance program is trained personnel. Craftsmen should have a thorough knowledge of the equipment or systems operation and have the ability to be able to make thorough inspections and necessary repairs.

General Contents

GENERAL CONTENTS – Continued

Chapter 1

The Maintenance Department

1.1 The Maintenance Department

Why does a plant or factory need a maintenance department?

The answer seems fairly obvious. This group, or department, is necessary to ensure availability of the machines and services needed by other parts of plant operations for performance of their functions; generally manufacturing or production of a specific product. The maintenance department must be considered an integral part of plant operations. It is responsible for the performance and the reliability of apparatus associated with all phases of a plant's manufacturing processes and end product.

A reasonable return on investment is expected by Management and, the cost of maintenance is steadily becoming a more significant factor in the total cost of manufacturing. Therefore, a maintenance department must be alert to the areas where their performance has direct bearing on managed costs. The dependency of a plant's operating departments on the maintenance group is intensifying. This is due mainly to the complexity of the equipment used in modern industry. It is important to remember that the maintenance department owes its existence to the fact that it is a necessary part of plant operations; it should also bring a return on investment. It can be considered efficient only when it is operating cooperatively as part of the Production team. It cannot be an independent group.

In actual practice, the size and activities of the maintenance department is influenced by many factors; plant size, type of product and the amount of equipment in the plant having frequent or regular maintenance requirements. Fundamentally, the responsibilities associated with the maintenance department can be briefly summarized.

> This department makes all repairs to machinery and related apparatus associated with production.
>
> It performs this function expeditiously and economically, anticipating maintenance requirements, including needed repairs.
>
> The basic objective is to avoid unexpected production outages due to equipment breakdowns. The usual cause is neglect or prolonged periods of operation without adequate maintenance.
>
> Department interest should be focused on preventive maintenance practices and the need for maximum utilization of the time important apparatus will be idle during normal shutdown periods. Frequently, this is the only time that equipment can be made available for repairs or servicing. The quality and thoroughness of any work performed at this time is very important. Nuisance interruptions and break-downs during normal production hours will be a continuing problem if incomplete or only routine maintenance is performed during plant shutdown periods.