Understanding Maintenance Contracts and Requirements for Low Voltage Power Distribution Equipment

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Summary

1.0 Abstract

Facility managers often complain that the final results of their desired maintenance contracts do not meet up with their intended expectations. This paper will provide a brief summary of common issues involving facilities managers and the selected electrical maintenance service contractor. It also includes a brief summary of items that should be incorporated into a maintenance check list, to help keep expectations in line with the desires of the intended maintenance contract.

This paper is not intended to provide guidelines and legal counseling toward the construction of any type of binding legal document.

2.0 Primary Purposes of an Effective Maintenance Program

2.1 Basic Maintenance and Testing

A comprehensive preventive maintenance and testing program should incorporate all electrical power distribution equipment, regardless of the manufacturer, to ensure that all electrical equipment and components operate safely and reliably as originally designed and intended. The ultimate goal is to minimize equipment malfunction, power outages, or interruptions to operations or service. All studies of electrical equipment maintenance programs show a strong correlation between maintenance levels and the reliability of electrical equipment and the power distribution system.

2.2 Policy Development

The development of a comprehensive preventive maintenance and testing program should incorporate detailed policies, procedures, and maintenance activities for a facility's entire electrical power distribution system.

2.3 Risk Assessment

A regular and systematic evaluation and analysis of the facility's electrical infrastructure will aid facility managers to identify risks and how such risks would potentially impact their operations.

2.4 Regulatory Compliance

A proactive and comprehensive preventive maintenance and testing program will assist a facility's management team to effectively document and meet the reporting requirements of applicable regulatory agencies such as State or Federal Regulatory Agencies, OSHA, NFPA, and other local authorities having jurisdiction.

3.0 Common Issues

Facility personnel are rarely knowledgeable or effectively trained in the specific electrical equipment or power distribution systems that make up the electrical infrastructure of their respective facility. Therefore, routine electrical equipment maintenance is commonly outsourced to outside maintenance contractors or local electrical contractors. Since most local electrical contractors' businesses focus on construction, there are a limited number of qualified local contractors who are experienced in the specific electrical maintenance needs of a facility. Following is a brief list of recommendations that facilities management might wish to consider prior to hiring an appropriate electrical maintenance contractor.

3.1 The electrical infrastructure of a facility typically consists of service entrance switchgear and switchboards, distribution panelboards, power panels, motor control centers, various sized circuit breakers, distribution transformers, fused disconnect switches, PDUs, UPS Units, battery banks, standby generators, paralleling switchgear and switchboards, and automatic transfer switches. Therefore, very few electrical maintenance or contracting companies can perform all of the required electrical maintenance necessary for each and every piece of electrical power and power distribution equipment within the facility. Although experienced third party electrical equipment service personnel, and specific National Electrical Testing Association (NETA) members can provide the general maintenance required on many pieces of electrical equipment, the best personnel to maintain power distribution equipment is often the original electrical equipment manufacturer, or the manufacturers' trained service agents or representatives.

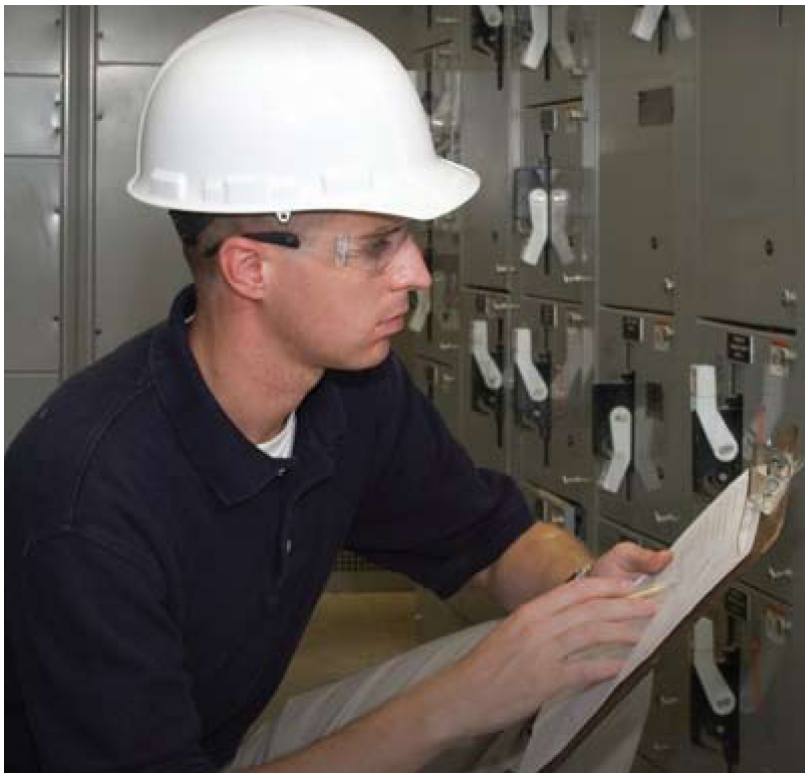
However, it is extremely important to note that any specific maintenance of separate pieces of electrical equipment does not guarantee a completely coordinated and reliable power distribution system as intended and necessary.

3.0 Common Issues (con't.)

3.2 A common deficiency in most facilities is the lack of current and up-to-date one-line diagrams. This type of diagram provides clear and precise information concerning the exact interconnections of all electrical equipment that make up the entire power distribution system of a facility's electrical infrastructure. Unfortunately, there are often additions, changes, or modifications made to a facility's electrical infrastructure and no revised electrical records are created after the fact. The services of a licensed professional electrical engineer should be contracted and commissioned to create and maintain current electrical one-line diagrams and equipment name plate data. The records should also indicate the specific location, room number, floor, or area location where each piece of electrical power distribution equipment can be found.

Such records will be very valuable to the facility's management, operations, and safety staff members, and any selected electrical maintenance service contractor. Therefore, before any maintenance program is initiated or contracted, it is strongly recommended that facility management insures that exact, detailed, and up-to-date one-line diagrams of the entire electrical power distribution system exist and are readily available.

3.3 Obtain and maintain all of the operations and maintenance manuals that accompanied the original electrical equipment. If such manuals have been discarded, misplaced or lost, then contact the original equipment manufacturer or their representative and request replacement copies of the applicable documents. Often such documents are available online via the internet on the worldwide web (www). Search by the manufacturer's name and electrical equipment identification.



3.0 Common Issues (con't.)

3.4 Before any maintenance program is initiated or contracted, it is strongly recommended that the facility's management contract and commission the services of a licensed professional electrical engineer to perform short circuit analyses, a time/current coordination study, and an arc flash analysis of all of the power distribution systems. These studies will insure that the existing electrical equipment is properly rated, set, and labeled. The selected licensed professional electrical engineer can assist facility management in identifying equipment that requires special care, specific maintenance, or replacement due to underrated or over-dutied issues. The selected licensed professional electrical engineer can also assist the facility's management in identifying safety concerns, deficiencies in the power distribution system, or circuit protection issues that might need to be addressed prior to any maintenance being performed.

There is wasted value in spending limited maintenance budget and resources to clean and/or service equipment that is later determined by a licensed professional electrical engineer as needing to be replaced or removed from service.

3.5 Qualify any proposed electrical equipment maintenance and service contractor prior to initiating any contract. Facility management needs to insure that the electrical equipment maintenance and service contractor is experienced in the specific electrical equipment or power system to be maintained. As noted previously, there are very few electrical service companies that have the experience and available staff to service all of the electrical power equipment within a facility. It is necessary to perform a thorough interview and obtain applicable qualifications and references for all potential electrical maintenance contractors. A licensed professional electrical engineer can assist facility management in the selection process for an electrical maintenance contractor.

3.6 Clear, exact and specific communications with the selected electrical equipment maintenance and service contractor is extremely important, and is a paramount portion of any preventive maintenance process. The facility's management needs to be very clear as to exactly which equipment they desire to have cleaned, inspected, maintained, serviced and tested, as well the specific order that each piece of electrical equipment is to be removed from service for inspections, maintenance or testing.

3.0 Common Issues (con't.)

The facility's management also needs to be very clear as to exactly what services they wish to have performed and by whom. Recommendations as to the specific cleaning, inspections, maintenance, servicing, and testing on specific electrical equipment or components can be obtained from the original operations and maintenance manuals from the original equipment manufacturer, NETA documents, the solicited preventive maintenance service contractor, or the advice and counsel of an experienced and trained testing engineer or licensed professional electrical engineer.

Most importantly, the facility's management needs to be aware that, with few exceptions, electrical equipment should NOT be cleaned, inspected, maintained, serviced, or tested while it is energized. Performing the necessary maintenance services on energized equipment is not only often impossible, but exposes personnel to the risk of shock, burns, or death, and also risks damaging the equipment beyond repair. Although, some operational down time is required to safely and successfully clean, inspect, maintain, service, and test electrical equipment, the risk of long term outages from working on equipment that is powered down pales in comparison to the risks to personnel or operations associated with working on energized equipment.

3.7 Facility's management should insure that the facility's needs for temporary electrical power are met during the scheduled interruption of normal electrical service. This might take the form of the use of the onsite optional stand-by generators. However, the automatic and manual transfer switches and all of the electrical distribution equipment and systems downstream of the emergency transfer switches are usually the weakest link as they are the last to ever be maintained or serviced. Therefore, at some point in the history of the facility's operations, the transfer switches and all of the associated downstream load equipment will require maintenance and service and facility's management will need to prepare for a total or partial power outage.

3.8 Bonding and grounding systems are the base foundation of all power distribution systems and are the most neglected part of any electrical power distribution system, or other utilities infrastructure. Phase-to-ground faults make up between 95 to 98 percent of all electrical faults. During any phase-to-ground fault, the bonding and grounding systems of a facility consist of 50 percent of the power distribution system during the time of the fault. If there is too much impedance in the ground fault return path from the point of the faulted circuit to the X_0 of the supplying transformer, then thermal-magnetic circuit breaker or fuses might not effectively sense a high impedance phase-to-ground fault.

3.0 Common Issues (con't.)

Therefore, by neglecting the maintenance of the bonding and grounding systems, a facility is ignoring 50 percent of its power distribution system. Most of the bonding and grounding systems of a facility can be safely and successfully inspected, maintained, serviced, and tested while the equipment is energized. However, any selected electrical equipment maintenance and service contractor must be qualified and trained to perform such work.

3.9 Hundreds of millions of dollars in sensitive electronic equipment is damaged or destroyed annually in the United Sates due to lightning strikes or surge events. Any preventive maintenance program should incorporate the inspections, assessments, or testing of any existing lightning abatement systems or surge protection systems. However, any selected electrical equipment maintenance and service contractor must be qualified and trained to perform such work.

3.10 Electrical services, and some feeder circuits, with voltage over 150V to ground and rated over 1000A require phase-to-ground fault protection. Where required, such require ground fault protection is located on the main overcurrent protective device. (Per NEC® 517.17 healthcare facilities require a minimum of two levels of ground fault protection.) NEC® 230.95C mandated and requires that the ground fault protection "system" be tested when first installed onsite. All ground fault protection systems should be tested on a regularly scheduled basis to insure effective and proper operation. In addition, all ground fault protection systems should be test via a high current, primary injection test method

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4.0 Recommended Items or Equipment to Incorporate into a Preventive Maintenance Program

Since commercial and institutional facilities primarily use low-voltage electrical equipment, references to medium-voltage equipment will be excluded from this specific paper. This section will focus only on low-voltage power distribution equipment.

4.1 Monitor Equipment, Metering Equipment and Protective Relays

Monitor equipment, metering equipment, and protective relays utilize inputs from current transformers and potential transformers. The operational characteristics of these transformers require periodic inspections and testing. The settings of all monitors, meters, and protective relays need to be inspected, tested, and calibrated on a routine basis. Any shunt trip circuit, alarm circuit, electro-mechanical circuit, or electronic relaying circuit needs to be inspected and tested as necessary.

4.2 Service Entrance Low-Voltage Switchgear

Any American National Standards Institute (ANSI) rated low-voltage switchgear distributes electrical power and contains power circuit breakers with overcurrent protection. Such switchgear is built to the requirements of ANSI Standard C37.20.1. This type of equipment should be cleaned, inspected, tightened, lubricated, and exercised on a regular basis. One manufacturer, for example, recommends inspections take place annually. However, under ideal environmental conditions, maintenance might only be required every two to five years. The frequency of maintenance depends on the operating conditions. Moisture and heat combined with dirt, dust, or other contaminates in the environment will deteriorate the insulation, conductive materials, and protective devices in the equipment at a highly accelerated rate.

Some facilities might choose UL 891 rated low-voltage switchboards as their selected service entrance equipment. The maintenance requirements for a switchboard are the same for switchgear.

4.3 Low-Voltage Circuit Breakers

There are essentially two classes of low-voltage circuit breakers that can be applied in a power system: Power circuit breakers (ANSI C37.13) or molded and insulated case circuit breakers (UL 489). Power breakers are used in draw-out switchgear while molded and insulated case circuit breakers are used in switchboards, panelboards, and other applications.

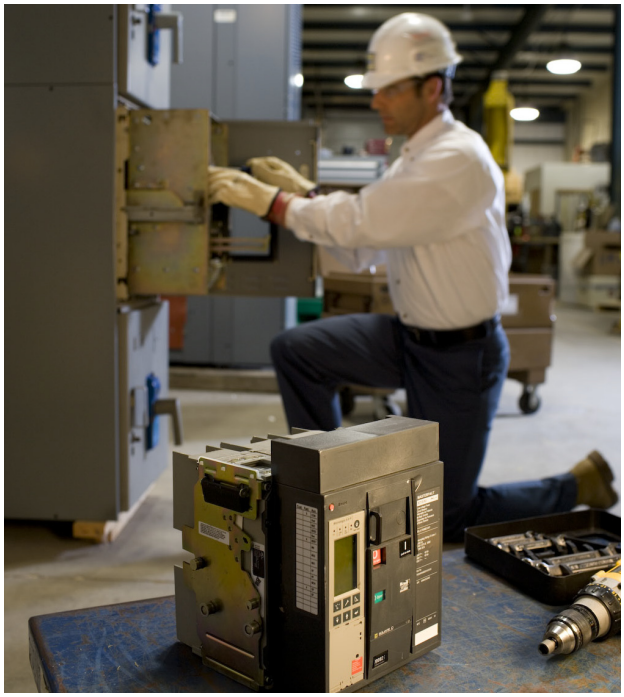
4.0 Recommended Items or Equipment to Incorporate into a Preventive Maintenance Program (con't.)

Low-voltage power breakers should be completely withdrawn from their cubicles before being maintained. The primary drawout contact clusters should be checked for signs of wear or damage. Insulation should be checked using dielectric, hi-potential or insulation resistance testing, and circuit breaker contact resistances should be measured with a digital micro-ohmmeter.

Many higher ampacity low-voltage breakers contain an integral trip unit. There are usually two ways to test the integral trip unit. There is the primary injection test method and the secondary injection test method. Primary injection is recommended since it tests the complete system, including the current sensors and interconnecting wiring. The secondary injection only tests the trip unit itself. It is important to note that primary injection requires a large test set that will need a reliable input power supply. The larger primary injection test units often require a single-phase, 480V, 100A input power supply for operation. Planning for this steady state power supply is necessary prior to any shut-down.

Insulated case circuit breakers can sometimes be maintained similarly to power circuit breakers. However, in many cases, their maintenance needs are more equivalent to a molded case breaker. Manufacturer's literature should be consulted for recommended practices.

Molded case circuit breakers require a minimal amount of maintenance. In fact, opening the case will void the manufacturer's warranty. Maintenance is limited to inspection in good operating conditions, and in some cases primary injection, dielectric testing, and contact-resistance testing. Testing should be performed with the circuit breaker removed from the enclosure. They should be manually operated annually. In addition, the "push-to-trip" button should be utilized to exercise the tripping mechanism.



4.0 Recommended Items or Equipment to Incorporate into a Preventive Maintenance Program (con't.)

4.4 Switchboards and Panelboards

Switchboards and panelboards are built per UL Standards. They are for low-voltage applications and contain either molded-case circuit breakers or fusible switches. Both are typically found downstream of the switchgear.

Maintenance is mostly limited to insuring good electrical and mechanical connections plus good housekeeping. Regular infrared scanning and cleaning is recommended to insure dependable operation.

4.5 Low-Voltage Motor Control Centers (MCCs)

Low-voltage motor control centers (MCCs) are manufactured to the requirements of UL 845. These are designed to contain starters for motors, located within buckets, or control units, located in the vertical sections of the enclosure. The buckets can also contain drives, simply molded case circuit breakers, fusible switches or contactors.

Maintenance on the enclosure and the interior bus bars of MCCs is very similar to switchgear and switchboards, aside from the additional maintenance needed for the drawout type buckets or vertical section enclosures. The buckets should be removed from the MCC before maintenance. Once removed, the primary contact stabs should be examined for signs of arcing or overheating. If a stab is badly pitted, it may be necessary to replace the vertical bus within the MCC. Within the bucket, any circuit breakers, switches, starters, control devices, and wiring should be examined. As always, refer to the specific manufacturers' operations and maintenance manuals for additional needs of specific MCCs.

4.6 Low-Voltage Transformers

NEMA low-voltage dry-type transformers are typically used for lighting and receptacle applications within commercial and institutional facilities. The frequency of inspection is based upon the operating conditions. Clean and dry conditions require less maintenance, while dusty, hot environments will require more frequent inspections. During maintenance, connections should be checked for looseness. In addition, any dust that restricts air flow or lies on insulating surfaces should be removed via vacuuming. Never blow forced air into electrical equipment as this can only drive and lodge possible contaminates deeper within the equipment. A visual inspection should also take place for overheating, tracking, and overall enclosure condition.

4.0 Recommended Items or Equipment to Incorporate into a Preventive Maintenance Program (con't.)

4.7 Automatic Transfer Switches (ATS)

ATS switch their downstream loads between separate power sources in the event of a specific source failure. There are basically two types of ATS: standard and bypass-isolation. Either can be open- or closed- transition. Bypass-isolation ATSs allow the switch to be racked out for inspection, testing, and maintenance without any interruption of power to the load.

The controller/switch combination should be checked on a regular basis for pitting, looseness, and excessive wear. One manufacturer recommends testing this equipment on a monthly basis. Any test conducted should verify the proper electrical operation of the controller and switch per the manufacturer's specifications.

One manufacturer recommends annual maintenance of the switch itself. The maintenance should include general cleaning of the enclosure along with the lubrication, inspection and testing of the contacts. All cables, lugs and cable connections should be thoroughly cleaned, inspected and properly tightened.

4.8 Uninterruptible Power Supply (UPS) Systems

UPS Systems provide the final safety net for a power system while providing clean, uninterrupted power to critical loads. They also can remove the momentary power interruption during open transition switching between utility and generator sources.

There are two basic types of UPS Systems, static (or battery) and rotary (or flywheel). Both systems have advantages, however, a detailed description is outside of the scope of this paper. Regardless of the UPS type, regular preventive maintenance is essential to ensure the system is operational and performs as designed and intended in the event of an emergency situation or loss of normal electrical power.

Due to the unique and technical nature of a UPS system, most manufacturers recommend that their own factory-trained and certified service personnel perform any major maintenance and system tests. In addition, since a UPS is designed and applied to provide constant power to specific or sensitive loads, extreme caution should be used when interrupting electrical power. As a result of the need to maintain power, the system should be designed so that switching can occur to allow the UPS (or each module of a multi-module UPS) to be isolated while maintaining power to critical loads.

4.0 Recommended Items or Equipment to Incorporate into a Preventive Maintenance Program (con't.)

Safety becomes a critical factor when you consider the magnitude of available short circuit current. Serious injury or death can result from unqualified personnel working in or around energized electrical equipment, which furthers the need for qualified and trained personnel.

Some less-complex routine maintenance may also be necessary for UPS units. It is important to keep the room UPS units are housed in clean and cool, air filters should be replaced regularly and the battery system should be inspected on a regular basis to identify weak or damaged cells. Also, depending on the UPS size and manufacturer, it is possible individual components of the system (static switches, molded case circuit breakers, etc.) need to also be maintained, as detailed in other parts of this paper.

4.9 Busway

While not every facility has busway, it is becoming more common in facilities with high ampacity loads. Busway is designed to be low-maintenance equipment. However, a regular visual inspection and IR scan are recommended to look for exterior damage and loose connections. An inspection should be conducted if a short-circuit or ground fault has taken place downstream of the busway.

Connections should be torqued and insulation resistance should be tested on a regular basis. In addition to the busway itself, plug-in busway will have "plugs" that contain either fusible switches or molded case circuit breakers. These switches and breakers should also be inspected and maintained as recommended above.

4.10 Optional Stand-By Generators and Associated Parallel Equipment

The necessary routine inspections, maintenance, and testing of permanently fixed or portable stand-by generators should only be performed by factory trained or experienced personnel. The authority to perform the care and routine maintenance requirements of such important and value equipment should never be given to amateurs or the poorly trained.

Associated paralleling equipment usually consists of switchgear or switchboards containing high ampacity circuit breakers and automated control systems. The necessary maintenance requirements of this type of equipment are the same as those described above in paragraphs 4.1, 4.2, and 4.3.

5.0 References

National Fire Protection Association (NFPA) 70B, Recommended Practice for Electrical Equipment Maintenance.

National Fire Protection Association (NFPA) 70, National Electrical Code.

National Electrical Manufacturer's Association (NEMA) Standard AB4, Procedures for Verifying Field Inspections and Performance Verification of Molded-Case Circuit Breakers.

National Electrical Testing Association (NETA), Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems.

IEEE Standard 902-1998, IEEE Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems

IEEE Standard 142-2007, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

National Electrical Manufacturer's Association (NEMA) Standard MG1.

IEEE Standard 1415, IEEE Guide to Introduction Machinery Maintenance Testing and Failure Analysis

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