Electrical Preventive Maintenance (PM) Guidelines and Requirements

Generally speaking, Preventive Maintenance of equipment has been a longtime Best Practice, and specific to electrical gear - is now moving into the realm of regulatory requirement. Interestingly – many Plant Engineers, Facilities Techs and other maintenance staffers who would not dream of ignoring PM on chillers, air conditioners, or other equipment – have not included electrical gear in their PM programs. That being said, we all know the disruption and/or damage that can occur when electrical gear fails.

Each piece of electrical equipment has its own specific maintenance requirements and schedule.

The following is a list of electrical equipment typically covered by electrical preventative maintenance program

- Air Circuit Breakers
- Air Disconnect Switches
- Battery Stations and Chargers
- Cables and Bus
- Molded-Case Circuit Breakers
- Motors
- Oil Circuit Breakers
- Protective Relays
- Surge Arrestors
- Switchgears
- Transformers
- Uninterruptable Power Supplies
- Vacuum Circuit Breakers

The Regulations

The Occupational Safety and Health Administration (OSHA) is a federal agency that operates under the U.S. Department of Labor. The mission of OSHA is: "to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance." (Source: OSHA.gov)

To address those hazards related to electrical safety, OSHA relies upon the consensus standards established by NFPA in its 70E Standard for Electrical Safety in the Workplace. OSHA refers to these standards when developing regulations for the CFR (Code of Federal Regulations) pertaining to federal labor laws. For example, OSHA requires that employees be trained to recognize and protect themselves from specific electrical hazards. So while the NFPA 70E standard itself is not law, it establishes the safety guidelines which enable employers to comply with OSHA laws dealing with electrical workplace safety and required employee electrical safety training.

NFPA 70E contains requirements that mandate the user of the standard consider the maintenance of electrical equipment. NFPA 70E defines the condition of maintenance as the state of the electrical equipment considering the manufacturers' instructions and recommendations, as well as applicable industry codes, standards and recommended practices. NFPA 70E contains requirements for employers with respect to maintenance when performing a shock or arc flash risk assessment. These are safety-driven requirements, not best practices designed to enhance system reliability. (Electrical Contractor Magazine, Dollard, Jim. 2020)

Finally, it is important to note that NFPA 70E 205.3 states, "The equipment **owner or the owner's designated representative shall be responsible** for maintenance of the electrical equipment and documentation."

From A Practical Point of View

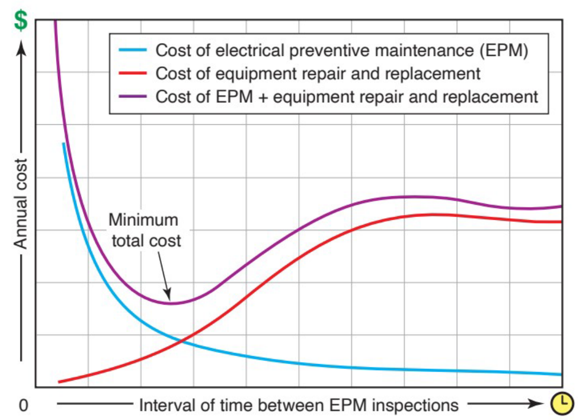
Depending on your source, the following are some cost benefits to an effective PM program:

- Return on investment: up to 3 times
- Reduction in maintenance costs: up to 30%
- Elimination of breakdowns: up to 75%
- Reduction in downtime: up to 45%
- Increase in production: up to 25%

Repairs completed during PM are much cheaper than unscheduled and/or break down repairs. The true cost of a machine breakdown has been estimated as between four to 15 times the (preventive) maintenance costs.

The Value of an Effective EPM Program

An EPM program can help identify impending issues and apply solutions well before they become major problems requiring more expensive, time-consuming solutions. To be effective, the program needs the support of top management, given that the maintenance of industrial electrical equipment is essentially a matter of business economics. Maintenance costs can be placed in either of two basic categories: preventive maintenance or breakdown repairs. The money spent on 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.



As the interval of time between EPM inspections increases, the cost of the EPM diminishes and, in turn, the cost of breakdown repairs and replacement of failed equipment increases. By maintaining an inspection frequency that keeps the sum of the repair/replacement and EPM costs at a minimum, the lowest total annual expense can be achieved.

The How

First and foremost, PM guidelines for equipment should always come from the manufacturer. That said, like most industries, several bodies have developed maintenance standards and processes.

The primary bodies that the industry refers to for standards and procedures are NETA, ANSI and IEEE. NETA is the (Inter)National Electrical testing Association, ANSI is the American National Standards Institute, and IEEE is the Institute of Electrical and Electronics Engineers.

IEEE Test Suite Specifications (TSS) provide comprehensive, dependable plans to evaluate standards based compliance. The TSS plans may contain requirements for design, performance, test equipment, measurements, and other specifications that can be used in testing products for eventual certification.

IEEE recommends the actual maintenance and testing methodology as an example, here is the information for Dry Transformers:

<u>3.9.1 Dry type transformers</u>

After de-energizing and grounding the transformer, clean all coils, connections, and insulators of loose dust or dirt deposits with a vacuum cleaner. Examine the transformer for signs of overheating, deterioration, arcing, loose or broken parts, or other abnormal conditions. Ensure all connections are tightened according to manufacturer's specifications. Clean enclosure of any dust and dirt accumulations and ensure that vent openings are free from obstruction. If cooling fans are installed, examine for proper operations and lubricate as necessary.

Additional suggested testing includes an insulation resistance test, a dielectric absorption test, and a power factor test. These are nondestructive tests which can be performed to track the condition of the insulation over time. Detailed records should be maintained and analyzed to identify undesirable trends that may indicate the onset of an insulation failure.

ANSI/NETA ATS
Acceptance tests are not manufacturers factory tests. They comprise those tests necessary to determine that the electrical equipment has been selected in accordance with the engineer's requirements, installed in accordance with applicable codes and installation standards, and perform in accordance with their design and setting parameters. The ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems assists designers, specifiers, architects, and users of electrical equipment and systems in specifying required tests on newly-installed power systems and apparatus, before energizing, to ensure that the installation and equipment comply with specifications and intended use as well as with regulatory and safety requirements.

ANSI/NETA MTS
Maintenance tests are those tests that allow the determination of whether or not the electrical equipment is suitable for safe and continued service.

When dealing with service-aged equipment, many criteria are used in determining what equipment is to be tested, at what intervals, and to what extent. Ambient conditions, availability of down time, and maintenance budgets are but a few of the considerations that go into the planning of a maintenance schedule. The owner must make many decisions each time maintenance is considered. It is the intent of the ANSI/NETA Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems to list a majority of the field tests available for assessing the suitability for continued service and reliability of the power distribution system.

ANSI/NETA ETT
The Standard for Electrical Test Technicians was developed to ensure that those individuals performing electrical tests are competent not only to perform the tests but are also able to evaluate the results and make a competent judgment on the condition of the electrical equipment. The Standard sets four levels of expertise from entry level to Senior Technician in describing a career path for those individuals desiring employment in this field. It establishes knowledge and skill requirements for each level and the testing requirements necessary to attain each certification.

As an example, here is a sample of recommended testing frequencies:

Factorial table for criticality or severity of service;

APPENDIX B

Frequency of Maintenance Tests

NETA recognizes that the ideal maintenance program is reliability-based, unique to each plant and to each piece of equipment. In the absence of this information and in response to requests for a maintenance timetable, NETA's Standards Review Council presents the following time-based maintenance schedule and matrix.

One should contact a NETA Accredited Testing Company for a reliability-based evaluation.

The following matrix is to be used in conjunction with Appendix B, Inspections and Tests. Application of the matrix is recognized as a guide only.

Specific condition, criticality, and reliability must be determined to correctly apply the matrix. Application of the matrix, along with the culmination of historical testing data and trending, should provide a quality electrical preventive maintenance program**.**

MAINTENANCE FREQUENCY MATRIX				
		EQUIPMENT CONDITION		
		POOR	**AVERAGE**	**GOOD**
EQUIPMENT RELIABILITY REQUIREMENT	**LOW**	1.0	2.0	2.5
	MEDIUM	0.50	1.0	1.5
	HIGH	0.25	0.50	0.75

APPENDIX B

Frequency of Maintenance Tests (*continued*)

Inspections and Tests Frequency in Months (Multiply These Values by the Factor in the Maintenance Frequency Matrix)				
Section	**Description**	**Visual**	**Visual & Mechanical**	**Visual & Mechanical & Electrical**
7.1	Switchgear & Switchboard Assemblies	12	12	24
7.2	Transformers			
7.2.1.1	Small Dry-Type Transformers	2	12	36
7.2.1.2	Large Dry-Type Transformers	1	12	24
7.2.2	Liquid-Filled Transformers	1	12	24
	Sampling	–	–	12
7.3	Cables			
7.3.1	Low-Voltage, Low-Energy	–	–	–
7.3.2	Low-Voltage, 600 Volt Maximum	2	12	36
7.3.3	Medium- and High-Voltage	2	12	36
7.4	Metal-Enclosed Busways	2	12	24
	Infrared Only	–	–	12
7.5	Switches			
7.5.1.1	Air, Low-Voltage	2	12	36
7.5.1.2	Air, Medium-Voltage, Metal-Enclosed	–	12	24
7.5.1.3	Air, Medium- and High-Voltage Open	1	12	24
7.5.2	Oil, Medium-Voltage	1	12	24
7.5.3	Vacuum, Medium-Voltage	1	12	24

Summary

Much like changing the oil in our cars, Preventive Maintenance on our electrical gear is a best practice that reduces repair costs, increases uptime, and extends the life of your equipment. As if that wasn't enough of a motivation, regulatory requirements (via NFPA 70E) now require a maintenance program, and an Arc Flash Hazard Analysis relies on knowing that the devices will operate as intended, in the event of a fault or overload. Finally, a comprehensive PM program reduces the risk of injury or even death, along with the associated liability. Liability that is more and more being pushed to not just owners, but owners' representatives, staff members, sub-contractors and even inspectors.

Acceptance and maintenance testing, along with preventive maintenance activities are not mythical black arts. They are specific testing protocols at prescribed frequencies, carried out by qualified personnel. These protocols and practices are developed by professional bodies, based on decades of testing and data, focused on reliability and safety.

Additional Information

C3 Engineering – Testing Services

NFPA 70B Fact Sheet

NFPA 70E Fact Sheet

JLL Whitepaper – Value of PM

OSHA - Relevance of NFPA 70E industry consensus standard to OSHA requirements

IEEE

NETA