

Planned Maintenance as a Safety Requirement

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Introduction

Planned maintenance is no longer an elective that companies once did, didn't do, or did poorly depending upon how critical their process and what they were willing to spend. It has become a safety issue and a safety requirement mandated by OSHA. A thermographic survey as part of a PM program today is not only to analyze systems, identify potential failures and serve to prevent failures before they happen, but also to help prevent failures that can cause injury to personnel. An integral part of a successful PM program must now include improving the safety environment for personnel.

NFPA Electrical Standards

These three standards work together to create electrical safety in the workplace:

- **NFPA 70 National Electrical Code:** correct, code-compliant installation promotes safety.
- **NFPA 70B Standard for Electrical Maintenance:** Properly maintained equipment is essential to ensuring safe and reliable operation.
- **NFPA 70E Standard for Electrical Safety in the Workplace:** an Electrical Safety Program (ESP) and procedures are necessary to identify hazards, assess risks and prevent injury to personnel. The ESP must also consider the condition of maintenance.

NFPA 70B Becomes a Standard

“The NFPA 70B was first issued in 1973 as a recommended practice. On December 27, 2022, it was issued as the 2023 edition of NFPA 70B as the Standard for Electrical Equipment Maintenance. It was approved as an American National Standard by the American National Standards Institute (ANSI) with an effective date of January 16, 2023. The NFPA 70B is now both utilized and enforced to ensure that proper conditions of maintenance have been established to further accomplish safety in the workplace.”¹

NFPA 70, 70B & 70E Consensus Standards

OSHA regulations are legal requirements that are subject to government enforcement. Many of the OSHA regulations came into existence from consensus standards. The consensus standards are the nuts and bolts of OSHA regulations. They provide detailed rules, guidelines, and requirements for regulations. So, what does this mean? OSHA relies on consensus standards as a basis for enforcing their regulations. Now that the NFPA 70B is a standard, OSHA can rely on it in enforcing equipment maintenance as it relates to safety. A Planned Maintenance (PM) program must now comply with the NFPA 70B.

“Consensus standards are not law; but even so, OSHA can cite an employer for not complying with standards. The standards can be enforced by OSHA’s “incorporation by reference” or by the OSHA General Duty Clause. The employer is not required to adhere to any consensus standards, but this won’t stop OSHA from citing them for lack of compliance.”²

OSHA’s General Duty Clause (Section 5a1 of the OSH Act) states that “each employer shall furnish to each of his employees’ employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.” What this boils down to is a lack of proper maintenance found to be the cause of injury or death will result in enforcement action by OSHA.

Relationship Between the NFPA 70E and NFPA 70B

NFPA 70E Purpose: To provide a practical safe working area for employees relative to the hazards arising from the use of electricity.

NFPA 70B Purpose: To provide for practical safeguarding of persons, property, and processes from the risks associated with failure, breakdown, or malfunction and a means to establish a condition of maintenance of electrical equipment and systems for safety and reliability.

The equipment owner is required by the 70B to implement and document an overall Electrical Maintenance Program (EMP) that directs activity appropriate to the safety and operational risks. It must further be designed to function in conjunction with the applicable electrical safety program. The EMP must also include an electrical safety program that addresses the condition of maintenance. The 70E is used as the resource for the electrical safety program.

The Electrical Safety Program (ESP) is a documented system consisting of electrical safety principles, policies, procedures, and processes that direct activities appropriate for the risk associated with electrical hazards. The employer is required by the 70E to implement and document an overall ESP that directs activity appropriate to the risk associated with electrical hazards. The ESP must also include elements that consider condition of maintenance of electrical equipment and systems. It follows that the 70B is a reference for this as well.

Normal operation of equipment is permitted when a normal operating condition exists. Among the requirements to achieve this condition, the equipment must be properly maintained.

“Properly maintained” means the equipment is maintained according to manufacturer’s recommendations and applicable industry codes and standards. The primary applicable standard is now the 70B.

Impact of Maintenance on Safety

The objective of proper maintenance is to enable normal operation. Normal operation is no likelihood of an occurrence of an equipment failure resulting in an arc flash event. Among the requirements for normal operation of equipment includes properly installed, properly maintained and has no signs of impending failure. Thermography is the most effective, non-contact tool for identifying signs of impending failure.

Shock Hazard vs. Arc Flash Hazard

A shock hazard requires exposure and contact or close proximity to an energized circuit. The magnitude of the hazard is consistent. That is the nominal voltage of a given circuit is about the same regardless of the type of equipment or conditions. It requires minimal PPE; quite often only rubber electrical insulating gloves. It is less influenced by poor maintenance.

An arc flash hazard does not require exposure, but by definition requires interaction with the equipment. It requires substantial PPE protecting the entire body. It does not require direct contact or even close proximity to cause injury. Many conditions influence magnitude that can vary greatly and requires calculation on a case-by-case basis. The cause and magnitude of an arc flash event are significantly influenced by the absence of or improperly performed maintenance.

Where Does Thermography Fit In?

Thermography detects heating problems in electrical equipment which begs the following questions:

- **Where does the heat come from?**
 - Resistance (impedance) is the culprit! It is the opposition to the flow of current. Poor connections result in higher resistance that increases current, and the higher current produces heat. As temperature increases, resistance also increases and as resistance increases so does the current creating more heat – a vicious circle. It continues to increase over time and will never improve on its own, often resulting in a catastrophic failure.
- **Why is heat a problem?**
 - Heat decreases insulation resistance, anneals and weakens metal, and cooks lubrication leading to sluggish or faulty operation. It can cause premature (nuisance) trips of overcurrent devices, acting directly on thermal overloads and indirectly on electronic overloads through increased current. Nuisance trips aren’t directly responsible for safety issues but can cause failures in critical systems that can create safety hazards. Heat also causes failures of electrical switches, fuses, circuit breakers, motor starters and more.

- Heat can severely damage insulation leading to phase-to-phase faults, ground faults, electrical equipment failures and arc flash events!

Poor Maintenance and Arc Flash Energy

The clearing time of a circuit breaker is the speed at which it operates to interrupt current flow. How long it takes to clear a fault is used in calculating the intensity of the arc flash event in calories. Arc flash intensity is directly proportional to operating speed (clearing time).

An example of an arc flash calculation for a properly maintained circuit breaker:

- The breaker opens in 60 milliseconds.
- It is calculated that the arc flash intensity will be 25 calories/cm²
- An arc flash suit rated at 40 calories is specified on the arc flash label and is sufficient protection if an arc flash event occurs.

The same circuit breaker poorly maintained:

- Breaker instead opens in 120 milliseconds (double its specified clearing time)
- Arc flash intensity is directly proportional to time and doubles to 50 calories/cm²
- The specified arc flash suit rated at 40 calories/cm² is now inadequate protection.

The following is an example of a circuit breaker failure resulting from not a lack of maintenance, but instead improper maintenance. This resulted in an arc flash event when the breaker failed as it was being racked onto an energized bus.



NFPA 70B: Fundamental Tests

The fundamental test procedures contained in Chapter 7 are used where required elsewhere in the 70B standard. The following is used wherever infrared thermography is specified.

Section 7.4 Infrared Thermography

- **7.4.1** Used to verify temperature differences (ΔT) of the following:
 - (1) Similar electrical components under similar loading
 - (2) Comparison between electrical components & ambient air temperatures
- **7.4.2** Remove covers for IR inspection to provide clear line of sight to equipment being scanned.
- **7.4.3** Document temperature differences between area of concern and reference area
- **7.4.4** Performed IR inspections at normal circuit loading.
- **7.4.5** If normal circuit loading is not feasible, loading at minimum 40 percent of normal is permitted.
- **7.4.6** Document circuit loading characteristics.

Testing Categories

8.3 Testing Category Types

- **Category 1** Online standard test: includes testing procedures performed while electrical equipment or device is connected to a source of power (i.e., energized)
- **Category 1A** Online enhanced test
- **Category 2** Offline standard test
- **Category 2A** Offline enhanced test

Thermography is always listed as a Category 1 test.

Basic Thermography Requirements

- Testing personnel must be qualified to operate the test equipment, qualified to perform the required tests, and qualified to perform them on the specific equipment to be tested.
- Test equipment that provides measurements must be calibrated, calibration information readily available, and calibration intervals appropriate to ensure accuracy.
- Create a test record for all field tests of electrical equipment that must contain a minimum of the following:
 1. Identification of the testing person and organization
 2. Identification of the equipment under test
 3. Nameplate or label data of the equipment under test
 4. Environmental conditions, such as humidity and temperature, that could affect results of the tests or calibrations.
 5. Date of the test
 6. Indication of the test performed.
 7. Indication of pass/fail criteria, where applicable

8. Indication of as-found and as-left results, where applicable
9. Test operator's comments or recommendations, where applicable

Equipment Condition Assessment

- **Equipment Physical Condition 1:** appears in like new condition and previous maintenance performed per EMP
- **Equipment Physical Condition 2:** where all criteria of Condition 1 apply and maintenance results deviate from last results or previous maintenance cycle required repair or parts replacement
- **Equipment Physical Condition 3:** equipment has missed the last two successive maintenance cycles or previous two maintenance cycles revealed issues *These are very brief descriptions. Refer to sections 9.3.1.1 through 9.3.1.3 for more details.*

Maintenance Intervals

- Infrared thermography: For all equipment it applies to, performed annually or semi-annually

Frequency of maintenance for common electrical equipment		Equipment condition assessment		
Product	Scope of work	Condition 1	Condition 2	Condition 3
All equipment	Infrared thermography	12 months	12 months	6 months
Busways	Visual inspection	60 months	60 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
	Electrical testing	60 months	36 months	12 months
Fuses	Special	60 months	36 months	12 months
	Visual inspection	60 months	36 months	12 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	36 months	12 months
	Mechanical servicing	60 months	36 months	12 months
Low-voltage ground-fault protection systems	Electrical testing	60 months	36 months	12 months
	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	Reserved	12 months
	Mechanical servicing	60 months	36 months	12 months
Medium-voltage ground-fault protection systems	Electrical testing	60 months	36 months	12 months
	Visual inspection	12 months	12 months	6 months
	Cleaning	60 months	36 months	12 months
	Lubrication	60 months	Reserved	12 months
	Mechanical servicing	60 months	36 months	12 months
Medium-voltage power circuit breakers	Electrical testing	60 months	36 months	12 months
	Visual inspection	60 months	36 months	12 months

Thermography – Where Specified? Tables specifying infrared thermography and test number(s):

- **Table 15.3.5** MCCB, ICCB, LVPCB (Circuit Breaker) Electrical Tests (1)
- **Table 16.3.5** Fuse Electrical Tests (1)
- **Table 17.3.5** Switch Electrical Tests (1)

- **Table 18.3.5** Power Cable and Conductor Electrical Tests (4)
- **Table 25.3.5** UPS Electrical Tests (1)
- **Table 30.4.5** PV (Photo-Voltaic) Electrical Tests (1-4)
- **Table 32.4.5** Battery ESS (Energy Storage System) Electrical Tests (1)
- **Table 36.4.5** Stationary Standby Battery Electrical Systems (7)

Although the emphasis has been on the relationship between electrical safety (NFPA 70E) and electrical equipment maintenance (NFPA 70B):

- Thermography is not limited or only applicable to equipment where thermography is specified in its required maintenance.
- All other electrical equipment that can suffer the ill-effects of overheating should be evaluated as well.

Key Points

- **NFPA 70E** specifies equipment maintenance must be considered as part of an electrical safety program
- **NFPA 70B** specifies the electrical maintenance to be performed
- **OSHA relies on 70B & 70E** to require electrical maintenance
- **Thermography is used extensively** to ferret out heating problems in equipment that can lead to failure
- Heat-related failures can create arc flash events leading to injuries, loss of production and increased operating costs
- IR scanning is specified extensively in NFPA 70B, but is not limited to only where it is specified

The Thermographer's Check List

Whether performing thermography within your company or for customers, consider the following:

-  Let people know the NFPA 70B is now an electrical maintenance standard
-  To be safety-compliant in the eyes of OSHA, their EPM program must agree with the procedures and directives contained in the 70B
-  Advise them that electrical equipment maintenance has long been part of the electrical safety program specified in the 70E, but is now more specific as detailed in the 70B
-  Although safety is focused on personnel, updating electrical maintenance procedures is definitely an economic benefit
-  They already have a software-based EPM; advise them to check for an update that will either update it or confirm its compliance to 70B
-  Thermography is not only an excellent, well-advised troubleshooting tool and maintenance practice, it is now specified in several sections of the 70B!

****About the author:** Craig Nelson is employed by JM Test Systems as a Senior Electrical Training Specialist providing formal training in OSHA and NFPA 70E compliant electrical safety, and a wide variety of electrical trade-related subjects. His qualifications and certifications include Journeyman Power Generation Electrician, Master Electrician – General Construction, U.S. Navy Construction Force (SEABEE) Master Chief Construction Electrician, Certified Electrical Safety Worker (CESW) and Certified Electrical Safety Compliance Professional (CESCP) with more than 54 year’s experience in the electrical industry.*

† Courtesy Jim White, Shermco Industries, pg 3

†† Brady, Scott, Understanding 2023 NFPA 70B: Standard for electrical equipment maintenance, pg 5

¹Hannahs, Corey, NFPA News Release, March 8, 2023, pg 1

²Graham, Toby, Do You Know the Difference Between OSHA Regulations and Consensus Standards? April 12, 2021, pg 1

References directly and indirectly to NFPA 70B Standard for Electrical Maintenance, 2023 Edition, and NFPA 70E Standard for Electrical Safety in the Workplace, 2024 Edition, were used extensively in this article