NFPA 70E 2018 Edition – Changes and Implications for Personnel Performing Condition Based Maintenance Tasks

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Abstract:

The 2018 Edition of NFPA 70E Standard for Electrical Safety in the Workplace, was released in late 2017 with little fanfare. However, there are several significant changes in this edition that have potentially wide-ranging implications for maintenance personnel collecting condition based data on their electrical and electromechanical assets. Included in this would be the performance of infrared inspections, ultrasound (partial discharge) inspections, motor current analysis, oil sampling (for oil analysis) on transformers and basic visual inspections.

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The NFPA 70 National Electrical Code (NEC) and the NFPA 70E are meant to work hand in hand. The NEC defines how to install listed electrical equipment properly including ensuring that items such as cable ampacity, fuse and breaker ratings, conduit fill guidelines and safe equipment clearances are correct. When electrical equipment has been designed, installed and maintained properly and is operated under "normal" conditions with all hinged doors closed, covers on and guards in place, workers are not exposed to any hazard. The NFPA 70E deals with how to reduce risk through safe work practices on equipment when it is under "abnormal" conditions, either intentionally or unintentionally, and the likelihood of occurrence of a shock exposure and arcing fault and arc flash are heightened.

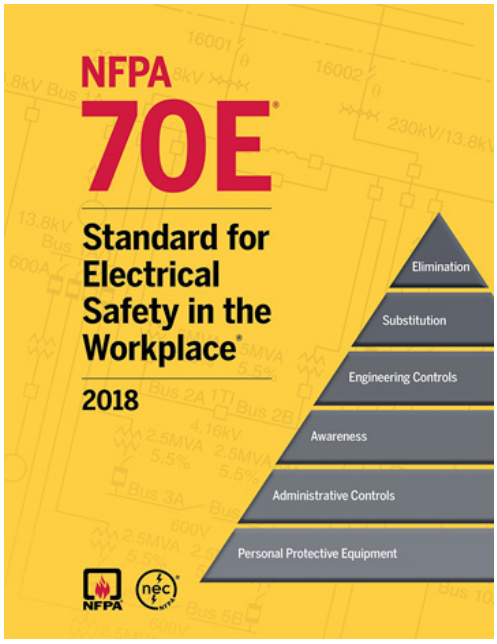


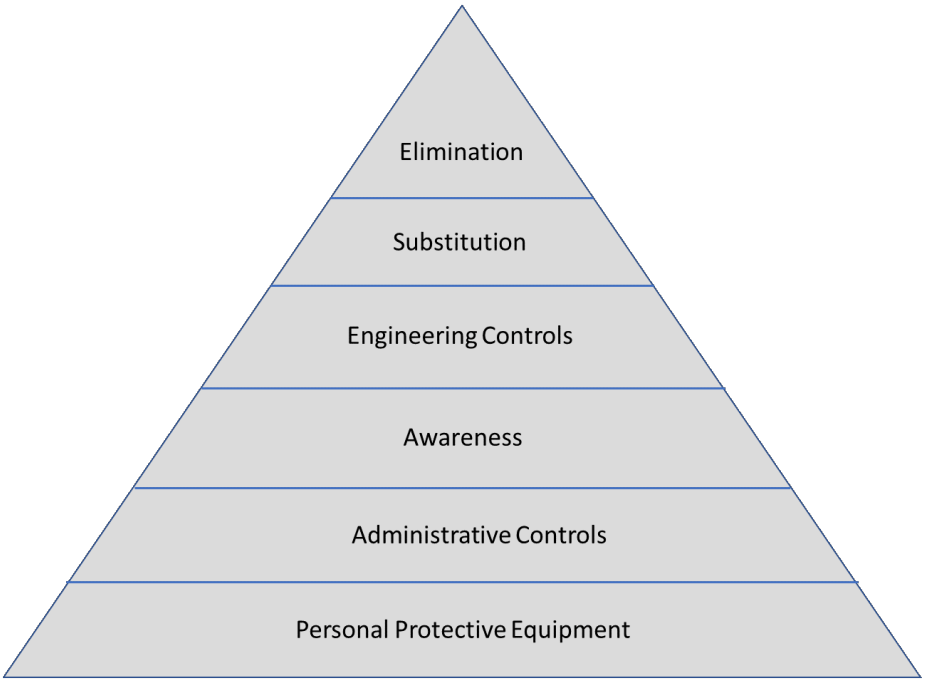
Figure 1 NFPA 70E

The first major change is that the Hierarchy of Risk Control Methods which were previously a suggested non-mandatory requirement has now been made mandatory to apply to any energized electrical work task to mitigate exposure or reduce risk [reference Article 110.1 (H)(3)]. The Hierarchy must be applied in sequence to reduce the inherent or initial risk to a residual risk level that is as low as reasonably practicable (ALARP). The Hierarchy of Risk Control Methods consists of six (6) controls each which must be considered fully and eliminated as an option to reduce risk before moving to the next lower control of the hierarchy. The effectiveness of the control reduces as we move down the hierarchy. The stages of the Hierarchy of Risk Control Methods are:

1. Elimination – Eliminate the hazardous energy altogether. Is it necessary to perform the task with the electrical equipment energized or can it be completed with the electrical equipment de-energized? In the case of Condition Based Maintenance (CBM) inspections, most data collection must be performed with the electrical equipment energized and under "normal" load conditions which usually means at least 60% of the normal operating load present. Infrared and Ultrasound inspections must be performed energized and under normal load and, in the case of infrared, thermal stability must be achieved. Most Motor Current Analysis (MCA) tests must be performed with the motor energized while oil sampling can be performed with equipment de-energized. The fact that taking an equipment shutdown would be inconvenient for the client is not necessarily sufficient cause to bypass Elimination and move to the next control in the hierarchy.

2. Substitution – Involves replacing something that produces a hazard with something that does not produce a hazard. To be an effective control, the substitution of process or product must not produce another (new) hazard. If we agree that a given CBM work task must be performed with the electrical equipment energized, is there a way to substitute a way to see or listen inside the equipment or collect a sample without exposing energized conductors or circuit parts? Can we avoid opening hinged doors and removing electrical equipment

covers? The use of Electrical Maintenance Safety Devices (EMSD) such as properly sized and located infrared viewing panes or ultrasound ports or sensors may allow the Qualified Person to inspect the electrical equipment and collect data without any exposure to energized conductors or circuit parts. External oil sampling ports can be installed on transformers that allow the Qualified Person to gather a sample without opening the energized terminal chamber. Motor Test Access Panels (MTAP) can be installed to allow safe closed panel testing of motors. Substitution can also be thought of as Design for Maintainability but can be incorporated both on new and retrofitted to existing older equipment. The cost burden of implementing EMSD is not necessarily sufficient defense to move the next control in the hierarchy.



NFPA 70E Hierarchy of Risk Control Methods

3. Engineering Controls – Involves a physical or design changes to the electrical equipment, rather than relying on worker's behavior or requiring workers to wear protective clothing. There can be some confusion as to when a change is Substitution versus Engineering Controls. My interpretation is that Engineering Controls are to protect the worker from himself (e.g. designing in more insulating, guarding or finger safe components) or implement design changes to reduce hazard levels (e.g. protective devices which reduce the maximum fault clearing time). Engineering Controls might include using high resistant grounding instead of solidly grounded systems to limit the phase to ground fault current or selecting Arc Resistant Switchgear. In this manner, the work task will expose the Qualified Person to reduced electrical hazards and will reduce the resultant potential for injury. With this thinking, other examples of Engineering Controls would be tamper resistant hardware and door interlocks (limit switches) that prevent access into hazardous energized electrical equipment or automatically de-energize the electrical equipment if someone manages to open an access point. Touch proof barriers inside of electrical equipment might also qualify as Engineering Controls – although they often need to be removed to perform Infrared inspections creating a secondary hazard for the thermographer. Engineering Controls should be implemented on electrical equipment before moving to the next control in the Hierarchy. Again, the cost burden of implementing Engineering Controls is not necessarily relevant.

4. Awareness – A stage that is not typically part of the Hierarchy you will find for other hazard control methodologies outside of the electrical realm. Awareness basically is ensuring that the personnel involved in a work task have a documented Job Safety Plan that was created by a Qualified Person and includes:
    a. A description of the job and individual work tasks.
    b. Identification of the electrical hazards associated with each work task.
    c. A documented shock risk assessment.
    d. A documented arc flash risk assessment.
    e. Use of work procedures involved as well as any special precautions and energy source controls.

   Awareness is basically making sure you have a plan and have considered all the potential risks of doing energized open panel CBM work. Until the plan is complete and documented, you cannot proceed to the next control in the Hierarchy. Additional Awareness controls would be ensuring signage is installed on electrical equipment including identification and arc flash and shock Equipment Labels.

5. Administrative Controls – Includes using electrical safe work procedures and employee training. Specific training for Qualified Persons would include Electrical Safety Training, Lockout Tagout Training, Emergency Response Training, First Aid / CPR (based on Jurisdictional requirements) and PPE training. Training must be documented and retraining / certification must be performed at proper intervals. Even Unqualified Persons who will not be working on electrical equipment need to be trained on basic electrical safety practices. With the Awareness and the Administrative Controls in place, only then can you move to the final control in the Hierarchy.

6. PPE – Personal Protective Equipment includes rubber insulating gloves with leather protectors, using insulated hand tools, arc-rated clothing, arc-rated faceshields, arc flash suits etc. PPE is the least effective means of controlling hazards because of the high potential for PPE to be damaged, worn improperly or selected incorrectly for the level of hazard that exists. PPE increases the physiological effort required to perform a work task. Frequent breaks and dress downs may be required to prevent heat stroke or fatigue leading to human error. Furthermore, even choosing the appropriate level of PPE will only limit, in the event of an arc flash, the burn injuries to only 1st and 2nd degree. Burn injuries along with contusions, lacerations, concussion and broken bones can all still occur due to the arc blast pressure wave that emanates out of an arcing fault event. Open panel CBM data collection is inherently high risk work without controls and should only be done as a last resort.

Beyond the formal adoption of the Hierarchy of Risk Control Methods, NFPA 70E 2018 Edition has also codified the need for Human Error to be considered as part of the Risk Assessment Procedure (RAP) for any work task under consideration. The document recognizes that Human Error will drive up the likelihood of occurrence of an arcing fault and arc flash or shock exposure to the Qualified Person. For CBM inspections, the greatest risk of human error occurs when removing a bolt on cover to be able to see into the electrical equipment to perform the CBM work task on the suspect conductors or circuit parts. Quite often, the exact internal nature of the electrical equipment is not known until it is opened as there is limited documentation on the electrical equipment construction available to the inspection personnel. They do not know just how close the energized conductors are and are often working in restricted spaces.

Figure 2 Arc Flash Incidents Occur Frequently in the United States

Another change to NFPA 70E was the addition of Table 130.5(C). This table states that, on electrical equipment in any condition (normal or abnormal), performing infrared thermography and other non-contact inspections outside the Restricted Approach Boundary does not increase the likelihood of occurrence of an arcing fault and arc flash incident and so, additional PPE is not required. However, the table further clarifies that this does not include opening equipment doors or covers that expose bare energized conductors or circuit parts which specifically does increase the likelihood of occurrence of an arcing fault and arc flash. Restricted Approach Boundaries on AC systems are further defined in Table 130.4 (D)(a) and are 1'-0" for 151-750Vac systems and 2'-2" on 751-15,000Vac systems. Restricted Approach Boundaries for higher voltages and on DC systems are also provided in the tables.

Although not specifically mentioned in Table 130.5(C), opening an EMSD cover like that on an infrared viewing pane does not expose bare conductors or circuit parts and so our interpretation, verified by others we have spoken to who were on the NFPA 70E Technical Committee, is that no PPE would be required. In this manner, the use of an EMSD and changing the work process to keep the equipment in a closed and guarded condition while performing the CBM task seems to follow Substitution stage guidelines of the Hierarchy of Control.

Figure 3 CBM (IR Inspection) Before & After EMSD Implementation

Finally, the language around the Energized Electrical Work Permit (EEWP) requirements in the NFPA 70E should be mentioned. An Energized Electrical Work Permit is required whenever personnel will perform work within the Restricted Approach Boundary or when personnel interact with equipment in such a way that an increased likelihood of injury from exposure to an arc flash hazard exists – even if conductors or circuit parts are not exposed during the work. . However, there is an exemption to the need for an EEWP for thermography, ultrasound or visual inspections provided the Restricted Approach Boundary is not crossed. At first

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blush, one might think that this gives a blanket EEWP exemption for open panel thermography. However, this only means that an EEWP may not be necessary but the Hierarchy of Risk Control Methods must still be followed when completing a Risk Assessment Procedure. In addition, an EEWP will still be needed if, in the process of removing the panel cover or opening a door, the Restricted Approach Boundary will be crossed. In my experience, crossing the Restricted Approach Boundary when removing a panel cover is a virtual certainty on most electrical equipment and so an EEWP should be executed. When opening a hinged door, this may not be the case but only prior user experience with the equipment will validate that assumption.

The language of the NFPA 70E 2018 Edition does not go so far yet as to mandate the use of specific electrical safety devices. However, a strict following of the Hierarchy and the statements embedded in Table 130.5(C) lead us to conclude that it is difficult to justify not using EMSD's as a matter of standard practice. Indeed, in the event of an arc flash or electrocution incident involving open panel collection of CBM data, the end user would be forced to justify to OSHA and possibly in civil litigation why they had not adopted this approach that is both readily available and cost effective to implement. The use of IR windows, for instance, has gained wide acceptance over the past 10 years with virtually all OEMs offering optional solutions on virtually all electrical equipment types. Retrofit solutions of IR viewing panes or custom replacement panels with built in IR viewing windows are also commonplace. Embedded ports or sensors for collecting Ultrasound data are also available from several vendors and are especially useful for equipment greater than 1kV. Motor Test Access Panels and external Oil Sampling extension kits are also widely available for retrofit on existing assets.

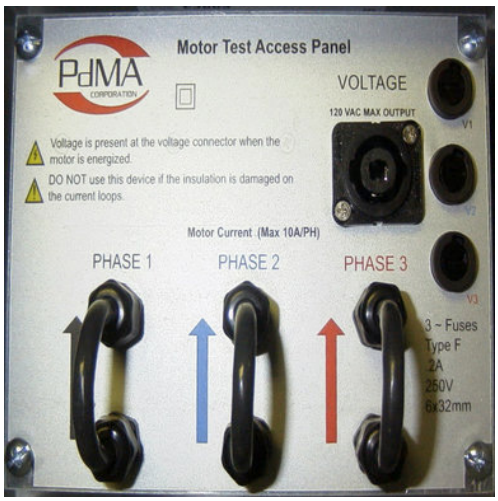

Figure 4 MTAP – Courtesy PdMA Corp.

Figure 5 External Oil Sampling – Courtesy SDMyers

CBM data collection can provide valuable insight into electrical equipment health and drive more intelligent decision making as to when to perform physical intervention maintenance tasks. Most of this must be done with the electrical equipment energized and under normal load conditions to allow the technology to catch the anomalies. The NFPA 70E recognizes the risk inherent with CBM data collection and is pushing for safer data collection practices via the most recent changes including the formal adoption of the Hierarchy of Risk Control Methods as well as updates to other language and reference tables in the document. End users and maintenance personnel should revisit their risk assessments of these work tasks and reconsider the implementation of EMSDs as a strategy to mitigate hazards and reduce risk and comply with the intent of NFPA 70E. Failure to do so not only puts people at increased risk of injury or death but could also result in an expensive legal lesson.

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Figure 6 IR inspection Windows come in many shapes and sizes

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