IR Window Installation Overview

Fig. 1: IR Windows mounted in switchgear

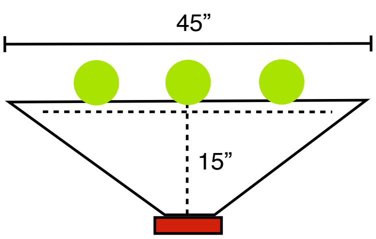

Figure 2: Field of view through an IR window. 3 fuses at a depth of field of 15” are clearly visible through a single window.

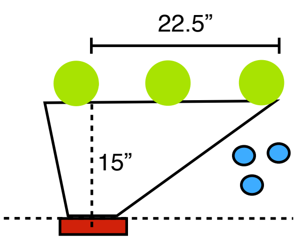

Figure 3: Field of view through an IR window around an obstruction in the cabinet

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Installation of infrared (IR) windows can appear, at first, to be a complex issue:

- Where should I install the windows?
- How do I optimize placement and viewing area?
- How many windows will I need?
- How much will I be able to see?

The 3X Rule of Thumb:

Luckily, it is much easier than it would at first appear. Working in the thermographers favor are three rules of thumb:

1. As the distance between the target and the viewer (“depth of field”) increases, the viewable area (“field of view”) through the IR window increases. Think of watching a ball game through a knot hole in a fence.
2. Typical IR camera lenses have a 24º field of view. (Note: some specialty lenses are available providing up to 90º field of view.)
3. Cameras can be angled up to an additional 30º from perpendicular (30º “angle of incidence”) relative to the IR window, while maintaining a high degree of accuracy. Therefore, targets do NOT have to be located directly behind the IR window. (Note: an angle that is steeper than 30º will tend to change the emissivity/reflectivity value of the target object.)

To estimate the field of view through an infrared window, we recommend using the *Rule of 3X*: Multiply the depth of field by 3X. The result is roughly what is visible through a 3” window -- side to side and up and down.

Example: in Figure 2, a thermographer wishes to monitor 3 fuses that are located 15” behind an enclosure panel (where the window would be mounted). Based on this depth of field, the thermographer will be able to view 45” x 45” area through the window. Put another way, the thermographer will be able to view roughly 22.5” to all sides from the center of a point directly behind the window. As long as the furthest target fuses are not further than 22.5” to the right of left of the window, the thermographer will have no problem seeing all phases.

What About Obstructions?

You will want to be aware of obstructions. If there are phase dividers, you will be unable to see all phases with one window. In this case, use 2 windows, each straddling a phase divider: window #1 will allow imaging of Phase A and Phase B; while window #2 will be used to monitor Phase B and Phase C.

In Figure 1, you will notice that the windows are mounted off-center. The three phases in this equipment are equally spaced and centered in the cabinet -- but the cables dropped along the right side of the interior of the cabinet. The position of the cables would have blocked visibility of the C Phase if the window was located in the center of the panel. Therefore, the installer located the windows off-center, so the thermographer could see behind the cables to view the C Phase, knowing that the 3X multiplier would allow them to view 22.5” from to the side.

Cut Cardboard Before Steel

One helpful trick is to cut a large piece of cardboard with a 3" x 3" hole and 4" x 4" hole. When the gear is open, you will be able to position the cardboard cutouts along the plane of the enclosure, look through the holes at up to a 30 degree angle to see what the window will allow you to shoot. This is a GREAT way to get a feel for estimating the quantities and positions of the windows.

Note: the information in this summary offers general guidance for positioning IR windows. Some applications might require unique considerations.

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ARC RESISTANCE & IR WINDOWS

Abstract

"How can a crystal or polymer optic stand up to the enormous blast-pressure, heat and molten shrapnel produced by an arc flash?" This is a question that many engineers ask when they begin researching infrared windows. Part of the reason for the question is a misconception that the infrared window can somehow hold back the blast forces generated from an arc flash.

In fact, the role of the IR window, is not one of "protection," but of prevention. Furthermore, there is no standard for arc resistant infrared windows, although windows are tested as a part of the larger system that is arc resistant switchgear, to prove that the windows will not be a source of weakness in that system. But that is not the same as being arc resistant in and of themselves.

This paper will explore the dangers of arc flash and the forces that the resulting arc *blast* produces. The reader will also gain an understanding of the considerable safety benefits, and arc flash risk control, that infrared windows provide, as well as the realistic limitations of the devices and their role in arc resistant switchgear and MCCs.

Arc Flash Statistics:

- There are one to two arc flash related fatalities daily across North America[1]
- An estimated five to ten arc flash explosions occur daily across the US[2]
- 2,000 workers are treated in specialized burn trauma centers each year as a result of arc flash injuries[1]. These high-tech facilities only treat the most devastated burn victims -- those who have sustained incurable third-degree burns over *more than half* of their body.
- Arc flash injuries are actually much higher than reported because workers receiving treatment for trauma and burns that do not require burn unit attention (i.e. second degree burns or third degree burns covering less than half their body) are admitted to standard hospitals which do not track these injuries as arc flash related.

What is an arc flash?

NIOSH (National Institute for Occupational Safety and Health) definition of an arc flash:

> *"An arc flash is the sudden release of electrical energy through the air when a high–voltage gap exists and there is a breakdown between conductors."*[2]

The causes of arc flash are many, ranging from rodents, to insulation breakdown, to dust and contaminants. However the predomination of causes are human initiated and occur when the panel covers are not in place, or during panel removal or reapplication or when opening or closing equipment doors.

In less than 1/1000th of a second, the center of an arc flash can reach temperatures of 35,000°F / 19427°C [3]-- nearly four times the temperature of the surface of the sun (roughly 9,000°F / 4982°C). This rapid heating causes copper bus bar to turn from solid to plasma state in a fraction of a second, expanding 67,000 times. At that rate, a pea sized piece of copper will expand to the size of a rail car.

This instantaneous expansion of machine parts and the surrounding air creates an "arc blast" carrying a pressure wave of thousands of pounds of force, super-heated gases and molten shrapnel.[4] The bomb-like blast can be as powerful as three sticks of dynamite blowing up just an arm's length from the worker. It's not surprising that victims of arc blast trauma report horrific burns, shrapnel wounds, damaged internal organs, hearing loss, blindness and lung damage.

No Two Arc Blasts are Created Equal:

The IEEE (Institute of Electrical and Electronics Engineers) states "it should be realized that [an arc flash] does not always behave in a repeatable manner."[5]

It goes on to explain that test results can be impacted by design characteristics ranging from dimensions and structure of enclosure, to partition architecture, bus bar orientation, pressure relief devices and insulation systems. For this reason, results

IR Window with metal cover closed and secured

from tests on one system cannot be extended to another system, even if the two systems appear to be very similar.

The power of an arc blast will also vary widely depending on the amount of fault current / incident energy available. This can be profoundly effected by the reliability, condition and configuration of safety devices such as current limiting fuses and breakers. Studies have found that 22% of devices in the field, operate less than optimally; and 10.5% of the units tested failed to clear the fault.[6] Even the slightest reduction in effectiveness of these devices can easily double or triple the incident energy levels of an arc flash -- keep in mind these devices are designed to clear in milliseconds. Meanwhile, if a breaker fails completely, a worker could be overwhelmed with 15 to 20 times the anticipated incident energy levels.[6]

Arc Resistance Versus Arc Avoidance:

Every industrialized country has instituted electrical safety standards to ensure workplace safety. Most of these standards are similar to the US standard: NFPA 70E Electrical Safety in the Workplace. In fact, many, like Canada's CSA Z462 are based in part or in whole on the NFPA 70E standard. As such, many / most of these international standards will have a large degree of focus on protecting workers from the effects of arc flash by seriously limiting the worker's exposure to "energized electrical conductors or circuit parts" over 50 volts. Eliminating the exposure, and therefore the risk, is at the heart of the ANSI Z10 Risk Control Hierarchy (sometimes referred to as the "Hierarchy of Risk").

The Risk Control Hierarchy systematically reduces risk to its lowest practicable level by prioritizing ways to mitigate a given risk. Higher priority and weight are given to methods that seek to control risk by proactive means as close as possible to the root cause. Meanwhile lower priority is placed on reactive methods of controlling damage *after* an incident has occurred. Specifically, Risk Control Hierarchy ranks the most effective to least effective ways to reduce risk as follows: [7]

> *"An electrical safety program shall identify a hazard/risk evaluation procedure to be used..."*
>
> *-- NFPA 70E, Article 110.7 (F)*

1. Elimination -- remove the hazard
2. Substitution -- replace higher risks with lower risks
3. Engineering Controls -- reinvent ways to limit/prevent the risk
4. Awareness -- raise knowledge of risks and consequences thereof
5. Administrative Controls -- create regulations, work processes, etc.
6. PPE -- use Personal Protective Equipment as *last defense*

An effective electrical safety program will include components of multiple levels of risk control, including PPE; but the most prized level of control is risk elimination. With this in mind, it is not surprising that OSHA specifically states "...with respect to arc-flash burn hazard prevention, the general provisions for the selection and use of work practices... generally require de-energization of live parts before an employee works on or near them." [8]

Arc Flash Protection:

If we accept that the best way to protect personnel from arc flash related injury is to eliminate the hazards which might cause the arc flash, then it is necessary that we proactively eliminate risk increasing behaviors: specifically we must eliminate the practice of allowing workers to be exposed to energized components -- ie. we must keep energized equipment "enclosed" and "guarded" (per NFPA 70E) whenever possible.

Using devices such as infrared windows (IR windows / infrared sightglasses) maintain the enclosed and guarded state and allow thermographers to perform their task without creating the electrical hazard inherent in opening and closing equipment. In most cases, opening energized applications 600V and higher, carries a Hazard/Risk Category (HRC) classification of three or four (on a scale of zero to four). [9] Conversely, closed panel work similar to thermography through an IR window, like reading a panel meter, only requires an HRC class zero.

NFPA specifically states that absent the introduction of electrical hazards such as those outlined in the HRC Tables, “under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard.” [10]

By removing high-risk, hazard-inducing activities, IR windows help to eliminate risks and thereby proactively protect workers by reducing risk in the most efficient manner. However, the word “protect” must be used with caution since there is not a window on the market that has been proven to actually offer “protection” to workers in the exceedingly unlikely event that an arc flash were to occur during inspection.

Arc resistant switchgear and similar systems utilize engineering controls, such as barriers, compartmentalization, and pressure relief mechanisms to redirect arc flash / arc blast gasses and forces away from panels where personnel are most likely to be interacting with equipment. In so doing, these *engineering controls* (in Risk Control Hierarchy terms) offer *reactive* protection to personnel from the effects of the arc flash / arc blast.

Arc Resistant Infrared Windows:

So where did the term “arc resistant IR window” come from?

Some infrared windows, such as the XIR and XP series IR windows have gone through “arc resistance testing.” In actuality, it is more accurate to say that those IR windows were in place as part of the system of arc resistant switchgear -- and it was that switchgear, with IR windows in place, that was arc resistance tested per the ANSI/IEEE C37.20.7, EIC 298, and IEC 62271-200 standards for performing arc fault testing on switchgear.

The standards are clear in there intention to apply only to the *system* of a piece of switchgear and all of the components in place at the time of the test. It implicitly does not extend any “arc resistant” ratings to the individual components which happened

Impact Resistance Versus Arc Resistance

IEEE impact resistance standards for switchgear dictate that "a transparent material covering an observation opening and forming a part of an enclosure … must be able to withstand a 3.4 J (2.5 ft-lbf) impact and a 445 N (100 lbf) load without cracking, shattering or dislodging." [11]

Arc resistance tests (like IEEE C37.20.7) are performed with the window cover closed and locked. Therefore the ability of the optic to withstand any blast forces are not checked. Instead the test is designed to certify that the window housing and cover are sufficient to keep heated gases from escaping from an arc resistant enclosure.

to be in place during the test. In fact the standards point out that the results of the tests cannot be loosely applied to other systems outside the parameters of the one tested. Therefore, even a simple variation in components used, geometry of the enclosure or construction of the enclosure would require retesting to be certain that the new system would protect users.

Any attempts to extend the results of an arc resistance test to a similar, but non-arc-resistant system (one that has no pressure relief mechanisms such as vents, plenums, etc.) is in clear opposition to the standard. The pressure relief system of the arc resistant system is integral to the arc rating of the system. Without the pressure mitigation, the switchgear is incapable of containing and redirecting the heat and pressures of the arc blast. In fact it is common for a switchgear manufacturer to sell essentially the same substation assembly in a non-arc-resistant version as well as an arc resistant version -- the primary difference being that the compartments all connect to a pressure relief system in the arc resistant model.

IR windows are not tested to withstand unvented blasts in equipment has no arc resistance features. Yet the vast majority (more than 90%) of equipment in the field is not arc resistant. Unfortunately, some consumers assume that an "arc resistant IR window" has been shown to withstand arcing faults on the broad spectrum of non-arc-resistant equipment. The tests do not prove this.

Another source of confusion is an expectation on the part of some consumers that the IR window optic (as opposed to a window that is closed with the cover properly secured and sealed) has been proven in arc resistance tests to protect the thermographer. But these tests are performed with the protective cover *closed*. As stated previously, arc resistant switchgear dramatically limits and redirects the pressure wave away from the panel where the window is installed. Even so, in these tests, the window's optic is typically compromised. However, because the cover is closed, the blast is contained during the test.

Why Use an Infrared Window?

Use of an infrared window will remove more than 99% of arc flash triggers during an infrared electrical inspection. By removing the hazards, infrared windows are providing the highest level of "protection" per the Risk Control Hierarchy as prescribed by NFPA.

Unfortunately, no infrared window on its own is capable of offering an arc resistant or similar level of protection in the event of an arc flash incident. However, they can be an effective part of a switchgear or MCC system that is designed to redirect the heat and pressure of the arc blast away from the panel that the IR windows are attached to.

Companies that are interested in controlling the risk of catastrophic arc flash events should seriously consider the benefits that infrared windows offer:

- They provide a safer, more efficient work process that will allow thermographers to obtain their images and data while remaining separated from energized electrical conductors.
- They do not raise the risk of creating an electrical hazard, and instead eliminate the typical high-risk behaviors that can create an arc flash incident.
- The inspection windows provide an easy way for companies and personnel to comply with regulatory (OSHA/CSA) and insurance mandates, while requiring a minimum level of PPE protection.

References:

[1] *CapSchell Group*

[2] *NFPA 70E; Electrical Safety in the Workplace; Annex K.3; 2009*

[3] *NIOSH; Arc Flash Awareness; DHHS (NIOSH) Publication No. 2007-116D; 2007*

[4] *NFPA 70E; Electrical Safety in the Workplace; Annex K.4; 2009*

[5] *IEEE.37.7 Standard; Guide for Testing Metal-Enclosed Switchgear Rated Up to 38kV for Internal arcing Faults; Section 1.2.4; 2007*

[6] *K. Heid, R. Widup; Field Measured Total Clearing Time of Protection Devices & its Effect on Electrical Maintenance; from the Proceedings of the 2009 IEEE IAS Electrical Safety Workshop; St. Louis, MO, 2009*

[7] *ANSI / AIHA Z10 Standard; American National Standard for Occupational Health & Safety Management Systems; 2005*

[8] *OSHA 1910.303, Linhardt interpretation*

[9] *NFPA 70E; Electrical Safety in the Workplace; Section 130.7(C)(9); 2009*

[10] *NFPA 70E; Electrical Safety in the Workplace; Article 100 FPN No. 1; 2009*

[11] *IEEE C37.20.2; IEEE Standard For Metal Clad Switchgear; Section A.3.6 ; 1999*

For More Information

For additional information on this and related topics, visit Exiscan at www.Exiscan.com. or email us at info@Exiscan.com.

Exiscan manufactures a line of robust infrared windows for use in industrial and facilities maintenance settings.

EXISCAN™
Closed-Panel Inspection Windows

Why a Polymer Optic?

Industrial Environments Require Industrial Materials

When Exiscan™ evaluated the infrared (IR) window market, it was evident that most solutions were still utilizing optics that were better suited for the controlled environments of research laboratories. The dominant crystal technology that is perfect for short wave (SWIR) R&D cameras, is mostly non-transmissive in the long wave (LWIR) spectrum where today's maintenance and reliability cameras are tuned. The laboratory crystals are also ill-suited to withstand the harsh environments of industrial / facilities maintenance applications. Simply put, industrial applications require industrial solutions.

Exiscan elected to use a proprietary polymer optic -- an HDPE derivative that has been proven over two decade of full-exposure use in industrial, office and outside applications.

Longevity

The impact resistant optic is thermoformed from a polymer with a proven track record of excellent resistance to the effects of moisture, humidity, vibration, UV, and a broad spectrum of acids and alkalis. In the extreme conditions of the desert or a paper mill, the optic's mechanical and transmission stability make Exiscan's™ optic uniquely qualified to stand the test of time. Exiscan's™ Lifetime Warranty ensures that only resilient materials are used: materials that won't need to be replaced.

Accuracy

Polymer is a giant step forward for for LWIR temperature accuracy. The relatively flat LWIR transmission curve, and the stability of the transmission rate over time make polymer the choice for accurate temperature calculations. Articles on these topics are available at www.Exiscan.com.

Specifications:

- ❑ **Camera Compatibility:** Exiscan™ optic is compatible with all brands and models of IR cameras
- ❑ **Chemical Resistance:** Broad Spectrum Acids / Alkalis
- ❑ **Moisture Resistance:** Excellent
- ❑ **UV Resistance:** Excellent
- ❑ **Vibration:** Unaffected
- ❑ **Indoor / Outdoor:** Yes
- ❑ **Operating Temperature:** -40°C (-40°F) to 150°C (300°F)
- ❑ **Impact & Load Resistance:** ANSI/IEEE C37.20.2 (A.3.6), and UL 746C
- ❑ **Flame Resistance:** UL 746C
- ❑ **LWIR Transmittance:** 68%

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2015 Revision to NFPA 70E & CSA Z462

> *"The only thing that is constant is change."*
> *-- Heraclitus (500 BC)*

There are few universal truths in life:

- The sun will rise in the east every morning.
- There is nothing in the world a cute as your baby… except maybe your dog.
- Politicians will always disappoint us… always.
- And, just when you think you really know the latest revision of a standard, the new revision is ready for print.

And so, the world turns. As new research is conducted, old topics debated, and best practices are refined, the world's most influential electrical safety standards evolve to keep pace. Now, sometime before the golf season ends and deer season begins NFPA 70E and CSA Z462 are set to release the latest revisions.

The following is a brief summary of some of the more significant changes and evolutions with some insight regarding the reasons for the revisions. This overview is *not* intended to be all-inclusive, nor is it intended to be a replacement for reading the standards in their entirety. At best, it is an attempt to provide the reader with an indication that they will need to (A) purchase a copy of the new revision, (B) study the modifications to the text, and (C) consider how the changes might influence their documented Electrical Safety Programs.

It is also important to note that the changes anticipated herein are based on the most recent drafts and final committee balloting – however the final revision could differ based on the results of final edits, approvals and votes which could affect the final text.

(Note: because CSA Z462 is harmonized with NFPA 70E, and the differences are minimal, this paper will focus on NFPA 70E.)

Concepts of Hazard and Risk:

The 2012 revision of NFPA 70E and CSA Z462 made several changes to separate the concepts of Hazard and Risk. The two concepts deserve to be separate, and are, in fact, distinct concepts in other occupational heath and safety (OHS) standards. The 2015 revisions of NFPA 70E and CSA Z462, continue this effort to separate and clarify these important, foundational concepts.

Hazard, Hazardous, Risk and Risk Assessment have all been added to the Definitions section, further delineating and separating of the use of those terms.

Whereas a *Hazard* is the *source* of potential injury, or damage to a worker's health; *Risk* is a combination of the *likelihood and potential severity* of that injury (paraphrased).

Consequently, any references to the hybridized "Hazard/Risk Categories" (or HRC) have been replaced with the more accurate and descriptive "PPE Category".

The various forms of "Hazard Analyses" have been changed to "Risk Assessments" which:

- *Identify* the hazard(s)
- *Estimate* of the potential *severity* and *likelihood* of injury / harm
- Determine what if any *protective measures* are appropriate.

These changes might not appear significant at first glance, but they are significant in the way that they bring these standards in line with other safety standards. And as you will see, they have a great deal of impact on the Task Tables in 130.7(C)(15).

Other Global Changes:

The term "harm" has been clarified to read, "injury or damage to health."

Because "probability" has the connotation of a mathematically derived calculation, the 2015 revisions of 70E and Z462 will refer to the "likelihood" of an event.

In a continuation of the effort from the 2012 revision, all references to Flame Resistant or "FR" are changed to Arc Resistant or "AR." It is an important detail that seeks to eliminate any potential confusion with regard to PPE appropriate for use around a potential Arc Flash Hazard.

Scope (for NFPA70E only):

Traditionally, the Scope of NFPA 70E has seen very few changes over the years. This cycle, however, brings about a few notable exceptions. For consistency with related standards and industry best practices, and to emphasize the importance of safety-related maintenance and administrative controls (such as training) the revised scope will also include "safety-related maintenance requirements, and other administrative controls." The committee also added an informational note warning that the highest risk of electrical-related injury "for other workers involve unintentional contact with overhead power lines and electric shock from machines, tools and appliances…" The addition of this note to the Scope continues the efforts to impress upon readers that electrical safety is something that effects workers across the organization -- not just the electrical group.

The most significant change to the scope, however, resulted from an MSHA (Mining Safety & Health Administration) decision to accept the NFPA 70E standard in much the same way that OSHA does, making it a de facto electrical safety standard for the mining industry. Consequently, the exemption for mining applications previously found in the Scope [section 90.2(B)] will be removed in 70E-2015.

Prohibited Approach Boundary:

The *Prohibited Approach Boundary* (distance from a conductor that was considered the same as making contact) has been eliminated from the definitions after some interesting debate.

Those who advocated for it's continued inclusion in the standard generally thought that it underscored the difference between working in contact with the conductor versus working in proximity that would require shock protection.

The Committee determined that previous changes to the standard have made the *Prohibited Approach Boundary* obsolete since it no longer triggers any behavior on the part of the worker or Manager. Generally speaking:

- The *Limited Approach Boundary* defines the boundary for unqualified workers.
- The *Restricted Approach Boundary* defines area in which qualified personnel are required to utilize PPE to prevent shock.
- The *Arc Flash Boundary* defines the area where arc resistant PPE is required.

But the *Prohibited Approach Boundary* had no actual instructional value within the standard -- no requirements associated with it -- it had essentially become an answer to a trivia question. The committee ultimately decided that the term added a layer of complexity and was a possible source of confusion without actually adding any direction to the user.

Maintenance and Your ESP:

The *Electrical Safety Program* (formerly 110.3) is being moved to the beginning of Article 110, *General Requirements for Electrical Safety-Related Work Practices,* to provide clarity since the implementation of an Electrical Safety Program (ESP) would naturally be the first element of the section that an employer would address, followed logically by the other considerations of the section (Training, Relationships with Contractors, etc.).

As with the previous (2012) revision, and as we saw earlier within the Scope, maintenance is once again being placed front-and-center as a keystone of electrical safety. After the mandate that the employer must implement an *Electrical Safety Program*, the first consideration listed [110.1(B) *Maintenance*] is that the ESP must give consideration to the equipment maintenance.

Because improperly or poorly maintained electrical equipment can result in failures, and can result in longer clearing times, personnel safety is directly affected by the condition of the equipment in their proximity. It only makes sense that the standards would continue to focus attention on the condition and maintenance of the equipment. We will see this again in the Task Tables in Article 130.

Auditing and Training Intervals:

Auditing the Electrical Safety Program [110.1(I)] will continue to be required at intervals of three years or fewer. But the audit of *Field Work* (to verify that workers and managers are following the ESP procedures) will now be required at least annually (whereas there was no prescribed interval previously).

Annual auditing of field work actually brings the section in line with various training intervals required in Article 110.2 (*Training Requirements*) of the standard. The annual training or refresher is required for aspects of emergency response training, including contact release, CPR, AED, as well as for training verification.

Normal Operation:

Do you wear a full “bomb suit” to plug in your laptop, or when you walk past an MCC? Then you will be very interested to learn about the

Normal Operations clause to the *Energized Work* [130.2(A)] section.

Past revisions added Informational Notes to indicate that enclosed electrical equipment that has been properly installed and maintained, and is under normal operating conditions is “not likely” to pose an a hazard. NFPA 70E-2015 will move this concept to the body of the standard, the reader is now given clear direction that *Normal Operation* of equipment will be permitted as long as the equipment is properly installed and maintained, doors and covers are closed and secured, and there is no evidence of pending failure. We will see these points echoed in the Task Tables later in article 130.

Energized Work Permits:

The requirements around *Energized Work Permits* (EWPs) have been loosened and clarified. No longer are the *Limited Approach Boundary* or the *Arc Flash Boundary* triggers for requiring a EWP. Instead, the permits will be required when working inside the *Restricted Approach Boundary* and, as previously, when conductors are not exposed, but there is an increased risk of injury due to arc flash.

The *Exemptions to Work Permit* also saw clarifications. As before, a permit is not required for testing and troubleshooting. Thermography, visual inspection, general housekeeping, access and ingress with no electrical work are all exempt when done outside the *Restricted Approach Boundary*. An exemption will also exist for tasks that a risk assessment determines has no arc flash hazard.

Selection of Arc Flash PPE

The committee has added additional language to stop the all too common practice of mixing the method of selecting appropriate PPE. Users may either use the *Incident Energy Analysis* method, or the *Arc Flash PPE Selection Categories* method (formerly referred to as the Hazard/Risk Categories method), <u>but not both</u> on the same piece of equipment.

Furthermore, sites that perform an *Incident Energy Analysis* to generate the Arc Flash Hazard Analysis Labels, are not permitted to then compare the calculated cal/cm^2 value to the *Arc Flash PPE Levels* from the tables, and then list the *Arc Flash PPE Level* on the labels. Instead, PPE selection based on specific cal/cm^2 requirements would be appropriate.

Similar restrictions are repeated in the labeling requirements, stating that incident energy or PPE category can be listed on the labels, “but not both.”

“No Bling Zone”

Jewelry wearers take note: the standard has clarified an ambiguity with regard to when conductive articles such watches, necklaces, etc. can be worn. Leave the bling in your locker when you are going to be working within the *Restricted Approach Boundary*.

Arc Flash Hazard Identification Table

Gone are the traditional Hazard/Risk Category Classification (HRC) Tables. The former table method for selecting PPE based on classifications of equipment (which in turn is based on the voltage, available fault current, clearing time and minimum working distance) and the risk associated with the task. Consequently, lower risk tasks required less

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PPE than higher risk tasks despite the fact that the thermal energy produced in an arc flash incident is in no way effected by the risk of the task. The potential result was that a worker could find himself under-protected.

It is worth pointing out that there has been no evidence to indicate that workers have been injured as a result of being under-protected when using the table method. However, the potential was there, and the committee addressed the potential issue proactively.

The new table method for PPE selection, separates the Tasks and the Arc Flash PPE Selection into two discrete tables.

The new *Task Table* identifies whether the task requires Arc Flash PPE or not. The determination is made based on whether the task increases the risk of triggering an arc event, and whether the equipment condition should be trusted, using the same criteria we saw earlier under *Normal Operation* (properly installed, properly maintained, covers secured, no evidence of impending failure). The *Task Table* combines AC & DC in the same table.

After the *Task Table* indicates that the task or equipment condition require personnel to utilize Arc Flash PPE, the user is instructed to consult the *Arc Flash PPE Categories* Table to determine what level of PPE is required. PPE requirements are based on the equipment parameters (similar to previous revisions: voltage, available fault current, clearing time and working distance). Whereas, previous revisions listed various levels of PPE for a category of equipment, now there is simply one level of PPE prescribed for each category of equipment.

Arc Flash Boundaries is a new column in the *Arc Flash PPE Categories* Table. The *Arc Flash Boundary* has been rounded up to the nearest foot for equipment falling into Category 2 or higher. Gone is the column indicating the requirement for rubber gloves. Similarly, the column for insulated tools no longer exists, but the *Insulated Tools and Equipment* section was modified so that the trigger to utilize insulated tools is now the *Restricted Approach Boundary* (as opposed to the *Limited Approach Boundary as with the 2012 revision*).

PPE Category 0

Category 0 PPE (formerly HRC 0) is no longer listed in the PPE Tables. Because users only consult the *Arc Flash PPE Categories* Table when they require Arc Flash PPE, any PPE listed in the table would have to be Arc Resistant. The former Category 0 was not actually Arc Resistant -- the cotton could ignite, it simply didn't melt. Eliminating Category 0 ensures that personnel who are at risk of encountering an arc flash will be dressed in materials that are Arc Resistant, which Category 0 never was.

One common complaint that people have with the elimination of Category 0 is that personnel will see it as a green light to begin wearing meltable fabrics when working with electrical applications. I would point out that a facility's Electrical Safety Program can require personnel to wear more conservative attire by making it part of their Electrical Safety Program, and site-specific policies. Furthermore, there are numerous references to the prohibition of wearing meltable fabrics as or with PPE.

Thermography

The task of performing infrared thermography outside the *Restricted Approach Boundary* does not require the use of Arc Flash PPE as long as the equipment is properly installed, properly maintained, covers secured, with no impending failure. This will make performing IR scans far more comfortable and easier for those who do not yet have IR windows to make the task safer and more efficient.

However, there are two important points to be made:

(1) If for any reason, the equipment condition is suspect (not properly installed, or not properly maintained, or covers not secured, or evidence of impending failure) the thermographer would need to wear appropriate arc flash PPE.

(2) The workers who are opening the hinged doors or removing bolted panels to expose the conductors for the thermographer's inspection are engaged in an inherently high-risk task -- one that could trigger an arc flash event. Therefore, the workers who are opening the equipment will still need to wear PPE appropriate to their potential exposure.

Barricades

A clarification was also made so that barricades are placed at the distance defined by the *Limited Approach Boundary* or the *Arc Flash Boundary*, whichever is greater.

Safety-Related Maintenance Requirements

NFPA 70E-2015 and CSA Z462-2015 consistently bolsters references to maintenance, and continued to drive home the importance of properly maintaining electrical equipment as an integral aspect of electrical safety. As we saw earlier, the Electrical Safety Program must now give consideration to equipment maintenance; and, for the first time, users of the tables are required to consider equipment condition as part of their Arc Flash Risk Assessment. Maintenance is truly taking center stage the 2015 revision.

Article 200: Safety-Related Maintenance Requirements continues that emphasis. A new Informational Note refers readers to the IEEE 3007.2-2010 *Recommended Practice for Maintenance of Industrial and Commercial Power Systems*. Then under *General Maintenance Requirements*, it makes the point that the equipment owner or it's representative are responsible for maintenance of their electrical equipment.

A new Informational Note was also added to suggest a system of labels to indicate calibration, condition and inspection status -- again, providing the worker with critical information about condition and maintenance.

Finally, an Informational Note was also added to point out that improper maintenance of protective devices can result in increased clearing times, which thereby results in higher incident energy.

Conclusion

This latest revision contains several changes that are significant advancements for safeguarding workers who may encounter electrical hazards on the job. The committees should be applauded.

There is no substitute for studying the standard in its entirety. This summary was not an all-inclusive detailing of the standard. The author strongly encourages anyone who works with electricity or who manages those who do, to purchase and study this important, life-saving standard.

> *"Without an EPM (Electrical Preventive Maintenance Program), management assumes a greatly increased risk of serious electrical failure and its consequences."*
>
> *NFPA 70B: 4.1.3*

> *"Infrared inspections of electrical systems are beneficial to reduce the number of costly and catastrophic equipment failures and unscheduled plant shutdowns."*
>
> *NFPA 70B: 11.17.1*

> *"Routine infrared inspections of energized electrical systems should be performed annually prior to shutdown. More frequent infrared inspections, for example, quarterly or semi-annually, should be performed where warranted by loss experience, installation of new electrical equipment, or changes in environmental, operational or load conditions."*
>
> *NFPA 70B: 11.17.5*

Q: Why did the insurance industry mandate annual infrared electrical inspections?

A: The mandate for annual IR inspections is taken from a standard which the insurance industry ask for -- NFPA 70B: Recommended Practice for Electrical Equipment Maintenance.

The adoption of NFPA 70: National Electric Code (or "NEC") in the beginning of the 20th century gave us safer electrical design principals and safer equipment installation practices.

Fast-forward to 1967: With the problem of poor design and installation largely behind them (thanks to the NEC), insurance providers noted that *improperly maintained electrical equipment* accounted for a "high frequency" of losses in human life and industrial assets. Consequently, the insurance industry approached the NEC committee to request that preventive maintenance requirements be added to the standard. The committee instead created a sister-standard -- NFPA 70B: Recommended Practice for Electrical Equipment Maintenance.

Insurance Industry Leverages it's Standard

Most large facilities with large distributed power systems will find that their insurance provider requires annual infrared (IR) inspections of their electrical systems. This mandate is a direct result of verbiage found in NFPA 70B -- not surprising since the standard was created at the behest of the insurance industry.

OSHA Requests Electrical Safety Standard

In the 1970s, the NEC Committee created another sister-standard, NFPA 70E: Electrical Safety in the Workplace, at the request of OSHA.

While there is a significant effort to focus the content of each standard on its specific area of relevance, the three standards are very interconnected, and they do reference each other repeatedly throughout each document. For example, in addition to referencing the standards by name, NFPA 70E makes repeated reference to the requirement for equipment to be "properly installed and properly maintained," a direct reference to the NEC and 70B.

Infrared (IR) Windows Make Compliance Practical

Some requirements of NFPA 70E appear to be at odds with 70B compliance. Cumbersome PPE makes camera operation difficult at best, while many Incident Energy Analyses ("Arc Flash Surveys") result in equipment being labeled "Dangerous," and therefore inaccessible to thermographers while energized. The non-intrusive work process that IR windows provide, makes compliance with both standards easier and much more efficient.

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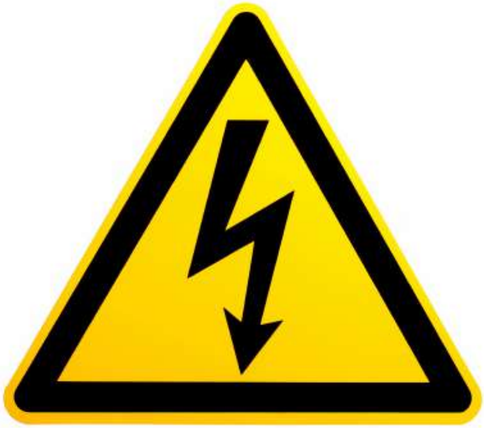
Top 10 OSHA Citations: 2014



Patrick Kapust, Deputy Director of OSHA's Directorate of Enforcement Programs announced the list of the 10 most cited OSHA violations for 2014.[1] As in 2013, three of the top ten citations were for electrically-related violations:

1.	Fall Protection	(1926.501)
2.	Hazard Communication (Chemical)	(1910.1200)
3.	Scaffolding	(1926.451)
4.	Respiratory Protection	(1910.134)
5.	Powered Industrial Trucks	(1910.178)
6.	**Lockout/Tagout**	**(1910.147)**
7.	Ladders	(1926.1053)
8.	**Electrical Wiring Methods**	**(1910.305)**
9.	Machine Guarding	(1910.212)
10.	**General Electrical Requirements**	**(1910.303)**

According to ANSI/ASSE Z10, NFPA 70E and CSA Z462, the most effective way to protect personnel (and therefore plant assets and process uptime) is through **"Hazard Elimination,"**[2,3,4] i.e. De-energize and Lockout/Tagout. Unfortunately, too many facilities are not actively enforcing this simple and foundational safety principle, as evidenced by it's #6 rank on this list.

When de-energizing is not feasible, such as when performing diagnostics like infrared or ultrasound scans, facilities should consider eliminating the high-risk task of opening the doors or panels. Closed-panel inspections using infrared (IR) windows, visual inspection windows and ultrasound ports are inherently safer, because energized conductors continue to be enclosed and guarded and in "normal operating condition." The work task reduces risk of shock and arc flash hazards to "as low as reasonably practicable." In addition to the de-risked work process being inherently safer and more efficient , it is also inherently compliant with NFPA 70E and CSA Z462 standards, and therefore compliant with OSHA and CSA directives.

For more information about electrical safety and tools that make safe electrical work practices and compliance easier or automatic, visit www.Exiscan.com.

[1] United States Department of Labor, Occupational Safety & Health Administration, "Top 10 Most Frequently Cited Standards," available at: https://www.osha.gov/Top_Ten_Standards.html
[2] American Society of Safety Engineers, ANSI/ASSE Z10-2012, *Occupational Safety and Health Management Systems*, Sec 5.1.2, p 15
[3] National Fire Protection Association, NFPA 70E-2015, *Standard for Electrical Safety in the Workplace*, Sec 110.1(G), p 16
[4] Canadian Standards Association, CSA Z462-2015, *Workplace Electrical Safety*, Sec 4.1.5.7, p 25,26

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