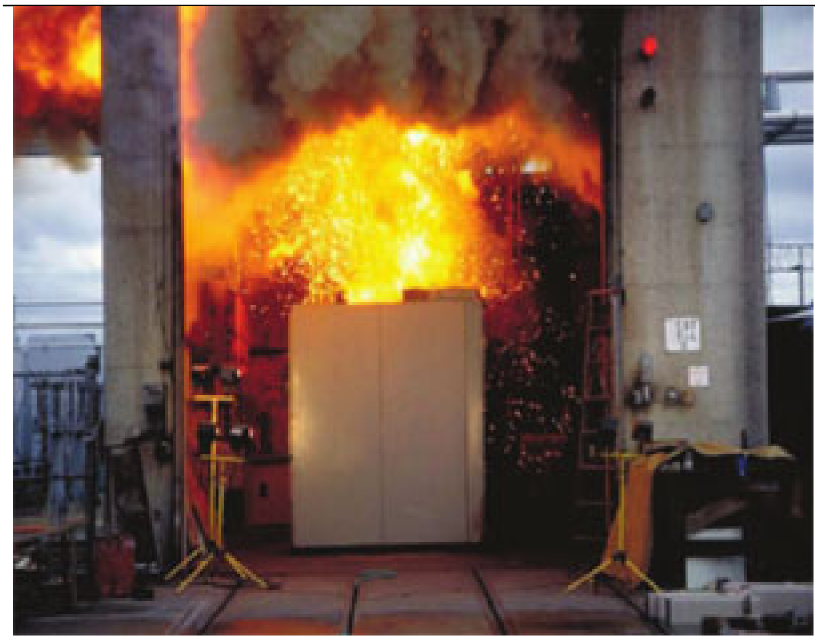
The Infrared Window Solution To Arc Flashes

This article is the second part in a two-part series on arc flash safety and infrared windows. The first part [1] was published on April 4, 2011.



Demonstration of the power of an Arc Flash. Photo courtesy of ewbengineering.

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How can infrared windows help?

An infrared window provides a solid barrier between the thermographer and the live conductors. By careful design, it is possible to not only to reduce the trigger effects of an arc but also provide the thermographer with a far safer working environment.

Thermography windows are relatively new technology, so there is no specific standard that relates to construction and testing. However, since they are invariably installed close to arc flash hazards, it is important that windows can withstand not only an arc flash incident but also the rigors of their environment and normal day-to-day operation.

In the United States, Canada and Europe, there are differing standards associated with testing equipment to be deemed “arc-resistant”, specifically: ANSI C37.30.7 (North America), EEMACS G14-1 (Canada), IEC62271 (Europe). These standards are manifestly different and cannot be translated from one to another. For example, a product tested to IEC62271 in Europe cannot be claimed to be suitable for North American ANSI C37.20.7 nor Canadian EEMACS G14-1.

End-use requirements vary considerably so testing and certification needs to be generic in order to provide an all-round product suitable for use in most if not all applications.

Manufacturers tend to design viewing panes to withstand accidental impacts from untrained personnel in transit rather than the combined pressure piling and sudden temperature increase effects of an internal electric arc.

Infrared windows, on the other hand, are constructed of crystal optic materials designed to better protect the infrared thermographer under an arc-flash condition during scheduled, periodic inspection of the internal equipment.

Inspection devices may also feature locking security covers. This ensures only a trained and authorized person can remove and complete an inspection or scan. It also protects the optic material from day-to-day impacts and offers further arc-flash protection. Properly constructed cover designs are manufactured from materials that offer substantially similar properties as the original panel wall knock-out—National Electric Code 110.12(A).

Selecting the correct material

There are numerous materials that can “transmit” infrared radiation from low cost thin film plastics used for home intruder alarm systems to germanium optics for military imaging.

Unfortunately, there are not many materials suitable for the task of permanent installation into electrical equipment due to the combined temperatures and pressure experienced during an arc-flash.

Typically, infrared windows are manufactured from a crystal optic material that allows infrared and visual inspection via the same product. This material choice, if designed and implemented correctly, can withstand an electric arc and provide a measure of protection to the thermographer.

Conversely, thin film polymers can transmit IR in certain wavelengths—although actual transmission is poor—however the polymer itself cannot withstand the temperature and pressure of an electric arc and hence could become a dangerous molten projectile.The most widely used optic material is that of crystal. A properly coated crystal optic can:

1. Maintain IR camera flexibility
2. Allow visual inspection
3. Enable corona inspection
4. Be arc-resistant

Understanding transmission

Infrared window transmission is a commonly misused term when it comes to obtaining a measurement. Since no material is 100 % transmissive, other factors come into play when attempting to correct for the apparent error. As any good thermographer knows from training:

Reflection + Absorption + Transmission = 1

A thermographer must think of the window and thermal imager as an integrated system.

A little known fact is that the spectral range of an infrared camera varies from one model to the next. This is down to the individual “Switch-on, Switch-off” parameter of the infrared detector.

For example, one longwave camera may have a working spectral response of 8.1 µm to 13.9 µm; the next unit to leave the line may operate at 7.9 µm to 13.5 µm. When this differing spectral response on the detector is mapped against an IR window product, the apparent “transmission” changes as a function of the detector/window relationship.

With a crystal window, this relationship is relatively straightforward to understand as the “route” through the optic is consistent. However, when mesh is introduced into the equation, the relationship becomes more complex still. The route through the combined polymer/mesh optic is confused and inconsistent resulting in a vignette problem (a vignette effect is known to photographers as the way a photograph fades towards its edges—often used for effect, it can be an unintentional result of the optical limitations of the camera’s lens). Even obtaining a good image consistently is a challenge when attempting to scan through mesh.

Window “Standards and codes”

An infrared window is first and foremost an industrial electrical component:

electrical design and testing parameters must be applied.

Within North America, an electrical component must be recognized by a Nationally Recognized Testing Laboratory (NRTL) in order for that component to be acceptable to OSHA. Underwriters Laboratories (UL) are probably the most widely known NRTL although there are others.

UL have standards and codes that apply to differing electrical components and infrared windows are no different. Some of the requirements are material specific whilst others are functionality based.

For example, UL746C is a material standard that must be adhered to if a product destined for use as part of electrical equipment contains polymers. If the product has no polymers used in its construction, then UL746C does not apply.

UL50, by comparison, is a functional test that is denoted by a type number and is harmonized to the NEMA environmental test. In order to obtain a simple UL50 Type 1 (Indoor) certification, a product must show that it is manufactured from components that are noncorrosive. There are no environmental tests such as hose-down or dust applied to type 1 components. If a component is designed for outdoor equipment, it will have a UL50 Type rating higher than Type 1. A typical outdoor rating is Type 3/12. To achieve Type 3/12, a component is subjected to a series of vigorous tests to ensure that the sealing system and general construction are sufficient to maintain the environmental integrity of the component when put into service outdoors.

It is not possible to derive a North American (NEMA) type rating from European (IP) rating. Terms such as “equivalent to IP65” or “self-certified” are often used by other manufacturers whose product cannot pass the more stringent North American environmental testing.

In order to be sure that an IR Window installation does not lower a panel’s environmental integrity, the original NEMA classification of the host equipment must be matched or exceeded by the NEMA/UL50 Type classification of the component. Reputable manufacturers will provide third party certification of the type rating of the component, to prove due diligence.

Arc-resistant windows

The strength of crystal infrared window optics has been increased to such an extent that they can withstand the effects of an arc fault. With the adoption of NFPA 70E and the industry’s focus on arc-flash safety, installing a product that can withstand arc-flash should be a primary concern for any end-user.

Finally, some arc flash myths

It is important to separate the truth from the myth: *“99.99 % of arc-flash events occur with the cover removed.”*

This statement is untrue: as mentioned earlier, 19 % of failures occur because of component failures with equipment during normal operation.

A simple industry pointer would be the manufacture of arc-resistant switchgear. If arc-flash events only occurred with open covers, there would be no market for arc-resistant switch-gear: it is only “arc-resistant” with the covers closed.

It is imperative that an infrared window product is designed to withstand the pressure and temperature of an arc-fault.

Conclusions

An electrical thermographer must work closely with live energized equipment and be aware of the dangers of this environment.

In addition to the obvious hazard of electrocution, workers must be particularly aware of the dangers of arc flash and arc blast events. Up to 77 % of all electrical injuries are caused by arc flash incidents. It is important to remember that NFPA 70E does not protect personnel against the effects of arc blast.

An arc flash is an explosive discharge resulting from a compromise of the insulation between two conductors or a conductor and ground. The event is characterized by its high temperature plasma and this can cause serious burns and other injuries to an unprotected worker several feet from the equipment.

NFPA 70E is the leading internationally recognized safety standard for arc flash prevention and protection. The guidelines recommend a thorough arc flash hazard analysis to establish the nature and magnitude of the hazard, calcu-late the shock and flash protection boundaries, and identify the appropriate protective clothing and personal protective equipment required for ‘Live’ work. Warning labels on the equipment must identify the hazard and summarize this information.

The use of windows can limit the exposure of a thermographer to energized equipment, reduce the hazards of both electrocution and arc flash and significantly reduce the need for bulky PPE. It is important that inspection equipment is constructed from suitable arc-resistant materials although there is currently no internationally recognized standard covering their manufacture.

For electrical inspections via a crystal window, the indicated temperature reading on the camera will almost certainly be lower than that of that target. Due to the consistent manner associated with the error, quantitative measurements are possible as long as the camera and crystal window are paired. This is generally a one-time requirement as window transmission is consistent for each model.

Conversely, a mesh/polymer optic cannot be used for quantitative inspection because of inconsistent transmission. This results from the mesh deflection angle and the differing reflectivity of the mesh material and polymer optic material. The thermographer may be able to correct for transmission in a lab using a one-time set of parameters but the poor performance of the mesh/polymer and lack of repeatability means that the this optic solution cannot be corrected for in a manner that is acceptable.

When selecting an IR Window, window or port an end-user must consider the electrical implications of the installation and insist on third party certification to back up any manufacturer claims. Potential mistakes such as installing a Type 1 component into a NEMA 4 panel could cost thousands of dollars in repairs due to leakage and equipment failure.

Finally, an optic material that may melt during an arc flash and cause contact burns could be more hazardous to a thermographer than simply having the panel open for the measurements. A true arc-tested optic should be used in order to demonstrate due diligence.

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