H.VIR COMET® Infrared Inspection Window Application Guide
Class 1910

Retain for future use.

UL Ratings

The Square D H.VIR Comet Infrared Viewing Window is an Underwriter's Laboratory Recognized Component and carries the UR (UL Recognized) label. The window has be evaluated by Underwriter's Laboratory and has been found suitable for application for types 1, 3, 3R, and 12 enclosures as would be classified either by NEMA or UL Std. 50.

Installation on MV MCC UL 347 Equipment

The Windows have UL recognition but some equipment standards such as UL347 have higher requirements than other UL Standards such as UL891 for Switchboards. A user would not be able to receive a favorable field inspection report after a UL recognized Window is placed on a UL347 motor control center. We are looking for relief in this restriction but may require years of committee activity. A user may install a window on his equipment as long as he assumes full responsibility and understand that he will be unable to receive a favorable UL Field Inspection.

NEMA Types 1, 3, 3R and 12 Ratings

The National Electrical Manufacturers Association originated the enclosure types and the associated tests to qualify the enclosure for the service intended. Later, Underwriter's Laboratory adopted these same standards and the designations are equivalent in nature and test. IR windows may be applied to NEMA Type 1, 3, 3R, and 12 enclosures.

Arc Flash (Pressure Withstand) Ratings

It is understood that the interest in the pressure withstand ability is relative to a possible event of an arcing fault within the electrical enclosure. Enclosures as defined by UL or NEMA as type 1, 3, 3R, and 12 are not required to demonstrate a degree of integrity in relation to an internal arcing fault. When such withstand ability is desired then the enclosure must conform to Arc Resistant specifications. Enclosures manufactured to Arc Resistant specifications typically have pressure relief devices installed to control the internal pressures to lower levels than what might exist for standard NEMA UL Type 1, 3, 3R, and 12. During tests to qualify Arc Resistant enclosures, it is common to record internal pressures. These pressures may range from 15 to 38 psig as a function of the short circuit current rating, size of the enclosure and the design and location of the pressure relief devices. Internal pressures for standard NEMA/UL Type 1, 3, 3R, and 12 enclosures are likely to be higher and are generally unknown. It is estimated that the pressures of these kinds of enclosures cannot be much over 50 psi because typical enclosures start blowing apart with doors opening and panels blowing off.

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For Arc Resistant enclosure application, we believe a number between 20 and 40 psi would be adequate for such applications. The H.VIR Infrared Window is successfully tested to 101 psi pressure withstand with the cover removed (open) and 1160 psi with the cover in place (closed). Also, the H.VIR has been tested per ANSI C37.20.7 and IEC 62271-200, specifically with Square D Motorpact arc-resistant switchgear, with arc flash testing at 25 kA for 1 second and 50 kA for 0.25 second. A general arc fault test has successfully passed at 63kA inside switchgear.

Emissivity

Emissivity is derived from the word Emission – "the act of sending out or that which is sent out." Emissivity is the relative power of a surface to emit heat by radiation: the ratio of the radiant energy emitted by a surface to that emitted by a blackbody at the same temperature. According to Thermographers, this is the most difficult parameter to deal with because it has a significant impact upon the apparent temperatures being measured. Thermographers say that Emissivity has more of an effect on the apparent temperature than the Transmissibility of the H.VIR IR Window.

Transmissibility

Transmissibility is the capability of being transmitted. We have used this term frequently relative to the IR Window. Some feel this may not be a correct term. Others have used the term "Transmission". Another term that might be employed would be "transferability", but this word is not recognized in some dictionaries. What we are talking about is the capability of a window to pass radiant information, considering some degree of attenuation or modification of that radiant energy as it passes through the window. We have represented the transmissibility in terms of the ratio of the apparent temperature as would be measured with and without the window being in the path of the radiation. This factor can then be applied to apparent readings making appropriate corrections to that which might be read without a window. As example, a window may have a transmissibility of 94%. When measuring the temperature of a "Black Body Radiator" one would divide the reading by .94 and achieve a corrected temperature of the object measured. If we would read 85.0 degrees the actual temperature would be 85.0 / 0.94 or 90.4 degrees.

Most infrared cameras in the field, and almost all newer ones, are of the long wave type. Transmission values in the long wave range are 7-13 μm (microns). For the temperature range concerned in thermal scanning of electrical equipment (30-60˚C), the majority of energy emission is in the 10-13 μm range. Many infrared windows on the market utilize a short-wave material, which absorbs more energy than one using a long-wave material, significantly affecting the temperature measurement values. Low transmission will reduce contrast and temperature precision, making it difficult to detect a problem. The short-wave materials on the market typically have minimal to no transmissibility above 10 μm. The H.VIR window utilizes a long-wave crystal, with transmissibility from .3-13 μm.

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If a thermographer does not properly calibrate their camera to compensate for transmission attenuation the results could be catastrophic misdiagnosis. But what if the thermographer does not know the transmission rate of the IR window? What if the transmission rate is variable or changing? Thermographers and anyone associated with or managing an electrical preventive maintenance program need to fully understand how this issue could affect their program if not controlled and compensated for.

Questions Concerning the Placement of IR Windows In Electrical Equipment

There are many questions concerning what electrical equipment and where windows should be placed for proper inspections by thermography. Any electrical equipment carrying currents above 10 amperes having a significant economic and safety impact on a facility should consider thermographic inspections. Specific electrical apparatus has been know to deteriorate in time and maybe attributed to thermal problems. The list provided below is not intended to be complete or comprehensive but represents items that commonly have thermal problems.

1. Wire and cable connections.
2. Bolted bus joints
3. Bolted component parts of electrical equipment.
4. Fuses and fuse clips
5. Switching devices including contactor & circuit breaker contacts
6. Draw-out device primary contacts and connections.

There are practical limitations to specifically what can be inspected by thermographic means. Practically, one can only measure that which can be visually seen by opening doors, compartments and removing accessible panels. The H.VIR Infrared Window simply eliminates the need to open the door or removing the panel. By being able to perform thermographic inspections with doors and panels closed offers several advantages. First, the thermal operational conditions are not disturbed. The process of opening door and panels significantly changes the airflow patterns and by the time thermographic inspections can be made, the operational "as found" temperature may have significantly changed. Secondly, the process of opening and the open doors and panels exposes the workmen to the hazards of the electrical energy. Thirdly, it eliminates the process of opening doors and panels and increases speed of capturing infrared images, thus offering significant economic advantages. On can simply walk up to the equipment open a protective shield and do the inspection.

For practical purposes, only those items that can be visually seen when the doors or panels are opened can be evaluated by thermographic inspection. There are many connections and components that typically cannot be seen while the equipment is in operation even with doors and panels open. Often times, however, there are portions of electrical conductors that are visible that are directly connected to components of interest that are not visible. The inspection of visible components can lead to conclusions concerning components that cannot be seen. In some instances barriers are used within electrical equipment for various reasons and should not be removed or compromised in any way in an effort to view operating equipment.

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One simply has to forego the desire to thermographically inspect some areas because the risk of making an area available for the inspection out weighs the value of the inspection. There have been suggestions to use radiant energy mirrors to reflect radiation for invisible areas to areas where measurements can be made. This is an extremely difficult application. The installer of the mirrors must have intimate knowledge of the development of the product so as to not affect such things as dielectric strength of the insulation systems, the airflow for cooling purposes, and gas flow for short circuit ratings. Due to the cost of the application of radiant energy mirrors, this technique is discouraged. As an alternate method, consider wireless temperature monitoring.

Dry and Power Cast Type Power Transformers

Typically high voltage and primary tap connections are located on one side of a power transformer. Two or three windows are suggested so that all high voltage power and tap connections can be viewed form the side of the transformer. Secondary windings are typically welded to secondary bus at the top of the core and coil unit. Since they are typically welded, a loose or over heated connection would be extremely rare and the inspection of these connections are not recommended. They may be evaluated if the installation is particularly critical. The secondary (low voltage) connections are typically made by bolted connections at one end of the transformer. Typically one or perhaps two IR windows are suggested to view multiple bus connections. Coil units are typically monitored by automatic temperature measuring equipment for possible fan cooling and alarm circuits and need no further attention by means of the IR Window.

Low Voltage Switchgear Equipment

Low Voltage Switchgear Equipment manufactured under ANSI / IEEE C37.20.1 offers a number of challenges to thermographic inspection due to its compact designs and compartmentalization. The front portion of the switchgear generally contains Draw-out Circuit breakers. Typically, from the front looking back, there are doors, panels, breaker mechanisms, insulating barriers before one gets to current carrying components such as the main electrical contacts. Thus is it not possible to evaluate a power circuit breaker by means of thermographic methods. Also of significant interest is the primary disconnect connections at the rear of the breaker. Since the disconnects are behind the breaker they cannot be seen. Thus, it is largely impractical to attempt the application of thermo-graphic inspections for low voltage switchgear circuit breakers. On occasion there will be auxiliary power equipment that might be mounted in circuit breaker compartments and, if the power equip-ment can be inspected from the front of the equipment, then by all means an IR window should be used. In general, it is usually impractical to mount IR windows on the front side of Low Voltage switchgear.

Considering the backside of Low Voltage Switchgear, the rear-most compartment is usually dedicated to cable and bus connections. Depending upon the size and complexity of the equipment, up to four windows might be required per vertical section to view all of the visible connections.

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A hot connection in cable connection area may lead to an investigation to a breaker problem in the front of the equipment.

Vertical and horizontal interconnecting bus is usually located between the breaker compartment and the areas reserved for cable or out going bus connections. In some cases specifications call for barriers between the vertical /horizontal interconnecting bus and the cable compartment. With out barriers, the vertical/ horizontal bus is difficult to see considering distance, compactness, and obstructions with cables. For the case where barriers are specified, inspections are impractical. In cases where barriers are not used, some portions of the bus may be visible. When applying up to four IR windows for observing outgoing cable or bus connections, the placement of these windows should be such so as to see as much of the vertical and horizontal bus as practical. It is possible in some cases to move and dress cables to provide a better view. In summary, thermographic inspections are effective for cable and bus connections that can be seen from the backside of the equipment.

Low Voltage Switchboards

As a general rule, Low Voltage Switchboards are not nearly as compact nor as heavily compartmentalized as is Switchgear. Thus, there is more opportunity for the placement of IR windows to view electrical conductors under operation. The use of some main circuit breakers offers the same challenges as switchgear. In many cases large fused switches are used as mains and ties. When large fused switches are used there is an opportunity for thermograph inspections in the front of the equipment. Switches typically employ barriers and it is a challenge to locate an IR window to see as much of the switch and fuse assemblies as possible. Two windows may need to be installed to insure good visibility.

In many cases Switchboards will use multiple molded circuit breakers as feeder devices. It would be of interest to view the load cable connections at each breaker. The arrangement of the breakers and connections are very close to the front cover. At least one window per breaker would be required. In some cases for large breakers, at least two windows per breaker would be required due to the short distances involved. Also, one must check to see that the UL electrical clearances are not violated by the mounting hardware and that any existing barriers are not violated. The number of windows required to inspect all molded case circuit breakers tends to be high and may become an economic burden for the value achieved.

Switchboards also use fused Switches in individual compartments for feeder circuits. In many cases the backside of the hinged covers have instruction labels and or barriers. In some instances fuses are mounted very close to the front cover and the cover is equipped with a fuse pressure relief device. The design of many of these fused switch devices prohibits the use of a window. It is also possible to open the fuse compartment doors while the fused switch is energized. Given the small size of these compartments, exposure to hazards is limited. These general design considera-tions limit the usefulness of the window.

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As with Switchgear the backside of Switchboards contain many buss and cable connections. In this case space is a little more generous and easier to utilize the benefits of the IR window and thermographic inspections. Again, up to four IR windows per vertical section might be required to view all of the important connections. In some cases, the backside of main breakers are in clear view and the thermographic inspections are very effective.

Metal Clad Switchgear

Metal Clad switchgear by design in accordance with C37.20.2 is extremely compartmentalized with all bus and connections insulated. Thermographic inspections are thus extremely limited by the nature of the design of the equipment. There are variations in equipment designs that may permit more or less opportunities. (In general, however, the front breaker compartments are much like the low voltage switchgear breaker compartments in that the conductors to view are barriered behind doors, panels, mechanisms and barriers.) Typically primary conductor disconnects are mounted on long insulated runbacks that are inserted into deep wells at the back of the breaker compartment and are not usually visible even when the front door is open and front panels are removed. Unless a particular design offers some outstanding opportunity the inspections of Metal Clad breakers and their compartments are not practically achieved. A Wireless Temperature Monitoring System may be a better alternative.

Other equipment that might be available for inspections would be draw-out Voltage Transformer truck. In some cases, windows might be applied through the front of the draw-out truck and may or may not require a compartment door to be opened to perform the inspection. The same would be true for Control Power Transformer compartments. For Voltage Transformers, the current levels are very small and loads are non-existent; it is unreasonable to install a window for this purpose. The power delivered from Control Power Transformers compartments can be significant and might justify a thermographic inspection. Primary fuses and fuse mounting to Control Power Transformers is good subject for inspection.

Considering the backside of the Metal Clad equipment, each compartment might have cable or bus connections. In most cases only one window would be required for single high equipment and two windows would be required for two high equipment. Generally the distance to components in the cable / bus compartments is great enough that low numbers of widows is required. In some instances there may be circumstances where a higher number of windows might be required to see unusual configurations. Conductors within Metal Clad equipment are always fully insulated and apparent temperature measurements will be much lower than actually exist at the internal connection.

Metal Clad switchgear also has horizontal cross bus located in the center of the equipment housed in metal barriers. It is impractical to attempt to try to view the cross bus and its connections. It is possible in many instances to install a window at the ends of the line-ups of Metal Clad Switchgear. A limited amount of inspection can be performed from the ends of the switchgear.

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High Voltage Interrupter Switchgear

The design of this equipment is such that nearly all important electrical components can be effectively viewed with a minimum number of windows. In many cases, they need only be viewed from one side. Two windows placed at the top of the fuse door will provide visibility for line and load side of the switch and the top fuse clip. A second set of two can be installed at the bottom of the fuse door to view the bottom fuse clips and out going cable connections. As an alternate, just two windows could be utilized with one centered on the interphase barrier between A & B phases and the other centered on the interphase barrier between B & C phases and centered vertically at about the center line of the fuses. A single window at the top of the switch can view the horizontal bus if so equipped. If runback bus and cable connections are located in the rear then a single window (centered on B phase and at about the same height as the lug landings) can be provided in the back to view each group of rear cable connections. It would be rare to need more than one window in the back of Load Interrupter Switchgear equipment.

For HVLcc equipment only one Window is needed at the top of the switch and one at the bottom. For an upright configured fused HVLcc switch the top window would be installed inside the low voltage control compartment to view switch connections to the bus and the one at the bottom would view both the line and load side fuse connections. Since the power poles of a HVLcc switch are arranged front to back, the windows need to be mounted to one side so as to view each of the three phases. The contacts of the HVLcc switch cannot be viewed for thermographic inspections because the switch is sealed within a gas chamber. The fixed terminals of the switch can be viewed from the top and bottom; an increase in temperature within the bottle will be quickly transferred to the top and bottom switch terminals and will be quite visible.

Medium Voltage Motor Starters

Motor starters vary significantly in design form manufacturer to manufacturer, model to model and among sizes. For the current production Square D Iso Flex starter, the 200 A starter would require two windows, one in the top section to view motor connections and one centrally located to view switch, fuse, and contactor connection. The 720 A starter would require six windows, one at the top to view the top part of the switch, two at the bottom of the switch to view the bottom of the switch and the top fuse connections, two at the bottom to view the bottom fuse connections and the contactor connections, and finally one in the motor connection area. If the starter were provided with a horizontal buss then two additional windows would be required in each bus compartment. With the above configuration, there are still some areas that would not be visible. Because of the present wording of UL Standard 347, it is not possible to achieve a favorable UL field inspection after an IR Window is installed.

Vacuum Interrupter Bottles

Due to the nature of the material use in the envelopes of Vacuum Interrupters, it is not possible to measure the temperature of the Vacuum Interrupter contacts. The contacts are an integral part of the conductors that extend to the top and bottom of the interrupter

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and measurements made of the ends would be a fair indication of the temperatures within the interrupter. Also it should be appreciated that there are no imposed limits on the temperature rise for the contact materials in Vacuum Interrupters because there is no oxygen or other gases to combine with the metals within the vacuum. The only temperature limitation for a vacuum interrupter is the melting point for the metals involved and the 105 degree C limit on the bolted connection to the external terminals. So the only important point of concern is the bolted electrical connection to the interrupter. These connections can be inspected quite effectively by thermographic inspections provided the equipment in which the Vacuum Interrupter is mounted is such that it presents the interrupter in view of the window and thermographic camera. For Square D VisiVac equipment, the whole Interrupter is presented in clear view, thus there are no problems. In the case of Metal Clad Switchgear, it is not possible to view any part of the interrupter or the conductor to which it is connected. For the Medium Voltage motor starter, some parts that are connected to the interrupter are visible but the interrupter itself is not visible.

Motor Cable Connection Boxes

Motor cable connection boxes are an ideal candidate for thermographic inspection. Motor connections are prone to loosen due to mechanical vibration. It is unlikely that the crystal window would be damaged by vibration due to the method of mounting. In some environmental conditions the protective shield could be abused and damaged. Either the shield or the entire window can be replaced in the event the window becomes damaged. The window may need to be removed and cleaned both internally and externally for best results. At this point in time, available windows are not suited for motors listed for Hazardous Locations per NEC Article 500 through 505**.**

WARNING: No one shall modify a motor terminal box for a Square D H.VIR window without determining the classification of the location and the rating of the motor with respect to NEC 500 through 505.

NEC 500 through 505 cover the requirements for electrical and electronic equipment and wiring for all voltages in locations where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust or ignitable fibers or flyings. When Square D modifies a motor connection box a written release is required with a statement that the motor is neither rated for hazardous areas nor is installed within a Hazardous area. Motor terminal boxes for motors not rated for hazardous locations and not located within hazardous areas may be modified.

Motor Starters, Distribution Panels and Other Equipment Rated or Installed in Hazardous (Classified) Locations

Contact Square D Services for applications for installation in electrical equipment located within Hazardous (Classified) Locations or on equipment so rated.

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