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Electrical equipment in cold weather applications

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Abstract

Electrical equipment used in cold weather regions are subjected to different environmental conditions than covered by most standard approvals. There are two main areas of concern for products used in cold weather—safety and function. For Class I locations, the ability of the equipment to maintain its explosion-protection properties at low temperatures is of major importance. Low temperatures affect both the properties of the materials used in the construction of the electrical equipment and the properties of the explosive atmospheres to which the equipment can be exposed. Functionality of the electrical equipment can also be altered or negatively affected by cold temperatures. This paper will examine factors affecting the safety of equipment in areas classified for explosive atmospheres as well as the functionality of electrical equipment at low temperatures.

Introduction

A large amount of the world's oil and gas reserves and processing and distribution facilities are found in locations that can experience extremely low temperatures. Low temperatures referred to throughout this paper are considered to be those occurring naturally due to weather. This paper does not discuss extremely low cryogenic temperatures.

Average temperatures during winter months will often be within the normal operating ranges of much electrical equipment. There may, however, exist prolonged periods of extreme cold that fall outside of the standard temperature ranges of commonly used electrical equipment not specifically designed for low temperature environments. In some areas, temperatures as low as –50°C can occur on a regular basis, with temperatures lower than –50°C occurring on occasion, but usually for short periods of time. Temperatures can also fluctuate fairly quickly and vary from 10°C to 30°C in a single day.

In these extreme cold environments, two main characteristics of electrical equipment may be impaired—safety and functionality. Safety is a primary concern for equipment being used in atmospheres potentially containing explosive gases or vapors.

There are two primary approaches to classifying areas containing explosive atmospheres used throughout the world. In the U.S. and existing facilities in Canada and other locations, areas potentially containing explosive gas atmospheres may be classified per the Division system as Class I Division 1 or 2. In the remainder of the world, new installations or reclassified areas in Canada, and optionally installations in the U.S., areas may be classified per the Zone system as Zone 0, Zone 1, or Zone 2. Regardless of the area's classification per the Division or the Zone system, the requirements for the design and installation of equipment is geared toward providing a safe installation for the conditions that are likely to occur.

Low temperatures can affect both the effectiveness of the electrical products being installed and their ability to withstand potential gas explosions. This can pose problems for the installation and use of electrical equipment in these locations. Studies have shown that the pressure produced by igniting explosive gases at low temperatures is greater than at higher temperatures [1]. **Figure 1** illustrates increased pressure testing required for Ex d (flameproof enclosures). As indicated, the pressure test requirements rise significantly with decreasing ambient temperatures. In addition, depending on the material used, the enclosures themselves may lose strength and become more brittle at lower temperatures. Depending on the standards to which the equipment is approved and tested, there could be potential problems because explosion-proof/flameproof enclosures may no longer be suitable for containing the internal explosions.

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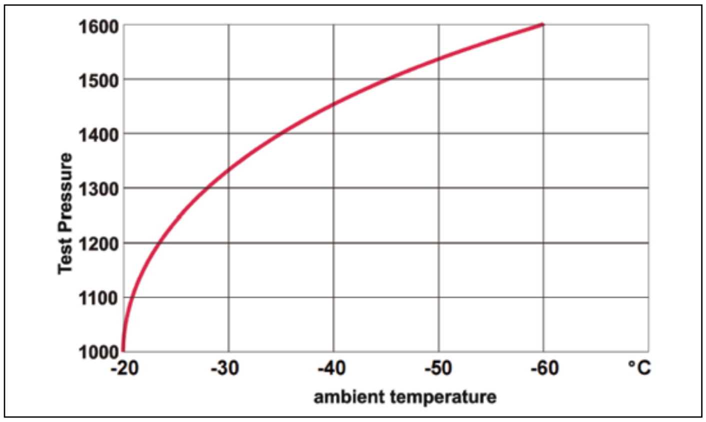

Figure 1. Increase of Test Pressure (kPa) for Ex d Enclosures at Low Ambient Temperatures

In addition to the safety of the equipment, its functionality is of major importance. Equipment may be made safe for use in hazardous locations by its construction; however, if it is not functional, it is of little use and could affect safety not related to explosive atmospheres. An explosion-proof enclosure that is certified as safe for use in ambient temperatures as low as –50°C may contain circuit breakers, switches, relays, and other electrical devices. If these devices are only rated to –25°C, then the overall equipment, while safe from an explosion protection viewpoint at –50°C, would only be suitable for –25°C ambient unless the internal temperature of the enclosure can be raised through the heat generated by internal devices or by a heater.

Standards

IEC hazardous location standards

IEC 60079-0 requires equipment for use in potentially explosive atmospheres to be suitable for use in an ambient temperature range of –20°C to +40°C, unless otherwise indicated in the approval certificate or on the product. IEC 60079-0 and other IEC 60079 series standards specify additional test requirements for temperatures outside of this normal ambient temperature range. This needs to be indicated in the certificate and on the product for products suitable/approved for use in ambient temperatures lower than –20°C. The product needs to be marked with T_{amb} or T_a and the special ambient temperature range, or with the symbol X indicating special conditions of use so that the installer knows to check the certificate and/or manufacturer's instructions.

It has been recognized within the IEC TC31 that in environments in which extreme cold conditions can exist, products need to be able to withstand adverse conditions caused by cold weather. To examine this, a working group, IEC TC31 WG39, was formed to look at requirements for equipment in adverse environments. Because this working group was only formed recently, no documentation has been published at the present time. However, draft documentation is being reviewed. In addition, there is also work being carried out to address installations in low temperatures.

NEC and CEC hazardous location standards

The ambient temperatures in the scopes of Canadian and U.S. adoptions of the 60079 series standards are the same as those in the IEC 60079 series, e.g., the normal minimum ambient temperature is –20°C. For CEC and NEC standards used for the approval of equipment per the Division system, e.g., Class I Groups A, B, C, D and Class II Groups E, F, G both Division 1 and Division 2. The scopes of both CEC and NEC standards vary in the required minimum ambient temperature levels and often are not part of the scope of the standard, but instead are specified by the manufacturer for testing and marking. For example, temperature ratings for process seals between electrical systems and flammable or combustible process fluids are specified by the manufacturer, and tests conducted on them are based on that temperature range [2]. Some standards specify minimum ambient temperatures within the scope of the standards. Explosion-proof equipment standards in the U.S. (UL® 1203) and Canada (CSA® C22.2 No. 30), for example, both specify a minimum ambient temperature of –50°C. Products constructed to these standards are generally required to withstand a four times maximum pressure test as part of their approval. This provides a large margin of safety for the equipment that will mitigate the change in explosive properties of gases at low temperatures and the possible effects of low temperatures on the integrity of the explosion-proof enclosures. This minimum ambient temperature is generally for the explosion-proof enclosure only, and does not take into account the functionality of equipment that may be installed in the enclosure. If, for example, you were to have an explosion-proof enclosure housing a circuit breaker, the housing would be required to provide protection against igniting an explosive atmosphere down to –50°C, but the switch inside may only be suitable to an ambient temperature of –25°C. Therefore, the overall assembly would only be suitable for use in a minimum ambient temperature of –25°C due to functionality, not safety. To improve on this low ambient temperature level, if allowed, a heater could be installed in the enclosure to elevate the temperature above the –25°C minimum.

Effects of cold weather on material and electrical equipment

General

Low temperatures can change the properties of the materials used in the construction of electrical equipment, making them unsafe or unsuitable for use. Additionally, changes to installation and operational methods may be necessary to mitigate the effects of low temperatures. While this paper primarily discusses only the effects of low temperatures on equipment, there are other conditions in cold weather regions such as low humidity, wind, and snow and ice formation that can also have an effect on electrical equipment. It is important to follow manufacturers' instructions and local electrical code requirements. Manufacturers will often provide important information on suitability and safe use of their equipment in low ambient conditions with their instructions on operation and maintenance manuals.

Materials

Metals

Metals can lose ductility and become more brittle in very low temperatures, affecting their ability to withstand impact and explosive pressures sufficiently enough to provide protection. Embrittlement is more prevalent in some materials than others. The crystal lattice structure of the metal is a strong determinate of the effects of temperatures on the ductility of metals. As shown in **Figure 2**, there are three primary crystal structures for metals—body centered cubic (BCC), face centered cubic (FCC) and hexagonal close packed (HCP). The most commonly used industrial metals have BCC and FCC lattice structures. Metals with a crystal lattice structure of the BCC type are generally more susceptible to loss of ductility from lower temperatures than other lattice types.

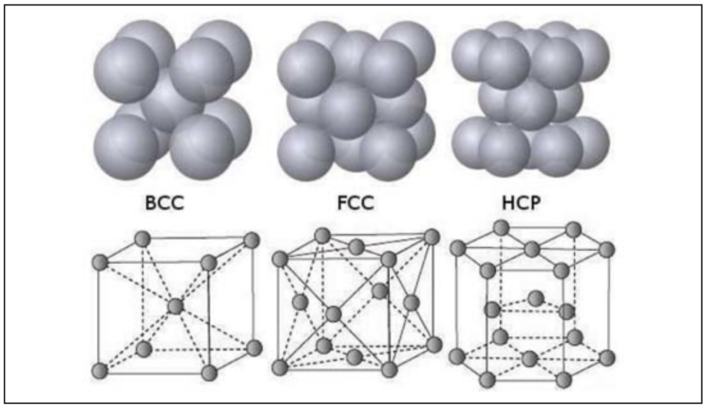

Figure 2. BCC, FCC, HCP Crystal Lattice Structures

Figure 3 illustrates the transition from ductile state to brittle state for BCC metals. While there are a number of factors that determine energy absorbed vs. temperature curve that illustrates the ductile to brittle transition, BCC metals generally follow the same transition form shown in **Figure 3**. The impact energy illustrated is normally derived from a Charpy impact test [3] that determines the energy absorbed in the fracture of a test piece. The change from a ductile to a brittle state is caused by the reduction of the movement of dislocations as the temperature decreases. Movement of dislocations enables plastic deformation. As the temperature decreases, this movement can decrease, as in the case of metals having a BCC lattice structure. The metal will become brittle when the temperature drops below the ductile-brittle transition (DBTT) temperature, e.g., the temperature at which the energy absorbed in testing is considered to be at the point where the metal changes from the ductile state to the brittle state. FCC lattice structures, on the other hand, have more slip systems for deformations to move along, and temperature has a lesser effect. As the temperature decreases, the impact energy absorbed in metals with an FCC lattice will generally have relatively flat curves and there will be little difference in the ductility as temperatures move lower, as illustrated in **Figure 3**.

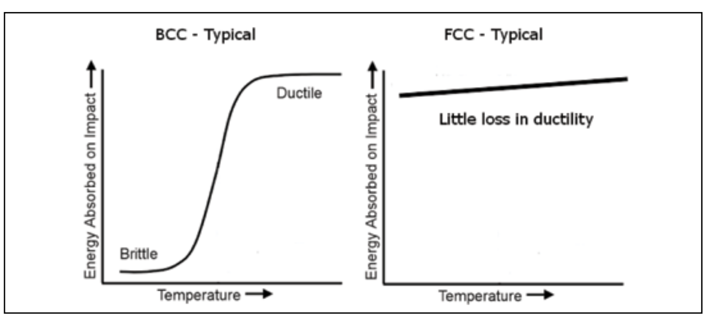

Figure 3. Ductile-Brittle Transition

Carbon steels have a BCC lattice structure and can be greatly affected by low temperatures with a fairly quick transition from ductile to brittle. Aluminum alloys, on the other hand, have FCC lattice structures and are only minimally affected by low ambient temperatures that would normally exist in cold weather environments. For the majority of the metals used for electrical enclosures and fittings, low temperatures would only have a negligible effect on their ductility. Care needs to be taken in selecting fasteners, mounting structures, terminal and equipment housings, and other parts that may be made of materials more susceptible to low temperature embrittlement. Materials used for components installed within enclosures may be negatively affected by low temperatures. Although materials are protected from impact by the enclosure they are housed in, if made brittle by the low temperatures, they could possibly fracture due to vibration, expansion/contraction, or other stresses.

Solder can also pose a problem. Standard lead-tin solder can have a fairly high ductile-brittle transition temperature (DBTT) and certain non-lead solders can also experience DBTT at relatively high temperatures [4]. Manufacturers producing products that use solders should ensure that the solder used is suitable for the operating temperature conditions. The solder used in field installations must be suitable for potential low ambient conditions.

Differential expansion and contraction is a potential concern with both metals and non-metals. Different materials have different coefficients of expansion. While the differential expansion and contraction of different metals is normally taken into account in the design of equipment, alloys and other materials can potentially cause problems. For explosion-proof and flameproof equipment where mating parts are of different materials, the minimum flame path gap requirements must be held at both the high and low ends of the ambient temperature range. If tolerances are tight on flameproof joints, differential expansion/contraction could bring that joint out of tolerance at low temperatures. For non-hazardous equipment, problems can also exist from differential expansions. This is especially true with electronics where differential expansion and contraction can potentially cause electronics to fail if not taken into account.

Plastics

Plastics can be affected by cold temperatures and become more brittle, much the same as certain metals. For some plastics, the temperature at which this occurs can be fairly high, with some becoming brittle around 0°C. For some plastics, the transition from ductile to brittle follows the same general form as that of BCC metals shown in **Figure 3** and moves through a ductile to brittle transition temperature or glass transition temperature where the plastic moves from a plastic state to a glass-like state. Most plastics used in electrical equipment have a composition that is designed to provide a certain degree of strength at low temperatures. This should always be verified with the manufacturer, though, as some plastics used could be very brittle at lower temperatures if the temperature goes below the glass transition temperature / ductile brittle transition temperature for the plastic. For plastics, the loss of ductility can be more gradual than that of metals [5].

Another potential issue with plastics is the potential buildup of static charges on plastic surfaces in cold weather regions due to lower humidity. An increased possibility of static charge can cause potential explosion hazards in explosive gas environments and potential problems with electronics and other electrical equipment. Additionally, static can cause devices such as analog meters with plastic faces to give incorrect or erratic readings and can also affect the operation of sensitive electronic devices.

Elastomers

Elastomers and rubber components can become increasingly stiff and less flexible at low temperatures. Loss of flexibility can lead to problems such as inadequate sealing on enclosures and loss of tightness and grip on glands. In hazardous locations, for enclosures relying on adequate IP protection as part of their explosion protection, inadequate sealing caused by loss of flexibility of gaskets can impair the explosion protection properties of the product. For explosion-proof enclosures, a gasket is sometimes used to provide protection against the ingress of water in conjunction with a flameproof joint acting as a flame path. If this gasket were to become inflexible and stiff at low temperatures, it may prevent the proper closing of a cover and the flameproof joint gap may not be sufficient to act as a flame path.

In the design of equipment such as enclosures or cable glands, a limiting factor with regards to low ambient temperature use is the elastomers used in construction, such as the enclosure gasket or the gland bushings. Manufacturers will often offer alternate constructions to allow for products to be used in lower temperatures, such as substituting a silicon gasket for a neoprene one. When specifying, purchasing, or installing a product that uses a gasket, bushing, or similar material, verify with the manufacturer that the product being used is constructed for low ambient temperatures.

Lubricants

Lubricants used in equipment are frequently a limiting factor in the suitability of equipment for low temperatures. Unless specifically formulated for low temperatures, lubricants can freeze and cause equipment to malfunction. In instances where it is required to use a lubricant, follow the manufacturer’s instructions and ensure that the lubricant being used is suitable for the low temperatures that may exist.

Equipment

Wire and cable

Insulation on wire and cable can harden and become brittle as the ambient temperature decreases. Damage to cables can occur when attempting to install the cables at low temperatures. In general, it is recommended that cables be installed in temperatures that are equal to or greater than their certified cold bend temperature plus 15°C. Additionally, it is generally recommended that cables be stored at temperatures over 10°C for one day before installing in a cold atmosphere. Care also needs to be taken during installation not to impact, drop, or sharply bend the cable, and the cable should be pulled slowly and trained the same day that is taken from warm storage.

Cable and conduit seals

Cable and conduit seals can cause problems with installations at low temperatures. Seals would not normally be installed in very cold weather, however, even temperatures at or slightly above the freezing point of water will cause problems and will not allow the proper installation of seals. The installed seal itself is normally approved for ambient temperatures at –50°C or lower; however, the seal itself must normally be poured and allowed to set at temperatures elevated a number of degrees above 0°C. The seal will not set properly and could potentially be dangerous if proper procedures are not followed. When pouring conduit seals, the fitting will often need to be preheated to an elevated temperature, and the area where the seal is being poured will need to be kept heated while pouring the seal and while the seal sets. Extreme cold weather regions, as well as many areas experiencing much milder but still cold weather, can experience temperatures lower than recommended for pouring seals throughout the year. This can make it difficult to perform installations requiring seals in all but a limited window of time when temperatures will be steadily warm throughout both day and night without having to keep the area heated.

The necessity of seals poured in the field is more of a concern within those countries installing equipment per the National Electrical Code (NEC®) or Canadian Electrical Code (CEC) for Division classified areas or with “Division style” equipment; however, seals may also be required for some IEC installations. The majority of IEC equipment as well as some traditional North American style equipment is designed in such a way that they are factory-sealed or use increased safety terminations, and field-made seals are not required. Use of factory-sealed and other products not requiring seals to be field-installed will eliminate the need to pour electrical seals, making it easier to install the equipment throughout the year.

Pushbuttons and switches

Pushbuttons can sometimes become stiff and difficult to operate in low temperatures. Often, the grease used to allow for smooth operation of pushbutton components can become extremely viscous in cold weather and can prevent proper operation. Certain greases can also absorb moisture and freeze during extreme cold periods. In explosion-proof and flameproof pushbuttons, the gap between the bearing and the shaft is a flame path joint and has close tolerances. Any foreign material or condensation can freeze within this flame path and prevent proper operation of the equipment, resulting in potentially unsafe conditions, e.g., nonoperational emergency stop device (ESD) pushbuttons. Differential expansion also needs to be taken into account if there are any different materials being used on close-fitting joints of flame paths. Generally, this is not of great concern because the materials used are usually the same or similar and have identical or near identical coefficients of expansion.

In low temperatures where it is likely that the operator would be wearing gloves or mittens, the operation of pushbuttons can be difficult unless they are oversized buttons or emergency stop mushroom-type buttons. Switches, while subject to some of the same potential problems as pushbuttons, can sometimes be easier to operate and may be better selections for low-temperature use. Whether using switches or pushbuttons, ensure that any lubricant used is rated for use at the lowest expected temperatures.

Lighting

The primary types of lighting used in industrial applications are:

- High Intensity Discharge (HID) lighting including High Pressure Sodium (HPS) and Metal Halide (MH)
- Fluorescent lighting
- Incandescent lighting
- Light Emitting Diodes (LED)
- Induction lighting

Some of these types of lighting are far better suited for cold weather use than others, and there are two aspects that need to be taken into account—starting of the luminaires at low temperatures and operating at low temperatures. Some types of lighting may operate at low temperatures, however, they may not be able to start due to limitations of their ballasts or drivers. Others may operate, but at a reduced light output level.

Incandescent lighting is suitable for both starting and operating at all low temperatures. Other than the potential of breakage from thermal shock, incandescent lighting is not affected by temperature.

HID lighting operates well at low temperatures, however, it may experience problems with starting at temperatures under –40°C or, in some cases, below –30°C.

LED lighting is also well suited for low temperatures. Due to a lower junction point temperature, LED chips function well at low temperatures and their lives and lumen/watt levels can be improved over higher temperatures. The current limiting factor for LED systems is the driver used for their operation. The commonly available and used drivers normally limit the use of LEDs to –30°C or –40°C. The LED lighting field is rapidly developing and there have been advances made for very low temperatures, bringing about the availability of drivers rated for as low as –55°C. In time, this will allow manufacturers to offer LED lighting products for very low temperature applications.

Fluorescent lighting is the least suitable for low temperatures, and would normally only be used for indoor use. For most fluorescents, light output begins to steadily decrease below 5°C and under –10°C and may only be 25 to 35 percent of light output at room temperature. At –40°C, light output would be negligible. There are lamps available that provide better output levels at low temperatures, however, even these, as illustrated in **Figure 4**, may only provide 50 percent output at –20°C and 10 percent or less at –40°C.

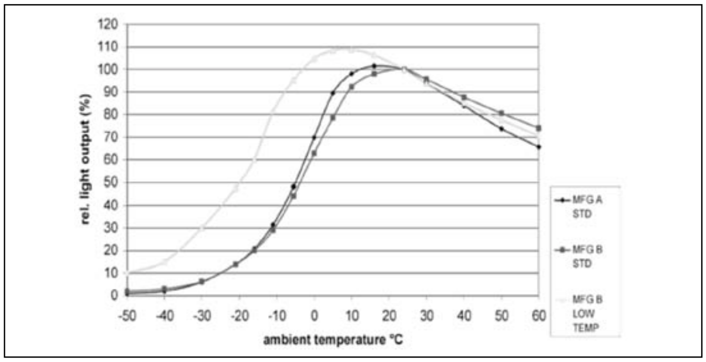

Figure 4. Relative Light Output vs. Ambient in Hazardous Location Fluorescent Luminaire with Different Lamps

Thermal-magnetic circuit breakers and panelboards

Generally, panelboards used in low temperature conditions will require the use of a controlled heater to function properly and safely at low temperatures. A heater will increase the internal ambient temperature of the panel to above the required level for the safe operation of the circuit breakers and will also help prevent the accumulation of frost in the panel during de-energized periods. In general, standard circuit breakers will not be tested or approved for very low temperatures. Even breakers specifically designed for low temperatures will, in general, be designated by manufacturers to be for use in ambient temperatures only down to –20°C or –25°C, however, there are very low temperature circuit breakers (–40°C) available. Very low temperatures will require evaluation of the materials used in construction of the circuit breaker, particularly the lubricant used. At very low temperatures, the standard grease used in the construction of the circuit breakers could freeze, preventing operation of the circuit breaker. Therefore, special low temperature rated lubricants would need to be used. For panels using standard circuit breakers, a heater and controller would be required in the enclosure housing the circuit breaker so as to bring the internal temperature above the low ambient temperature level of the circuit breaker as provided by the manufacturer [6].

For hazardous location panelboards, there are two styles that are in common usage. The traditional North American style uses a large cast explosion-proof housing for all of the panel's breakers. These panels may be supplied factory-wired and sealed back to a terminal housing, or may require direct entry to the panel housing with sealing required. The standard IEC style of panel houses is circuit breakers in their own individual flameproof housing. These flameproof breakers (Ex d type) are then housed in an increased safety enclosure (Ex e) and wired to terminals. North American standards for explosion-proof housings require them to be suitable for –50°C. The circuit breakers themselves, though, would not normally be suitable for use at –50°C, so they would be the limiting factor in the suitable ambient temperature for the complete assembly. If the desired ambient temperature is to be lower than the normal ambient temperature for the circuit breakers, a heater would be needed within the panelboard that would keep the internal temperature above the minimum ambient temperature of the circuit breakers.

Hazardous location panelboards approved to IEC 60079 series standards are required to be suitable to –20°C. For a minimum ambient different than this, whether higher or lower, a notation would be made to the certificate indicating the deviation, and the product would be marked with the alternate ambient temperature or with an X in its certificate to indicate that there are special conditions for use. As with the cast panelboards, the IEC style panels would require the use of a regulated heater to elevate the internal panel temperature above the minimum operating temperatures of breakers. As the enclosure used in this style of panel is normally an Ex e type, the heater and controller, e.g., thermostat used in it, would need to be Ex protected types and part of the panel certification.

Electronics and miscellaneous electrical device

There are several factors that can have an effect on electrical and electronic devices. For some electronic equipment, special precautions may be required for satisfactory operation at subzero temperatures [7]. As temperatures decrease, changes can occur in the resistance and capacitance resulting in timing changes on integrated circuits, waveform changes, and other electrical properties of electrical and electronic components. If not taken into account, this can have an effect on the behavior of sensitive electronic equipment.

In addition to the effects on electrical properties, the various materials used to make and mount the components can be greatly affected by differential expansion contraction and thermal cycling effects. Components need to be designed in such a way as to eliminate the risks associated with this for the desired ambient conditions. Components used will either need to be suitable for the low ambient temperature required or need to be a means of raising the temperature within the housing that they are installed.

Motors

Care needs to be taken in the selection of the materials, lubricants, and construction of motors for use in low temperature applications. Materials used must be able to withstand possible effects of temperature-related embrittlement. Fit between different component materials that may be affected by differential expansion and contraction must stay within the required tolerances when there are temperature changes. Lubricants used must be suitable for the temperatures in which the motor is to be used. As temperatures decrease, lubricants will become more viscous and some lubricants will not be suitable. Always confirm with the manufacturer that the motor is designed and tested for the low ambient temperature to which it will be subjected.

Conclusions

As exploration and development in northern regions increases, the need for equipment and installation methods geared toward these areas also increases. Both the safety of equipment and the functionality of equipment must be taken into account when developing, specifying, or installing products for installations that will be subject to low temperatures. Equipment must be suitable for installation in temperatures in which they are to be installed and must also be suitable for use in temperatures they will experience during operation. Installation in very cold temperatures is normally avoided, although it may sometimes be required. Operation of equipment is required for very low temperatures, so the equipment used must be both safe and functional at the low ambient temperature in which it is installed. Care must be taken in the selection of materials used because certain materials are not suited to be used at low temperatures. Temperature effects on electrical properties must also be taken into account. In some equipment, such as panelboards and control panels, heaters will need to be installed within the panels to elevate the temperature within the enclosures above the minimum operating temperatures of the components installed.

For areas that could potentially contain explosive atmospheres (hazardous locations), most Class I Division 1 products approved to U.S. and Canadian standards are certified for use in temperatures as low as –50°C from an explosion safety perspective. They may not, however, be suitable from a functionality perspective due to internal components not suitable for low temperatures. For this combination to function, a heater capable of increasing the internal temperature above the minimum ambient temperature is required for components to function. For equipment approved per the IEC 60079 series standards, the minimum ambient temperature is –20°C only. If this equipment is to be used in lower ambient temperatures, it should be approved and marked for the lower ambient temperature. This will sometimes require the product to be modified so that the materials used in its construction are suitable for the lower ambient temperature. IEC style products, if suitable for the low temperature ambient, often have an installation advantage over some Division style products, as the IEC products are normally factory-sealed. It is important to note that there are also a number of Division style products available that are also factory-sealed. Products requiring seals will be difficult to install in winter conditions because to pour seals, the temperature will often need to be several degrees above 0°C for an extended period of time.

In addition to following local electrical code requirements, it is very important to follow manufacturers' operating and maintenance instructions for the equipment being used. Manufacturers' instructions will often provide equipment specific instructions for suitability of the equipment. Whether for hazardous or ordinary locations, the electrical products selected must be suitable in terms of both function and safety for the ambient conditions to which they will be exposed. In the area where the equipment is installed, materials must be suitable, electrical property and functionality must meet requirements, and the installation must be carried out per the manufacturer's instructions and the area's electrical code.

Authors

Brian Keane has worked for Cooper Crouse-Hinds since 1989 in various manufacturing, product design, and application support functions and is currently an Application and Product Engineering Specialist for hazardous location and industrial products. He is a graduate of Ryerson University with a diploma in metallurgical technology (1984) and a B.Tech in industrial engineering (1987). He is an author of several papers presented at PCIC, PCIC Europe, IEEE Megaproject, and safety workshop as well as papers at other hazardous location equipment conferences. He is vice chair for the Integrated Committee for Hazardous Locations and a member of the subcommittee for Section 18 of the CEC, the Canadian Subcommittee for IEC TC31, and several IEC TC31 working groups.

Gerhard Schwarz received his master's degree in engineering in Mannheim. He has worked in sales, product management, and design for products used in hazardous areas for more than 40 years. Until the end of 2011, Gerhard was responsible for R&D explosion-protected light and switchgear at Cooper Crouse Hinds GmbH and was also responsible for the worldwide certification of hazardous area products. In 2012, he worked as senior technical consultant at Cooper Crouse Hinds for all general questions related to explosion protection, R&D, and certification. Since spring 2013, he has owned a consulting company in the explosion protection field. He is chairman of the German committee "Electrical equipment for use in hazardous areas" at DKE, the German standardization association, and chairman of the working group "explosion protected apparatus" at ZVEI, the German manufacturer association. He is also convener of the IEC TC 31 MT 60079-18 maintenance team on encapsulation "m," and convener of the IEC TC 31 WG 40 luminaires working group. He is head of the German delegation in CLC TC 31 and IEC TC 31, and is involved in numerous CLC and IEC standards committees for electrical products used in hazardous areas such as flameproof, increased safety, and intrinsic safety. He has also worked as German expert in the IEC MT 60079-14 maintenance team on electrical installations design, selection, and erection. Last but not least, he is involved in IEC EX Scheme as a German expert.

Peter Thurnherr studied mechanical engineering, electrical engineering, and business administration in Basel, B.Sc. diploma. Thuba Ltd, which was founded in 1932, has been manufacturing explosion-proof electrical apparatus since 1955, and he has been in charge of the company since 1977. His field of work is in the design and production of electrical apparatus for gas and dust explosive atmospheres in all types of protection. He is chairman of Technical Committee TC31 in Switzerland, member of International TC 31 Working Groups and Maintenance Teams: General Requirements IEC 60079-0, Increased Safety ICE 60079-7, Non-Sparking IEC 60079-15, Risk of Ignition of Optical Radiation IEC 60079-28, Trace Heating IEC 62086-1 and IEC 62086-2. He is also convener of Electrical Installations in Hazardous Areas IEC 60079-14.

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