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TECHNICAL SPECIFICATION

Explosive atmospheres –
Part 43: Equipment in adverse service conditions

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FOREWORD

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 60079-43, which is a technical specification, has been prepared by IEC Technical committee 31: Equipment for explosive atmospheres.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
31/1311/DTS	31/1328A/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60079 series, published under the general title *Explosive atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

IEC 60079-0 specifies the requirements for electrical equipment intended for use in explosive atmospheres at standard atmospheric conditions:

- temperature –20 °C to +60 °C;
- pressure 80 kPa (0,8 bar) to 110 kPa (1,1 bar); and
- air with normal oxygen content, typically 21 % v/v.

In some cases, other parts of the IEC 60079 series also specify conditions outside the above range, for example in IEC 60079-1.

IEC 60079-0 states the normal ambient temperature range as –20 °C to +40 °C and states that electrical equipment designed for use in other than this normal ambient temperature range is considered to be special and includes additional marking to communicate this to the user.

IEC 60079-14 includes requirements for users to select and install equipment so that it is suitable for the environmental conditions, but does not provide any specific guidance for installations outside of the standard atmospheric conditions or for other adverse environmental conditions.

Extreme climate conditions in Polar environments are challenging to explosion protection technology and solutions. Conditions such as snow build-up, icing from spray and freezing of precipitation can negatively affect the operation and safety of equipment. Extreme low temperatures and weather conditions make it difficult to process hydrocarbons in open outdoor process areas and it can also be challenging for equipment operation. Measures to deal with these challenges are often called 'winterization'.

This document is a guide for equipment subject to adverse service conditions, for example equipment considered as 'special' in IEC 60079-0. It is applicable to the design, manufacture, installation, inspection and use of such equipment. Annex A gives recommendations on materials and Annex C gives information on electric motors in low temperatures. It is possible that some details in this technical specification will be relocated to relevant parts of the IEC 60079 series at the next edition of each of those relevant parts as guidance material.

This technical specification does not at this time address other environmental conditions such as high temperatures, which will be explored further at a later date.

EXPLOSIVE ATMOSPHERES –

Part 43: Equipment in adverse service conditions

1 Scope

This part of IEC 60079, which is a Technical Specification, provides guidance for equipment for use in explosive atmospheres in environments which may include ambient temperatures below –20 °C, and additional adverse conditions, including maritime applications.

The purpose of this document is to provide recommendations to be considered for the design, manufacture and use of equipment. It is intended that this document be used for equipment operating within the environmental range specified on the certificate for the equipment.

NOTE For detailed classification of climate conditions refer to IEC 60721 series and IEC 60068-1.

This document is intended to be used in conjunction with the IEC 60079 series and the ISO/IEC 80079 series.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-5, *Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification*

IEC 60068 (all parts), *Environmental testing*

IEC 60079-0, *Explosive atmospheres - Part 0: Equipment - General requirements*

IEC 60079-11, *Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-14, *Explosive atmospheres - Part 14: Electrical installations design, selection and erection*

IEC 60079-17, *Explosive atmospheres - Part 17: Electrical installations inspection and maintenance*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60721-1, *Classification of environmental conditions - Part 1: Environmental parameters and their severities*

IEC 60721-2-1, *Classification of environmental conditions - Part 2-1: Environmental conditions appearing in nature - Temperature and humidity*

IEC TR 60721-4 (all parts), *Classification of environmental conditions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60079-0 apply.

NOTE Additional definitions applicable to explosive atmospheres can be found in IEC 60050-426, *International Electrotechnical Vocabulary – Part 426: Equipment for explosive atmospheres*.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Environmental conditions affecting the equipment used in explosive atmospheres

4.1 General

For the purposes of this document, the environmental conditions and specific operating parameters are considered to the extent that they can cause failure of the equipment or its parts related to explosion protection properties.

Useful information on climate classifications can be found in the IEC 60721 series. These documents provide for five classifications of Tropical, Arid, Temperate, Cold and Polar. If a manufacturer wishes to reference equipment as conforming to one of those classifications, it is recommended the temperatures shown in the specific part of IEC 60721 be used, for example in establishing the temperatures to be applied for the thermal endurance to heat and cold tests in IEC 60079-0.

The main environmental factors which may affect the equipment addressed by this document individually or in combination, include:

– low temperature;
– humidity;
– corrosive media;
– powder snow;
– precipitation;
– spray from waves;
– high winds;
– solar radiation; and
– mechanical effects.

The effect of these factors can be significant, particularly if they arise jointly. Information on these effects is provided below.

4.2 Low temperature effects

For low temperatures, the following may be relevant and should be considered:

– electrochemical capacitors may freeze and fail;
– battery units may discharge;
– wax and protective compounds may become solid and crack;
– rubber materials may lose elasticity and fail;
– greases may freeze affecting parts such as hinges and shafts;

– relays may malfunction;
– amplifying properties of transistors may decrease;
– loss of ductility or embrittlement of materials or welded joints may occur;
– differential expansion or contraction of materials may have an impact on correct fitting of components;
– oil viscosity increases, and flow may be restricted or cease, which may cause loss of protection, or failure of mechanical systems;
– oil as dielectric insulation in aged electrical equipment may contain higher water content which may reduce its dielectric strength or even cause dielectric failure.

4.3 Other environmental effects

High humidity can occur due to changes in temperature, for example, in maritime conditions. In these cases, the following may be relevant and should be considered:

– dielectric permeability of insulation materials may increase;
– surface resistance of insulation materials may decrease;
– permittivity of air gaps may decrease;
– auxiliary physical-chemical processes in dielectrics and metals may occur, for example corrosion or biological changes.

These conditions may cause undesirable changes in the capacitance of capacitors, decrease in insulation resistance, swelling and peeling of dielectrics, metal corrosion, or formation of mould inside the equipment.

Salt or other contaminants may exacerbate many of the problems that humidity creates, such as reduced insulating properties and increased corrosion.

5 Recommendations for design of equipment

5.1 General

IEC 60079-0 requires equipment to be constructed in accordance with the applicable safety requirements of relevant industrial standards. Such standards can include the IEC 60068 series of standards on environmental testing which include some tests relevant to adverse service conditions. The IEC TR 60721-4 series includes references to relevant tests in the IEC 60068 series.

Where equipment can be subject to adverse service conditions while in operation, the manufacturer should supply additional information necessary for the selection, installation, operation and maintenance of the equipment under those conditions. The upper and lower values of temperature and humidity should be specified. The recommended values for the climate classifications are given in IEC 60721-1 and IEC 60721-2-1. Where relevant, the rate of temperature change for which the equipment is intended should also be specified in the instructions for the equipment.

NOTE For the same type of equipment, different ranges of temperature are often specified depending on the specific application.

When storage and transportation conditions before installation exceed the temperature range covered by the certificate, the potential impact of these temperatures on the Type of Protection of the equipment should be addressed in the instructions supplied by the manufacturer. Where such information is not provided in the instructions, it is recommended that the storage temperatures are not outside the range covered by the certificate.

Types of Protection should remain effective while such equipment is exposed to adverse service conditions. This will need to be considered during selection and installation, and also considered during inspection and maintenance. Guidance on these aspects is included in Clauses 7 and 8.

The selection of equipment, design of installations and maintenance should consider the environmental factors and performance as required by IEC 60079-14 and IEC 60079-17. This technical specification can also be used to provide additional guidance for these aspects.

5.2 Atmospheres containing salt and chlorides

When equipment is intended for use in areas where it can be exposed to salt mist, requirements for corrosion resistance due to salt mist should be applied.

NOTE Useful information on classification of chemically active substances and the effect of these substances on equipment can be found in the IEC 60721-3 series, IEC 60654-4 and ISO 9223.

5.3 Snow conditions

Under powder snow conditions equipment with an ingress protection rating of IP6X, according to IEC 60529 or IEC 60034-5, is recommended to prevent powder snow entering an enclosure in a similar way to dust ingress.

Heat dissipating equipment, particularly those with rotating parts, should be protected against the effect of fallen snow that can melt when the equipment is switched on and re-freeze when it is switched off. Such equipment should be installed so it is protected against snow or heated to prevent freezing.

5.4 Solar Radiation

The requirements for the resistance to solar radiation may only need to be applied to parts which are exposed to solar radiation in working conditions rather than to the whole equipment. Annex B contains additional information and recommendations regarding solar radiation.

NOTE For equipment with other than white or silver-white surfaces that are subject to solar radiation, the surface temperatures could rise at least 5K. See Annex B for details.

5.5 Mechanical integrity

At low temperatures, increased requirements for mechanical integrity should be considered. For equipment, this is addressed during the preparation of a certificate as required by IEC 60079-0. For installations, this may mean additional requirements, for example mounting requirements.

NOTE Some grades of steel and cast iron become more brittle at temperatures below -20 °C.

For equipment intended for use in the open air or in rooms (spaces), where the air temperature and humidity variations do not significantly differ from those in the open air, at a temperature below -20 °C, the following should be considered:

- In threaded joints, where dissimilar materials with different temperature expansion coefficients mate, consideration should be given to avoid damage to materials and to ensure the required tightness when the dimensions of parts change due to the wide range of temperatures that may be encountered;
- Parts subject to wear, for example as a result of friction, should not wear at a faster rate at low temperatures compared with wear in temperate climates;
- For parts that may have low impact resilience at low temperature, additional measures may be necessary to ensure their integrity.

5.6 Icing and winterization

If operating conditions of equipment and their design parameters do not exclude ice deposits (icing) that affect the Type of Protection, then appropriate measures should be applied, for example by 'winterization'.

Winterization can be achieved by placing the equipment in temperature controlled areas or other anti-icing actions that prevent ice formation on surfaces, structures or equipment. Action against icing includes heating of the air or the equipment.

5.7 Impact of rapid cooling

Snow, rain, spray or failure of winterization systems can lead to rapid cooling of equipment, resulting in falling pressure and condensation inside equipment. Enclosures can deform and lose their ingress protection after exposure to heat and humidity followed by rapid cooling.

Pressure differentials caused by variations in temperatures can cause water to migrate from one enclosure to another via interconnecting cables.

The use of a suitable breathing device for pressure relief may be a solution for the above problems.

6 Impact of low temperatures on types of protection

6.1 General

Atmospheric temperatures below -20 °C can compromise the Type of Protection of the equipment and this should be addressed in the assessment and testing of the equipment. Where these low temperatures are not specifically addressed in the Type of Protection standard, consideration should be given to critical aspects that can arise, with examples given in the clauses below.

6.2 Intrinsic safety "i"

The performance characteristics of components used in intrinsically safe apparatus such as barriers and power supplies with limited spark duration with dynamic intrinsically safe elements change at low temperatures. Such changes should be considered by selection of appropriate components and should be assessed in accordance with IEC 60079-11 using the manufacturer's specified operating temperature. This rating should consider changes in the operation of semiconductor components that impact the ability of intrinsically safe apparatus to provide the required intrinsically safe function.

Efficiency of intrinsic safety of the power supplies with dynamic intrinsically safe elements applied in such systems depends on ambient temperature where they are used. Under low temperatures, the sensitivity of dynamic semiconductor elements of intrinsically safe power supplies degrades and the switching time increases. IEC 60079-11 specifies that spark ignition tests shall be carried out with the circuit arranged to give the most incendive conditions, but in practice, the tests are normally carried out at laboratory temperatures.

Hence, where lower temperatures are involved, it is necessary to perform testing of intrinsic safety of the systems with the power supplies with dynamic intrinsic protection (for example Power-i) at temperatures in the application range, including lowest temperature for the dynamic semiconductor elements and with appropriate loads connected to the spark test apparatus at the maximum service temperature.

For semiconductor components providing intrinsic protection at ambient temperatures below -40 °C, special heating systems may be required. For equipment intended for use under cold maritime climates, a higher degree of ingress protection than IP54 may be required to ensure protection against possible chloride deposits on printed circuits boards that could lead to tracking despite the equipment complying with the creepage distances and the comparative tracking index (CTI) of insulating materials of IEC 60079-11.

6.3 Flameproof enclosure "d"

Fasteners which ensure the integrity of enclosures should be made of materials that retain their strength under low temperatures. This is especially important for temperatures below -40 ºC.

For cemented joints, cold-resistant cements should be used.

Additional protection of flameproof surfaces against corrosion might be required, especially for equipment for maritime climates.

In joints where dissimilar materials with different temperature coefficients mate, the temperature changes from upper to lower temperature values should be considered for the effect on the flamepath gap.

6.4 Pressurized enclosure "p"

Pressurized systems operating at low temperatures may require additional features to ensure reliable operation.

Stationary heaters, environmental purge or other anti-condensation devices might be required.

6.5 Liquid immersion "o"

Liquids suitable for low temperature applications should be used or pre-heating of equipment should be provided. This should be specified in the instructions.

7 Selection, installation and use of equipment

7.1 Limited functionality

While the equipment certificate may permit operation at low temperatures, the functionality of the equipment at those low temperatures is not normally addressed. This document addresses a few elements of functionality below that should be considered for safety reasons. For example, heaters can be used even though the equipment is operating within the temperature limits covered by its certificate.

In low temperatures, some batteries should not be relied upon as a backup power supply for emergency lighting. This may be addressed by an uninterruptible power supply system with the batteries located in an area of higher temperature or other adequate measures, for example heating. Light output from fluorescent tubes will be lower. Other light sources may be considered that provide the necessary light output.

Simpler approaches regarding backup power might be necessary for other systems which would normally rely on battery backup.

7.2 Cables and cable glands

In addition to the requirements of IEC 60079-14, the following should be considered:

- The hardness of cable sheaths and sealing elements in glands may change at low temperatures. For installation, inspection and maintenance, the recommendations given by the cable and cable gland manufacturers should be observed.

- The permissible minimum bending radii may have to be increased for cables at low temperatures.
- While specific glands are not required by IEC 60079-14 for intrinsic safety, for low temperature applications the use of glands without a certificate for “d”, “e”, or “t” should be avoided because it is unlikely they have been tested for low temperatures.

7.3 Seals and sealing materials

Elastomeric seals should be selected according to their low-temperature properties and freezing conditions should be avoided.

An adequate treatment of the seal is recommended to assist installation and maintenance, for example lubrication of the seal.

8 Maintenance of equipment

Where equipment is exposed to adverse service conditions, additional periodic checks and maintenance should be done to those requirements specified in IEC 60079-17, in order to maintain the effectiveness of explosion protection under such conditions.

The following should be considered:

– More frequent inspections to ensure proper operation of items such as heaters, bearing lubrication and machine serviceability.
– Because many sealing materials become harder at temperatures below -20 °C, maintenance and inspections should not be performed at low temperatures to prevent damage to the seals or other parts.
– The torque of fasteners, and the sealing they create, should be checked.
– Manufacturers' instructions should include the requirements for maintenance, use of special tools, lubricants and spare parts.
– The temperature of oil-cooled bearings before start up should be maintained as recommended by the manufacturer.
– Periodic checks of insulation systems may be required (using a high-resistance ohmmeter).

9 Hazardous area classification

Consideration should be given to the effect of low temperatures as part of the classification of areas, for example the potential for larger sources of release due the effect of extreme low temperatures on seals and other components.

Annex A
(informative)

Recommendations on materials

In principle, all austenitic steels are more ductile and have a higher notch impact strength at low temperatures.

To avoid brittle failures, materials for low temperature service conditions should be suitable for the minimum metal design temperatures in accordance with appropriate requirements. The purchaser and the vendor should agree on any special precautions necessary with regard to conditions that may occur during operation, maintenance, transportation, erection, commissioning and testing.

Good design practice should be followed in the selection of fabrication methods, welding procedures, and materials for vendor furnished steel pressure retaining parts that may be subject to temperatures below the ductile-brittle transition temperature. The published design-allowable stresses for many materials in internationally recognised standards such as the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code and other American National Standards Institute (ANSI) standards are based on minimum tensile properties. Some standards do not differentiate between rimmed, semi-killed, fully killed hot-rolled, and normalised material, nor do they consider whether materials were produced under fine or coarse grain practices. The vendor should exercise caution in the selection of materials intended for services below -20 °C.

Annex B
(informative)

Solar radiation

B.1 General

Solar radiation can be a significant issue at low temperatures, particularly in polar regions where the sun may be present for 24 hours a day during summer months. Intense solar radiation can provide additional heating to equipment that may lead to the following:

- degradation of non-metallic materials;
- surface temperatures that have an impact on temperature class;
- service temperatures in which components, including electronic components, are operating.

B.2 Temperature gradients

Temperature gradients can be significant in cold environments. Intense solar radiation can provide heating of over 1 kW/m^2 and result in temperatures of over 90 °C on flat metal surfaces, but this increase in temperature should not be assumed to apply to objects in general. Not all surfaces of equipment will be exposed to the solar radiation at any given time. Heat gain from the solar radiation and heat transfer rates away from the equipment will vary dependent on ambient temperature, humidity, surface configuration, air movement, size, shape, mass and other factors.

B.3 Recommendations

B.3.1 Cables and glands

Where degradation of cables and glands may occur, they should be provided with additional solar protection. This may include painting, installation in cable trays fitted with covers or other suitable measures. Shrouds are not recommended because condensation inside the shroud can cause chemical reactions.

B.3.2 Equipment

Consideration should be given to additional protection for equipment that may degrade due to intense solar radiation, for example by providing shading.

Consideration should also be given to any increase in temperature that may exceed the rated service temperature of materials used in the assembly, e.g. rated maximum temperature of any insulation materials.

Where intense solar radiation is encountered, equipment should be selected to account for this influence or be provided with additional protection.

B.3.3 Protective measures

Measures to protect against solar radiation may include the use of a roof, shelter or similar structure.

Annex C
(informative)

Electric motors in low temperatures

C.1 General

Explosion-protected electric motors in low temperatures may present particular problems. The following are considerations that may need addressing in addition to those covered in the body of this technical specification.

C.2 Explosion-protection

For Flameproof “d” equipment, IEC 60079-1 contains particular requirements where equipment is intended to be used at temperatures below −20 °C. The most significant issue is the increase in reference pressure that occurs at low temperatures and hence the value of overpressure that the equipment is required to withstand. For Type of Protection Flameproof “d” motors, potential issues with pressure piling and possible detonation may be amplified at low temperatures and hence lead to even higher pressures than might normally be expected.

For Level of Protection “eb”, “ec” and Type of Protection “n” equipment, the relevant standards (IEC 60079-7 and 60079-15) do not include any special requirements for low temperatures beyond those required by IEC 60079-0. However, this does not mean ”e” or “n” motors can automatically be assumed to be suitable for use in low temperatures. For example, a very critical element will be the ability of the entire insulation system to remain effective and compliant at such temperatures. Protection systems for Level of Protection “eb” motors may also require attention to ensure they operate effectively and that t_E times and I_A/I_N ratios remain relevant. A more critical element may be how embedded temperature sensors are used. When the sensor is located in the stator but the rotor is more likely to have a higher temperature, the sensor in the stator may need to be set to a lower temperature, or a current-dependent device to sense motor current can be provided. This may need to be evaluated as part of the assessment and testing of the motor. The location of the motor protection device is also critical. These should not be located in an area of lower temperature than the motor they are protecting, because these devices normally use a reference element that is affected by temperature, for example a bimetal element.

C.3 Factors that may affect design and performance

Bearings should be such that the lubrication does not freeze at low temperatures. In some cases, it may be necessary to provide heaters that can warm the bearings prior to the starting the motors. Bearing lubricants need to be kept moisture free.

Water freezing between the rotor and stator can act like a brake at start up. This may also necessitate the use of heaters prior to starting.

The use of drain holes will be problematic as they may remain iced up for a time even as temperatures rise above freezing. A way of clearing them or warming them may be necessary if draining moisture is required.

The coefficient of expansion of bearing materials, the shaft and the housing need to be considered to ensure appropriate fits and clearances are maintained.

Gaskets and shaft slingers need to use materials, such as silicone rubber elastomers, that will remain resilient and functional at low temperatures.

Motor performance, including starting current and efficiency, will be affected.

Shaft steels will become tougher as temperature decreases but lose ductility and hence may be less resistant to impact or shock loading and so the use of special shaft steels may be necessary.

Increase in brittleness in other materials and welded joints needs to be considered.

Where motors are located outside and might not be operating continuously, the provision of a protective shroud might be needed to prevent accumulation of snow and ice that could prevent starting.

In such conditions, it may be necessary to provide more effective sealing to avoid entry of snow dust as well as normal dust.

Plastic fans and other plastic components are not recommended for low temperatures because they become brittle.

Motors subject to large and rapid variations in temperature should be supplied with anti-condensation heaters intended to maintain the motor temperature above dew point. Heaters may also be used for other purposes, such as heating of bearings.

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ASME BPVC, *(American Society of Mechanical Engineers) Boiler and Pressure Vessel Code*

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