Chapter 9

Standards and Approvals

Control Valve Standards

Numerous standards are applicable to control valves. International and global standards are becoming increasingly important for companies that participate in global markets. Following is a list of codes and standards that have been or will be important in the design and application of control valves.

American Petroleum Institute (API)

Spec 6D, Specification for Pipeline Valves (Gate, Plug, Ball, and Check Valves)

598, Valve Inspection and Testing

607, Fire Test for Soft-Seated Quarter-Turn Valves

609, Lug- and Wafer-Type Butterfly Valves

American Society of Mechanical Engineers (ASME)

B16.1, Cast Iron Pipe Flanges and Flanged Fittings

B16.4, Gray Iron Threaded Fittings

B16.5, Pipe Flanges and Flanged Fittings (for steel, nickel-based alloys, and other alloys)

B16.10, Face-to-Face and End-to-End Dimensions of Valves (see ISA standards for dimensions for most control valves)

B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings

B16.25, Buttwelding Ends

B16.34, Valves - Flanged, Threaded, and Welding End

B16.42, Ductile Iron Pipe Flanges and Flanged Fittings

B16.47, Large Diameter Steel Flanges (NPS 26 through NPS 60)

European Committee for Standardization (CEN)

European Industrial Valve Standards

EN 19, Marking

EN 558-1, Face-to-Face and Centre-to-Face Dimensions of Metal Valves for Use in Flanged Pipe Systems - Part 1: PN-Designated Valves

EN 558-2, Face-to-Face and Centre-to-Face Dimensions of Metal Valves for Use in Flanged Pipe Systems - Part 2: Class-Designated Valves

EN 593, Butterfly valves

EN 736-1, Terminology - Part 1: Definition of types of valves

EN 736-2, Terminology - Part 2: Definition of components of valves

EN 736-3 Terminology - Part 3: Definition of terms (in preparation)

EN 1349, Industrial Process Control Valves (in preparation)

EN 12266-1,Testing of valves - Part 1: Tests, test procedures and acceptance criteria (in preparation)

EN 12516-1, Shell design strength - Part 1: Tabulation method for steel valves (in preparation)

EN 12516-2, Shell design strength - Part 2: Calculation method for steel valves (in preparation)

EN 12516-3, Shell design strength - Part 3: Experimental method (in preparation)

EN 12627, Butt weld end design (in preparation)

EN 12760, Socket weld end design (in preparation)

EN 12982, End to end dimensions for butt welding end valves (in preparation)

European Material Standards

EN 10213-1, Technical conditions of delivery of steel castings for pressure purposes - Part 1: General

EN 10213-2, Technical conditions of delivery of steel castings for pressure purposes - Part 2: Steel grades for use at room temperature and elevated temperatures

EN 10213-3, Technical conditions of delivery of steel castings for pressure purposes - Part 3: Steel grades for use at low temperatures

EN 10213-4, Technical conditions of delivery of steel castings for pressure purposes - Part 4: Austenitic and austeno-ferritic steel grades

EN 10222-2, Technical conditions of delivery of steel forgings for pressure purposes - Part 2: Ferritic and martensitic steels for use at elevated temperatures

EN 10222-3, Technical conditions of delivery of steel forgings for pressure purposes - Part 3: Nickel steel for low temperature

EN 10222-4, Technical conditions of delivery of steel forgings for pressure purposes - Part 4: Fine grain steel

EN 10222-5, Technical conditions of delivery of steel forgings for pressure purposes - Part 5: Austenitic martensitic and austeno-ferritic stainless steel

European Flange Standards

EN 1092-1, Part 1: Steel flanges PN designated

EN 1092-2 (September 1997), Part 2: Cast iron flanges PN designated

EN 1759-1, Part 1: Steel flanges Class designated (in preparation)

Fluid Controls Institute (FCI)

70-2-1991, Control Valve Seat Leakage

Instrument Society of America (ISA)

S51.1, Process Instrumentation Terminology

S75.01, Flow Equations for Sizing Control Valves

S75.02, Control Valve Capacity Test Procedures

S75.03, Face-to-Face Dimensions for Flanged Globe-Style Control Valve Bodies (Classes 125, 150, 250, 300, and 600)

S75.04, Face-to-Face Dimensions for Flangeless Control Valves (Classes 150, 300, and 600)

S75.05, Terminology

S75.07, Laboratory Measurement of Aerodynamic Noise Generated by Control Valves

S75.08, Installed Face-to-Face Dimensions for Flanged Clamp or Pinch Valves

S75.11, Inherent Flow Characteristic and Rangeability of Control Valves

S75.12, Face-to-Face Dimensions for Socket Weld-End and Screwed-End Globe-Style Control Valves (Classes 150, 300, 600, 900, 1500, and 2500)

S75.13, Method of Evaluating the Performance of Positioners with Analog Input Signals

S75.14, Face-to-Face Dimensions for Buttweld-End Globe-Style Control Valves (Class 4500)

S75.15, Face-to-Face Dimensions for Buttweld-End Globe-Style Control Valves (Classes 150, 300, 600, 900, 1500, and 2500)

S75.16, Face-to-Face Dimensions for Flanged Globe-Style Control Valve Bodies (Classes 900, 1500, and 2500)

S75.17, Control Valve Aerodynamic Noise Prediction

S75.19, Hydrostatic Testing of Control Valves

S75.20, Face-to-Face Dimensions for Separable Flanged Globe-Style Control Valves (Classes 150, 300, and 600)

S75.22, Face-to-Centerline Dimensions for Flanged Globe-Style Angle Control Valve Bodies (Classes 150, 300, and 600)

RP75.23, Considerations for Evaluating Control Valve Cavitation

International Electrotechnical Commission (IEC)

The majority of International Electrotechnical Commission (IEC) standards for control valves, several of which are based on ISA standards. have been re-published as EN standards and utilize an EN prefix. The IEC encourages national committees to adopt them and to withdraw any corresponding national standards. IEC standards are increasingly being applied by manufacturers and purchasers. Below is a list of IEC industrial-process control valve standards (60534 series).

60534-1, Part 1: Control valve terminology and general considerations

60534-2-1, Part 2: Flow capacity - Section One: Sizing equations for incompressible fluid flow under installed conditions (based on ISA S75.01)

60534-2-3, Part 2: Flow capacity - Section Three: Test procedures (based on ISA S75.02)

60534-2-4, Part 2: Flow capacity - Section Four: Inherent flow characteristics and rangeability (based on ISA S75.11)

60534-4, Part 4: Inspection and routine testing

60534-5, Part 5: Marking

60534-6-1, Part 6: Mounting details for attachment of positioners to control valve actuators - Section One: Positioner mounting on linear actuators

60534-6-2, Part 6: Mounting details for attachment of positioners to control valve actuators - Section Two: Positioner mounting on rotary actuators

60534-7, Part 7: Control valve data sheet

60534-8-1, Part 8: Noise considerations - Section One: Laboratory measurement of noise generated by aerodynamic flow through control valves (based on ISA S75.07)

60534-8-2, Part 8: Noise considerations - Section Two: Laboratory measurement of noise generated by hydrodynamic flow through control valves

60534-8-3, Part 8: Noise considerations - Section Three: Control valve aerodynamic noise prediction method (based on ISA S75.17)

60534-8-4, Part 8: Noise considerations - Section Four: Prediction of noise generated by hydrodynamic flow

International Standards Organization (ISO)

5752, Metal valves for use in flanged pipe systems - Face-to-face and centre-to-face dimensions

7005-1, Metallic flanges - Part 1: Steel flanges

7005-2, Metallic flanges - Part 2: Cast iron flanges

7005-3, Metallic flanges - Part 3: Copper alloy and composite flanges

Manufacturers Standardization Society (MSS)

SP-6, Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings

SP-25, Standard Marking System for Valves, Fittings, Flanges and Unions

SP-44, Steel Pipe Line Flanges

SP-67, Butterfly Valves

SP-68, High Pressure Butterfly Valves with Offset Design

NACE International

NACE MR0175/ISO 15156, Petroleum and Natural Gas Industries − Materials for Use in H_2S-Containing Environments in Oil and Gas Production

NACE MR0175-2002, Sulfide Stress Corrosion Cracking Resistant Metallic Materials for Oil Field Equipment

NACE MR0103, Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Envoronments

Product Approvals for Hazardous (Classified) Locations

References

Canadian Standards Association (CSA) Standards

C22.1, Canadian Electrical Code (CEC)

C22.2 No. 94-M91, Special Industrial Enclosures

European Committee for Electrotechnical Standardization (CENELEC) Standards

EN 50014, Electrical apparatus for potentially explosive atmospheres—General requirements

Instrument Society of America (ISA) Standards

S12.1, Definitions and Information Pertaining to Electrical Instruments in Hazardous (Classified) Locations

International Electrotechnical Commission (IEC) Standards

60079-4, Electrical apparatus for explosive gas atmospheres. Part 4: Method of test for ignition temperature

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

National Electrical Manufacturer's Association (NEMA) Standards

250, Enclosures for Electrical Equipment (1000 Volts Maximum)

National Fire Protection Association (NFPA) Standards

70, National Electric Code (NEC)

497M, Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations

North American Approvals

The National Electric Code (NEC) in the United States and the Canadian Electric Code (CEC) require that electrical equipment used in hazardous locations carry the appropriate approval from a recognized approval agency.

Approval Agencies

The three main approval agencies in North America are Factory Mutual (FM) and Underwriters Laboratories (UL) in the United States and Canadian Standards Association (CSA) in Canada.

Types of Protection

The types of protection commonly used for instruments in North America are:

- **Dust Ignition−proof:** A type of protection that excludes ignitable amounts of dust or amounts that might affect performance or rating and that, when installed and protected in accordance with the original design intent, will not allow arcs, sparks or heat otherwise generated or liberated inside the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust.

- **Explosion−proof:** A type of protection that utilizes an enclosure that is capable of withstanding an explosion of a gas or vapor within it and of preventing the ignition of an explosive gas or vapor that may surround it and that operates at such an external temperature that a surrounding explosive gas or vapor will not be ignited thereby.

- **Intrinsically Safe:** A type of protection in which the electrical equipment under normal or abnormal conditions is incapable of releasing sufficient electrical or thermal energy to cause ignition of a specific hazardous atmospheric mixture in its most easily ignitable concentration.

- **Non−Incendive:** A type of protection in which the equipment is incapable, under normal conditions, of causing ignition of a specified flammable gas or vapor-in-air mixture due to arcing or thermal effect.

Nomenclature

Approval agencies within North America classify equipment to be used in hazardous locations by specifying the location as being Class I or II; Division 1 or 2; Groups A, B, C, D, E, F, or G; and Temperature Code T1 through T6. These designations are defined in the NEC and CEC, as well as the following paragraphs. The approval consists of the type of protection and the class, division, groups, and temperature, e.g. Class I, Division 1, Groups A, B, C, D, T6.

Hazardous Location Classification

Hazardous areas in North America are classified by class, division, and group.

Note

The method of classifying locations as zones instead of divisions was

introduced into the 1996 edition of the NEC as an alternate method, but it is not yet in use. The zone method is common in Europe and most other countries.

Class: The Class defines the general nature of the hazardous material in the surrounding atmosphere.

- **Class I**—Locations in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.

- **Class II**—Locations that are hazardous because of the presence of combustible dusts.

- **Class III**—Locations in which easily ignitable fibers or flyings may be present but not likely to be in suspension in sufficient quantities to product ignitable mixtures.

Division: The Division defines the probability of hazardous material being present in an ignitable concentration in the surrounding atmosphere. See ISA S12.1 for more detailed definitions.

- **Division 1**: Locations in which the probability of the atmosphere being hazardous is high due to flammable material being present continuously, intermittently, or periodically.

- **Division 2:** Locations that are presumed to be hazardous only in an abnormal situation.

Group: The Group defines the hazardous material in the surrounding atmosphere. The specific hazardous materials within each group and their automatic ignition temperatures can be found in Article 500 of the NEC and in NFPA 497M. Groups A, B, C and D apply to Class I, and Groups E, F and G apply to Class II locations. The following definitions are from the NEC.

- **Group A:** Atmospheres containing acetylene.

- **Group B:** Atmospheres containing hydrogen, fuel and combustible process gases containing more than 30 percent hydrogen by volume, or gases or vapors of equivalent hazard such as butadiene, ethylene oxide, propylene oxide, and acrolein.

- **Group C:** Atmospheres such as ethyl ether, ethylene, or gases or vapors of equivalent hazard.

- **Group D:** Atmospheres such as acetone, ammonia, benzene, butane, cyclopropane, ethanol, gasoline, hexane, methanol, methane, natural gas, naphtha, propane, or gases or vapors of equivalent hazard.

- **Group E:** Atmospheres containing combustible metal dusts, including aluminum, magnesium, and their commercial alloy, or other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment.

- **Group F:** Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coal, or dusts that have been sensitized by other materials so that they present an explosion hazard.

- **Group G:** Atmospheres containing combustible dusts not included in Group E or F, including flour, grain, wood, plastic, and chemicals.

Temperature Code

A mixture of hazardous gases and air may be ignited by coming into contact with a hot surface. The conditions under which a hot surface will ignite a gas depend on surface area, temperature, and the concentration of the gas.

The approval agencies test and establish maximum temperature ratings for the different equipment submitted for approval. Equipment that has been tested receives a temperature code that indicates the maximum surface temperature attained by the equipment. The following is a list of the different temperature codes:

Class 1	Division 1	Groups ABCD	T4
Hazard Type	Area Classification	Gas or Dust Group	Temperature Code

North American Temperature Codes

TEMPERATURE CODE	MAXIMUM SURFACE TEMPERATURE	
	°C	°F
T1	450	842
T2	300	572
T2A	280	536
T2B	260	500
T2C	230	446
T2D	215	419
T3	200	392
T3A	180	356
T3B	165	329
T3C	160	320
T4	135	275
T4A	120	248
T5	100	212
T6	85	185

The NEC states that any equipment that does not exceed a maximum surface temperature of 100 °C (212 °F) [based on 40 °C (104 °F) ambient temperature] is not required to be marked with the temperature code. Therefore, when a temperature code is not specified on the approved apparatus, it is assumed to be T5.

NEMA Enclosure Rating

Enclosures may be tested to determine their ability to prevent the ingress of liquids and dusts. In the United States, equipment is tested to NEMA 250. Some of the more common enclosure ratings defined in NEMA 250 are as follows.

General Locations

- **Type 3 (Dust-tight, Rain-tight, or Ice-resistance, Outdoor enclosure):** Intended for outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust, and damage from external ice formation.

- **Type 3R (Rain-proof, Ice-resistance, Outdoor enclosure):** Intended for outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation.

- **Type 3S (Dust-tight, Rain-tight, Ice-proof, Outdoor enclosure):** Intended for outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust, and to provide for operation of external mechanisms when ice ladened.

- **Type 4 (Water-tight, Dust-tight, Ice-resistant, Indoor or outdoor enclosure):** Intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.

- **Type 4X (Water-tight, Dust-tight, Corrosion resistant, Indoor or outdoor enclosure):** Intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water, and damage from external ice formation.

Hazardous (Classified) Locations

Two of the four enclosure ratings for hazardous (classified) locations are described as follows in NEMA 250:

- **Type 7 (Class I, Division 1, Group A, B, C or D, Indoor hazardous location, Enclosure):** For indoor use in locations classified as Class I, Division 1, Groups A, B, C or D as defined in the NEC and shall be marked to show class, division, and group. Type 7 enclosures shall be capable of withstanding the pressures resulting from an internal explosion of specified gases, and contain such an explosion sufficient that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure will not be ignited.

- **Type 9 (Class II, Division 1, Groups E, F or G, Indoor hazardous location, Enclosure):** Intended for use in indoor locations classified as Class II, Division 1, Groups E, F and G as defined in the NEC and shall be marked to show class, division, and group. Type 9 enclosures shall be capable of preventing the entrance of dust.

The above two NEMA ratings are often misunderstood. For example, the above definition of Type 7 is essentially the same as that for explosion−proof. Therefore, when an approval agency approves equipment as explosion−proof and suitable for Class I, Division 1, the equipment automatically satisfies the Type 7 requirement; however, the agency does not require that the equipment be labeled Type 7. Instead it is labeled as suitable for Class I, Division 1. Similarly, Type 9 enclosures would be labeled as suitable for Class II, Division 1.

CSA Enclosure Ratings

CSA enclosure ratings are defined in CSA C22.2, No. 94. They are similar to the NEMA ratings and are designated as type numbers; for example, Type 4. Previously they were designated with the prefix CSA ENC (for example, CSA ENC 4).

Intrinsically Safe Apparatus

Intrinsically safe apparatus must be installed with barriers that limit the electrical energy into the equipment. Two methods determine acceptable combinations of intrinsically safe apparatus and connected associated apparatus (for example, barriers) that have not been investigated in such combination: entity concept and system parameter concept.

Entity Concept

The entity concept specifies four parameters: voltage, current, capacitance, and inductance. The length of cable connecting intrinsically safe equipment with associated equipment may be limited because of the energy storing characteristics of cable. The entity parameters are:

V_{max} = maximum voltage that may safely be applied to the intrinsically safe apparatus.

I_{max} = maximum current which may safely be applied to the terminals of the intrinsically safe apparatus

C_i = internal unprotected capacitance of the intrinsically safe apparatus that can appear at the terminals of the device under fault conditions

L_i = internal unprotected inductance of the intrinsically safe apparatus that can appear at the terminals of the device under fault conditions

Barriers used with the intrinsically safe apparatus must meet the following conditions, which are noted on the loop schematic (control drawing).

V_{max} must be greater than V_{oc} or V_t

I_{max} must be greater than I_{sc} or I_t

C_a must be less than $(C_i + C_{cable})$

L_a must be less than $(L_i + L_{cable})$

where:

V_{oc} or V_t = maximum open circuit voltage, under fault conditions, of the associated apparatus (barrier). For multiple associated apparatus, FM uses the maximum combination of voltage V_t in place of V_{oc}.

I_{sc} or I_t = maximum short circuit current that can be delivered under fault conditions by the associated apparatus. For multiple associated apparatus, FM uses the combination of current I_t in place of I_{sc}

C_a = maximum capacitance that can safely be connected to the associated apparatus

L_a = maximum inductance that can safely be connected to the associated apparatus

C_{cable} = capacitance of connecting cable

L_{cable} = inductance of connecting cable

The entity parameters are listed on the loop schematic (control drawing). The entity concept is used by FM and UL and will be used by CSA if requested.

CSA System Parameter Concept

The parametric concept is only used by CSA. For an intrinsically safe apparatus, the parameters are:

- The maximum hazardous location voltage that may be connected to the apparatus.
- The minimum resistance in ohms of the barrier that may be connected to the apparatus.
- CSA will also investigate specific barriers, which may be listed on the loop schematic along with the parametric rating.

Loop Schematic (Control Drawing)

Article 504 of the NEC specifically requires intrinsically safe and associated apparatus to have a control drawing that details the allowed interconnections between the intrinsically safe and associated apparatus. This drawing may also be referred to as a loop schematic. The drawing number is referenced on the apparatus nameplate and is available to the user. It must include the following information:

- **Wiring diagram:** The drawing shall contain a diagram of the apparatus showing all intrinsically safe terminal connections. For intrinsically safe apparatus, all associated apparatus must be defined either by specific equipment identification or by entity parameters.
- **Entity parameters:** The entity parameters (or system parameters in case of CSA) shall be supplied in a table showing allowable values for each applicable Class and Group.
- **Hazard location identification:** A demarcation line shall be provided on the drawing to show the equipment in the hazardous location and the non-hazardous location. The Class, Division, and Group of the hazardous location should be identified.
- **Equipment identification:** The equipment shall be identified by model, part number, etc. to permit positive identification.
- **Division 2:** Division 2 installation requirements for FM approved equipment shall be shown.

Comparison of Protection Techniques

Explosion-proof Technique:

This technique is implemented by enclosing all electrical circuits in housings and conduits strong enough to contain any explosion or fires that may take place inside the apparatus.

Advantages of this Technique

- Users are familiar with this technique and understand its principles and applications.

- Sturdy housing designs provide protection to the internal components of the apparatus and allow their application in hazardous environments.

- An explosion-proof housing is usually weatherproof as well.

Disadvantages of this Technique

- Circuits must be de-energized or location rendered nonhazardous before housing covers may be removed.

- Opening of the housing in a hazardous area voids all protection.

- Generally this technique requires use of heavy bolted or screwed enclosures.

Installation Requirements

- The user has responsibility for following proper installation procedures. (Refer to local and national electrical codes.)

- Installation requirements are listed in Article 501 of the NEC or Article 18-106 of the CEC.

- All electrical wiring leading to the field instrument must be installed using threaded rigid metal conduit, threaded steel intermediate metal conduit, or Type MI cable.

- Conduit seals may be required within 18 inches of the field instrument to maintain the explosion−proof rating and reduce the pressure piling effect on the housing.

Intrinsically Safe Technique:

This technique operates by limiting the electrical energy available in circuits and equipment to levels that are too low to ignite the most easily ignitable mixtures of a hazardous area.

Advantages of this Technique

- This technique offers lower cost. No rigid metal conduit or armored cable are required for field wiring of the instrument.

- Greater flexibility is offered since this technique permits simple components such as switches, contact closures, thermocouples, RTD’s, and other non-energy-storing instruments to be used without certification but with appropriate barriers.

- Ease of field maintenance and repair are advantages. There is no need to remove power before adjustments or calibration are performed on the field instrument. The system remains safe even if the instrument is damaged, because the energy level is too low to ignite most easily ignitable mixtures. Diagnostic and calibration instruments must have the appropriate approvals for hazardous areas.

Disadvantages of this Technique

- This technique requires the use of intrinsically safe barriers to limit the current and voltage between the hazardous and safe areas to avoid development of sparks or hot spots in the circuitry of the instrument under fault conditions.

- High energy consumption applications are not applicable to this technique, because the energy is limited at the source (or barrier). This technique is limited to low-energy applications such as DC circuits, electro-pneumatic converters, etc.

Dust Ignition-proof Technique:

This technique results in an enclosure that will exclude ignitable amounts of dusts and will not permit arcs, sparks, or heat otherwise generated inside the enclosure to cause ignition of exterior accumulations or atmospheric suspension of a specified dust on or near the enclosure.

Non-Incendive Technique:

This technique allows for the incorporation of circuits in electrical instruments that are not capable of igniting specific flammable gases or vapor-in-air mixtures under normal operating conditions.

Advantages of this Technique

- This technique uses electronic equipment that normally does not develop high temperatures or produce sparks strong enough to ignite the hazardous environment.

- There is lower cost than other hazardous environment protection techniques, because there is no need for explosion−proof housings or energy limiting barriers.

- For non−incendive circuits, the NEC permits any of the wiring methods suitable for wiring in ordinary locations.

Disadvantages of this Technique

- This technique is limited to Division 2 applications only.

- This technique places constraint on control room to limit energy to field wiring (normal operation is open, short or grounding of field wiring) so that arcs or sparks under normal operation will not have enough energy to cause ignition.

- Both the field instrument and control room device may require more stringent labeling.

European and Asia/Pacific Approvals

Approval Agencies

Some of the common approval agencies in Europe and Asia/Pacific are listed below:

Approval Agencies

Location	Abbreviation	Agency
United Kingdom	BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmospheres
Germany	PTB	Physikalische-Technische Bundesanstalt
France	LCIE	Laboratorie Central des Industries Electriques
Australia	SAA	Standards Association of Australia
Japan	JTIISA	Japanese Technical Institution of Industry Safety Association

CENELEC Approvals

CENELEC is the acronym for European Committee for Electrotechnical Standardization. CENELEC standards are applicable to all European Union countries plus other countries that choose to use them. A piece of equipment that is successfully tested to the relevant CENELEC standard has CENELEC approval. The testing may be performed by any recognized testing laboratory in Europe. Approvals may be based on national standards, but CENELEC approvals are preferred.

Types of Protection

The types of protection commonly used outside North America are:

Flameproof:

- A type of protection in which an enclosure can withstand the pressure developed during an internal explosion of an explosive mixture and that prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure and that operates at such an external temperature that a surrounding explosive gas or vapor will not be ignite there. This type of protection is similar to explosion−proof. It is referred to by IEC as Ex d.

Increased Safety:

- A type of protection in which various measures are applied to reduce the probability of excessive temperatures and the occurrence of arcs or sparks in the interior and on the external parts of electrical apparatus that do not produce them in normal service. Increased safety may be used with the flameproof type of protection. This type of protection is referred to by IEC as Ex e.

Intrinsically Safe:

- A type of protection in which the electrical equipment under normal or abnormal conditions is incapable of releasing sufficient electrical or thermal energy to cause ignition of a specific hazardous atmospheric mixture in its most easily ignitable concentration. This type of protection is referred to by IEC as Ex i.

Non-Incendive:

- A type of protection in which the equipment is incapable, under normal conditions, of causing ignition of a specified flammable gas or vapor-in-air mixture due to arcing or thermal effect. This type of protection is referred to by IEC as Ex n.

Nomenclature

Approval agencies that use the IEC nomenclature (for example, BASEEFA, LCIE, PTB, and SAA) classify equipment to be used in hazardous locations by specifying the type of protection, gas group, and temperature code as follows:

E	Ex	ia	IIC	T4
Denotes CENELEC Approval	Denotes Hazardous Area Approval	Types of Protection ia—Intrinsic safety (2 faults allowed) ib—Intrinsic safety (1 fault allowed) d—Flameproof e—Increased safety n—Type n (non−incendive) (SAA only) N—Type N (non−incendive) (BASEEFA only)	Group	Temperature Code

For CENELEC approvals, the nameplate must also include the following symbol to indicate explosion protection:

This mark indicates compliance with CENELEC requirements and is recognized by all European Union member countries.

Hazardous Location Classification

Hazardous locations outside North America are classified by gas group and zone.

Group

Electrical equipment is divided into two groups. Group I covers electrical equipment used in mines, and Group II covers all other electrical equipment. Group II is further subdivided into three subgroups: A, B, and C. The specific hazardous materials within each group can be found in CEN-

ELEC EN 50014, and the automatic ignition temperatures for some of these materials can be found in IEC 60079-4.

- **Group I (Mining):** Atmospheres containing methane, or gases or vapors of equivalent hazard.

- **Group IIA:** Atmospheres containing propane, or gases or vapors of equivalent hazard.

- **Group IIB:** Atmospheres containing ethylene, or gases or vapors of equivalent hazard.

- **Group IIC:** Atmospheres containing acetylene or hydrogen, or gases or vapors of equivalent hazard.

Note

An apparatus approved for one subgroup in Group II may be used in the subgroup below it; for example, Group IIC may be used in Group IIB locations.

Zone

The zone defines the probability of hazardous material being present in an ignitable concentration in the surrounding atmosphere:

- **Zone 0:** Location where an explosive concentration of a flammable gas or vapor mixture is continuously present or is present for long periods. The area classified as Zone 0, although not specifically defined, is contained within the United States and Canada classifications of a Division 1 location and constitutes an area with the highest probability that an ignitable mixture is present.

- **Zone 1:** Location where an explosive concentration of a flammable or explosive gas or vapor mixture is likely to occur in normal operation. The area classified as Zone 1 is contained within the United States and Canada classifications of a Division 1 location.

- **Zone 2:** Location in which an explosive concentration of a flammable or explosive gas or vapor mixture is unlikely to occur in normal operation and, if it does occur, will exist only for a short time. Zone 2 is basically equivalent to the United States and Canadian classifications of a Division 2 location.

Temperature Code

A mixture of hazardous gases and air may be ignited by coming into contact with a hot surface. The conditions under which a hot surface will ignite a gas depends on surface area, temperature, and the concentration of the gas.

The approval agencies test and establish maximum temperature ratings for the different equipment submitted for approval. Group II equipment that has been tested receives a temperature code that indicates the maximum surface temperature attained by the equipment. It is based on a 40 °C (104 °F) ambient temperature unless a higher ambient temperature is indicated.

IEC Temperature Codes

TEMPERATURE CODE	MAXIMUM SURFACE TEMPERATURE	
	°C	**°F**
T1	450	842
T2	300	572
T3	200	392
T4	135	275
T5	100	212
T6	85	185

IEC Enclosure Rating

According to IEC 60529, the degree of protection provided by an enclosure is indicated by the IP Code. The code consists of the letters IP (ingress protection) followed by two characteristic numerals indicating conformity with the degree of protection desired (for example, IP54). The first numeral indicates the degree of protection against the following: human contact with or approach to live parts; human contact with moving parts inside the enclosure; and ingress of solid foreign objects. The second numeral indicates the degree of protection provided by the enclosure against the ingress of water. The characteristic numerals are defined in the following table:

NEMA and IEC Enclosure Rating Comparison

The following table provides an equivalent conversion from NEMA type numbers to IEC IP designations. The NEMA types meet or exceed the test requirements for the associated IEC classifications; for this reason, the table cannot be used to convert from IEC classification to NEMA types.

Conversion of NEMA Types to IEC IP Codes

NEMA Type	IEC IP
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP65

Ingress Protection (IP) Codes

First Numeral Protection against solid bodies	Second Numeral Protection against liquid
0 No protection	0 No protection
1 Objects greater than 50 mm	1 Vertically dripping water
2 Objects greater than 12.5 mm	2 Angled dripping water (75° to 90°)
3 Objects greater than 2.5 mm	3 Sprayed water
4 Objects greater than 1.0 mm	4 Splashed water
5 Dust-protected	5 Jetting
6 Dust-tight	6 Powerful jetting
- -	7 Temporary immersion
- -	8 Permanent immersion

Comparison of Protection Techniques

Flameproof Technique:

This technique is implemented by enclosing all electrical circuits in housing and conduits strong enough to contain any explosion or fires that may take place inside the apparatus.

Advantages of this Technique

- Users are familiar with this technique and understand its principles and applications.
- Sturdy housing designs provide protection to the internal components of the apparatus and allow their application in hazardous environments.
- A flameproof housing is usually weatherproof as well.

Disadvantages of this Technique

- Circuits must be de-energized or location rendered nonhazardous before housing covers may be removed.
- Opening of the housing in a hazardous area voids all protection.
- This technique generally requires use of heavy bolted or screwed enclosures.

Increased Safety Technique:

The increased safety technique incorporates special measures to reduce the probability of excessive temperatures and the occurrence of arcs or sparks in normal service.

Advantages of this Technique

- Increased safety enclosures provide at least IP54 enclosure protection.

- Installation and maintenance are easier for flameproof enclosures.

- This technique offers significantly reduced wiring costs over flameproof installations.

Disadvantages of this Technique

- This technique is limited in the apparatus for which it may be used. It is normally used for apparatus such as terminal boxes and compartments.

Intrinsically Safe Technique:

This technique requires the use of intrinsically safe barriers to limit the current and voltage between the hazardous and safe areas to avoid the development of sparks or hot spots in the circuitry of the instrument under fault conditions.

Advantages of this Technique

- This technique costs less because of less stringent rules for field wiring of the apparatus.

- Greater flexibility is offered because this technique permits simple components such as switches, contact closures, thermocouples, RTD’s, and other non-energy-storing apparatus to be used without special certification but with appropriate barriers.

- Ease of field maintenance and repair characterize this technique. There is no need to remove power before adjustments or calibration are performed on the field instrument. The system remains safe even if the instrument is damaged, because the energy level is too low to ignite most easily ignitable mixtures. Diagnostics and calibration instruments must have the appropriate approvals for hazardous areas.

Disadvantages of this Technique

- High energy consumption applications are not applicable to this technique because the energy is limited at the source (or barrier). This technique is limited to low-energy applications such as DC circuits, electro-pneumatic converters, etc.

Type n Technique:

This technique allows for the incorporation of circuits in electrical instruments that are not capable of igniting specific flammable gases or vapor-in-air mixtures under normal operating conditions. This type of protection is not available from CENELEC.

Advantages of this Technique

- This technique uses electronic equipment that normally does not develop high temperatures or produce sparks strong enough to ignite the hazardous environment.

- Cost is lower than other hazardous environment protection techniques because there is no need for flameproof housings or energy limiting barriers.

- This technique provides a degree of protection of IP54.

Disadvantages of this Technique

- This technique is applicable to Zone 2 locations only.

- Constraints are placed on control room to limit energy to field wiring (normal operation is open, short or grounding of field wiring) so that arcs or sparks under normal operation will not have enough energy to cause ignition.