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Standard

Definitions and Information Pertaining to Electrical Instruments in Hazardous (Classified) Locations

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

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Preface

This preface is included for informational purposes and is not Part of ISA-S12.1.

This standard has been prepared as part of the service of ISA toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static, but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms, and asks that they be addressed to the Secretary, Standards and Practices Board, ISA, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709, Telephone (919) 549-8411, e-mail: standards@isa.org.

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to USA users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards to the greatest extent possible. *The Metric Practice Guide,* which has been published by the Institute of Electrical and Electronics Engineers as ANSI/IEEE Std. 268- 1982, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

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Contents

1 Purpose

This standard provides definitions and information pertaining to protection techniques, terminology, and the installation of electrical instruments in hazardous (classified) locations and provides an introduction and basic background to the ISA-SP12, Electrical Safety, series of publications and committee activities. It replaces the original ISA-RP12.1, Electrical Instruments in Hazardous Atmospheres, published in 1960.

This document provides a general review of applicable codes and standards, and it should not be used in lieu of those codes and standards for equipment design, manufacture, installation, and maintenance.

2 Scope

2.1 This standard provides general guidance for safe design, installation, and maintenance of electrical instrument systems in hazardous (classified) locations using appropriate means to prevent ignition of flammable gases and vapors, flammable liquids, combustible dusts, or ignitible fibers or flyings.

2.2 This standard covers only locations made hazardous, or potentially hazardous, due to the presence of flammable gases or vapors, flammable liquids, combustible dusts, or ignitible fibers or flyings. The standard is not necessarily relevant to the hazards posed by pyrophoric materials such as explosives or propellants containing their own oxidizers.

2.3 This standard is primarily intended to provide guidelines for electrical process measurement and control instruments; however, the principles may be applied to other types of electrical equipment.

2.4 This standard is concerned only with equipment design, construction, installation, and test criteria related to arc or thermal ignition in electrical equipment that may cause ignition of flammable gas or vapor-in-air mixtures, clouds or blankets of combustible dust, or easily ignitible fibers or flyings. Equipment should also comply with ordinary location requirements (e.g., ISA-S82.01 and ISA-S82.03) for particular types of equipment.

2.5 This standard does not cover mechanisms of ignition from external sources, such as static electricity or lightning. Some process-sensing instruments may produce static electricity. The materials of construction of parts in such instruments will be an important consideration for application in hazardous locations. The extra precautions necessary for this are beyond the scope of this standard.

2.6 This standard does not consider the effects of installation in corrosive atmospheres and the resulting deleterious conditions to the original design integrity of the equipment. The additional precautions necessary for these conditions are outside the scope of this document.

2.7 This standard is not an instruction manual for untrained persons. However, it is intended to provide guidance to those involved with the design, manufacture, installation, and maintenance of instruments used in hazardous (classified) locations. It is also intended to promote uniformity of practice among those skilled in the art. Nothing contained in this standard is to be construed as a fixed rule without regard to sound engineering judgment.

2.8 For hazardous location equipment, atmospheric conditions are generally considered to be:

a) an ambient temperature range of -13°F (-25°C) to 104°F (40°C);

b) an oxygen concentration of not greater than 21 percent by volume;

c) a pressure of 12.5 psia (86 kPa) to 15.7 psia (108 kPa); and

d) a relative humidity of 5% to 95%.

NOTE: Equipment specified for atmospheric conditions beyond the above may be subject to additional requirements.

2.9 Specialized industries such as, but not limited to, mining and shipping may be regulated by the specific authority having jurisdiction. This standard does not include specific requirements or the rules and regulations unique to any specific industry.

2.10 Various organizations have developed codes, guides, and standards that have substantial acceptance by industry and governmental bodies. Codes, guides, and standards useful in the design and installation of electrical instruments in hazardous (classified) locations are listed in Appendix C. These are not considered to be a part of this standard except for those specific sections of documents referenced elsewhere in this standard.

2.11 Due to the purpose of this standard, an attempt was made to avoid originality in principles whenever possible, but rather to utilize definitions, explanations, etc., from accepted publications. As a result, much of the material, except for minor changes, is directly as published by others. While specific credit is not given for each reference, all references are included in Appendix B.

3 Definitions

The list is not intended to be all inclusive. Throughout this standard, reference is made to areas, spaces, locations, and zones. These terms should be considered interchangeable terms designating a three-dimensional space. The term "international" is used to designate practices other than those of the United States and Canada.

3.1 accessible surface: A surface to which a flammable or combustible mixture has access.

3.2 adequately ventilated area: An adequately ventilated area is an area that has a ventilation system (natural or artificial) that, as a minimum, prevents the accumulation of gases or vapors to an explosive level. Most standards and recommended practices recommend preventing levels in excess of 25 percent LEL.

NOTE: Adequate ventilation of an area alone is not an effective means for the prevention of dust explosions.

3.3 approved: Acceptable to the authority having jurisdiction.

NOTE 1: See "authority having jurisdiction."

NOTE 2: In determining the acceptability of installations or procedures, equipment, or material, the authority having jurisdiction may base acceptance on compliance with appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listing or labeling practices of product-testing organizations. These organizations are in a position to determine compliance with appropriate standards for the current production of listed or labeled items.

3.4 arcing device: A device, such as make/break component, that under normal conditions produces an arc with energy sufficient to cause ignition of an ignitible mixture. See also “nonincendive circuit."

3.5 associated apparatus: Apparatus in which the circuits are not intrinsically safe themselves but affect the energy in the intrinsically safe circuits and are relied upon to maintain intrinsic safety. Associated electrical apparatus may be either:

a) electrical apparatus that has an alternative type of protection for use in the appropriate hazardous (classified) location, or

b) electrical apparatus that is not protected and, therefore, cannot be used within a hazardous (classified) location.

See also "intrinsic safety."

3.6 authority having jurisdiction: The organization, office, or individual that has the responsibility and authority for approving equipment, installations, or procedures.

NOTE: The phrase "authority having jurisdiction" is used in a broad manner since "jurisdiction" and "approval" agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state/provincial, local, other regional department, or an individual such as an inspector from a labor or health department, electrical inspector, or others having statutory authority. An insurance inspection agency, rating bureau, or other insurance company representative may be the "authority having jurisdiction." An owner or his designated agent may also assume the role. At government-owned installations, the commanding officer, departmental official, or designated agent may be the "authority having jurisdiction."

3.7 bonding: The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

3.8 certified equipment: Equipment that has been evaluated by a recognized testing agency and confirmed to be in compliance with the applicable standard(s).

NOTE: Some agencies use the terms "approved," "listed," or "labeled equipment" to indicate compliance with the applicable standard.

3.9 Class I location: A location in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce ignitible mixtures.

3.10 Class I, Division 1 location: A location (1) in which ignitible concentrations of flammable gases or vapors can exist under normal operating conditions; (2) in which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors and might also cause simultaneous failure of electrical equipment that could act as a source of ignition.

3.11 Class I, Division 2 location: A location (1) in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; (2) in which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation and might become hazardous through failure or abnormal operation of the ventilating equipment; or (3) that is adjacent to a Class I, Division 1 location and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classified as a Class I, Division 2 location if the outside of the conduit and enclosures is a nonhazardous (unclassified) location. Refer to 6.1.3.2.

3.12 Class II location: A location that is hazardous because of the presence of combustible dust.

3.13 Class II, Division 1 location: A location (1) in which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures; (2) in which mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced and might also provide a source of ignition through simultaneous (the word "simultaneous" is not included in the Canadian definition) failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present in hazardous quantities.

3.14 Class II, Division 2 location (United States): A location in which combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment and where combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation or failure of electrical equipment.

3.15 Class II, Division 2 location (Canada): A location in which combustible dusts are not normally in suspension in air or likely to be thrown into suspension by the normal or abnormal operation or the failure of equipment or apparatus in quantities sufficient to produce explosive or ignitible mixtures, but in which:

a) deposits or accumulations of dust may be sufficient to interfere with the safe dissipation of heat from electrical equipment or apparatus; or

b) deposits or accumulations of dust on, in, or near electrical equipment may be ignited by arcs, sparks, or burning material from the electrical equipment.

3.16 Class III location: A location that is hazardous because of the presence of easily ignitible fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures.

3.17 Class III, Division 1 location: A location in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

3.18 Class III, Division 2 location: A location in which easily ignitible fibers are stored or handled (except in the process of manufacture).

3.19 Code of Practice: An international term referring to a document that describes basic safety features and methods of protection and recommends the selection, installation, and maintenance procedures that should be followed to ensure the safe use of electrical apparatus.

3.20 continuous dilution: The technique of supplying a protective gas flow continuously to an enclosure containing an internal potential source of flammable gas or vapor for the purpose of diluting any flammable gas or vapor that could be present to a level well below its LEL. Refer to 5.2.2.

3.21 control drawing: A drawing or other document provided by the manufacturer of the intrinsically safe or associated apparatus that details the allowed interconnections between the intrinsically safe and associated apparatus.

3.22 degrees of protection of enclosures: An international system of rating standard levels of protection provided by enclosures for the protection of persons against contact with live or moving parts inside the enclosure, as well as the protection provided by an enclosure against ingress of solids and/or liquids. This type of protection classification is in addition to (and not an alternative to) the types of protection necessary to ensure protection against ignition in hazardous (classified) locations. Definitions are found in IEC Publications 529 and 144. This system is similar to the NEMA enclosure rating system in the United States.

3.23 dust: Any finely divided solid material 420 µm* or smaller in diameter (material passing a U.S. No. 40 standard sieve).

> **NOTE:** Larger-sized particles can also cause explosions.

3.24 dust, combustible: Dust that (when mixed with air in certain proportions) can be ignited and will propagate a flame. The combustible properties of dust are dependent upon test conditions and dust particle size, chemical structure, and other dust particle characteristics.

3.25 dust-ignitionproof: A term used in the United States to describe an enclosure that will exclude ignitible amounts of dusts or amounts that might affect performance or rating and that, when installed and protected in accordance with the original design intent, will not permit arcs, sparks, or heat otherwise generated or liberated inside the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust.

> **NOTE:** Such equipment installed in Class II locations shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of any organic dust deposits that may occur.

3.26 dust layer, combustible: Any surface accumulation of combustible dust that is thick enough to propagate flame or will degrade and ignite.

3.27 dust-protected enclosure: An international term describing an enclosure in which the ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with the safe operation of the equipment or accumulate in a position within the enclosure where it is possible to cause an ignition hazard.

3.28 dust-tight: An enclosure so constructed that dust will not enter the enclosing case under specified test conditions. Refer to 5.2.5.

Most documents use 74 µm (U.S. No. 200 standard sieve).

3.29 encapsulation: An international term describing a type of protection in which the parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in an encapsulant in such a way that this explosive atmosphere cannot be ignited. This type of protection is referred to by CENELEC as "Ex m" in draft Standard EN50028.

> **NOTE:** Encapsulation is the potting or casting of electrical components with epoxy, elastomer, silicone, asphaltic, or similar compounds for the purpose of excluding moisture or vapors. Encapsulated components are not necessarily hermetically sealed.

3.30 explosionproof enclosure: 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. This type enclosure is similar to a flameproof enclosure.

3.31 explosionproof equipment (apparatus): Equipment or apparatus enclosed in an explosionproof enclosure.

3.32 fault (as applicable to intrinsically safe systems): A defect or electrical breakdown of any component, spacing, or insulation that alone or in combination with other defects or breakdowns may adversely affect the electrical or thermal characteristics of the intrinsically safe system. If a defect or breakdown leads to defects or breakdowns in other components, the primary and subsequent defects and breakdowns are considered to be a single fault. Certain components may be considered not subject to fault when analyses or tests for intrinsic safety are made. See also "protective component."

3.33 fibers and flyings: Materials not normally in suspension in air; such materials are of larger particle size than dusts. Fibers and flyings include materials such as cotton linters, sawdust, textile fibers, and other large particles that are usually more a fire hazard than an explosion hazard.

3.34 fibers and flyings, easily ignitible: Fibers and flyings that are easily ignitible including rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

3.35 flameproof enclosure: An international term describing an enclosure that 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 ignited thereby. This enclosure is similar to an explosionproof enclosure. This type of protection is referred to by IEC as "Ex d."

3.36 flammable (explosive) limits: The flammable (explosive) limits of a gas or vapor are the lower (LFL or LEL) and upper (UFL or UEL) percentages by volume of concentration of gas in a gas-air mixture that will form an ignitible mixture. Reference NFPA 325M.

3.37 flammable liquid: Any liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40.1 psia (276 kPa) at 100°F (37.8°C).

3.38 flammable gas or vapor: Any substance that exists in the gaseous or vapor state at normal atmospheric temperature and pressure and that is capable of being ignited and rapidly oxidizing when mixed with proper proportions of air or oxygen.

3.39 flash point: The minimum temperature at which a liquid emits vapor in a concentration sufficient to form an ignitible mixture with air near the surface of the liquid but not sufficient to sustain combustion, as determined by appropriate test procedures and apparatus.

3.40 ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

3.41 grounded (earthed): Connected to earth or to some conducting body that serves in place of earth.

3.42 group: Lists of materials of similar explosion hazard. Refer to Section 4.

3.43 hazardous (classified) location: A location in which fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or easily ignitible fibers or flyings.

3.44 hermetically sealed device: A device that is sealed against the entrance of an external atmosphere and in which the seal is made by fusion. Continuous soldering, brazing, welding, and the fusion of glass to metal are examples of recognized methods.

3.45 high temperature device: A device in which the maximum operating temperature (including ambient temperature effect) exceeds 80 percent of the autoignition temperature in degrees Celsius (°C) of the gas or vapor involved.

3.46 ignitible gas mixture: A gas-air mixture that is capable of being ignited by an open flame, arc or spark, or high temperature.

3.47 ignition (autoignition) temperature: The minimum uniform temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gaseous substance (independent of any other ignition source).

> **NOTE:** A distinction is made between ignition temperature and flash point. See "flash point."

3.48 ignition capable: Equipment or wiring that under normal conditions may release sufficient electrical or thermal energy to cause ignition of a specific ignitible atmosphere.

3.49 increased safety: An international term that describes a type of protection in which various measures are applied so as 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.

This type of protection is referred to by IEC as "Ex e." These measures typically involve "robust" construction features such as special cable glands, specially spaced and secured terminal connections, double insulation of windings, rugged enclosure design, or combinations of such features.

3.50 internal wiring: Wiring and electrical connections that are made within apparatus by the manufacturer. Within racks or panels, interconnections between separate pieces of apparatus made in accordance with detailed instructions from the apparatus manufacturer are also considered to be internal wiring.

3.51 intrinsic safety: A type of protection in which a portion of the electrical system contains only intrinsically safe equipment (apparatus, circuits, and wiring) that is incapable of causing ignition in the surrounding atmosphere. No single device or wiring is intrinsically safe by itself (except for battery-operated self-contained apparatus such as portable pagers, transceivers, gas detectors, etc., which are specifically designed as intrinsically safe self-contained devices) but is intrinsically safe only when employed in a properly designed intrinsically safe system. This type of protection is referred to by IEC as "Ex i." See also "associated equipment (apparatus)."

3.52 intrinsic safety barrier: A component containing a network designed to limit the energy (voltage and current) available to the protected circuit in the hazardous (classified) location under specified fault conditions.

3.53 intrinsically safe circuit: A circuit in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, under specified test conditions, of causing ignition of a mixture of flammable or combustible material in air in the mixture's most easily ignited concentration.

3.54 intrinsically safe equipment (apparatus, circuits, and wiring): Equipment and wiring that, under normal or abnormal conditions, are incapable of releasing sufficient electrical or thermal energy to cause ignition of a specific hazardous atmospheric mixture in its most easily ignitible concentration.

3.55 intrinsic safety ground bus: A grounding system that has a dedicated conductor separate from the power system so that ground currents will not normally flow and that is reliably connected to a ground electrode (e.g., in accordance with Article 250 of NEC, ANSI/NFPA 70, or Section 10 of CEC Part 1, CSA C22. 1).

3.56 intrinsically safe system: An assembly of interconnected intrinsically safe apparatus, associated apparatus, other apparatus, and interconnecting cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits.

3.57 labeled equipment: Equipment or materials, to which has been attached a label, symbol, or other identifying mark of an organization concerned with product evaluation, that may maintain periodic inspection of the production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

> **NOTE:** Some agencies use the terms "approved," "listed," or "certified equipment" to indicate compliance with the applicable standard.

3.58 liquid, combustible: A liquid having a flash point at or above 100°F (37.8°C). Combustible liquids are subdivided as follows:

a) Class II liquids include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).

b) Class IIIA liquids include those having flash points at or above 140°F (60°C) and below 200°F (93°C).

c) Class IIIB liquids include those having flash points at or above 200°F (93°C).

Reference NFPA 321, Basic Classification of Flammable and Combustible Liquids, for additional information.

3.59 listed: Equipment or materials, included in a list published by an organization concerned with product evaluation, that maintain periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or materials meets appropriate standards or has been tested and found suitable for use in the specified manner.

> **NOTE:** The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should be familiar with the system employed by the listing organization to identify a listed product. Some agencies use the terms "approved," "labeled," or "certified equipment" to indicate compliance with the applicable standard.

3.60 lower explosive limit (LEL): Refer to "flammable (explosive) limits."

3.61 lower flammable limit (LFL): Refer to "flammable (explosive) limits."

3.62 maintenance, corrective: Any maintenance activity that is not normal in the operation of equipment and requires access to the equipment's interior.

Such activities are expected to be performed by qualified personnel who are aware of the hazards involved. Such activities typically include locating causes of faulty performance, replacement of defective components, adjustment of internal controls, and the like.

3.63 maintenance, operational: Any maintenance activity, excluding corrective maintenance, intended to be performed by the operator and required in order for the equipment to serve its intended purpose. Such activities typically include the correcting of "zero" on a panel instrument, changing charts, record keeping, adding ink, and the like.

3.64 make/break component: Components having contacts that can interrupt a circuit (even if the interruption is transient in nature). Examples of make/break components are relays, circuit breakers, servo potentiometers, adjustable resistors, switches, connectors, and motor brushes.

3.65 maximum surface temperature: The highest temperature attained by a surface accessible to flammable gases, vapors, or combustible dusts under conditions of operation within the ratings of the apparatus (including recognized overloads and defined fault conditions).

3.66 minimum cloud ignition temperature: The minimum temperature at which a combustible dust atmosphere will autoignite and propagate an explosion.

3.67 minimum dust layer ignition temperature: The minimum temperature of a surface that will ignite a dust lying on it after a long time (theoretically, until infinity). In most dusts, free moisture has been vaporized before ignition.

3.68 minimum explosive (dust) concentration: The minimum concentration of a dust cloud that, when ignited, will propagate a flame away from the source of ignition.

3.69 minimum ignition energy: The smallest amount of energy that can ignite the most easily ignitible mixture of a specific gas or vapor-in-air mixture or dust-in-air mixture.

3.70 nonhazardous (unclassified) location: A location in which fire or explosion hazards are not expected to exist specifically due to the presence of flammable gases or vapors, flammable liquids, combustible dusts, or ignitible fibers or flyings. Internationally, such a location is referred to as a safe area.

3.71 nonincendive circuit: A circuit in which any arc or thermal effect produced in normal operating conditions of the equipment is not capable, under prescribed conditions, of igniting the specified flammable gas, vapor-in-air mixture, combustible dusts, or ignitible fibers or flyings.

3.72 nonincendive component: A component having contacts for making or breaking a specified incendive circuit in which the contacting mechanism is constructed so that the component is not capable of ignition of the specified flammable gas or vapor-in-air mixture when tested as specified by appropriate test procedure. The housing of a nonincendive component is not intended to (1) exclude the flammable atmosphere or (2) contain an explosion.

3.73 nonincendive equipment: Equipment having electrical/electronic circuitry and components that are 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." Ex n protection is limited to gas and vapor hazards.

NOTE: Normal use includes operation:

a) at rated voltage, current, and frequency;

b) under specified environmental conditions;

c) with all adjustments at most unfavorable settings;

d) with all tool-removable parts in place; and

e) of make/break (arcing) components.

3.74 nonincendive field wiring: Wiring that enters or leaves an equipment enclosure and, under normal operating conditions of the equipment, is not capable, due to arcing or thermal effects, of igniting a specified flammable gas or vapor-in-air mixture or combustible dust-in-air mixture. Normal operation includes opening, shorting, or grounding the field wiring.

3.75 normal conditions: As related to intrinsically safe and nonincendive systems, equipment is under normal conditions when it conforms electrically and mechanically with its design specifications and is used within the limits specified by the manufacturer.

Normal conditions for intrinsically safe equipment include the following:

a) supply voltage at maximum rated value;

b) environmental conditions within the ratings given for the apparatus or associated apparatus;

c) tolerances of all components in the combination that represents the most unfavorable condition;

d) adjustments at their most unfavorable settings; and

e) opening of any one, shorting of any two, and grounding of any one of the field wires of the intrinsically safe circuit(s).

NOTE: CSA practice differs in philosophy for condition e). The CSA wording would be: "The shorting, opening, grounding, or any combination of these conditions at field wiring terminals of the circuit."

Normal conditions for nonincendive equipment include the following:

a) supply voltage, current, and frequency at rated values;

b) environmental conditions within the ratings given for the apparatus;

c) all tool-removable parts (e.g., covers) in place;

d) all operator-accessible adjustments at their most unfavorable setting; and

e) opening, shorting, and grounding of the nonincendive field wiring.

3.76 oil-immersed equipment: Equipment immersed in electrical insulating oil for the purpose of preventing an ignitible gas or vapor from coming in physical contact with the source of ignition. This type of protection is referred to by IEC as "Ex o."

> **NOTE:** This type of equipment may also serve the purpose of preventing a particular corrosive gas or vapor from coming in physical contact with the electrical components, provided one considers the solubility of the corrosive atmosphere in the oil.

3.77 powder filling: An international term that describes a type of protection in which an enclosure of electrical apparatus is filled with a material in a finely granulated state so that, in the intended conditions of service, any arc occurring within the enclosure of an electrical apparatus will not ignite the surrounding atmosphere. No ignition is allowed to be caused either by flame or by excessive temperature of the accessible surfaces of the enclosure. This type of protection is referred to by IEC as "Ex q."

3.78 pressurization: The technique of preventing an external atmosphere, which may be ignitible, from entering an enclosure by maintaining the internal pressure of the enclosure's protective gas (with or without continuous flow) at a pressure level above that of the external atmosphere. This type of protection is referred to by IEC as "Ex p."

> **NOTE:** In the United States, pressurization is the process of supplying an enclosure in a Class II application with clean air or an inert gas, with or without continuous flow, at sufficient pressure to prevent the entrance of combustible dusts. Refer to 5.2.1 and 5.2.1.2.

3.79 protection techniques: Internationally, a term used to describe a technique of explosion protection that is applied to an apparatus to provide an assurance of safety. Examples are "Type e" and "Type n."

3.80 protective component (as applied to intrinsic safety): A component that is so unlikely to become defective in a manner that will lower the intrinsic safety of the circuit that it may be considered not subject to fault when analyses or tests for intrinsic safety are made.

3.81 protective gas: The gas used for pressurization or for the dilution of flammable gases to a level well below their lower explosive limit, usually below 25 percent LEL. The protective gas may be air, nitrogen, other nonflammable gas, or a mixture of such gases.

3.82 purging: The process of supplying an enclosure with clean air or inert gas at a specified flow rate and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptably safe level and to maintain this safe level by positive pressure with or without continuous flow. Refer to 5.2.1 and 5.2.1.2 and definitions of Type X, Y, and Z purging.

3.83 purging, Type X: In the United States and Canada, a method of reducing the classification within an enclosure from Division 1 to nonhazardous (unclassified).

3.84 purging, Type Y: In the United States and Canada, a method of reducing the classification within an enclosure from Division 1 to Division 2.

3.85 purging, Type Z: In the United States and Canada, a method of reducing the classification within an enclosure from Division 2 to nonhazardous (unclassified).

3.86 restricted breathing: A Zone 2 protection technique in which the tightness of an enclosure is assured so that short-term presence of a flammable gas or vapor cloud around the enclosure will not cause the concentration inside the enclosure to reach the LEL because of breathing or diffusion.

3.87 safe area: Refer to "nonhazardous (unclassified) location."

3.88 seal, cable, explosionproof: A cable terminator filled with compound and designed to contain an explosion in the enclosure to which it is attached or to minimize passage of flammable gases or vapors from one location to another. A conduit seal may also be used as a cable seal. This method differs from the international practice, which requires cable glands.

3.89 seal, conduit, explosionproof: A sealing fitting, poured with cement-like potting compound, designed to contain an explosion in the enclosure to which it is attached and to minimize passage of flammable gases or vapors from one location to another.

3.90 seal, factory: A seal provided in an explosionproof device during manufacture for the purpose of eliminating the need for an external, field-installed "conduit seal" for that device.

> **NOTE:** Factory seals are typically not rated to withstand process temperature and pressure conditions to which they will be subjected upon failure of the primary process seal or barrier.

3.91 sealed device: A device so constructed that it cannot be opened during normal operational conditions or operational maintenance; it has a free internal volume less than 100 cubic centimeters (6.1 cubic inches) and is sealed to restrict entry of an external atmosphere. Reference ISA-SI2.12 for aging, vapor exposure, and leakage test requirements. Reference also IEC 79-15.

3.92 simple apparatus (as applied to intrinsic safety): A device that will not generate or store more than 1.2 V, 0.1 A, 25 mW, or 20 µJ. Examples are: switches. thermocouples, light-emitting diodes, and resistance temperature detectors (RTDs).

3.93 source of release: A point from which flammable gases or vapors, flammable liquid, combustible dusts, or ignitible fibers or flyings may be released into the atmosphere.

3.94 special protection: A protection technique other than those that have been standardized. This type of protection is referred to by IEC as "Type s."

3.95 temperature identification number (temperature class): A system of classification by which one of 14 temperature identification numbers (internationally, six temperature classes) is allocated to an electrical apparatus. The temperature identification number represents the maximum surface temperature of any component that may come in contact with the flammable gas or vapor mixture. See Table 2.

3.96 type of protection: Refer to "protection techniques."

3.97 upper explosive limit (UEL): Refer to "flammable (explosive) limits."

3.98 upper flammable limit (UFL): Refer to "flammable (explosive) limits."

3.99 zone: The international method of specifying the probability that a location is made hazardous by the presence, or potential presence, of flammable concentrations of gases and vapors.

> **NOTE:** Zone classification has not yet been defined for dusts and flyings.

3.100 Zone 0: Classification of a location in which 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 Canadian classifications of a Division 1 location and constitutes an area with the highest probability that an ignitible mixture is present.

3.101 Zone 1: Classification of a location in which 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 Canadian classifications of a Division 1 location.

3.102 Zone 2: Classification of a 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.

4 Area (location) classification

The type of protective technique selected and the level of protection it must provide depend upon the potential hazard caused by using electrical apparatus in a location where a combustible, flammable, or ignitible substance may be present. Area classification schemes and systems of material classification have been developed to provide a succinct description of the hazard so that appropriate safeguards may be selected. All useful area classification systems specify the kind of flammable material that may be present and the probability that it will be present in ignitible concentrations.

4.1 North American methods

4.1.1 In the United States, area classification principles are stated in Article 500 of the National Electrical Code, ANSI/NFPA 70. Similar requirements in Canada are given in the Canadian Electrical Code, Part 1, Section 18, (CSA C22.1).

Various organizations have developed numerous guides and standards that have substantial acceptance by industry and governmental bodies for area classification. Refer to Appendix C.

Area classification descriptions used in the United States and Canada include the following:

Locations are classified (1) by CLASS—the generic form of the flammable materials in the atmosphere (gas or vapor, dusts, or easily ignitible fibers or flyings); (2) by DIVISION—an indication of the probability of the presence of the flammable material in ignitible concentration; and (3) by GROUP—the exact nature of the flammable material. For formal definitions, refer to 3, Definitions. Abbreviated definitions follow.

4.1.1.1 Classes

Class I locations are those in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitible mixtures.

Class II locations are those that are hazardous because of the presence of combustible dusts.

Class III locations are those in which easily ignitible fibers or flyings may be present but not likely to be in suspension in sufficient quantities to produce ignitible mixtures.

4.1.1.2 Divisions

Class 1, Division 1 locations are those in which:

a) hazardous concentrations exist continuously, intermittently, or periodically under normal operating conditions;

b) hazardous conditions may exist frequently because of repair or maintenance operations or because of leakage; or

c) breakage or faulty operation of process or other nonelectrical equipment or processes might release flammable concentrations or gases or vapors and might also cause simultaneous failure of electrical equipment that causes a source of ignition.

Class I, Division 2 locations are those in which:

a) hazardous volatile liquids, vapors, or gases are normally confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment;

b) flammable concentrations are normally prevented by positive mechanical ventilation but might become hazardous through failure or abnormal operation of the ventilating system; or

c) areas adjacent to Division 1 locations to which hazardous concentrations of gases or vapors might occasionally be communicated.

Class II, Division 1 locations are those in which:

a) combustible dust is, or may be, in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures;

b) breakage or faulty operation of a process or machinery may produce combustible concentrations of dusts and might also cause simultaneous failure of electrical equipment, which, in turn, may act as a source of ignition; or

c) electrically conductive combustible dusts may be present.

Class II, Division 2 locations are those in which:

a) combustible concentrations of suspended dust are not likely, but where deposits or accumulations of dust may interfere with the safe dissipation of heat from electrical equipment or apparatus; or

b) combustible concentrations of suspended dust are not likely, but where deposits or accumulations of dust on, in, or in the vicinity of electrical equipment might be ignited by arcs, sparks, or burning material from such equipment.

Class III, Division 1 locations are those in which easily ignitible fibers or materials producing combustible flyings are handled, manufactured, or used.

Class III, Division 2 locations are those in which easily ignitible fibers may be stored or handled (except in the process of manufacture).

NOTE: Some plant areas in the manufacture, handling, and storage of explosives or ammunition and nitrocellulose products (such as celluloid photographic films), etc., involve conditions that are not covered by NEC Classifications. This is particularly true where black powders, smokeless powder, dust from TNT, and other explosives are present. See NFPA 495, Reference Code for Explosive Materials, for guidance.

4.1.1.3 Groups

The United States and Canadian standards recognize seven groups: Groups A, B, C, D, E, F, and G. Groups A, B, C, and D apply to Class I locations; Groups E, F, and G apply to Class II Locations. These groups include the following:

Group A—Atmospheres containing acetylene.

Group B—Atmospheres such as butadiene*, ethylene oxide*, propylene oxide*, acrolein*, or hydrogen (or gases or vapors equivalent in hazard to hydrogen, such as manufactured gas).

Group C—Atmospheres such as cyclopropane, ethyl ether, ethylene, hydrogen sulfide, or gases or vapors of equivalent hazard.

Group D—Atmospheres such as acetone, alcohol, ammonia*, benzene, benzol, butane, gasoline, hexane, lacquer solvent vapors, methane, naphtha, natural gas, propane, or gases or vapors of equivalent hazard.

In the United States:

Group E—Atmospheres containing combustible metal dusts regardless of resistivity or other combustible dusts of similarly hazardous characteristics having resistivity of less than 10^2 ohm-centimeter (magnesium, aluminum, bronze powder, etc.)

Group F—Atmospheres containing carbon black, charcoal, coal, or coke dusts that have more than 8 percent total volatile material (coal and coke dusts per ASTM 3175-82) or atmospheres containing these dusts sensitized by other materials so that they present an explosion hazard and having resistivity greater than 10^2 ohm-centimeter but equal to or less than 10^8 ohm-centimeter.

Group G—Atmospheres containing combustible dusts (flour, starch, pulverized sugar and cocoa, dairy powders, dried hay, etc.) having resistivity of 10^8 ohm-centimeter or greater.

> **NOTE:** See NFPA 497M for a more detailed treatment of dusts.

In Canada, the ranges of resistivities are not specified.

4.2 European methods

In Europe, area classification principles for gas-air mixtures are stated in IEC Publication 79-10. A partial listing of other worldwide codes, guides, and standards is included in Appendix C.

4.2.1 Zones

4.2.1.1 Zone 0 is an area in which an explosive gas-air mixture is continuously present or present for long periods. The vapor space of a closed but vented process vessel or storage tank is an example of a Zone 0 area. Zone 0 is encompassed by Division 1 in the United States and Canadian classifications.

4.2.1.2 Zone 1 is an area in which an explosive gas-air mixture is likely to occur in normal operation. Zone 1 is encompassed by Division 1 in the United States and Canadian classifications.

4.2.1.3 Zone 2 is an area in which an explosive gas-air mixture is not likely to occur, and, if it does occur, will exist only for a short time. Zone 2 is basically equivalent to Division 2 in the United States and Canadian classifications.

These definitions of "Zones" are based on IEC Publication 79-10.

4.2.2 Groups

4.2.2.1 Group I is for application in below-ground installations in which methane (firedamp) may be present.

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*Refer to Article 500-3, Special Precaution, of the *National Electrical Code*.

4.2.2.2 Group IIA is for application in above-ground installations in which hazards due to gases or vapors with flammability properties similar to those of propane may exist. This group most closely matches Group D in the United States and Canada.

4.2.2.3 Group IIB is for application in above-ground installations in which hazards due to gases or vapors with flammability properties similar to those of ethylene may exist. This group most closely matches Group C in the United States and Canada.

4.2.2.4 Group IIC is for application in above-ground installations in which hazards due to gases or vapors with flammability properties similar to those of hydrogen and acetylene may exist. This group includes both Groups A and B in the United States and Canada.

4.3 Additional background information

4.3.1 Several decades ago in the United States and Canada, the first groupings of gases and vapors were based on the explosionproof properties of commercial enclosures. At present, a similar but more definitive method is used to classify Class I materials. Classifications are based on consideration of the maximum experimental safe gap (MESG), which is the measure of the maximum distance between flanges of a specified width that will prevent transmission of an explosion.

The values of MESG are determined in a test apparatus. In the United States the Westerberg unit located at Underwriters Laboratories is used for this purpose. In this apparatus, two cylindrical chambers are separated by an adjustable flange gap that simulates the flanged joint of an explosionproof enclosure. Both chambers are filled with the flammable mixture, which is then ignited in one chamber. The maximum gap between flanges at which the explosion is not transmitted from one chamber to the other is the MESG. During MESG determinations, both pressure rise and the rate of pressure rise in the chambers are measured. The explosion is ignited under both quiescent conditions and turbulent conditions and by both a spark plug in one chamber and a spark plug located at the end of a length of conduit connected to the first chamber. Criteria used in the classification of a material include the MESG, maximum pressure rise, and rate of pressure rise determined during all tests. The results of earlier research and testing on many materials are found in Underwriters Laboratories, Inc., Bulletins of Research, Nos. 58, 58A, and 58B.

Internationally, a device similar in concept and described in IEC 79-1A is used for this purpose.

It should be noted that MESG testing is but one of the criteria to be evaluated in the final determination of the grouping of gases and vapors. The actual determination is a very involved and difficult process, and testing methods and criteria vary among other organizations and countries. The IEC has documents for classification of materials. Refer to IEC 79-12. The IEC recognizes classifications by both MESG and minimum igniting currents (MIC). In some cases, both methods are sometimes required. The NFPA Committee on Electrical Equipment in Chemical Atmospheres has the responsibility for the publication of NFPA 497M. This document includes an expanded listing of chemicals and their group identification.

4.3.2 Division 2 concept

The concept of Division 2, a location in which flammable material will be present only occasionally, was initiated in North America. It was recognized that if the probability of the presence of flammable material is low, the protective measures necessary to prevent an explosion can be much less restrictive (and normally also much less expensive) than those required in Division 1 locations. In Division 1 locations the probability that the flammable material is present is much higher than in Division 2 locations because, in the former, the flammable atmosphere is present frequently during normal operations. Although many international corporations, particularly oil and chemical companies, used the North American nomenclature and practice, it was not until the 1960s that Division 2 began to be accepted outside North America. At the present time the concept of Division 2 area classification is recognized universally. The relaxation of protective measures in Division 2 has not yet reached the same level of acceptance, however. In Japan, for example, the less onerous levels of protection permitted in Division 2 by the National Electrical Code and the Canadian Electrical Code are not yet recognized.

4.3.3 Zone 0 concept

In the 1960s Europe made its own contribution to the practice of area classification by introducing the concept of Zone 0. The intent of defining Zone 0 was to define those locations in which the flammable material is present for such a high percentage of the time that extraordinary measures should be taken to protect against ignition by electrical apparatus. The objective of defining Zone 0 and Zone 1 was to allow a less restrictive practice in the remainder of locations formerly classified within Division 1. IEC has recognized three levels of probability that a flammable concentration is present. In IEC terminology, these three levels are Zones 0, 1, and 2. North American Division 1 includes both Zone 0 and Zone 1, and North American Division 2 is basically equivalent to Zone 2. Though the definitions of zones are very similar in almost all standards, the application of the words to specific industrial situations is somewhat different.

4.3.4 Temperature classification

Prior to 1971 the autogenous ignition (or autoignition) temperature, AIT, was a criterion for group classification. Inclusion of the AIT as one of the classification criteria caused problems for those trying to classify new materials that had not been tested, because other flammability and combustion parameters of flammable gases and vapors are not correlated to AIT. For example, the AIT of diethyl ether is 160°C. Hydrogen has an AIT of approximately 520°C. Methane has an AIT of approximately 630°C. Yet hydrogen is much more easily ignited by an arc than diethyl ether. Methane is much less easily ignited. Hydrogen requires very close-fitting flanges to prevent transmission of an explosion, but the flanges for an enclosure to protect against transmission of an explosion in diethyl ether may be much more widely separated, i.e., the MESG of diethyl ether is several times that of hydrogen.

When the 1971 *National Electrical Code* and the *Canadian Electrical Code* removed AIT as one of the criteria for material classification, the practice of temperature marking was introduced. Table 1 lists the temperature codes recognized in the NEC. Enclosures containing heat-producing devices must be marked by a temperature code or with the maximum surface temperature of the enclosure based on 40°C ambient. Those that do not have an alphabetical suffix, i.e., T1-T6, are recognized internationally by the IEC (International Electrotechnical Commission), by CENELEC, and by many national standards bodies. In the United States and Canada, equipment of the nonheat-producing type (such as junction boxes, conduit, and fittings) and equipment of the heat-producing type (such as industrial process transmitters and transducers) having a maximum temperature not more than 100°C need not be marked. The temperature classification marking also applies to surfaces other than those of the enclosures in the case of intrinsically safe and nonincendive equipment.ta

Table 1 — Temperature identification numbers

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

4.3.5 Grouping of materials

4.3.5.1 A hazard grouping of materials is always relative to a stated property, i.e., to a particular ignition mechanism or a means of hazard reduction. Materials that are very much alike relative to ignition by electrical arcs or materials that have similar MESG may behave quite differently with respect to ignition by a hot surface.

4.3.5.2 Table 2 compares several countries'/organizations' designations of gas groups. At the present time most national standards use the IEC group designations, where "II" indicates an above-ground facility and "I" indicates a hazard due to methane in the below-ground works of a mine. The comparisons of Table 2 are approximate: for example, North American Group C is approximately the same list of materials as IEC Group IIB. Grouping is an arbitrary designation of dividing lines in a continuous series of values of a particular parameter.

Table 2 — Comparison of classifications of flammable vapors and gases (approx.)

<table>
<tr><th>IEC
(79-12)</th><th>UK
(BS4683)</th><th>UK
(BS229:1957)
*</th><th colspan="2">Germany
(VDE0171)
*</th><th colspan="2">USA
National Electrical
Code
Group</th><th>Typical gases
and vapors</th></tr>
<tr><td>IIA</td><td>IIA</td><td>II</td><td colspan="2">1</td><td>D</td><td rowspan="6">CLASS I</td><td>Ethane. propane, butane, pentane, hexane, heptane, octane, nonane, decane, acetic acid, acetone, methanol, toluene, ethylacetate</td></tr>
<tr><td>IIB</td><td>IIB</td><td>III</td><td colspan="2">2</td><td>C</td><td>Ethylene, coke oven gas, dimethyl ether, diethylene, ethylene oxide</td></tr>
<tr><td>IIC</td><td>IIC</td><td rowspan="4">IV</td><td rowspan="4">3n</td><td>3a</td><td>B</td><td>Hydrogen</td></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td>3b</td><td></td><td>Carbon disulphide</td></tr>
<tr><td>3c</td><td>A</td><td>Acetylene</td></tr>
<tr><td></td><td></td><td>Ethyl nitrate</td></tr>
</table>

*Prior to CENELEC

5 Protection techniques for electrical apparatus in hazardous (classified) locations

The most basic protection technique is to avoid placing electrical equipment in a hazardous (classified) location. Facility planning should take this factor into account, leaving only those situations where there is no alternative.

Three basic methods of protection are:

a) explosion confinement;

b) isolation of the ignition source; and

c) energy release limitation.

Within each basic method, one (or more) specific technique necessitates specialized design in order to minimize the potential risk of operating electrical apparatus in hazardous (classified) locations.

5.1 Explosion confinement

5.1.1 Explosionproofing (internationally referred to as flameproofing)

Explosionproofing, applicable to Class I areas only, is a specific protection technique in which the ignition source, fuel, and oxidizer may coexist and ignition may occur. However, any ignition that does occur is confined within an enclosure strong enough to withstand any explosion pressure associated with the gas groups for which it is designated. Also, all joints have close enough values and tolerances so that flame, sparks, or escaping hot gases are cooled sufficiently to prevent the external atmosphere from being ignited. Additionally, all external surfaces must be kept below the autoignition temperature for the specific gases or vapors involved.

5.1.2 The explosionproofing technique is gas group-dependent, i.e., an enclosure designed and tested for Class 1 Group C would not be suitable for use with a Group B material.

5.2 Isolation

Isolation of the ignition source from the flammable atmosphere may be accomplished by several techniques. Some of the most common techniques include pressurization, purging, continuous dilution, and inerting.

5.2.1 Purging (internationally referred to as pressurization)

In the United States and Canada the purging technique, applicable only to Class I applications, reduces the concentration of any flammable gas or vapor initially present to an acceptably safe level and isolates electrical components from the external atmosphere by maintaining a pressure within the equipment enclosure higher than that of the external atmosphere. Thus, the external atmosphere is prevented from entering the enclosure. Unlike explosionproofing, the purging technique is not gas group-dependent with the following exceptions:

a) For Type Y, a nonincendive component and nonincendive circuits must be gas group rated.

b) For Type X, door interlock and purge fail power cutoff must be rated for the location.

In the case of enclosures in which flammable materials are intentionally introduced within the enclosure (such as with gas analyzers), a different technique, commonly referred to as continuous dilution, is required. Refer to NFPA 496, although this standard does not use the term "continuous dilution." Also refer to 5.2.2.

5.2.1.1 In North America the purging technique is used for reducing the classification within the enclosure to a lower level, such as from Division 1 to Division 2 or nonhazardous (unclassified) or from Division 2 to nonhazardous (unclassified). The European and North American requirements agree in principle, but the bases for the respective requirements are equipment construction criteria. The end result is essentially the same. Reference IEC Publications 79-2 and 79-13.

A discussion of three different sets of requirements dependent upon the area classification and the nature of the enclosed apparatus follows.

United States and Canada

Type X Purging. In the United States and Canada, Type X purging is a method of reducing the classification within an enclosure from Division 1 to nonhazardous (unclassified). Type X purging requires that the enclosure pressure be monitored and that the electrical power be mechanically disconnected upon loss of positive pressure.

Type Y Purging. In the United States and Canada, Type Y purging is a method of reducing the classification within an enclosure from Division 1 to Division 2. Devices that employ Type Y purging must be suitable for use in Division 2 locations without purging. A visual or audible warning is required for loss of positive pressure.

Type Z Purging. In the United States and Canada, Type Z purging is a method of reducing the classification within an enclosure from Division 2 to nonhazardous (unclassified). A visual or audible warning is required for loss of positive pressure.

International

Types X, Y, and Z purging are not recognized outside the United States and Canada. The IEC uses the designation "first case" for Type X and Type Y purging and "second case" for Type Z purging, although "purging" is referred to as "pressurizing." International requirements for visual and/or audible alarms for loss of enclosure pressure, when the pressurization technique is used, vary from country to country. Loss of pressure may also require power disconnection.

5.2.1.2 Pressurization

In the United States the term "pressurization" is limited to Class II applications. It is the technique of supplying an enclosure with clean air or an inert gas, with or without continuous flow, at sufficient pressure to prevent the entrance of combustible dusts. Internationally, the term "pressurization" refers to a purging technique for Zone 1 and Zone 2 locations. Refer to 5.2.1 and NFPA 496 for further information.

5.2.2 Continuous dilution

Continuous dilution is a derivation of the purging technique and is intended for electrical equipment enclosures in which a flammable material is deliberately introduced. Such equipment may include gas analyzers, chromatographs, and similar instruments. The principle involved is to introduce sufficient flow of protective gas to dilute any flammable gas present during normal operating conditions or failure conditions to a level well below the lower explosive limit (normally, 25 percent of LEL). An example of a failure condition would be a broken tube transporting flammable gas. As with purging, there are three types of protection, depending upon the conditions of release within the enclosure. The safeguards include: (1) monitoring the presence of the protective gas, (2) removing electrical power, and (3) alarming—depending on the conditions of internal release and the nature of the enclosed electrical components. Safeguards depend upon whether or not the electrical parts are normally a source of ignition or meet the requirements for operation in a Division 2 hazardous (classified) location. A continuous dilution system may also be used as a purging or pressurization system to prevent any external flammable gas or vapor or combustible dusts from entering the enclosure.

> **NOTE:** This technique is not recognized in CENELEC standards but is recognized by IEC 79-2.

5.2.3 Oil Immersion

While oil immersion is not a common protection technique for instruments, it is an acceptable isolation method. The most common application is for static electrical equipment (such as transformers). All electrical parts are submersed in either nonflammable or low-flammability oil, which prevents the external atmosphere from contacting the electrical components. The oil often serves also as a coolant. Refer to UL 698 and IEC 79-6.

5.2.4 Sealing (sealed device)

Sealing is a technique primarily applicable to Division 2 classified areas. The basic principle provides for the isolation of electrical components within an enclosure by sealing the enclosure well enough to prevent the casual entrance of any external flammable atmosphere. Sealing may be accomplished by several means, from simple gasketing to a glass-to-metal hermetic seal. Refer to ISA-S12.12, IEC 79-15, and CEC C22.2 Number 213 for further information.

A hermetic seal is considered effective enough to be insensitive to gas group, but a gasketed enclosure is sensitive to particular gases/vapors (based on their diffusion constants and on the effectiveness of the gasket seal). For example, hydrogen, with its small molecular structure, will diffuse much more easily than the heavier hydrocarbons.

The sealing technique has been applied in Europe to a variety of process control equipment. In North America, hermetically sealed components such as relays, push button contacts, and limit, level, and pressure switches are commonly used.

The following are two levels of protection provided by sealing: (1) the enclosure is sealed and (2) application is restricted to areas that become hazardous only upon equipment or process failure (Division 2).

5.2.5 Encapsulation

Potting or casting are both isolating techniques in which the electrical parts are encapsulated in a solidified electrically insulating material, preventing the flammable atmosphere from contacting the electrical components. Most encapsulation has been for the purpose of isolating hot components from the atmosphere in order to obtain a lower temperature rating or to permit reduced creepage distances because the spacings are shielded from conductive contamination.

5.2.6 Sand filling

Refer to 5.2.7.

5.2.7 Powder filling

Powder filling is a technique whereby the electrical components are immersed in a powder to a depth sufficient to ensure that any arcing below the powder cannot ignite the flammable atmosphere surrounding the apparatus.

The concept was developed in France and generally refers to a sand or quartz filling but allows other powders with similar characteristics to be used.

5.2.8 Inert gas filling

Inert gas filling is a technique of filling the interior of an enclosure with an inert gas. It typically is used in conjunction with sealed or pressurized enclosures. Refer to 5.2.4.

5.3 Energy release limitation

5.3.1 Intrinsic safety

The application of intrinsic safety is limited to equipment and circuits in which the available energy required for operation is inherently low. Intrinsic safety involves the limitation of the available energy in a circuit to a level at which any spark or thermal effect is incapable of causing ignition of a flammable atmosphere under test conditions that include the application of circuit and component faults. As a result, the technique is widely used in the instrument industry, e.g., 4 to 20 mA signal circuits, temperature, flow, pressure, and level measurement instruments, portable battery-operated instruments (radios, combustible gas detectors). Certain fault conditions need to be considered in the design and evaluation. For installation information, refer to ISA-RP12.6 and NEC Article 504.

5.3.2 Nonincendive equipment (internationally referred to as energy limited apparatus and circuits)

The nonincendive approach is similar to the intrinsic safety approach in basic principle but differs greatly in detail. There are two major differences. First, nonincendive circuits are evaluated under normal conditions only (i.e., no fault conditions need to be considered). Equipment meeting the nonincendive criteria is suitable for use only in Division 2 areas in which the atmosphere is normally nonflammable and requires a breakdown in the process or the process equipment to make it flammable.

Second, relative to the components used, few detailed requirements must be met other than those applicable to nonhazardous (unclassified) location use as related to personnel shock and fire hazard. A typical analysis involves itemizing all parts that could potentially interrupt a circuit such as switches, relays, connectors, and potentiometers. These components are then analyzed or tested to see if they can ignite the specified flammable atmosphere.

5.4 Other methods of protection

5.4.1 Restricted breathing

Restricted breathing is a technique developed by the Swiss. It can be considered to be a modified form of sealing. In the Swiss utilization of the technique, fairly large enclosures of relays and other ignition-capable apparatus are gasketed so they are tightly sealed. The protection principle employed is that the enclosure is sufficiently tight to make it highly unlikely that a flammable cloud of gas would surround the enclosure for the length of time necessary for enough flammable material to enter the enclosure that a flammable concentration would exist in the enclosure. This technique is applicable only to Division 2 locations. Refer to IEC 79-15.

5.4.2 Increased safety

Increased safety is a European technique developed in Germany. It has been used specifically for sparkless motors and lighting fixtures. The motors are specially designed to remain below the autoignition temperature, even under certain locked rotor conditions, and have special connection facilities designed to prevent loosening even under severe vibration. Increased safety is not recognized in the United States and Canadian codes although the technique is used in certain specific applications. Refer to IEC 79-7.

5.4.3 Dust-ignitionproof

Dust-ignitionproof enclosures are essentially sealed enclosures that prevent the entrance of dusts. Additionally, the outer enclosure temperature must be maintained below specific limits. For additional information, refer to ISA-S12.10.

5.5 Summary of protection techniques

Table 3 provides a summary of various international protection techniques and locations in which they are permissible.

5.5.1 The first column of Table 3 lists the various classifications of areas external to the enclosures. Each of the subsequent columns represents a different protection technique. The Ex designations at the head of each column are the International Electrotechnical Commission's (IEC) codes for the protection techniques. An "na" in a box indicates that the corresponding protection technique is not recognized for use in the corresponding area classification. An "a" in a box indicates that the corresponding protection technique is recognized for use in the corresponding area classification.

Table 3 — Summary of international protection techniques (flammable gases or vapors-in-air mixtures)

Enclosures not containing a source of release												
Area classifica-tion external to enclosure	Type of Protection											
	Special protection	Intrinsic safety		Flame -proof	Pressurization		Increased safety	Encapsu-lation	Hermetic sealing	Type N protec-tion	Restricted breathing	Certain unprotected electrical apparatus
					Alarm	Isolate						
	Ex s	Ex ia	Ex ib	Ex d	Ex p	Ex p	Ex e	Ex m	Ex h	Ex n	Ex n	
Unclassified	**	a	a	a	a	a	a	a	a	a	a	a
Zone 2	**	a	a	a	a	a	a	a	a	a	a	a
Zone 1	**	a	a	a	a***	a	a	a	na	na	na	na
Zone 0	**	a	na	na	na	na	na	na	na	na	na	na

a = allowed

na = not allowed

* There is no direct correlation between Zones and Divisions. Therefore, Table 3 is not directly applicable for use in the United States and Canada.

** Refer to 5.5.2.

*** In Zone 1 applications, the enclosed equipment must be suitable for Zone 2 (i.e., present no source of ignition in normal operation). Refer to 5.5.5.

5.5.2 The special protection category, "Type s," is a technique other than those that have been standardized. When an area is classified Zone 0, it is quite common to provide two or more protection techniques, such as pressurizing an explosionproof enclosure. "Ex s" has also been applied for Division 1 (specifically Zone 1 in Europe), where, for example, a transmitting device nearly satisfies the increased safety requirements and also nearly satisfies the intrinsic safety requirements. The combination results in a device that is safe for use in a hazardous (classified) location but does not satisfy a specific set of requirements for a single protection technique.

5.5.3 The intrinsic safety column indicates that, internationally, there are two sets of requirements—"Ex ia" and "Ex ib." "Ex ia" is intended for Zone 0 applications while "Ex ib" is for Zone 1 applications. The difference in requirements is that "Ex ia" considers two simultaneous faults while "Ex ib" considers only one. The approach of the United States and Canada uses the two-fault criteria for all intrinsic safety applications since a Division 1 area classification includes both the International Zone 0 and Zone 1, and equipment must be rated to the most stringent (Zone 0) requirements.

5.5.4 The flameproof (explosionproof) enclosure column is designated "Ex d" and is suitable for Zone 1 areas internationally. Flameproof enclosures cannot necessarily be used in Division 1 areas in the United States and Canada because different testing standards are applied.

5.5.5 The pressurization (purging in the United States and Canada) column uses the IEC "Ex p" designation and indicates the requirements for an alarm and/or isolation (removal) of power. In the alarm column, the "***" means that in Zone 1 applications the enclosed electrical equipment must be suitable for Zone 2, i.e., present no source of ignition in normal operation.

5.5.6 Increased safety is designated “Ex e" and is normally considered a Zone 1 technique. The suitability of "Ex e" equipment in a Zone 1 area has been a controversial subject in Europe because it is considered by many as being suitable for Zone 2 only. German practice and experience have prevailed, however, at least in its official classification.

5.5.7 Type "Ex n" protection describes a variety of component and device requirements that make equipment suitable for use in Division/Zone 2 locations. The next column, restricted breathing, also falls in this category.

5.5.8 The last column indicates that certain equipment can be used "off the shelf" in Division/Zone 2 locations. This concept has been used successfully in North America for years, with no known accidents due to the direct use of such equipment. Much instrumentation, squirrel cage motors (sparkless) and the like, fall into this category and are normally not marked to indicate suitability. In the United States, refer to the NEC. In Canada, CSA C22.2 No. 213 is the standard for Division 2 equipment.

6 Wiring methods for hazardous (classified) locations

For the installation of electrical apparatus in hazardous (classified) locations (areas), three basic installation systems are allowed:

a) conduit systems (refer to Figures 9, 11, and 12);

b) cable systems with indirect entry (refer to Figure 4); and

c) cable systems with direct entry (refer to Figure 7).

NOTE: Intrinsically safe and nonincendive equipment and associated wiring can be installed with less restrictive wiring methods.

In the United States, NEC Article 501-4 allows only the conduit system or mineral-insulated (MI) cables for all applications in Class 1, Division 1 locations. MI cables are used primarily for heating cables and for flame-resistant signal or control cables.

NEC Article 501-4(b) allows for the use of certain other types of cables in Division 2 areas. The authority having jurisdiction may allow the use of certain cables in Division 1 areas in specific industries (e.g., offshore oil and gas production; Refer to API RP1 4F).

The European harmonized standards, EN 50014 through EN 50020, permit apparatus to be designed that can be installed using one or more of the three installation approaches. The installation requirements, however, are not identical from country to country. In Italy, for example, only the conduit system can be used for Zone 1 (Division 1). In Germany the installation standards VDE 0165/6.80, adapting to the European standards, allow for all three systems. Prior to 1980, only the cable system with indirect entry was possible.

6.1 Conduit system

6.1.1 General

With conduit systems in Class I, Division 1 locations in the United States, the electrical wiring is installed inside closed threaded metal pipes (rigid steel or intermediate metal conduit) approved for the purpose. The pipes, in turn, are screwed into entrances in the enclosures, which contain electrical equipment (Figure 1). The entire conduit system, including all fittings, is required to be explosionproof (flameproof) and frequently requires a seal between the connected enclosure and the pipe. In Class I, Division 2 locations, the conduit system need be explosionproof only between any explosionproof enclosure and the required sealing fittings.

In Class I, Division 1 locations in Canada, one difference is that threaded steel intermediate conduit is not acceptable.

In this section all references to "seal(s)" and "sealing" refer to an approved conduit or cable seal that is filled with suitable compound, is designed to contain an explosion in the enclosure to which it is attached, and is approved for use in Class I locations [Figures 2(a) and (b)]. (See Article 501 of the NEC.)

6.1.2 Conduit and cable seals

Seals are installed in conduit and cable systems (except for MI cable systems with approved explosionproof terminations) to:

a) confine an explosion occurring in an enclosure or a conduit system to only that enclosure or that portion of the conduit system;

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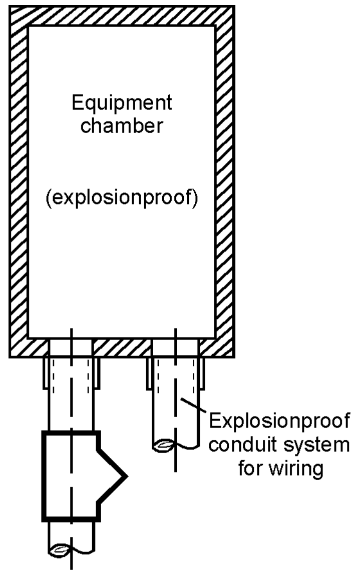


Figure 1 — Conduit system (direct entry)

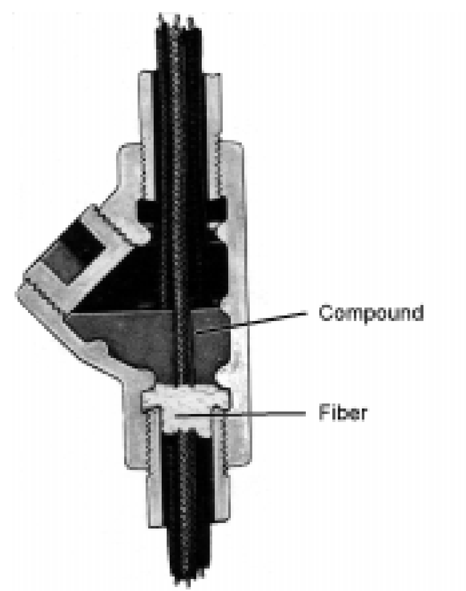


Figure 2a — Vertical seal

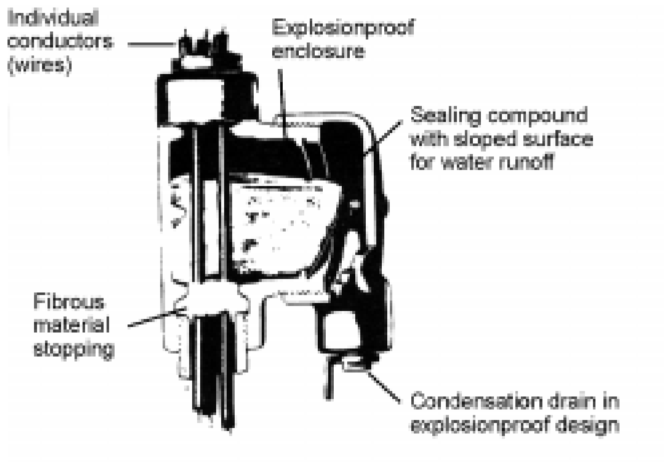


Figure 2b — Drain seal

b) minimize the passage of gases, vapors, or liquids and prevent the passage of flames through the conduit or cable system from a classified to an unclassified area, or from one enclosure to another;

c) prevent the entrance of process gases, vapors, or liquid from process piping to the conduit or cable systems (reference 6.1.3.2); and

d) prevent "pressure piling"—the buildup of pressure inside conduit systems (ahead of an explosion's “flame front") caused by precompression as the explosion travels through the system. Exploding precompressed gases may reach pressures that would exceed the design pressure of the enclosures.

6.1.3 Seal requirements

6.1.3.1 Enclosure entries

In Division 1 and Division 2 locations, a seal must be installed in every conduit or cable (refer to NEC for requirements) that enters an enclosure containing an arcing or high-temperature device in which the enclosure is required to be explosionproof.

Multiconductor cables should be sealed in an approved fitting only after removing the jacket and any other coverings so the sealing compound will surround each individual insulated conductor and the outer jacket of the cable. The conduit system between an enclosure and the required seal must be explosionproof, even in Division 2 locations, since the conduit system must be able to withstand the same internal explosion as the enclosure to which it is attached. In Division 1 and Division 2 locations, approved explosionproof unions, couplings, elbows, reducers, and conduit bodies similar to "L," "T," or "cross" types are the only enclosures or fittings allowed between the sealing fitting and the enclosure. The conduit body cannot be larger than the trade size of its associated conduit.

In addition to the above, in Division 1 areas only, seals must be installed in each two-inch or larger conduit run entering an enclosure that contains splices, taps, or terminals. All seals must be installed within 18 inches from the enclosures to which they are attached.

6.1.3.2 Process Instruments

Conduit seals or barriers and drains shall be installed in each conduit or cable connection to devices installed on process lines that contain flammable fluids and depend upon a single compression seal, diaphragm, or tube (such as a Bourdon tube) as a barrier between the process fluid and the conduit or cable. This is to prevent flammable process fluids from entering conduit or cable systems and being transmitted to unclassified areas or to electrical arcing or high temperature devices in other portions of the system if the process seal fails. The additional seal or barrier and the interconnecting enclosure or conduit system shall meet the temperature and pressure conditions to which they will be subjected upon failure of the compression seal. Ordinary conduit seals typically cannot meet this criterion due to their leakage rate. Typical examples of such devices are solenoid valves and pressure, temperature, and flow switches or transmitters. This requirement applies even in unclassified areas. Draining provisions must be such that process line leaks past the process seal will be obvious.

6.1.3.3 Classified area boundaries

Wherever a conduit run passes from a Division 1 to a Division 2 area, from a Division 2 to an unclassified area, or any other combination thereof, a seal must be placed in the conduit run at the boundary, on either side. The conduit system must not contain any union, coupling, box, or other fitting between the sealing fitting and the point at which the conduit leaves the Division 1 or Division 2 area. An exception to the above is that an unbroken rigid metal conduit that passes completely through a Division 1 or a Division 2 area is not required to be sealed if the termination points of the unbroken conduit are in unclassified locations and the conduit has no fitting less than 12 inches beyond each boundary.

If drain seals are used at an area classification boundary, care must be exercised in the placement of such seals to ensure that gases or vapor cannot be communicated across the boundary through the conduit system by way of the seal's drain passage. Reference Figure 3.

Cables with an impervious continuous sheath do not have to follow the same sealing requirements as conduit systems when crossing Division 2—unclassified area classification boundaries. Such cables are not required to be sealed unless the cable is attached to process equipment or devices that may cause a pressure in excess of 6 inches of water (1.5 kPa) to be exerted at a cable end. In this case, a seal, barrier, or other means shall be provided to prevent migration of flammables into an unclassified area or to arcing or high temperature devices in other portions of the system, in accordance with NEC Article 501. No seal is then required at the boundary location. Cables with an unbroken, impervious, continuous sheath are permitted to pass through a Division 2—unclassified area classification—boundary without seals. The authority having jurisdiction may allow the use of certain cables in Division 1 locations in specific areas (e.g., offshore oil and gas production; refer to API RP 14F).

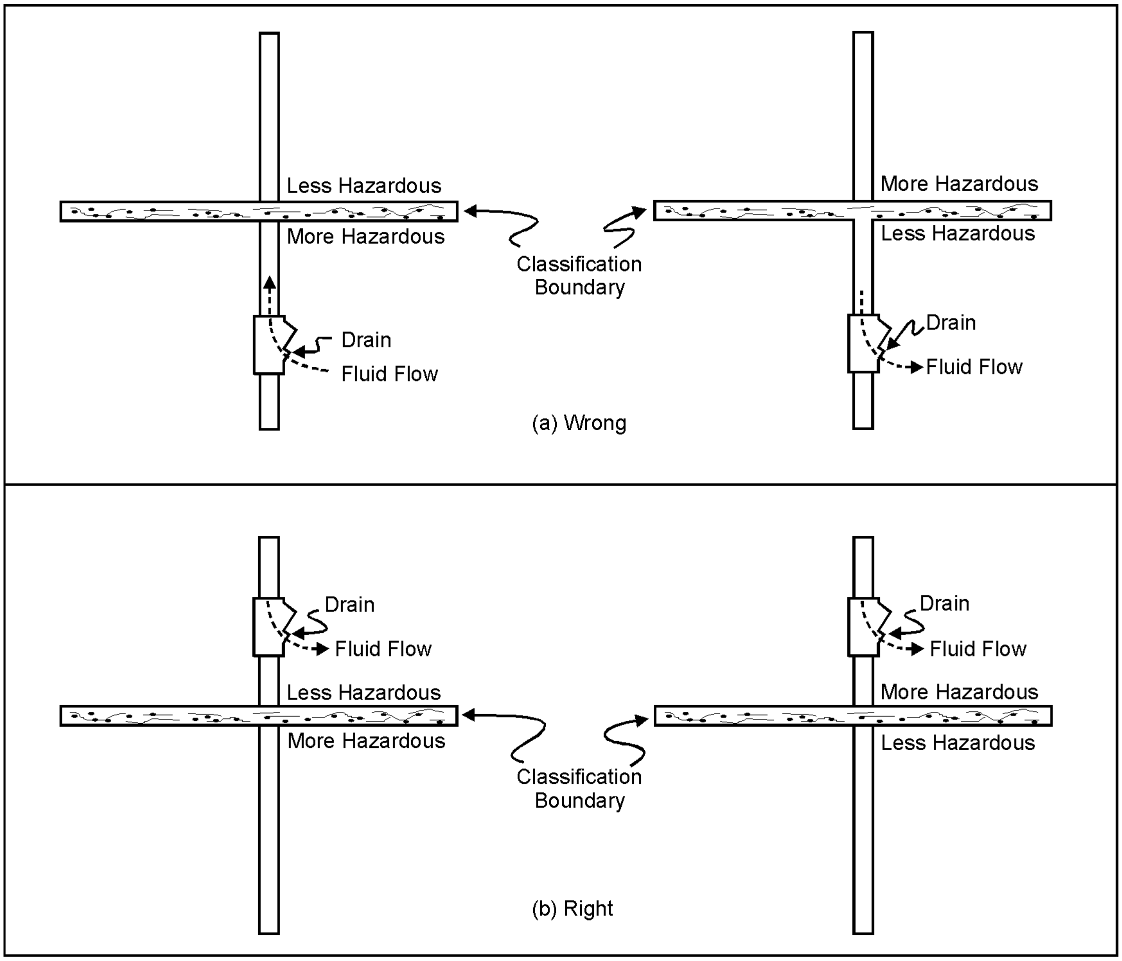


Figure 3 — Placement of drain seals

(Reference: API RP14F, Figure 4.8G, Design and Installation of Electrical Systems for Offshore Production Platforms.)

6.1.4 Installation

In addition to being placed in proper locations, the following practices should be observed when installing sealing fittings:

a) Sealing fittings must be accessible.

b) Sealing fittings must be mounted only in the positions for which they were designed. Some seals are designed only to be installed vertically; some can be installed either vertically or horizontally; a third type can be installed in any position.

c) Pouring hubs must be properly oriented. The hub through which the sealing compound is to be poured must be installed above the sealing cavity to properly pour the seal.

d) Only a sealing compound and fiber approved for a particular sealing fitting should be used, and the manufacturer's instructions should be followed for the preparation of dams (if applicable) and the preparation and installation of the sealing compound.

e) No splices or taps are allowed in sealing fittings. Sealing compounds may not be insulation materials that may absorb moisture, causing grounding of the circuit conductors.

f) Sealing fittings with drain provisions should be installed at the low points of a conduit system to allow drainage of conduits where water or fluids may accumulate in the conduit/ system.

g) Factory-sealed devices such as toggle switches, push buttons, lighting panels, and lighting fixtures eliminate the need for externally sealing those particular devices.

6.2 Cable systems

In the United States, the NEC will not allow cables [except for mineral-insulated (MI) cable] and cables used in intrinsically safe systems to be installed in Class I, Division 1 locations. For Class I, Division 2 locations, certain cable constructions are allowed. Refer to Table 4(b). The authority having jurisdiction may allow the use of certain cables in Division 1 areas in specific industries (e.g., offshore oil and gas production; refer to API RP14F).

In Canada, in Class I, Division 1 locations, armored and metal-sheathed cables with matching cable glands, tested to the requirements of CSA Standard C22.2 No. 174, are permitted for direct entry to explosionproof equipment. The cable must have an FT4 flame rating and be capable of withstanding the impact and crushing forces as specified in the standard. The cable gland normally is provided with a chamber for accepting the sealing compound and a means to prevent against slippage or loosening of the cable under pulling forces prescribed in the standard. The effectiveness of the cable/gland combination, in confining an explosion in the enclosure and minimizing the passage of gas or vapor through the interstice of the cable, is verified by explosion, flame propagation, and over-pressure testing.

Internationally, openly installed cable systems are common, using high-quality, heavy-duty sheathed cables (i.e., with an outer sheath of rubber, plastic, or lead). Only in locations where mechanical damage is expected are they installed in protective pipes or tubes. These protective pipes or tubes are not usually closed (to avoid corrosion due to condensation) and must provide drainage at low points. Armored or braided cable is often required in Zone 1 or in areas where damage might occur to unprotected cable. The metal braid is covered by an outer sheath of rubber, plastic, or other synthetics, and the braid is grounded.

Different technologies have been developed in various countries regarding the entry of cables into explosionproof (flameproof) enclosures. In the course of harmonizing the standards, all these entry possibilities were included in the CENELEC standards.

6.2.1 In Germany, and in many other countries influenced by German technology, only the indirect entry via a terminal chamber that provided "increased safety" protection was allowed until the CENELEC standards were adopted (Figure 4). Cables enter the terminal chambers via cable glands and connect to “increased safety" terminals. Then the single conductors enter into the explosionproof (flameproof) chamber via post-type bushings or conductor bushings (Figures 5a and 5b).

The bushings are installed by the manufacturer of the enclosure, and a routine test is performed to verify the integrity of the "Ex d" portion of the enclosure. The installer needs only to open the terminal chamber of "increased safety" for connection, not the explosionproof (flameproof) chamber.

6.2.2 British technology has always allowed a direct entry of cables into the flameproof (explosionproof) chamber. For circuit components of low switching capacity (control switches, for instance) built into flameproof enclosures, the connection cables are allowed to enter directly into the enclosure. Circuit components with a higher switching capacity, however, require a separate flameproof terminal chamber, contrary to German technology. Connection is made in the flameproof terminal chamber, not in the flameproof equipment chamber, which contains apparatus capable of causing sparks during normal operation. For cable entry into the terminal chamber, special flameproof cable glands must be used (Figure 6). The elastomeric seal, together with the cable sheath, must form a flameproof joint.

The selection of the cable gland is dependent on the type and arrangement of the cable and on the location where the installation is to be used. The bushings between the chamber containing the apparatus and the terminal chamber correspond largely to German technology.

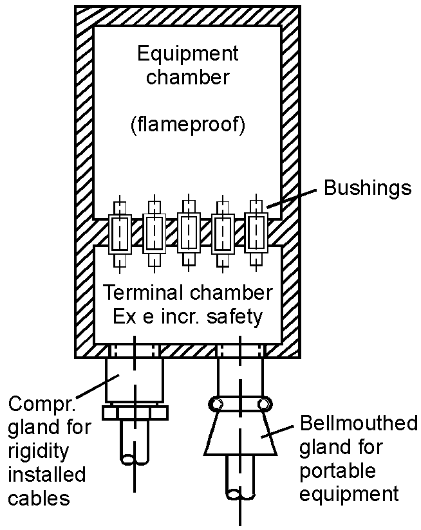


Figure 4 — Cable system (indirect entry)

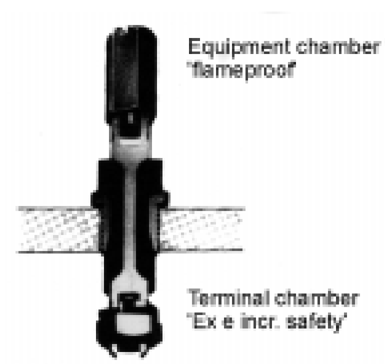


Figure 5a — Post-type bushing (sectional)

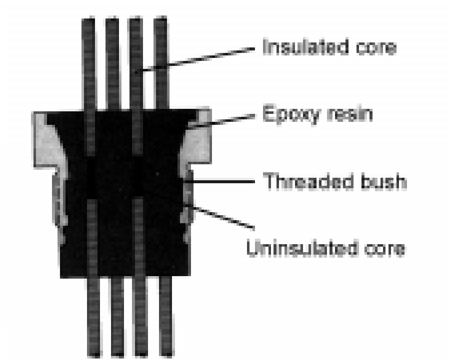


Figure 5b — Multiple-conductor bushing (sectional)

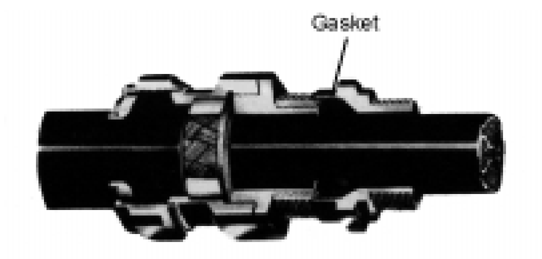


Figure 6 — Cable gland

6.2.3 French technology allows direct cable entry into the flameproof equipment chamber containing the apparatus (which causes sparks during normal operation) (Figure 7). The principle of the French cable gland is shown in Figure 8. As in British technology, the flameproof joint is formed by the cable sheath and the elastomeric seal. The French seal, however, is stronger than the British seal, and better compensates for varying cable diameters.

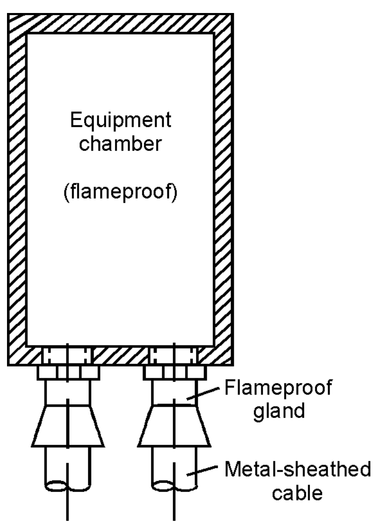


Figure 7 — Cable system (direct entry)

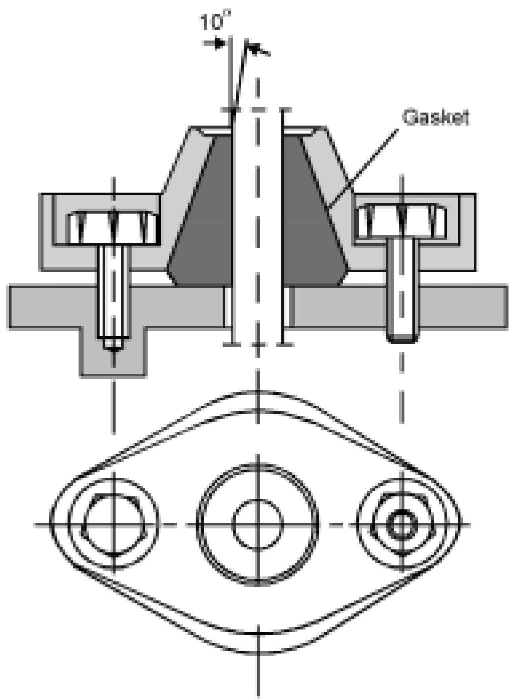
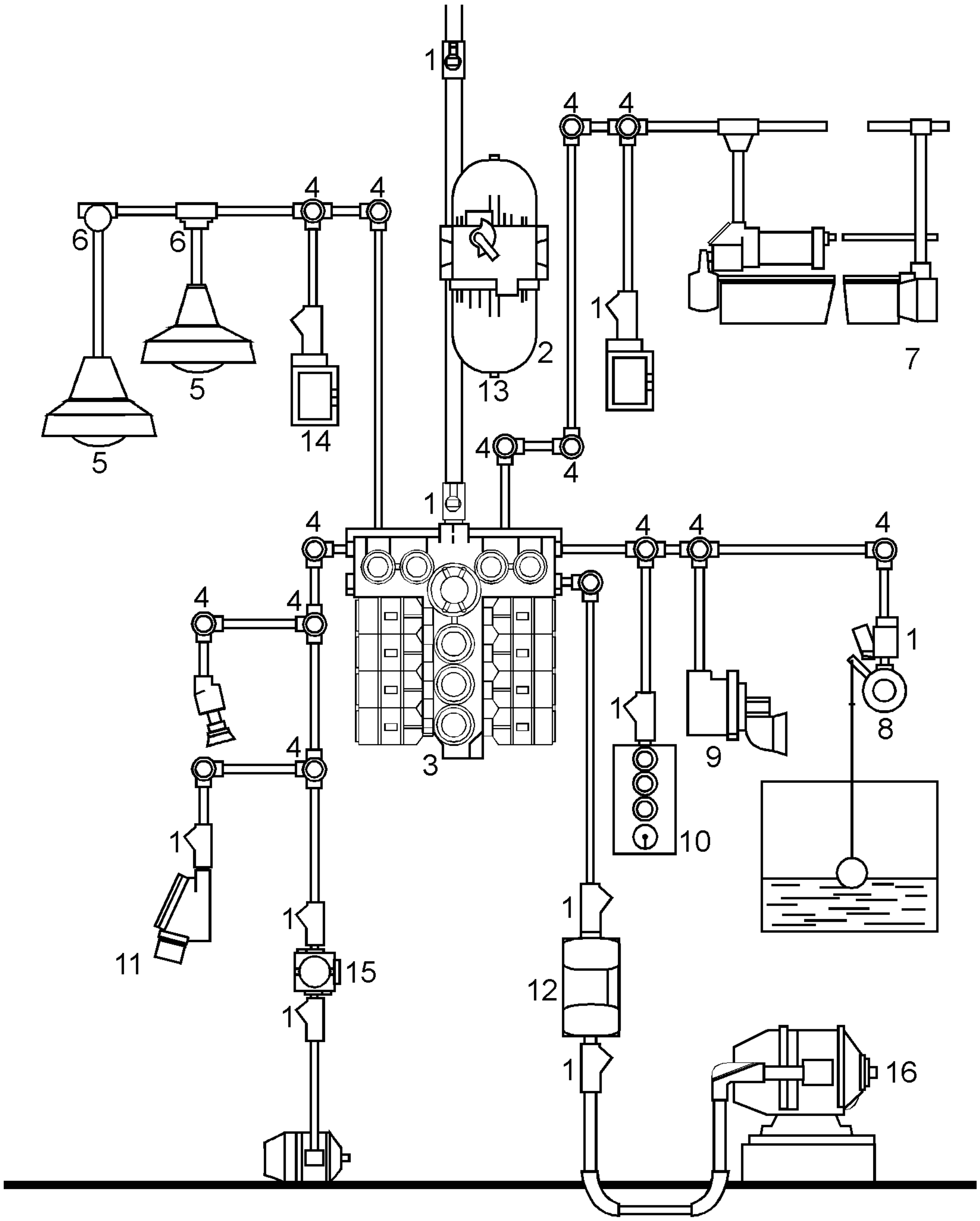


Figure 8 — Cable entry according to French technology

6.3 Comparison of the installation systems

Figure 9 depicts a typical international Group II, Zone 1 conduit system installation.

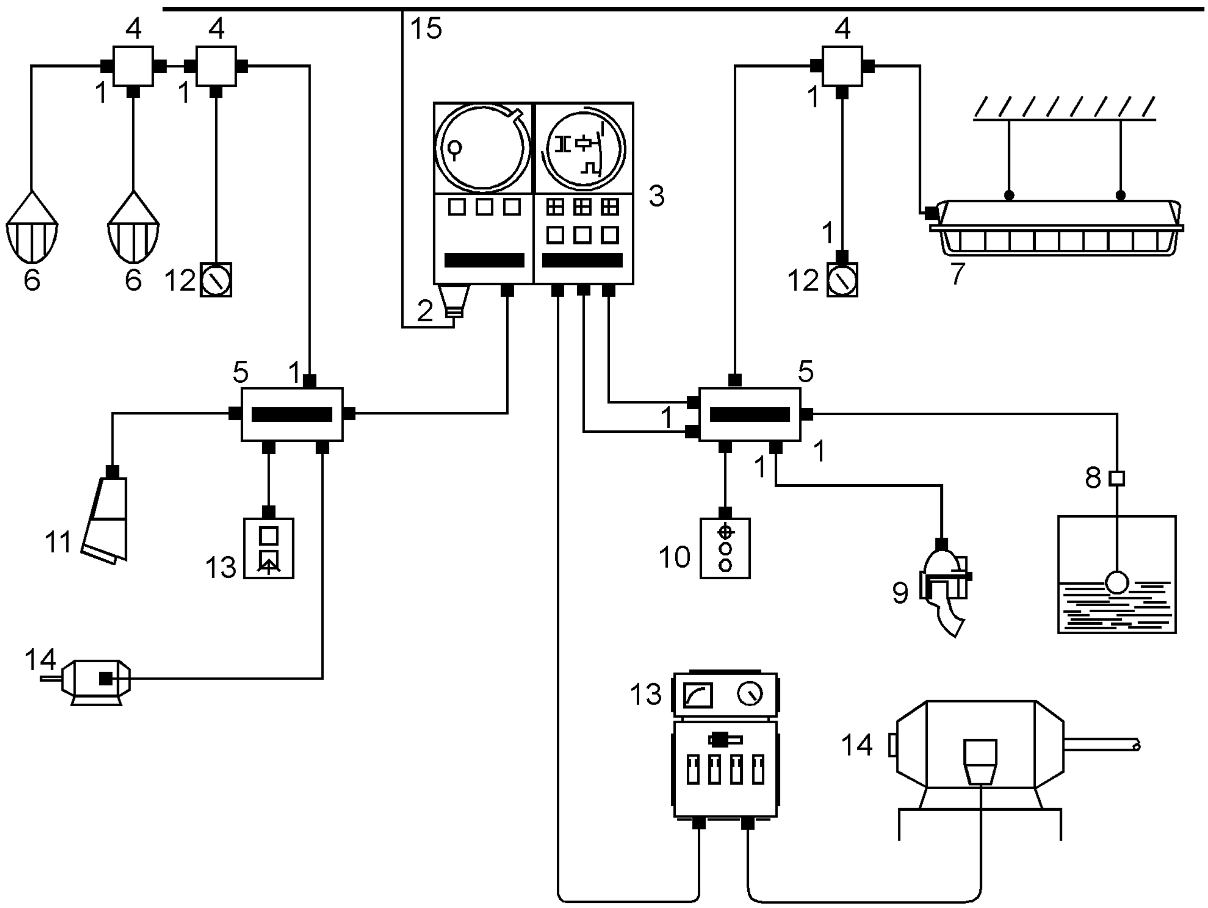
NOTE: Conduit systems are recognized or accepted in all countries.



1	Seal	8	Float switch
2	Isolator	9	Alarm
3	Control/distribution board with factory sealed subcircuits	10	Control and indicating equipment
4	Explosionproof junction box	11	Socket
5	Pendant light fitting	12	Breather
6	Explosionproof junction box, serving as support for pendant light fittings	13	Drain
		14	Installation switch
		15	Motor protection circuit breaker
7	Fluorescent light fitting	16	Explosionproof motor

Figure 9 — Typical international Group II, Zone 1 conduit system installation

Figure 10 depicts a typical international Group II, Zone 1 cable system for a similar installation.



1	Cable glands for fixed cables, trumpet glands for flexible cables
2	Cable sleeve for larger cable diameters
3	Flameproof encapsulated control panel Ex d with terminal chamber Ex e, built-in main indicator, control push button indicating light
4	Junction boxes of "increased safety" type Ex 3
5	Distribution terminal boxes Ex e
6	Pendant light fittings Ex e or Ex d
7	Fluorescent light fittings Ex e or Ex d
8	Float switch "flameproof enclosure" or in standard design connected to an intrinsically safe circuit
9	Alarm
10	Control box Ex e with modules Ex d
11	Socket Ex d
12	Light switch Ex d
13	Motor connection control box Ex e with modules Ex d
14	Motors Ex e or Ex d
15	Cables or tough rubber-sheathed flexibles

Figure 10 — Typical international Group II, Zone 1 cable system (indirect entry) installation

Figure 11 depicts a typical United States and Canadian Class I, Division 1 conduit system installation.

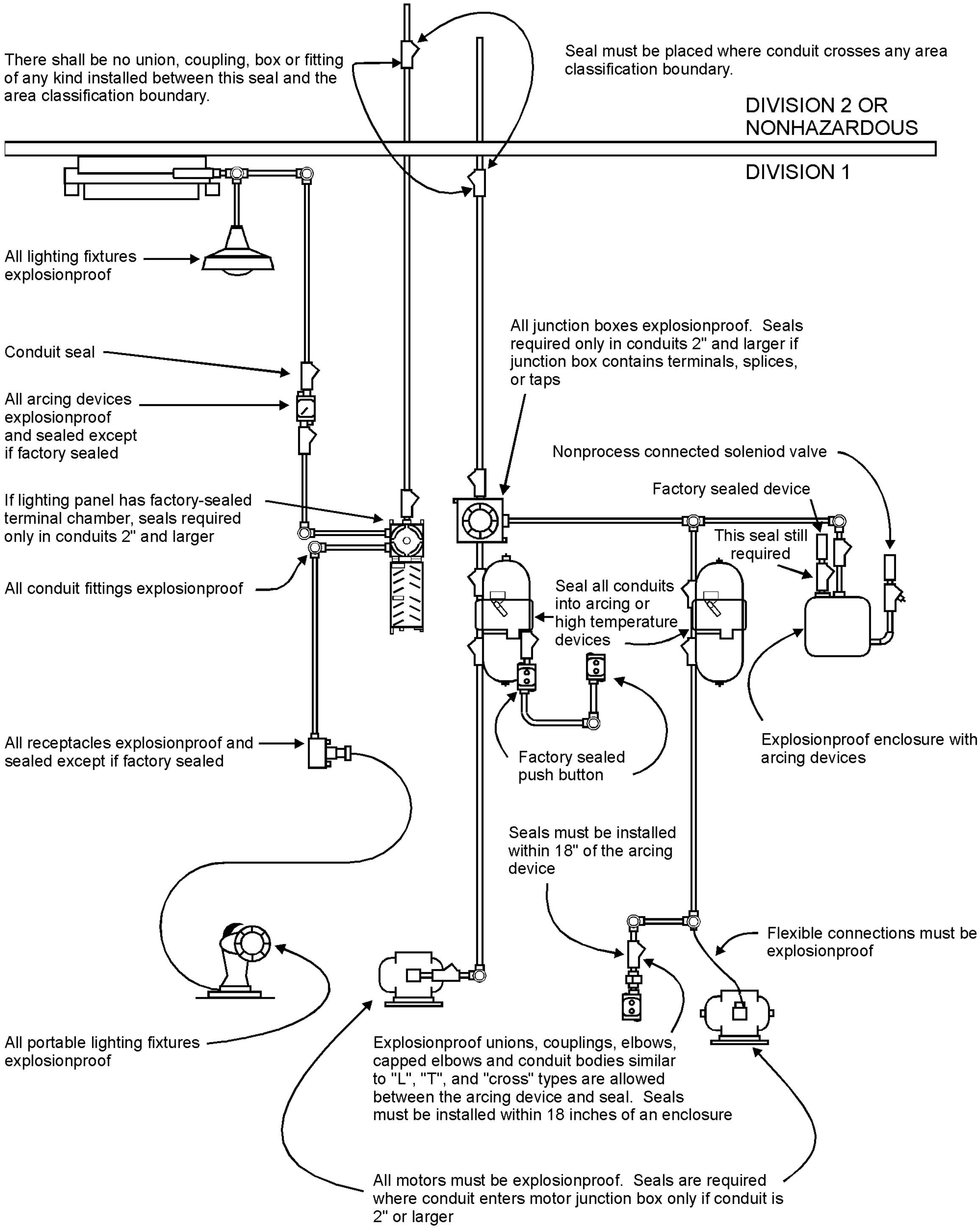


Figure 11 — Typical United States and Canadian Class I, Division 1 conduit system installation

(Reference: API RP 14F: Design and Installation of Electrical Systems for Offshore Production Platforms.)

Figure 12 depicts a typical United States and Canadian Class I, Division 2 conduit/cable system installation.

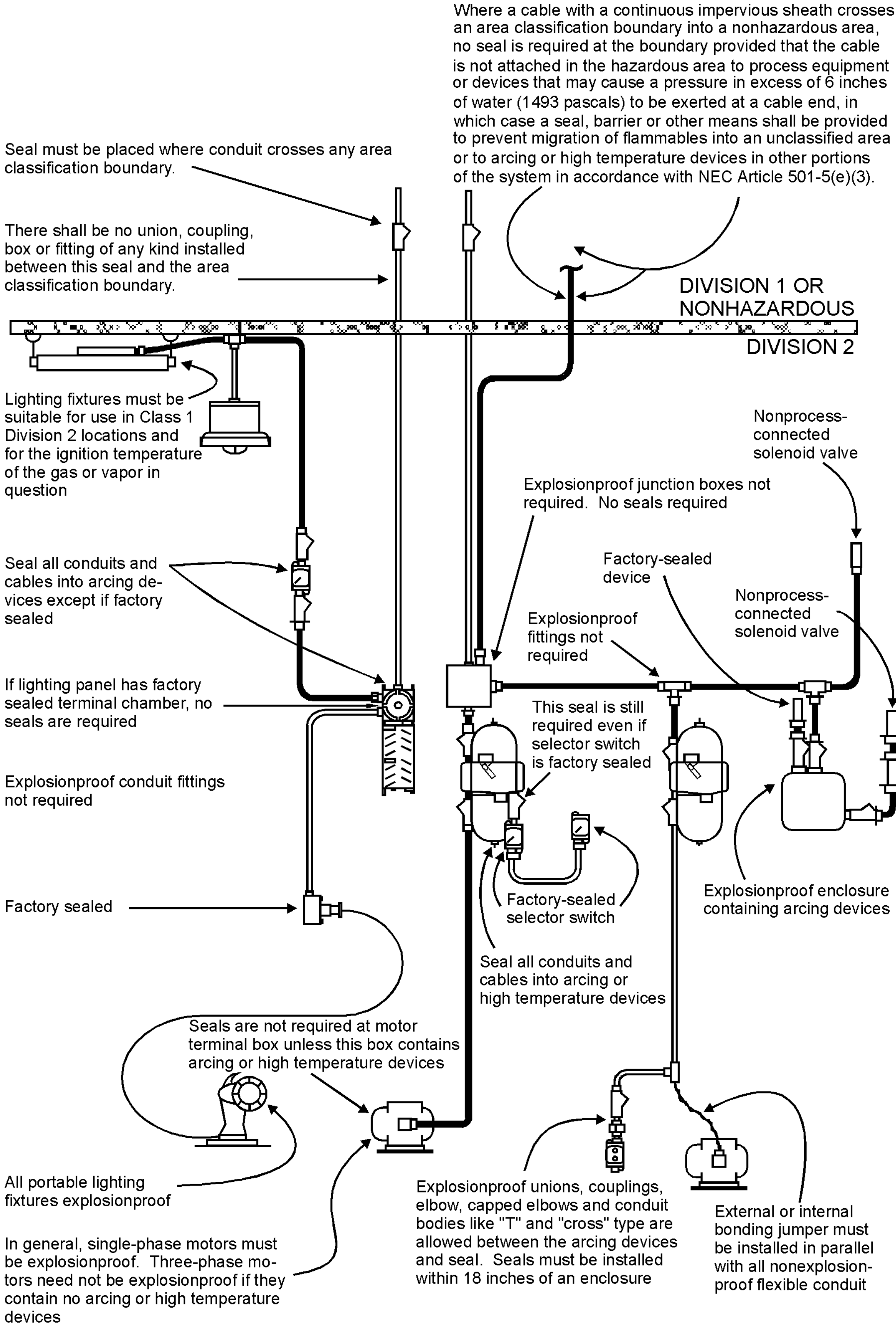


Figure 12 — Typical United States and Canadian Class I, Division 2 conduit/cable system installation

(Reference: API 14F: Design and Installation of Electrical Systems for Offshore Production Platforms.)

6.4 Comparisons of wiring methods (see Tables 4a and 4b)

6.4.1 Comparison of cable and conduit systems

Due to its robust mechanical construction, conduit systems offer superior protection against mechanical damage or external fire influence. Conduit systems also prevent the transmission of an internally generated fire from one conduit to an adjacent conduit, thus offering superior circuit integrity. Ferrous metallic conduit can provide substantial magnetic shielding on sensitive circuits. Conduit systems are widely used in hazardous areas in the United States and Canada. Such installations must rely on properly located and correctly installed conduit seals to provide explosionproof system integrity. Conduit systems may be subject to internal condensation and resulting corrosion, which, if unchecked, can compromise explosion protection, especially with regard to offshore or shoreline locations. Also, under certain conditions conduit systems can provide a passageway for liquids and gases, possibly transmitting corrosive or toxic substances to control rooms, electrical equipment buildings, and the like. In some areas of Europe and Scandinavia, conduit systems are not recognized or accepted.

In many instances, cable systems offer an attractive alternative to conduit systems. Cable systems may be less labor intensive during the initial installation and in follow-up maintenance. In the United States, except in rare circumstances such as for offshore oil and gas facilities, cable systems are not allowed in Class I, Division 1 locations. In Europe and Canada, certain types of cables are allowed in most hazardous areas.

6.4.2 Comparisons between direct and indirect cable entries

A comparison between cable systems with direct and indirect entry shows some advantages to the indirect method, the system with terminal chambers that uses the "increased safety" type of protection. The installer can connect the indirect-entry type without opening the flameproof equipment chamber. With the cable system that uses direct entry, the flameproof protection completion can be achieved only during installation (on site). This, however, is problematic with British as well as French cable entries, because the safe nontransmission of flammable gases between the cable sheath and the seal is highly dependent upon the tolerances of the cables and the reliable and careful installation of the cable entries. The long-term explosion protection depends upon the mechanical, chemical, and thermal resistance of the seal or the cable sheath and can, therefore, be ensured only by regular maintenance and preventive repair.

Direct entry technology requires that the wiring connections be accomplished in the flameproof chamber. When using indirect entry, the connection is to terminals made in an “increased safety" terminal chamber.

7 Grounding and bonding practices

7.1 In the United States and Canada, grounding and bonding practices in hazardous (classified) areas must follow the same standards as grounding and bonding practices in nonhazardous (unclassified) areas, but, in addition, special precautions must be followed:

a) Locknut bushings and double-locknut bushings must not be used solely for bonding purposes but must be paralleled with bonding jumpers. Reference NEC 501-16(a).

b) Flexible metal conduit or liquid-tight flexible metal conduit must not be used solely for a grounding path but must be paralleled with internal or external bonding jumpers. Reference NEC 501-16(b).

c) All conduit must be threaded (NPT standard threads with 3/4 inch taper per foot) and made up wrench-tight or provided with bonding jumpers across threaded joints to minimize sparking when fault current flows through the conduit system. Reference NEC 500-2.

d) When required by the control drawing, intrinsically safe systems must be provided with a dedicated grounding conductor separate from the power system so that ground currents will not normally flow. The systems must be reliably connected to a ground electrode in accordance with NEC Article 250 or CEC Part 1, Section 10.

Reference ISA-RP12.6.

7.2 Internationally, the term "earthing" is used in lieu of "grounding," but the same basic practices are followed.

Table 4a — Field wiring in United States Class I locations [a,b]

	Division 0		Division 1		Division 2	
Wiring system	IS	NIS	IS	NIS	IS or Nonincendive	NIS
Threaded rigid metal conduit	A	Notes 1 or 2	A	A	A	A
Threaded steel intermediate metal conduit	A	Notes 1 or 2	A	A	A	A
Flexible metal explosionproof fitting	A	Notes 1 or 2	A	A	A	A
Type MI cable	A	Note 2	A	A[d]	A	A
Type PLTC, MC, HV, SNM, and TC cable	A	NA	A	NA	A	A
Flexible metal conduit	A	NA	A	NA	A	A[c,f]
Liquid-tight, flexible metal conduit	A	NA	A	NA	A	A[c,f]
Electrical metallic tubing (steel)	A	NA	A	NA	A	NA
Flexible cord	A	NA	A	Note 3	A	A[c,e] Note 3 or 4
Any other wiring method suitable for nonhazardous locations	A	NA	A	NA	A	NA

a Abbreviations: IS = intrinsically safe; NIS = not intrinsically safe; A = acceptable; NA = not acceptable.

b See the NEC for description and use of wiring systems. Divison 0 wiring is not defined by the 1990 or earlier editions of the NEC; Division 1 and 2 wiring requirements are per the 1990 NEC. Divison 0 requirements are provisional recommendations only and do not represent a proposed standard.

c Acceptable only where flexibility is needed.

d Acceptable only with termination fittings approved for Class I, Division 1 locations of the proper groups.

e Extra-hard usage type with a grounding conductor only acceptable.

f Special bonding/grounding methods are required.

NOTES:

1 - Acceptable if entire conduit system and all enclosures are purged and pressurized using Type X purging. Acceptable if entire conduit system and all enclosures are purged and pressurized using Type Y purging, and if there are no ignition-capable parts (arcing, sparking, or high temperature) under normal operating conditions (see NFPA 496).

2 - Acceptable if circuit, under nomal conditions, cannot release sufficient energy to ignite hazardous atmospheric mixtures when conductors are opened, shorted or grounded.

3 - Acceptable on approved portable equipment where provisions are made for cord replacement, per NEC 501-11.

4 - Acceptable on process control instruments to facilitate replacements, per NEC 501-3(b) (6).

Table 4b — Field wiring in United States Class II locations [a,b]

	Division 1		Division 2	
Wiring system	IS	NIS	IS or Nonincendive	NIS
Threaded rigid metal conduit	A	A	A	A
Threaded steel intermediate metal conduit	A	A	A	A
Flexible metal explosionproof fitting	A	A[c]	A	A[c]
Type MI cable	A[d]	A[e]	A	A
Type MC and SNM cable	A[d]	NA	A	A
Type PLTC and TC cable	A[d]	NA	A	A[f]
Flexible metal conduit	A[d]	NA	A	NA
Liquid-tight, flexible metal conduit	A[d]	A[c, d, g]	A	A[c, d, g]
Flexible cord	A[d]	A[c, d, h]	A	A[c, d, h]
Dust-tight wireways and raceways	A	NA	A	A
Any other wiring method suitable for nonhazardous locations	A[d]	NA	A	NA
Electrical metallic tubing	A[d]	NA	A	A

a Abbreviations: IS = intrinsically safe; NIS = not intrinsically safe; A = acceptable; NA = not acceptable.

b See the NEC for description and use of wiring systems.

c Acceptable only where flexibility is needed.

d Acceptable only with dust-tight seals at both ends when electrically conductive dusts will be present.

e Acceptable only with termination fittings approved for Class II, Division 1 locations of the proper groups.

f Acceptable in ventilated channel-type cable trays in a single layer for a space not less than the larger cable diameter between adjacent cables.

g Special handling/grounding methods are required.

h Only extra-hard usage type with a grounding conductor acceptable.

8 Maintenance practices

Special attention must be focused on hazardous location equipment maintenance procedures in order to maintain the integrity of the original installation. The following are pertinent maintenance practices:

8.1 Intrinsically safe equipment can be repaired by the manufacturer or by any qualified person. Some codes of practice require the recording of repairs and the inspection of the completed repair by a second competent person.

8.2 Maintenance personnel should ensure that all explosionproof enclosures are properly closed and furnished with the proper number and type of fasteners. Care should be exercised to assure that all machine-finished flanges are protected from damage during maintenance to ensure surface integrity.

8.3 Maintenance personnel should ensure that all grounding conductors are properly terminated.

8.4 Any physical abnormalities noted should be corrected or reported to the next level of supervision.

8.5 All threaded connections (including flame paths) should be regularly coated with a lubricant approved for the purpose.

8.6 Defective circuit protection devices (primarily fuses) must be replaced with functional equivalent devices (proper amperage, voltage, characteristics, etc.).

8.7 Periodic inspections should be made to ensure that intrinsically safe circuits are isolated from nonintrinsically safe circuits.

8.8 Periodic inspections should be made to ensure that the equipment is suitable for the current area classification.

8.9 Special care must be taken to ensure that different intrinsically safe circuits do not become shorted together during calibration and maintenance.

Appendix A

Acronyms

Throughout the text, many acronyms or abbreviations are used. The following list of acronyms provides a ready reference.

AIT	Autogenous Ignition Temperature (formerly referred to as autoignition temperature)
ANSI	American National Standards Institute
API	American Petroleum Institute
AS	Australian Standard
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmospheres (United Kingdom)
BS	British Standard
BSI	British Standards Institution
BVS	Berggewerkschafitliche Versuchsstrecke (Germany)
CEC	Canadian Electrical Code
CENELEC	European Committee for Electrotechnical Standardization
CERCHAR	Centre d'Etudes et Recherches des Chourbonnage de France (France)
CESI	Centro Elettrotecnico Sperimentale Italiano (Italy)
CSA	Canadian Standards Association (Canada)
DEMKO	Danmarks Elektriske Material Kontrol (Denmark)
DIP	Dust-ignition-proof
DNV	Det Norske Veritas (Norway)
EMR	Energy Mines and Resources (Canada)
EN	European Norm (Standard)
EP	Explosionproof
FM	Factory Mutual Research Corporation (USA)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
INIEX	Institut National des Industries Extractives (Belgium)
ISA	ISA
ISO	International Organization for Standardization
LCIE	Laboratoire Central Des Industries Electriques (France)
LEL	Lower Explosive Limit (Lower Flammable Limit)
LFL	Lower Flammable Limit (Lower Explosive Limit)
MEIC	Most Easily Ignited Concentration
MESG	Maximum Experimental Safe Gap
MIC	Minimum Ignition Current
MIE	Minimum Ignition Energy
MMS	Minerals Management Service, U.S. Department of the Interior

MSHA	Mine Safety and Health Administration
NAS	National Academy of Science
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEMCO	Norges Elektriske Materiellkontroll (Norway)
NFPA	National Fire Protection Association
NRC	National Research Council
OSHA	Occupational Safety and Health Act (or Administration)
PTB	Physikalisch-Technische Bundesanstalt (Germany)
RIIS	The Research Institute of Industrial Safety of the Ministry of Labour (Japan)
SAA	Standards Association of Australia
SABS	South African Bureau of Standards (South Africa)
SAMA	Scientific Apparatus Makers Association
S-COMMISSION	Komisija Za Ispitivanje S-Vredaja (Yugoslavia)
SEV	Schweizerischer Elektrotechnischer Verein (Switzerland)
SIT	Spontaneous Ignition Temperature
SMRE	Safety in Mines Research Establishment (UK)
UEL	Upper Explosive Limit (Upper Flammable Limit)
UFL	Upper Flammable Limit (Upper Explosive Limit)
UK	United Kingdom
UL	Underwriters' Laboratories, Inc. (USA)
US	United States
USCG	United States Coast Guard
USBM	United States Bureau of Mines

Appendix B

References

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

C34.1 Voltage Ratings for Electrical Power Systems and Equipment (60 Hz)

Available from: American National Standards Institute
11 West 42nd Street
New York, NY 10036 Tel: (212) 642-4900

AMERICAN PETROLEUM INSTITUTE (API)

RP14F, Recommended Practice for Design and Installation of Electrical Systems for Offshore Production Platforms

RP 500, Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities

Available from: American Petroleum Institute
1220 L Street, NW
Washington, DC 20005 Tel: (202) 682-8357

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS, INC (ASHRAE)

ASHRAE Fundamentals Handbook

Available from: American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
1791 Tullie Circle, N.E.
Atlanta, GA 30329

BRITISH STANDARDS INSTITUTE (BSI)

BS5501, Part 1 or CENELEC EN50014, General Requirements
Part 2 or CENELEC EN50015, Oil Immersion "o"
Part 3 or CENELEC EN50016, Pressurized Apparatus "p"
Part 4 or CENELEC EN50017, Powder Filling "q"
Part 5 or CENELEC EN50018, Flameproof Enclosure "d"
Part 6 or CENELEC EN50019, Increased Safety "e"
Part 7 or CENELEC EN50020, Intrinsic Safety "i"
Part 8 Encapsulation "m"
Part 9 or CENELEC EN50039, Intrinsically Safe Electrical Systems "i"

BS5345, Code of Practice in the Selection, Installation, and Maintenance of Electrical Apparatus for Use in Potentially Explosive Atmospheres (Other than Mining Applications or Explosive Processing and Manufacture)

BS6020, Parts 1, 2, 3, 4, and 5 (CENELEC EN50 054 055, 056, 057, and 058) Instruments for the Detection of Combustible Gases

BS6941, Electrical Apparatus for Explosive Atmospheres with Type of Protection N.

Available from: American National Standards Institute
11 West 42nd Street
New York, NY 10036 Tel: (212) 642-4900

or

British Standards Institution
Newton House
101 Pentonville Road
London, N19ND Tel: 01-837-8801 Telex: 266933

or

CENELEC
European Committee for Electrotechnical Standardisation
Secretariat General
Rue Brederode
2 boite no. 5
8-1000 Bruxelles
Belgique

CANADIAN STANDARDS ASSOCIATION (CSA)

C22.1, Part 1,	Canadian Electrical Code
C22.2, No. 25,	Enclosures for Class II, Groups E, F, and G Hazardous Locations
C22.2, No. 30,	Explosionproof Enclosures for Use in Class I Hazardous Locations
C22.2 No. 145,	Motors and Generators for Use in Hazardous Locations
C22.2 No. 152,	Combustible Gas Detection Equipment
C22.2 No. 157,	Intrinsically Safe and Nonincendive Equipment for Use in Hazardous Locations
C22.2 No. 174,	Cables and Cable Glands for Use in Hazardous Locations
C22.2 No. 213,	Non-incendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations, A Guide for the Design, Construction and Installation of Electrical Equipment, John Bossert and Randolph Hurst

Available from:Canadian Standards Association
178 Rexdale Boulevard
Rexdale, Ontario M9W 1R3
Canada
Tel: (416) 747-4044 Telex: 06 989344

FACTORY MUTUAL RESEARCH CORPORATION (FM)

Approval Standard Class No. 3600
Electrical Equipment for Use in Hazardous (Classified) Locations, General Requirements

Approval Standard Class No. 3611

Electrical Equipment for Use in Class I, Division 2, Class II, Division 2, and Class III, Divisions 1 and 2 Hazardous Locations

Approval Standard Class Nos. 6310-6330

Combustible Gas Detectors

Approval Standard Class No. 3615

Explosionproof Electrical Equipment

Approval Standard Class No. 3610

Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations

Available from: Factory Mutual Research Corporation
1151 Boston-Providence Turnpike
Norwood, MA 02062
Tel: (617) 762-4300 Telex: 924415

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

Std. 45, Recommended Practice for Electrical Installation on Shipboard

Std. 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems

Available from: Institute of Electrical and Electronic Engineers
345 East 47th Street
New York, NY 10017

ISA

ANSI/ISA-S5.1-	Instrumentation Symbols and Identification
ANSI/ISA-S7.3-	Quality Standard for Instrument Air
ISA-S12.1-	Definitions and Information Pertaining to Electrical Instruments in Hazardous (Classified) Locations
ISA-S12.4-	Instrument Purging for Reduction of Hazardous Area Classification
ISA-RP12.6-	Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations
ANSI/ISA-S12.10-	Area Classification in Hazardous (Classified) Dust Locations
ISA-Sl2.11-	Electrical Instruments in Hazardous Dust Locations
ANSI/ISA-S12.12-	Electrical Equipment for Use in Class 1, Division 2 Hazardous (Classified) Locations
ANSI/ISA-S12.13, Part I-	Performance Requirements, Combustible Gas Detectors
ANSI/ISA-Sl2.13, Part II-	Installation, Operation, and Maintenance of Combustible Gas Detection Instruments
ISA-Sl2.15, Part I-	Performance Requirements for Hydrogen Sulfide Detection Instruments (10-100 ppm)
ISA-RP12.15, Part II-	Installation, Operation, and Maintenance of Hydrogen Sulfide Detection Instruments

ANSI/ISA-S51.1-	Process Instrumentation Terminology
ANSI/ISA-S71.01-	Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity
ANSI/ISA-S82.01 -	Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment—General Requirements
ANSI/ISA-S82.02 -	Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment—Electrical and Electronic Test and Measuring Equipment
ANSI/ISA-S82.03 -	Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment—Electrical and Electronic Process Measurement and Control Equipment

Electrical Safety in Hazardous Locations,
William Calder and Ernest C. Magison
ISA, 1983

Electrical Instruments in Hazardous Locations,
Ernest C. Magison
ISA, 1978

Available from: ISA
67 Alexander Drive, P.O. Box 12277
Research Triangle Park, NC 27709
Tel: (919) 549-8411

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

79,	Electrical Apparatus for Explosive Gas Atmospheres
79-0,	General Requirements
79-1,	Construction and Test of Flameproof Enclosures of Electrical Apparatus, Amendment No. 1
79-1A,	First Supplement: Appendix D: Method of Test for Ascertainment of Maximum Experimental Safe Gap
79-2,	Electrical Apparatus - Type of Protection "p"
79-3,	Spark Test Apparatus for Intrinsically-Safe Circuits
79-4,	Method of Test for Ignition Temperature
79-4A,	Method of Test for Ignition Temperature
79-5,	Sand-Filled Apparatus
79-6,	Oil-Immersed Apparatus
79-7,	Construction and Test of Electrical Apparatus, Type of Protection "e" (Increased Safety)
79-8,	Classification of Maximum Surface Temperatures
79-9,	Marking
79-10,	Classification of Hazardous Areas
79-11,	Construction and Test of Intrinsically-Safe and Associated Apparatus

79-12, Classification of Mixtures of Gases or Vapors with Air According to Their Maximum Experimental Safe Gaps and Minimum Igniting Currents

79-13, Construction and Use of Rooms and Buildings Protected by Pressurization

79-14, Electrical Installation in Explosive Gas Atmospheres (Other than Mines)

79-15, Electrical Apparatus, Type of Protection "n"

144, Degrees of Protection of Enclosures for Low Voltage Switchgear and Control Gear

529, Classification of Degrees of Protection Provided by Enclosures

654-1, Temperature, Humidity, and Barometric Pressure

Available from: American National Standards Institute
11 West 42nd Street
New York, NY 10036 Tel: (212) 642-4900
or
International Electrotechnical Commission
Bureau Centrale de la Commission Electrotechnique International
1 rue de Varembe
Geneve, Suisse

MISCELLANEOUS

Hilada, C. J., "A Method for Estimating Limits of Flammability," *J. Fire and Flammability*, Vol. 6, pp 130-139 (April 1975).

Schimmele, A., "Explosion Protection Standards for Electrical Apparatus in USA and Europe," *Magazine for Ex-people*, No. 9, pp 4-12, (October 1983), published by R. Stahl.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ICS 6, Enclosures for Industrial Controls and Systems

No. 250, Enclosures for Electrical Equipment (1000 Volts Max.)

Available from: National Electrical Manufacturers Association
2101 L Street, NW
Washington, DC 20037 Tel: (202) 457-8474

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

No. 30,	Flammable and Combustible Liquids Code
No. 37,	Installation and Use of Stationary Combustion Engines and Turbines
No. 45,	Fire Protection for Laboratories Using Chemicals
No. 70,	National Electrical Code
No. 77,	Recommended Practice on Static Electricity
No. 90A,	Installation of Air Conditioning and Ventilating Systems
No. 91,	Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying
No. 321,	Basic Classification of Flammable and Combustible Liquids
No. 325M,	Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids
No. 496,	Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations
No. 497A,	Recommended Practice on Classification of Class I Hazardous Locations for Electrical Installation in Chemical Plants
No. 497M,	Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations

Available from: National Fire Protection Association
Batterymarch Park
Quincy, MA 02269 Tel: (708) 770-3000

UNDERWRITERS' LABORATORIES, INC. (UL)

UL 58,	An Investigation of Fifteen Flammable Gases or Vapors with Respect to Explosionproof Electrical Equipment
UL 58A,	An Investigation of Additional Flammable Gases or Vapors with Respect to Explosionproof Electrical Equipment
UL 58B,	An Investigation of Additional Flammable Gases or Vapors with Respect to Explosionproof Electrical Equipment
UL 583.	Standard for Electric-Battery-Powered Industrial Trucks
UL 674,	Standard for Electric Motors and Generators for Use in Hazardous Locations, Class I, Groups C and D, and Class II, Groups E, F, and G
UL 698,	Standard for Industrial Control Equipment for Use in Hazardous Classified Locations
UL 877,	Standard for Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G
UL 886,	Standard for Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
UL 894,	Standard for Switches for Use in Hazardous (Classified) Locations
UL 913,	Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous Locations

UL 1002, Standard for Electrically Operated Valves for Use in Hazardous Locations, Class I, Groups A, B, C, and D, Class II, Groups E, F, and G

UL 1010, Standard for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations

UL 1067, Standard for Electrically Conductive Equipment and Materials for Use in Flammable Anesthetizing Locations

UL 1203, Explosionproof and Dust-Ignitionproof Electrical Equipment for Use in Hazardous Locations

UL 1484, Residential Gas Detectors

UL 1604, Electrical Equipment for Use in Hazardous (Classified) Locations

Available from: Underwriters' Laboratories, Inc
333 Pfingsten Road
Northbrook, IL 60062
Tel: (708) 272-8800 Telex: 72 4336

UNITED STATES CODE OF FEDERAL REGULATIONS

Title 30, Part 250, Oil and Gas and Sulphur Operations in the Outer Continental Shelf

Title 46, Parts 110 Through 113, Shipping Subchapter J, Electrical Engineering,

(United States Coast Guard)

Available from: Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Appendix C

Listing of worldwide codes, guides, and standards

> **NOTE:** Appendix C is filled as much as possible at the time of publication, but should not be considered complete. Additions known to the users for consideration for future editions should be directed to:

ISA
67 Alexander Drive
P. O. Box 12277
Research Triangle Park, NC 27709
Attn:Standards Department/SP12

Country	Australia	Austria*	Belgium*	Canada	CENELEC
Agency Standards	SAA	ETVA	INIEX	CSA	
General Requirements	AS 2380 Part 1 AS 2381 AS 3000 Section 9	OVE-EX EN 50 014 OVE-EX 65	NBN C23-001 EN 50 014	CEC 22.1 CEC 22.2 Part 1	EN 50 014
Oil Immersion/Type “o”		OVE-EX EN 50 015	NBN C23-104 EN 50 015		EN 50 015
Purged/Pressurized/Type “p”	AS 1021 AS 1825 AS 1828	OVE-EX EN 50 016	NBN C23-105 EN 50 016	NFPA 496 IEC 79-2	EN 50 016
Powder Filling/Type “q”		IEC 79-5	NBN C23-106 EN 50 017		EN 50 017
Explosion/Flameproof/Type “d”	AS 1828 AS 2480	OVE-EX EN 50 018	NBN C23-103 EN 50 018	C22.2 No. 30	EN 50 018
Increased Safety/Type “e”	AS 2380 Part 6	OVE-EX EN 50 019	NBN C23-102 EN 50 019		EN 50 019
Intrinsic Safety/Type “i”	AS 2380 Part 7	OVE-EX EN 50 020	NBN C23-101 EN 50 020	C22.2 No. 157	EN 50 020
Nonincendive/Type “n”	AS 2238 AS 2380 Part 9			C22.2 No. 213	
Encapsulation/Type “m”	AS 2431	IEC 79-5			EN 50 028
Intrinsically Safe Electrical Systems	AS 1076		RGPT Article 251 bis NBN C23-201 EN 50 039	CEC Appendix F	EN 50 039
Classification of Hazardous Locations	AS 2430 Part 1 AS 2430 Part 2	OVE-EX65 EX-RL Guidelines No. 11	NBN C23-001 EN 50 014	CEC Section 18	
Classification of Maximum Surface Temperature		OVE-EX EN 50 014		CEC Section 18	EN 50 014
Marking	AS 2380 Part 1				ECC Directive 76/117/ ECC
Method of Test for Ignition Temperature					
Spark Test Apparatus for Intrinsic Safety Circuits				C22.2 No. 157	
Classification of Mixtures of Gases & Vapors			NBN C23-001 EN 50 014	CEC Appendix B	
Construction of Room & Bldg. Protected by Pressurization				IEC 79-13	
Area Classification in Hazardous Dust Location	AS 2430 Part 2			CEC Section 18	
Electrical Instruments in Hazardous Dust Locations	AS 2236	OVE A50		C22.2 No. 25	

***CENELEC member country**

Country	Czechoslovakia	Denmark*	Finland*	France*	Germany*
Agency Standards		DEMKO		UTE CERCHAR	VDE
General Requirements	CSN 330300 CSN 330370 CSN 332310 CSN 32340	Afsnit 7A Afsnit 50 EN 50 014	SFS 4094 EN 50 014	NF C23-514 EN 50 014 UTE Interpretation Sheets “23S”	Elexv; VDE 0165; EX-RL VDE 0170/0171 Part 1 EN 50 014
Oil Immersion/Type “o”	CSN 330376	Afsnit 50-1 EN 50 015	SFS 4095 EN 50 015	NF C23-515 EN 50 015 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 2 EN 50 015
Purged/Pressurized/Type “p”	CSN 330373	Afsnit 50-2 EN 50 016	SFS 4096 EN 50 016	NF C23-516 EN 50 016 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 3 EN 50 016
Powder Filling/Type “q”	CSN 330374	Afsnit 50-3 EN 50 017	SFS 4097 EN 50 017	NF C23-517 EN 50 017 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 4 EN 50 017
Explosion/Flameproof/Type “d”	CSN 330372	Afsnit 50-4 EN 50 018	SFS 4098 EN 50 018	NF C23-518 EN 50 018 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 5 EN 50 018
Increased Safety/Type “e”	CSN 330375	Afsnit 50-5 EN 50 019	SFS 4099 EN 50 019	NF C23-519 EN 50 019 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 6 EN 50 019
Intrinsic Safety/Type “i”	CSN 330380	Afsnit 50-6 EN 50 020	SFS 4100 EN 50 020	NF C23-520 EN 50 020 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 7 EN 50 020
Nonincendive/Type “n”					
Encapsulation/Type “m”	CSN 332377			EN 50 028 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 9 EN 50 028
Intrinsically Safe Electrical Systems	CSN 330380			NF C23-539 EN 50 039 UTE Interpretation Sheets “23S”	VDE 0170/0171 Part 10 EN 50 039
Classification of Hazardous Locations	CSN 332340	Afsnit 7A	Section 41		VDE 0165
Classification of Maximum Surface Temperature		Afsnit 7A			VDE 0165
Marking			EN 50 014		
Method of Test for Ignition Temperature		Afsnit 7A			
Spark Test Apparatus for Intrinsic Safety Circuits					VDE 0170/0171 Part III
Classification of Mixtures of Gases & Vapors		Afsnit 7A			VDE 0165 VDE 0171
Construction of Room & Bldg. Protected by Pressurization					
Area Classification in Hazardous Dust Location		Afsnit 7A			
Electrical Instruments in Hazardous Dust Locations	CSN 332330		SFS 2972	NF C20-010	DIN 40050

*CENELEC member country

Country	Greece*	Hungary	IEC	Irish Republic	Italy*
Agency Standards	IEC		IEC		CEI
General Requirements	79-0		79-0	IS 231	CEI 31-8 CEI 64-2 EN 50 014
Oil Immersion/Type “o”	79-6		79-6	IS 232	CEI 31-5 EN 50 015
Purged/Pressurized/Type “p”	79-2		79-2	IS 233	CEI 31-2 EN 50 016
Powder Filling/Type “q”	79-5		79-5	IS 234	CEI 31-6 EN 50 017
Explosion/Flameproof/Type “d”	79-1 79-1A	MS2 4814	79-1 79-1A	IS 235	CEI 31-1 EN 50 018
Increased Safety/Type “e”	79-7		79-7	IS 236	CEI 31-7 EN 50 019
Intrinsic Safety/Type “i”	79-11		79-11	IS 237	CEI 31-9 EN 50 020
Nonincendive/Type “n”	79-15		79-15		CEI 31-11
Encapsulation/Type “m”					CEI 31-13 EN 50 028
Intrinsically Safe Electrical Systems					
Classification of Hazardous Locations	79-10		79-10		CEI 64-2
Classification of Maximum Surface Temperature	79-8		79-8		
Marking					
Method of Test for Ignition Temperature	79-4 79-4A		79-4 79-4A		
Spark Test Apparatus for Intrinsic Safety Circuits	79-3		79-3		IEC 79-3
Classification of Mixtures of Gases & Vapors	79-12		79-12		
Construction of Room & Bldg. Protected by Pressurization	79-13		79-13		
Area Classification in Hazardous Dust Location					
Electrical Instruments in Hazardous Dust Locations					

***CENELEC member country**

Country	Japan	Netherlands*	Norway*	Poland	Portugal*
Agency Standards	JIS	NEN	NVE		
General Requirements	JIS C0903	NEN-1010 NEN-1041 NEN-3125 NEN-3410 NEN-EN 50 014	NEN-110 NVE Communication 1/77 NEK-EN 50 014		Decree No. 740/74 Decree No. 36270
Oil Immersion/Type “o”		NEN-EN 50 015	NEN-111 NEK-EN 50 015		
Purged/Pressurized/Type “p”	JIS C0903 JIS C0904	NEN-EN 50 016	NEN-112 NEK-EN 50 016		
Powder Filling/Type “q”		NEN-EN 50 017	NEN-113 NEK-EN 50 017		
Explosion/Flameproof/Type “d”	JIS C903 JIS C904	NEN-EN 50 018	NEN-114 NEK-EN 50 018	PN 721E	
Increased Safety/Type “e”	JIS C903 JIS C904 JIS C905	NEN-EN 50 019	NEN-115 NEK-EN 50 019		
Intrinsic Safety/Type “i”	JIS C903 JIS C904	NEN-EN 50 020	NEN-116 NEK-EN 50 020		
Nonincendive/Type “n”		NEN-3125			
Encapsulation/Type “m”			NEK-EN 50 028		
Intrinsically Safe Electrical Systems					
Classification of Hazardous Locations	BS 5345 Part 1	Directorate-General of Labor Report No. 2E	NVE Communication 1/77		
Classification of Maximum Surface Temperature					
Marking					
Method of Test for Ignition Temperature			NVE Communication 1/77 Appendix II		
Spark Test Apparatus for Intrinsic Safety Circuits					
Classification of Mixtures of Gases & Vapors	VDE 0171 VDE 0165				
Construction of Room & Bldg. Protected by Pressurization					
Area Classification in Hazardous Dust Location					
Electrical Instruments in Hazardous Dust Locations	Labour Ordinance No. 16 RIIS	NEN-1010	NVE Communication 1/77 Appendix II		

*CENELEC member country

Country	Russia	S. Africa	Spain*	Sweden*	Switzerland*
Agency Standards		SABS	SIEV / SAI	UNE	SEV
General Requirements		SABS 086 SABS 087 SABS 808	SS EN 50 014 SEN 421 0819	Instruccion MI.BT UNE 20318 SS EN 50 014	SEV 1068 SS EN 50 014
Oil Immersion/Type “o”			SS EN 50 015	UNE 20326 UNE 21815 SS EN 50 015	SEV 1069 SS EN 50 015
Purged/Pressurized/Type “p”		SABS 0119	SS EN 50 016	UNE 20319 UNE 21816 SS EN 50 016	SEV 1070 SS EN 50 016
Powder Filling/Type “q”			SS EN 50 017	UNE 20321 UNE 21817 SS EN 50 017	SEV 1071 SS EN 50 017
Explosion/Flameproof/Type “d”	GOST	SABS 314	SS EN 50 018	UNE 20320 UNE 21818 SS EN 50 018	SEV 1072 SS EN 50 018
Increased Safety/Type “e”		SABS 1031	SS EN 50 019	UNE 20327 UNE 20328 SS EN 50 019	SEV 1073 SS EN 50 019
Intrinsic Safety/Type “i”		SABS 549	SS EN 50 020 SEN 421 0879	UNE 20327 UNE 21820 SS EN 50 020	SEV 1074 SS EN 50 020
Nonincendive/Type “n”		SABS 970			
Encapsulation/Type “m”					
Intrinsically Safe Electrical Systems			EN 50 039		SEV 3538
Classification of Hazardous Locations		SABS 089 Part II SABS 0108	SAI SIND-FS SS 421 0820 SS 421 0821	MI.BT 009 MI.BT 026 UNE 20322	SEV 3307-1
Classification of Maximum Surface Temperature				UNE 20327	
Marking				UNE 20323 UNE 20327	
Method of Test for Ignition Temperature				UNE 20325	
Spark Test Apparatus for Intrinsic Safety Circuits					
Classification of Mixtures of Gases & Vapors				UNE 20320	
Construction of Room & Bldg. Protected by Pressurization			SEN 421 0823		
Area Classification in Hazardous Dust Location					
Electrical Instruments in Hazardous Dust Locations		SABS 969	SEN 2121 SS IEC 529		SEV 1000

***CENELEC member country**

Country	U.K.*	U.S.A.	U.S.A.	U.S.A.	U.S.A.
Agency Standards	BS / BASEEFA	ANSI	API	FM	ISA
General Requirements	BS 5501 Part 1 BS 5345 EN 50 014	ANSI/UL 508 ANSI/UL 698	RP 14F RP 540	Class No. 3600	S12.1
Oil Immersion/Type “o”	BS 5501 Part 2 EN 50 015				
Purged/Pressurized/Type “p”	BS 5501 Part 3 EN 50 016			Class No. 3620	RP12.4
Powder Filling/Type “q”	BS 5501 Part 4 EN 50 017				
Explosion/Flameproof/Type “d”	BS 5501 Part 5 BS 229 EN 50 018	ANSI/UL 698		Class No. 3615	
Increased Safety/Type “e”	BS 5501 Part6 EN 50 019				
Intrinsic Safety/Type “i”	BS 5501 Part 7 SFA 3012 EN 50 020	ANSI/UL 913		Class No. 3610	RP12.6
Nonincendive/Type “n”	BS 4683 Part 3 BS 4533 BS 5000 BS 6941	ANSI/IEEE Std. 303		Class No. 3611	S12.12
Encapsulation/Type “m”	BS 5501 Part 8				
Intrinsically Safe Electrical Systems	BS 5501 Part 9 EN 50 039	ANSI/UL 913			
Classification of Hazardous Locations	BS 5345 Part 2		RP 500		
Classification of Maximum Surface Temperature	BS 5345 Part 1	ANSI/UL 698			S12.10
Marking					
Method of Test for Ignition Temperature					
Spark Test Apparatus for Intrinsic Safety Circuits		ANSI/UL 913		Class No. 3610	
Classification of Mixtures of Gases & Vapors	BS 5345 Part 1				
Construction of Room & Bldg. Protected by Pressurization					
Area Classification in Hazardous Dust Location					S12.10
Electrical Instruments in Hazardous Dust Locations	BS 6467 Part 1	ANSI/UL 698		Class No. 3611	S12.11

***CENELEC member country**

Country	U.S.A	U.S.A.	Yugoslavia		
Agency Standards	NFPA	UL	OOUR / S-Commission		
General Requirements	NEC/NFPA 70	UL: 508, 698, 1092			
Oil Immersion/Type “o”					
Purged/Pressurized/Type “p”	NEC/NFPA 496				
Power Filling/Type “q”					
Explosion/Flameproof/Type “d”		UL: 674, 698, 781, 783, 823 UL: 844, 877, 886, 894, 1002 UL: 1010, 1203, 1604	JUSN 58		
Increased Safety/Type “e”					
Intrinsic Safety/Type “i”		UL 913	JUSN 58301		
Nonincendive/Type “n”		UL 1604			
Encapsulation/Type “m”					
Intrinsically Safe Electrical Systems		ANSI/UL 913			
Classification of Hazardous Locations	NEC/NFPA 497A				
Classification of Maximum Surface Temperature		ANSI/UL 698 UL: 1203, 1604			
Marking					
Method of Test for Ignition Temperature					
Spark Test Apparatus for Intrinsic Safety Circuits		ANSI/UL 913			
Classification of Mixtures of Gases & Vapors	NEC/NFPA 497M	UL: 58, 58A, 58B			
Construction of Room & Bldg. Protected by Pressurization					
Area Classification in Hazardous Dust Location	NEC/NFPA 497B				
Electrical Instruments in Hazardous Dust Locations		UL: 674A, 698, 781, 823, 844 UL: 877, 886, 894, 1002 UL: 1203, 1604			

Appendix D

Listing of worldwide installation requirements

> **NOTE:** Appendix D is filled as much as possible at the time of publication, but should not be considered complete. Additions known to the users for consideration for future editions should be directed to:

ISA
67 Alexander Drive
P.0. Box 12277
Research Triangle Park, NC 27709
Attn:Standards Department/SP12

	Australia	Austria	Belgium	Canada	Denmark	Finland	France	Germany	Greece	Italy	Japan
Code of Practice for selection, installation and maintenance basic requirements	AS 3000	OVE EX 65	NBN C23-201 EN 50 039 RGIE RGIE Article 251	CEC	Heavy Current Regulations	Electrical Safety Regulatons	NF C23-539 EN 50 039	EX-RL Guidelines No. 11 Elexv ZHI/227 Elexv ZHI/200 Elexv ZHI/309 VDE 0107 VDE 0166	PCC Regulations for interior electrical installation - Chapter X	Presidential decree DPR 547 Chapter X CEI 64-2	JISHA - Recommended Practice for Explosion-Protected Electrical Installations in General Industries. JISHA - Recommended Practice for Electrical Equipment for use in Explosive Dust Atmospheres in General Industries.
Flareproof/ Explosionproof enclosure				CEC							
Intrinsically safe apparatus				CEC Appendix F							
Pressurization/ Purging				CEC							
Increased Safety Type “E”											
Combustible Gas Detectors											

	Netherlands	Norway	Portugal	S. Africa	Spain	Sweden	Switzerland	U.K.	U.S.A.	IEC
Code of Practice for selection, installation and maintenance basic requirements	NEN 1010	NVE Communications No. 1/77	Decree No. 740/74 Decree No. 517/80 Decree No. 36270	SABS 086 SABS 0119	Instruccion MI.BT 026	SIEV-FS Safety Regulations SIND-FS Classification Regulations	SEV 1000 SEV 3538	BS 5345 Pt. 1	NEC/NFPA 70 API RP 14F API RP 540	79-14
Flareproof/ Explosionproof enclosure								BS 5345 Pt. 3		
Intrinsically safe apparatus								BS 5345 Pt. 4	ISA RP 12.6	
Pressurization/ Purging								BS 5345 Pt. 5	NFPA 496	
Increased Safety Type “E”								BS 5345 Pt. 6 BS 5345 Pt. 7		
Combustible Gas Detectors								BS 6959	ISA RP 12.13 Part II API RP 500	

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