UL 120101

STANDARD FOR SAFETY

Definitions and Information Pertaining to Electrical Equipment in Hazardous Locations

UL Standard for Safety for Definitions and Information Pertaining to Electrical Equipment in Hazardous Locations, UL 120101

First Edition, Dated December 3, 2019

Summary of Topics

This revision of ANSI/UL 120101 dated May 23, 2024 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated April 5, 2024.

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Standard for Definitions and Information Pertaining to Electrical Equipment in Hazardous Locations

First Edition

December 3, 2019

This ANSI/UL Standard for Safety consists of the First Edition including revisions through May 23, 2024.

The most recent designation of ANSI/UL 120101 as a Reaffirmed American National Standard (ANS) occurred on May 23, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in ULSE's Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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Preface (UL)

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1 Purpose

1.1 This document provides definitions and information pertaining to protection techniques, terminology, and the installation of electrical equipment in hazardous (classified) locations and provides an introduction and basic background to the UL Standards Technical Panel (STP) 60079, Electrical Equipment for Hazardous (Classified) Locations, series of publications and committee activities.

1.2 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, maintenance and test criteria.

2 Scope

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

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

2.3 This document is concerned only with design, manufacture, installation, maintenance, and test criteria related to arcs, sparks, or hot surfaces produced by electrical and non-electrical* equipment that may cause ignition of flammable gas or vapor-in-air mixtures, clouds or blankets of combustible dust, or easily ignitable fibers or flyings. Equipment is also required to comply with the applicable ordinary location requirements (e.g.,UL 508 and UL 61010-1) either by direct reference in hazardous locations standards or by other regulations.

* Under development (Mechanical and ESD for example). Some equipment may produce static electricity or cause high temperatures or sparks due to mechanical failure. The materials of construction of parts in such equipment will be an important consideration for application in hazardous locations.

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

2.5 This document 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.

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

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

a) an ambient temperature range of -20 °C (-4 °F) to 40 °C (104 °F) for zones and to -25 °C (-13 °F) to +40 °C (104 °F) for divisions;

b) air with normal oxygen content, typically 21 percent by volume; and

c) a pressure of 80 kPa (11.6 psia) to 110 kPa (16 psia).

NOTE Equipment specified for atmospheric conditions beyond the above is generally permitted but may be subjected to additional requirements.

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

2.9 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 Annex C. These are not considered to be a part of this document except for those specific sections of documents referenced elsewhere in this document.

2.10 In accordance with the purpose of this document, 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 Annex B.

3 Definitions

The following are terms and definitions commonly used for hazardous (classified) locations.

NOTE The list is not intended to be all inclusive. Throughout this document, reference is made to areas, spaces, locations, and zones. These terms should be considered interchangeable terms designating a three-dimensional space. Additional definitions may be found in IEC 60050-426 (The International Electrotechnical Vocabulary (IEV 426-04-07).

3.1 ABNORMAL OPERATION – process-linked malfunctions that occur infrequently. (IEV 426-03-29)

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 of the Lower Flammable Limit, LFL.

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

3.3 AEx – required marking prefix for equipment meeting one or more types of protection in UL 60079-0 or previously in ANSI/ISA-61241-0.

3.4 AMBIENT TEMPERATURE – temperature of the air or other media, in the immediate vicinity of the equipment or component. (IEV 426-04-09)

NOTE 1 This does not refer to the temperature of any process media, unless the equipment or component is totally immersed in the process media.

NOTE 2 If Ex Equipment or an Ex Component is located inside or adjacent to another piece of equipment, the ""ambient temperature"" is the temperature of the air or other media surrounding the Ex Equipment or Ex Component and may be higher than the ambient air surrounding the complete equipment due to the additional heat dissipated within the complete equipment.

NOTE 3 The ambient temperature referred to in the UL 60079 series, CSA 60079 series and IEC 60079 series is only related to the explosion safety and not the performance of the Ex Equipment or Ex Component.

3.5 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.

3.6 AREA – three-dimensional region or space. (IEV 426-03-28).

3.7 ASSOCIATED APPARATUS – electrical apparatus which contains both intrinsically safe circuits and non-intrinsically safe circuits and is constructed so that the non-intrinsically safe circuits cannot adversely affect the intrinsically safe circuits. (IEV 426-11-03)

NOTE Associated apparatus is either:

a) additionally protected by a type of protection suitable for use in the appropriate explosive atmosphere; or

b) not protected by a type of protection suitable for use in the appropriate explosive atmosphere and therefore is not to be used within an explosive atmosphere.

See also INTRINSIC SAFETY.

3.8 ATEX, ATEX Directive – European Directive 2014/34/EU related to equipment and protective systems intended for use in potentially explosive atmospheres. A parallel directive for use, 1999/92/EC (also referred to as ATEX 137 Directive) requires area classification and risk assessment in the workplace.

3.9 AUTHORITY HAVING JURISDICTION (AHJ) – the organization, office, or individual that has the responsibility and authority for approving equipment, installations, or procedures.

NOTE The term 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.

3.10 AUTO-IGNITION TEMPERATURE (AIT) – the minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heating elements.

NOTE 1 For additional information refer to NFPA Fire Protection Handbook.

NOTE 2 A distinction is made between ignition temperature and flash point. See FLASH POINT.

3.11 AUTOMATIC – self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

3.12 BONDING – connecting to establish electrical continuity and conductivity.

3.13 CABLE GLAND – a device permitting the introduction of one or more electric and/or fibre optics cables into an electrical Ex Equipment enclosure so as to maintain the relevant Type of Protection, and provide a degree of strain relief. (IEV 426-04-18)

3.14 CERTIFICATE – document that conveys the assurance of the conformity of a product, process, system, person, or organization with specified requirements. (IEV 426-04-23)

NOTE The certificate may be either the supplier's declaration of conformity or the purchaser's recognition of conformity or certification (as a result of action by a third party) as defined in ISO/IEC 17000.

3.15 CERTIFIED – generic term referring to 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.

3.16 CLASS I LOCATION – a location in which flammable gases, flammable liquid – produced vapors, or combustible liquid – produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. (NEC 500.5 (B))

NOTE Class I locations can include those rated Division 1 or 2 and Zone 0, 1 or 2.

3.17 CLASS I, DIVISION 1 LOCATION – a location (1) In which ignitible concentrations of flammable gases, flammable liquid – produced vapors, or combustible liquid – produced vapors can exist under normal operating conditions, or; (2) In which ignitible concentrations of such flammable gases, flammable liquid–produced vapors, or combustible liquids above their flash points 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, flammable liquid – produced vapors, or combustible liquid – produced vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition. (NEC 500.5 (B) (1))

NOTE In some Division 1 locations, ignitible concentrations of flammable gases or vapors may be present continuously or for long periods of time. Examples include the following:

(1) The inside of inadequately vented enclosures containing instruments normally venting flammable gases or vapors to the interior of the enclosure

(2) The inside of vented tanks containing volatile flammable liquids

(3) The area between the inner and outer roof sections of a floating roof tank containing volatile flammable fluids

(4) Inadequately ventilated areas within spraying or coating operations using volatile flammable fluids

(5) The interior of an exhaust duct that is used to vent ignitible concentrations of gases or vapors

Experience has demonstrated the prudence of avoiding the installation of instrumentation or other electrical equipment in these particular areas altogether or where it cannot be avoided because it is essential to the process and other locations are not feasible, using electrical equipment or instrumentation approved for the specific application or consisting of intrinsically safe systems.

3.18 CLASS I, DIVISION 2 LOCATION – a location (1) In which volatile flammable gases, flammable liquid – produced vapors, or combustible liquid – produced vapors 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, or (2) In which ignitible concentrations of flammable gases, flammable liquid – produced vapors, or combustible liquid – produced vapors are normally prevented by positive mechanical ventilation and which 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 flammable gases, flammable liquid – produced vapors, or combustible liquid – produced vapors above their flash points 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. (NEC 500.5 (B) (2))

3.19 CLASS II LOCATION – a location that is hazardous because of the presence of combustible dust. (NEC 500.5 (C))

NOTE Class II locations can include those rated Division 1 or 2 and Zone 20, 21 or 22.

3.20 CLASS II, DIVISION 1 LOCATION – (1) In which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures, or (2) Where 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 failure of electrical equipment, through operation of protection devices, or from other causes, or (3) In which Group E combustible dusts may be present in quantities sufficient to be hazardous. (NEC 500.5 (C) (1))

3.21 CLASS II, DIVISION 2 LOCATION – a location (1) In which combustible dust due to abnormal operations may be present in the air in quantities sufficient to produce explosive or ignitible mixtures; or (2) Where combustible dust accumulations are present but are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but could as a result of infrequent malfunctioning of handling or processing equipment become suspended in the air; or (3) In which combustible dust accumulations on, in, or in the vicinity of the electrical equipment could be sufficient to interfere with the safe dissipation of heat from electrical equipment, or could be ignitible by abnormal operation or failure of electrical equipment. (NEC 500.5 (C) (2))

3.22 CLASS III LOCATION – a location that is hazardous because of the presence of easily ignitible fibers or where materials producing combustible flyings are handled, manufactured, or used, but in which such fibers/flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. (NEC 500.5 (D)

NOTE Class III locations can include those rated Division 1 or 2 and Zone 20, 21 or 22.

3.23 CLASS III, DIVISION 1 LOCATION – a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used. (NEC 500.5 (D) (1))

3.24 CLASS III, DIVISION 2 LOCATION – a location in which easily ignitable fibers are stored or handled other than in the process of manufacture). (NEC 500.5 (D) (2))

3.25 COMPOUND – any thermosetting, thermoplastic, epoxy resin or elastomeric materials with or without fillers and/or additives, in their solid state. (IEV 426-04-41)

3.26 CONNECTION FACILITIES – terminals, screws or other parts, used for the electrical connection of conductors. (IEV 426-04-25)

3.27 CONTINUOUS DILUTION – the technique of supplying a protective gas flow continuously to an enclosure containing an internal potential source of flammable gas or vapor release for the purpose of diluting any flammable gas or vapor that could be present to a level below its LFL. Refer to 6.2.2.

3.28 CONTROL DRAWING – drawing or other document that is prepared by the manufacturer for the intrinsically safe or associated apparatus, detailing the electrical parameters to allow for interconnections to other circuits or apparatus. (IEV 426-11-46)

NOTE Refer to UL 120202 for the applicable ANSI recommendations for the preparation, content, and organization of control drawings.

3.29 DEGREE OF PROTECTION (IP) – numerical classification according to IEC 60529 or IEC 60034-5 (as applicable) preceded by the symbol IP applied to the enclosure of equipment to provide:

- protection of persons against contact with, or approach to, live parts and against contact with moving parts (other than smooth rotating shafts and the like) inside the enclosure;

- protection of the equipment against ingress of solid foreign objects; and

• where indicated by the classification, protection of the equipment against harmful ingress of water. (IEV 426-04-02)

NOTE 1 The detailed test requirements for rotating electric machines are in IEC 60034-5.

NOTE 2 The enclosure which provides the degree of protection IP is not necessarily the same as the equipment enclosure providing the Type of Protection.

NOTE 3 An enclosure which provides the degree of protection required by one of the types of protection will have been subjected to other tests prior to the tests for degree of protection.

NOTE 4 See also enclosure type.

3.30 DUST, COMBUSTIBLE – finely divided solid particles, 500 µm or less in nominal size, which may form explosive mixtures with air at standard atmospheric pressure and temperatures. (IEV 426-02-18)

NOTE See ASTM E 1226-12a, Standard Test Method for Explosibility of Dust Clouds, or ISO 6184-1, Explosion protection systems – Part 1: Determination of explosion indices of combustible dusts in air, for procedures for determining the explosibility of dusts.

3.31 DUST-IGNITIONPROOF – under the division system, a term used to describe an enclosure that will exclude dust and that, when installed 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 atmosphere suspensions of a specified dust in the vicinity of the enclosure.

NOTE Refer to UL 1203 or CSA 25 for applicable ANSI and CAN certification requirements respectively.

3.32 DUST LAYER, COMBUSTIBLE – any surface accumulation of combustible dust that is thick enough to propagate flame or will degrade and ignite.

3.33 DUST-PROTECTED ENCLOSURE – for ordinary locations ingress protection, enclosure in which the ingress of dust is not totally excluded, but is unlikely to enter in sufficient quantity to interfere with the safe operation of the equipment and does not accumulate in a position within the enclosure where it is liable to cause an ignition hazard. (IEV 426-04-35)

NOTE Refer to NEMA 250 or IEC 60529 for the applicable ANSI and IEC ingress protection requirements respectively.

3.34 DUST-TIGHT ENCLOSURE – under the Division System or for ordinary locations ingress protection, enclosure capable of excluding the ingress of observable dust particle deposits. (IEV 426-04-34)

NOTE Refer to UL 121201, CSA 213, NEMA 250 or IEC 60529 for the applicable ANSI, CAN and IEC ingress protection requirements respectively.

3.35 ELECTRICAL EQUIPMENT – items applied as a whole or in part for the utilization of electrical energy. These include, among others, equipment for the generation, transmission, distribution, storage, measurement, regulation, conversion, and consumption of electrical energy and items for telecommunication.

3.36 ENCLOSURE – all of the walls, doors, covers, cable glands, rods, spindles, and shafts, etc. which contribute to the Type of Protection or the degree of protection IP of the equipment. (IEV 426-04-01)

3.37 ENCLOSURE TYPE – for ordinary locations ingress protection, a North American system of rating standard levels of protection provided to electrical equipment by enclosures for 1) the protection of persons against contact with live or moving parts inside the enclosure, 2) the protection provided by the enclosure against ingress of solids and/or liquids, 3) the protection provided by the enclosure against the deleterious effects of corrosion, and 4) the protection provided by the enclosure against damage due to the formation of external ice. This enclosure type is in addition to (and not an alternative to) the types of protection necessary to ensure protection against ignition in hazardous (classified) locations.

NOTE 1 Refer to Definitions found in UL 50, UL 50E, CSA 94.1, CSA 94.2 or NEMA 250 for the applicable ANSI, CAN or IEC definitions.

NOTE 2 See also DEGREE OF PROTECTION. -

3.38 ENCAPSULATION – under the Zone system, a type of protection in which the parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that this explosive atmosphere cannot be ignited. This type of protection is referred to as “ma”, "mb", or "mc".

Also: process of applying a compound to enclose an electrical device(s) by suitable means. (IEV 426-04-77)

NOTE Refer to UL 60079-18, CSA 60079-18 or IEC 60079-18 for the applicable ANSI, CAN or IEC certification requirements.

3.39 ENERGIZED – electrically connected to a source of potential difference.

3.40 ENTITY CONCEPT – method used to determine acceptable combinations of intrinsically safe apparatus and associated apparatus through the use of intrinsically safe parameters assigned to connection facilities. (IEV 426-11-47)

The criteria for interconnection is that the voltage (V_{max} or U_I) current (I_{max} or I_I) and power (P_{max} or P_I) which intrinsically safe equipment can receive and remain intrinsically safe, considering faults, must be equal to or greater than the voltage (V_{oc} or V_o), and current (I_{sc} or I_o) and power (P_o) levels which can be delivered by the associated apparatus, considering faults and applicable factors. In addition, the maximum unprotected capacitance (C_i) and inductance (L_i) of the intrinsically safe equipment, including interconnecting wiring, must be equal to or less than the capacitance (C_a or C_o) and inductance (L_a or L_o) that can safely be connected to the associated apparatus. If these criteria are met, then the combination may be connected without compromising intrinsic safety.

NOTE Refer to ANSI/ISA-RP12.06.01, UL 60079-25, CSA 60079-25 and IEC 60079-25 for additional ANSI, CAN and IEC information.

3.41 ENTRY, DIRECT – a method of connection of an electrical equipment to the external circuits by means of the connecting facilities inside the main enclosure or in a terminal compartment having a free opening to the main enclosure. (IEV 426-04-07)

3.42 ENTRY, INDIRECT – a method of connection of an electrical equipment to the electrical circuits by means of a terminal box or a plug and socket connection which is external to the main enclosure.

3.43 EQUIPMENT – apparatus, fittings, devices, and the like used as part of, or in connection with, an installation.

NOTE When specific measures of a Type of Protection are applied to equipment to provide explosion protection, it can be “Ex Equipment” or an “Ex Component”.

3.44 EQUIPMENT GROUPING – classification system of equipment related to the explosive atmosphere for which they are intended to be used:

NOTE UL 60079-0, CSA 60079-0 and IEC 60079-0 identify three equipment groups:

- Group I, equipment for mines susceptible to fire damp;

- Group II, which is divided into sub-groups, equipment for all places with an explosive gas atmosphere other than mines susceptible to fire damp; and

- Group III, which is divided into sub-groups, equipment for all places with an explosive dust atmosphere other than mines susceptible to fire damp.

3.45 EQUIPMENT PROTECTION LEVEL EPL – level of protection assigned to equipment based on its likelihood of becoming a source of ignition and distinguishing the differences between explosive gas atmospheres, explosive dust atmospheres, and the explosive atmospheres in mines susceptible to firedamp. (IEV 426-01-15)

NOTE Although the markings identifying the equipment protection level (EPL) may appear on equipment, they are not yet recognized in NFPA 70.

3.46 Ex – designation of explosion-protected electrical equipment in accordance with the IEC 60079 series standards or national adoptions.

NOTE EEx designation was used for explosion-protected electrical equipment complying with EN50014. The publication of EN60079 was just the next edition of EN50014 and does not indicate that the equipment certified to EN50014 was immediately made obsolete, but might not comply with the latest requirements. See also 3.3.

3.47 Ex COMPONENT – equipment intended to be part of Ex Equipment, marked with symbol "U", which is not intended to be used alone, and requires additional consideration when incorporated into Ex Equipment. (IEV 426-01-13)

3.48 Ex EQUIPMENT – equipment with explosion protection. (IEV 426-01-14)

3.49 EXPECTED MALFUNCTION – disturbances or equipment malfunctions which normally occur in practice. (IEV 426-04-57)

3.50 EXPLOSIONPROOF – under the Division system, a term used to describe an enclosure that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and that operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby. (NEC)

NOTE 1 See also "explosionproof" and "flameproof" are similar concepts, but the performance and technical requirements are not the same.

NOTE 2 Refer to UL 1203 or CSA 30 for the applicable ANSI and CAN certification requirements respectively.

3.51 EXPLOSIVE ATMOSPHERE – a mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapor, mist, or dust in which, after ignition, permits self-sustaining propagation. (IEV 426-01-06)

3.52 EXPLOSIVE DUST ATMOSPHERE – a mixture with air, under atmospheric conditions, of flammable substances in the form of dust which, after ignition, permits self-sustaining propagation.

3.53 EXPLOSIVE GAS ATMOSPHERE – a mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour which, after ignition, permits self-sustaining propagation. (IEV 426-01-07)

3.54 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.

3.55 FIBERS AND FLYINGS – these are materials not normally in suspension in air; and 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.

3.56 FIREDAMP – flammable mixture of gases naturally occurring in a mine.

NOTE Firedamp consists mainly of methane, but always contains small quantities of other gases, such as nitrogen, carbon dioxide, and hydrogen, and sometimes ethane and carbon monoxide. The terms firedamp and methane are used frequently in mining practice as synonyms. (IEV 426-02-24)

3.57 FLAMEPROOF – under the Zone system, a type of protection of electrical equipment in which an enclosure will withstand an internal explosion of a flammable mixture which has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, of an external explosive atmosphere consisting of one or more of the gases or vapors for which it is designed. This type of protection is referred to as “da”, "db" or "dc".

NOTE See also "explosionproof" and "flameproof" are similar concepts, but the performance and technical requirements are not the same.

3.58 FLAMMABLE LIMITS – the flammable limits of a gas or vapor are the lower (LFL) and upper (UFL) flammable limit, stated in percent by volume of gas in a gas-air mixture, between which a flammable mixture is formed.

NOTE 1 For additional information refer to NFPA Fire Protection Handbook and IEC 80079-20-1.

NOTE 2 In the past, flammable and explosive have been used interchangeably in many texts, but the trend is to avoid the confusion that this causes. The term flammable relates to the properties of the material that determine its ability to produce self-sustaining flame propagation in any direction (upwards, sideways or downwards). The term explosive relates to flame propagation that is accompanied by pressure rise and noise (usually higher-speed propagation) and is significantly affected by (non-material related) test-chamber conditions (geometry, degree of confinement...). LFL concentrations are typically lower than LEL concentrations for the same material and UFL concentrations are typically higher than UEL concentrations for the same material.

3.59 FLAMMABLE LIQUID – liquid capable of producing a flammable vapour under any foreseeable operating conditions. (IEV 426-02-33)

NOTE For additional information, refer to NFPA Fire Protection Handbook.

3.60 FLAMMABLE GAS OR VAPOR – a gas or vapor which, when mixed with air in certain proportions, will form a flammable gas atmosphere. (IEV 426-02-34)

3.61 FLAMMABLE SUBSTANCE – gases, vapours, liquids or mixtures thereof that are capable of being ignited. (IEV 426-09-10)

3.62 FLASH POINT – lowest liquid temperature at which, under specified test conditions, a liquid gives off vapours in quantity such as to be capable of forming an ignitable vapour/-air mixture. (IEV 426-02-14)

NOTE For additional information, refer to NFPA Fire Protection Handbook.

3.63 GAS – gaseous phase of a substance that cannot reach equilibrium with its liquid or solid state in the temperature and pressure range of interest. (IEV 426-02-26)

3.64 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.

3.65 GROUNDED (EARTHED) – connected to earth or to some conducting body that serves in place of earth.

3.66 GROUP – a classification of combustible materials.

NOTE Refer to Clause 4 for additional information.

3.67 HAZARDOUS AREA – area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical equipment. (IEV 426-03-01). See also hazardous (classified) locations.

NOTE 1 IEC 60079-10-1 gives a classification of hazardous areas containing explosive gas atmospheres.

NOTE 2 IEC 60079-10-2 gives a classification of hazardous areas containing explosive dust.

3.68 HAZARDOUS (CLASSIFIED) LOCATIONS – locations where fire or explosion hazards may exist due to flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, combustible dusts, or ignitible fibers/flyings. Commonly abbreviated "HazLoc". See also hazardous area.

3.69 HERMETICALLY SEALED DEVICE – under the Division and Zone systems, device which is so constructed that the external atmosphere cannot gain access to the interior and in which any seal is made by fusion. (IEV 426-09-11). Under the Zone system, this type of protection is referred to as type of protection "nC".

NOTE 1 The seal is made by fusion of metal to metal, ceramic to metal, or glass to metal.

NOTE 2 Refer to UL 121201 or CSA 213 under the Division system and UL 60079-15, CSA 60079-15 or IEC 60079-15 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

3.70 HIGH TEMPERATURE EQUIPMENT – as specified by NEC, Articles 501.15 and 505.16, the term "*high temperatures*" is to be interpreted as those where the maximum operating temperature (including ambient temperature effect) exceeds 80 percent of the auto-ignition temperature in degrees Celsius (°C) of the gas or vapor involved.

3.71 IECEx SYSTEM – under the Zone system, an international system for certification to standards relating to equipment for use in explosive atmospheres. The objective is to facilitate international trade in equipment and services for use in explosive atmospheres, while maintaining the required level of safety. More information can be found at www.iecex.com.

3.72 IDENTIFIED (as applied to equipment) – recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular requirement, e.g. NEC.

NOTE Suitability of equipment for a specific purpose, environment, or application may be determined by a qualified testing laboratory, inspection agency, or other organization concerned with product evaluation. Such identification may include labeling or listing. For additional information see *labeled* and *listed*.

3.73 IGNITION CAPABLE EQUIPMENT – equipment which in normal operation constitutes a source of ignition for a specified explosive atmosphere (electrical or thermal energy including electrostatic, frictional sparking or hot surfaces).

3.74 INCREASED SAFETY – under the Zone system, a type of protection applied to electrical equipment or Ex Component in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks. (IEV 426-08-01) This type of protection is referred to as "eb" or "ec".

NOTE Refer to UL 60079-7, CSA 60079-7 or IEC 60079-7 for the ANSI, CAN and IEC certification requirements respectively.

3.75 INTERNAL WIRING – wiring and electrical connections that are made within equipment by the manufacturer. Within racks or panels, interconnections between separate pieces of equipment made in accordance with detailed instructions from the equipment manufacturer are also considered to be internal wiring.

3.76 INTRINSIC SAFETY – under the Division and Zone system, a type of protection in which a portion of the electrical system contains only intrinsically safe equipment, 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 equipment 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. Under the Zone system, this type of protection is referred to as “ia”, "ib" or "ic".

NOTE 1 See also ASSOCIATED APPARATUS.

NOTE 2 Refer to UL 913 or CSA 157 under the Division systems or UL 60079-11, CSA 60079-11 or IEC 60079-11 under the Zone systems for the ANSI, CAN and IEC certification requirements respectively.

3.77 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.

3.78 INTRINSICALLY SAFE CIRCUIT – a circuit in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, in the specified test conditions, of causing ignition of a given explosive atmosphere.

3.79 INTRINSICALLY SAFE ELECTRICAL EQUIPMENT – electrical equipment in which all the circuits are intrinsically safe circuits.

3.80 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.

NOTE For further information, refer to Article 504 of NEC, or Section 10 of CSA C22.1, or ANSI/ISA-RP12.06.01.

3.81 INTRINSICALLY SAFE SYSTEM – an assembly of interconnected intrinsically safe equipment, associated apparatus, other equipment, and interconnecting cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits.

3.82 LABELED: equipment or materials with a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by who's labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

NOTE Some agencies use the term *approved*, *listed*, or *certified* to indicate compliance with the applicable standard.

3.83 LIQUID, COMBUSTIBLE – a liquid having a flash point at or above 37.8 °C (100 °F). Combustible liquids are subdivided as follows:

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

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

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

NOTE For additional information, refer to NFPA 30. It should also be noted that these classes have no relation to the hazardous location classes

3.84 LIQUID IMMERSION (formerly oil-immersion) – under the Zone system, type of protection in which the electrical equipment or parts of the electrical equipment are immersed in a protective liquid in such a way that an explosive atmosphere which may be above the liquid or outside the enclosure cannot be ignited. This type of protection is referred to as “ob” or "oc".

NOTE Refer to UL 60079-6, CSA 60079-6 or IEC 60079-6 for the applicable ANSI, CAN and IEC certification requirements respectively.

3.85 LISTED – equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.

NOTE 1 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 utilize the system employed by the listing organization to identify a listed product.

NOTE 2 Some agencies use the term approved, listed, or certified to indicate compliance with the applicable standard.

3.86 LOWER EXPLOSIVE LIMIT (LEL) – refer to 3.58 NOTE 2.

3.87 LOWER FLAMMABLE LIMIT (LFL) – refer to FLAMMABLE LIMITS.

3.88 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 a qualified person. Such activities typically include locating causes of faulty performance, replacement of defective components, adjustment of internal controls, and the like.

3.89 MAINTENANCE, LIVE – any maintenance activity that occurs while power is still connected to the equipment.

3.90 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.

3.91 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.

3.92 MALFUNCTION – situation where equipment or components do not perform their intended function with respect to explosion protection

NOTE This can happen due to a variety of reasons, including:

• failure of one (or more) of the component parts of the equipment or components;

• external disturbances (e.g. shocks, vibration, electromagnetic fields);

• design error or deficiency (e.g. software errors);

• disturbance of the power supply or other services;

• loss of control by the operator (especially for portable equipment).

(IEV 426-04-56).

3.93 MAXIMUM EXPERIMENTAL SAFE GAP (MESG) – maximum gap of a joint of 25 mm in width which prevents any transmission of an explosion during 10 tests made under the conditions specified in ISO/IEC 80079-20-1.

3.94 MAXIMUM SURFACE TEMPERATURE – the highest temperature which is attained in service under the most adverse conditions (but within the specified tolerances) by any part or surface of Ex Equipment.

NOTE 1 For Ex Equipment in an explosive gas atmosphere, this temperature may occur on an internal component or on the external surface of the enclosure, depending upon the type of protection employed.

NOTE 2 For Ex Equipment in an explosive dust atmosphere, this temperature occurs on the external surface of the enclosure and may include a defined dust layer condition.

3.95 MINIMUM CLOUD IGNITION TEMPERATURE – the minimum temperature at which a combustible dust atmosphere will auto-ignite and propagate an explosion.

3.96 MINIMUM DUST LAYER IGNITION TEMPERATURE – the minimum temperature of a surface that will ignite a dust on it after a long time (theoretically, until infinity). In most dusts, free moisture has been vaporized before ignition.

3.97 MINIMUM EXPLOSIVE (DUST) CONCENTRATION – the minimum concentration of a dust cloud that, when ignited, will propagate a flame away from the source of ignition.

3.98 MINIMUM IGNITING CURRENT RATIO (MIC Ratio) – minimum current in the test circuit specified in ISO/IEC 80079-20-1 that causes ignition of the explosive test mixture in the spark test apparatus according to UL 60079-11 or IEC 60079-11.

NOTE For additional information, refer to UL 60079-11 or IEC 60079-11.

3.99 MINIMUM IGNITION ENERGY (MIE) – minimum energy that can ignite a mixture of a specified flammable material with air, measured by a standard procedure.

NOTE See ASTM E582 or IEC 80079-20-1 for gases and vapors and ISO/IEC 80079-20-2, ASTM E2019 and EN 13821 for dust clouds.

3.100 MIST – liquid released through a small opening, at temperatures below its flash point, resulting in extremely small droplets forming a cloud.

3.101 NONAUTOMATIC – non-self-acting – requiring personal intervention for control. As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

3.102 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 ignitable fibers or flyings. Such a location may also be referred to as a safe area.

3.103 NONINCENDIVE CIRCUIT – a circuit, other than field wiring, in which any arc or thermal effect produced, under intended operating conditions of the equipment, is not capable, under specified test conditions, of igniting the flammable gas-, vapor-, or dust-air mixture. See also NONINCENDIVE FIELD WIRING.

3.104 NONINCENDIVE COMPONENT – under the Division and Zone systems, a component having contacts for making or breaking an ignition-capable circuit and in which the contacting mechanism is constructed so that the component is incapable of igniting the specified explosive atmosphere. The housing of a nonincendive component is not intended to (1) exclude the flammable atmosphere or (2) contain an explosion. Under the Zone system, this type of protection is referred to as "nC."

NOTE Refer to UL 121201 or CSA 213 under the Division system and UL 60079-15, CSA 60079-15 or IEC 60079-15 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

3.105 NONINCENDIVE EQUIPMENT – under the Division and Zone systems equipment having electrical/electronic circuitry and components that are incapable, under normal conditions, of causing ignition of the flammable gas-, vapor-, or dust-air mixture due to arcing or thermal effect. Under the Zone system, this type of protection is referred to as "nA," "nC," or "nR."

NOTE Refer to UL 121201 or CSA 213 under the Division system and UL 60079-15, CSA 60079-15 or IEC 60079-15 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

3.106 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 the flammable gas-, vapor-, or dust-air mixture. Normal operation includes opening, shorting, or grounding the field wiring. See also NONINCENDIVE CIRCUIT.

3.107 NORMAL CONDITIONS, NORMAL OPERATION – equipment is generally considered to be under normal conditions or normal operation when it conforms electrically and mechanically with its design specifications and is used within the limits specified by the manufacturer.

3.108 OIL-IMMERSED – under the division system, equipment immersed in a protective liquid in such a way that an explosive gas atmosphere that can be above the liquid or outside the enclosure cannot be ignited.

NOTE Refer to UL 121201 or CSA 213 for the applicable ANSI or CAN certification requirements respectively.

3.109 POWDER FILLING – under the Zone system, a type of protection in which the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by filling material to prevent the ignition of an external explosive gas atmosphere. This type of protection is referred to as "q."

NOTE 1 This type of protection may not prevent the surrounding explosive atmosphere from penetrating into the equipment and Ex components and being ignited by the circuits. However, due to the small free volumes in the filling material and due to the quenching of a flame that may propagate through the paths in the filling material, an external explosion is prevented.

NOTE 2 Refer to UL 60079-5, CSA 60079-5 or IEC 60079-5 for the applicable ANSI, CAN or IEC certification requirements respectively.

3.110 PRESSURE PILING – the results of an ignition, in a compartment or subdivision of an enclosure, of a gas mixture pre-compressed, for example, due to a primary ignition in another compartment or subdivision.

3.111 PRESSURIZATION – under the Division and Zone systems, type of protection guarding against the ingress of the external atmosphere into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere. Under the Division system, this type of protection is referred to as "Type X", "Type Y" or "Type Z". Under the Zone system, This type of protection is referred to as “px”, "py" or "pz". See 3.112, 3.113 and 3.114.

NOTE Refer to ANSI/NFPA 496 under the Division system and UL 60079-2, CSA 60079-2 or IEC 60079-2 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

3.112 PRESSURIZATION, TYPE X – a method of reducing the classification within an enclosure from Division 1/Zone 1 to nonhazardous (unclassified). See 6.2.1.

3.113 PRESSURIZATION, TYPE Y – a method of reducing the classification within an enclosure from Division 1/Zone 1 to Division 2/Zone 2. See 6.2.1.

3.114 PRESSURIZATION, TYPE Z – a method of reducing the classification within an enclosure from Division 2/Zone 2 to nonhazardous (unclassified). See 6.2.1.

3.115 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.

3.116 PROTECTIVE GAS – the air or inert gas used for purging and maintaining an overpressure and, if required, dilution and purging of flammable gases to a level well below their lower explosive limit, usually below 25 percent LFL. The *protective gas* may be air, nitrogen, other nonflammable gas, or a mixture of such gases.

3.117 PURGING – in a pressurized enclosure, the operation of passing a quantity of protective gas through the enclosure and ducts, so that the concentration of the explosive gas atmosphere is brought to a safe level.

3.118 QUALIFIED PERSON – one familiar with the construction and operation of the equipment and the hazards involved

3.119 RARE MALFUNCTION – type of malfunction, which may happen, but only in rare instances. (IEV 426-04-58)

NOTE Two independent expected malfunctions which, separately, would not create a source of ignition, but which, in combination, do create a source of ignition, are regarded as a single rare malfunction.

3.120 RESTRICTED BREATHING – under the Zone system, a 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 LFL/LEL because of breathing or diffusion. This type of protection is referred to as “nR.”

NOTE Refer to UL 60079-15, CSA 60079-15 or IEC 60079-15 for the applicable ANSI, CAN or IEC certification requirements respectively.

3.121 SAFE AREA – refer to NONHAZARDOUS (UNCLASSIFIED) LOCATION.

3.122 SEAL, CABLE, EXPLOSIONPROOF – a cable termination fitting 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 in combination with a cable termination fitting may also be used as a cable seal.

3.123 SEAL, CONDUIT, EXPLOSIONPROOF – a sealing fitting, filled with a poured 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.

3.124 SEALED DEVICE – under the Division and Zone systems, 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. Under the Zone system, this type of protection is referred to as “nC.”

NOTE Refer to UL 121201 or CSA 213 under the Division system and UL 60079-15, CSA 60079-15 or IEC 60079-15 under the Zone system for the applicable ANSI, CAN or IEC certification requirements respectively.

3.125 SEAL, FACTORY – a construction where components capable of initiating an internal explosion due to arcing, sparking, or thermal effects under normal conditions are isolated from the wiring system by means of factory installed flameproof seal or joint for the purpose of eliminating the need for an external, field-installed conduit seal and, in some cases, a field-installed cable seal.

3.126 SIMPLE APPARATUS (as applied to intrinsic safety) – a device that will not generate or store more than 1.5 V, 0.1 A, or 25 mW. Examples are: switches, thermocouples, light-emitting diodes, and resistance temperature detectors (RTDs).

3.127 SOURCE OF RELEASE – point or location from which a flammable gas, vapor, mist, or liquid may be released into the atmosphere in such a way that an explosive gas atmosphere could be formed.

NOTE IEC 60079-10-1 gives a classification of sources of release.

3.128 SPECIAL PROTECTION – a protection technique other than those that have been standardized.

3.129 SYMBOL "U" – under the IEC Zone system, suffix to the certificate number used to denote an Ex Component.

NOTE The symbol "U” is used to identify that the equipment is incomplete and is not suitable for installation without further evaluation.

3.130 SYMBOL "X" – under the IEC Zone system, symbol used to denote specific conditions of use for Ex Equipment.

NOTE The symbol "X” is used to provide a means of identifying that essential information for the installation, use, and maintenance of the Ex equipment is contained within the certificate.

3.131 TEMPERATURE, AMBIENT – the temperature of air or other media where electrical equipment is to be used.

3.132 TEMPERATURE CLASS – classification system of equipment based on its maximum surface temperature, related to the specific explosive gas atmosphere for which it is intended to be used. See Table 2. Also, referred to as "temperature classification" or "T-Code".

3.133 TYPE OF PROTECTION – specific measures applied to equipment to avoid ignition of a surrounding explosive atmosphere. Examples are "e" and "n".

3.134 UPPER EXPLOSIVE LIMIT (UEL) – refer to 3.58 NOTE 2.

3.135 UPPER FLAMMABLE LIMIT (UFL) – refer to FLAMMABLE LIMITS.

3.136 VAPOR – gaseous phase of a substance that can reach equilibrium with its liquid or solid state in the temperature and pressure range of interest.

3.137 VAPOR PRESSURE – pressure exerted when a solid or liquid is in equilibrium with its own vapor.

NOTE It is a function of the substance and of the temperature of the substance.

3.138 VENTILATION – movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors).

NOTE IEC 60079-10-1 gives types and degrees of ventilation.

3.139 ZONE – a method of specifying the probability that a location is made hazardous by the presence, or potential presence, of flammable concentrations of gases and vapors, or combustible mixtures of dusts.

3.140 ZONE 0 (IEC) – an area in which an explosive gas atmosphere is present continuously or for long periods, or frequently. (IEV 426-03-03).

3.141 ZONE 0, CLASS I (NEC) – a Class I, Zone 0 location is a location (1) in which ignitable concentrations of flammable gases or vapors are present continuously; or (2) in which ignitable concentrations of flammable gases or vapors are present for long periods of time. (NEC Section 505.5 (B)(1))

3.142 ZONE 1 (IEC) – an area in which an explosive gas atmosphere is likely to occur in normal operation occasionally. (IEV 426-03-04)

3.143 ZONE 1, CLASS I (NEC) – a Class I, Zone 1 location is a location (1) in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or (2) in which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or (4) that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided. (NEC Article 505.5 (B)(2))

3.144 ZONE 2 (IEC) – an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, will persist for a short period only. (IEV 426-03-05)

3.145 ZONE 2, CLASS I (NEC) – a Class I, Zone 2 location is a location (1) in which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation, and if they do occur, will exist only for a short period; or (2) in which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors normally are confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or (3) in which ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as the result of failure or abnormal operation of the ventilation equipment; or (4) that is adjacent to a Class I, Zone 1 location from which ignitable concentrations of flammable gases or vapors could 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. (NEC Section 505.5 (B)(3))

3.146 ZONE 20 –

(IEC) – an area in which an explosive atmosphere in the form of a cloud of combustible dust in the air is present continuously, or for long periods or frequency. (IEV 426-03-23)

(NEC) – an area where (1) Ignitible concentrations of combustible dust or ignitible fibers/flyings are present continuously or (2) Ignitible concentrations of combustible dust or ignitible fibers/flyings are present for long periods of time. (NEC Section 506.5 (B)(1))

3.147 ZONE 21 –

(IEC) – an area in which an explosive atmosphere in the form of a cloud of combustible dust in the air is likely to occur, occasionally, in normal operation. (IEV 426-03-24)

(NEC) – an area where (1) Ignitible concentrations of combustible dust or ignitible fibers/flyings are likely to exist occasionally under normal operating conditions; or (2) Ignitible concentrations of combustible dust or ignitible fibers/flyings may exist frequently because of repair or maintenance operations or because of leakage; or (3) Equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitible concentrations of combustible dust or ignitible fibers/flyings and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or (4) The location is adjacent to a Zone 20 location from which ignitible concentrations of dust or ignitible fibers/flyings could be communicated.

Exception: When communication from an adjacent Zone 20 location is minimized by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. (NEC Section 506.5 (B)(2))

3.148 ZONE 22 –

(IEC) – an area in which an explosive atmosphere in the form of a cloud of combustible dust in the air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

NOTE The potential of creating an explosive dust cloud from a dust layer also needs to be considered. (IEV 426-03-24)

(NEC) – an area where (1) Ignitible concentrations of combustible dust or ignitible fibers/flyings are not likely to occur under normal operation and if they do occur, will only persist for a short period; or (2) Combustible dust or fibers/flying are handled, processed, or used but in which the dust or fibers/flyings are normally confined within closed containers of closed systems from which they can escape only as a result of the abnormal operation of the equipment with which the dust or fibers/flyings are handled, processed, or used; or (3) The location is adjacent to a Zone 21 location, from which ignitible concentrations of dust or fibers/flyings could be communicated.

Exception: When communication from an adjacent Zone 21 location is minimized by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. (NEC Section 506.5 (B)(3))

4 Area (location) classification

Area classification schemes should specify the kind of flammable material that may be present and the probability that it will be present in ignitable concentrations. 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. The type of protection technique selected and the level of protection it must provide depend upon the potential hazard caused by using electrical equipment in a location in which a combustible, flammable, or ignitable substance may be present.

4.1 North American methods

In the United States, the area classification definitions are stated in Articles 500, 505 and 506 of the National Electrical Code, (NEC) NFPA 70. In Canada, use of the Zone System of area classification is mandatory for all new installation and is definitions are given in Canadian Electrical Code (CEC), CSA C22.1 – Part 1, Section 18 similar definitions are given in the Canadian (Note: the term "Class" is not used in the main part of the CEC), for existing installations the Division system may be used as identified in Electrical Code (CEC), CSA C22.1 – Part 1, Annex J18 (only this section of the CEC uses the term "Class").

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

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

a) CLASS – the generic form of the flammable materials in the atmosphere, which may include gas or vapor, dusts, or easily ignitable fibers or flyings (see Clause 3 for detailed definitions);

b) DIVISION (or ZONE) – an indication of the probability of the presence of the flammable material in ignitable concentration (see Clause 3 for detailed definitions); and

c) GROUP – the exact nature of the flammable material (see 4.1.1 and 4.1.2).

4.1.1 Groups (NEC Article 500 / CEC Annex J18)

The United States and Canadian Electrical Codes 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. In NEC these groups are defined as:

Group A – Acetylene

Group B – Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) less than or equal to 0.45 mm or a minimum igniting current ratio (MIC ratio) less than 0.4.

NOTE 1 A typical Class I, Group B material is hydrogen.

Group C – Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) values greater than 0.45 mm and less than or equal to 0.75 mm or a minimum igniting current ratio (MIC ratio) greater than or equal to 0.4 and less than or equal to 0.80.

NOTE 2 A typical Class I, Group C material is ethylene.

Group D – Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having a maximum experimental safe gap (MESG) greater than 0.75 mm or a minimum igniting current ratio (MIC ratio) greater than 0.80, or gases or vapors of equivalent hazard.

NOTE 3 A typical Class I, Group D material is propane.

Additional information on group classification can be found in NFPA 497, Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

Group E: Atmospheres containing combustible metal dusts, including aluminum, magnesium, and their commercial alloys, or other combustible dusts whose particle size, abrasiveness, and conductivity present similar hazards in the use of electrical equipment. For Class II, Division 1 applications only.

Group F: Atmospheres containing combustible carbonaceous dusts that have more than 8 percent total entrapped volatiles (see ASTM D3175-89 for coal and coke dusts) or that have been sensitized by other materials so that they present an explosion hazard. Coal, carbon black, charcoal, and coke dusts are examples of carbonaceous dusts.

Group G: Atmospheres containing other combustible dusts, including flour, grain, wood flour, plastic, and chemicals.

Additional information on Group Classification can be found in NFPA 499 Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.

NOTE 4 Equipment for divisions is marked for each group that it is rated for (ex: CI D2 ABCD). Prior to 1971, a piece of equipment that was rated for group B may not have been acceptable for groups C and D because its maximum surface temperature was tied to the gas group, rather than a separate temperature code. This is why we mark all of the gas groups for divisions and not for Zones.

4.1.2 Groups (NEC Article 505/CSA C22.1 Section 18/IEC 60079-20-1)

These groups are defined as:

Group IIC – Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either maximum experimental safe gap (MESG) less than or equal to 0.5 mm or minimum igniting current ratio (MIC ratio) less than 0.45, or gases or vapors of equivalent hazard.

NOTE 1 This group is similar to a combination of Groups A and B as described in 4.1.1, although the MESG and MIC ratio numbers are slightly different.

NOTE 2 Typical gases include acetylene, carbon disulfide, hydrogen, and gases or vapors of equivalent hazard.

NOTE 3 Equipment tested and marked for group IIC may also be used in IIB and IIA areas.

Group IIB – Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having either maximum experimental safe gap (MESG) values greater than 0.5 mm and less than or equal to 0.9 mm or minimum igniting current ratio (MIC ratio) greater than or equal to 0.45 and less than or equal to 0.80, or gases or vapors of equivalent hazard.

NOTE 1 This group is similar to Group C as described in 4.1.1, although the MESG and MIC ratio numbers are slightly different.

NOTE 2 Typical gases include ethylene and gases or vapors of equivalent hazard.

NOTE 3 Equipment tested and marked for group IIB may also be used in IIA.

Group IIA – Flammable gas, flammable liquid-produced vapor, or combustible liquid-produced vapor mixed with air that may burn or explode, having maximum experimental safe gap (MESG) greater than 0.9 mm or minimum igniting current ratio (MIC ratio) greater than 0.80, or gases or vapors of equivalent hazard.

NOTE 1 This group is similar to Group D as described in 4.1.1, although the MESG number is slightly different.

NOTE 2 Typical gases include propane and gases or vapors of equivalent hazard.

Additional information on group classification can be found in IEC 60079-20-1.

4.1.3 Dust Groups

4.1.3.1 Groups (NEC Article 506)

The dust groups are defined in NEC article 506.

4.1.3.2 Groups (UL 60079-0, CSA 60079-0 and IEC 60079-0)

Electrical equipment of Group III is intended for use in places with an explosive dust atmosphere other than mines susceptible to firedamp. Electrical equipment of Group III is subdivided according to the nature of the explosive dust atmosphere for which it is intended.

Group III subdivisions:

(A) Group IIIC. Combustible metal dust. For Zone 20 (EPL Da) applications only.

NOTE Group IIIC is equivalent to Class II, Group E.

(B) Group IIIB. Combustible dust other than combustible metal dust.

NOTE Group IIIB is equivalent to Class II, Groups F and G.

(C) Group IIIA. Solid particles, including fibers, greater than 500 µm in nominal size, which may be suspended in air and could settle out of the atmosphere under their own weight.

NOTE 1 Group IIIA is equivalent to Class III. Examples of flyings include rayon, cotton (including cotton linters and cotton waste), sisal, jute, hemp, cocoa fiber, oakum, and baled waste kapok.

NOTE 2 Equipment tested and marked for group IIIC may also be used in IIIB and IIIA areas. Equipment tested and marked for group IIIB may also be used in IIIA.

4.2 Additional background information

4.2.1 History

Historically, the topic of Hazardous (Classified) Locations first appeared in the National Electrical Code (NEC) in 1920, when a new article entitled “Extra-Hazardous Locations” was accepted. This article addressed rooms or compartments in which highly flammable gases, liquids, mixtures or other substances were manufactured, used, or stored. In 1931, “Classifications” consisting of Class I, Class II, etc., for the hazardous locations were defined. However it was not until 1935 that Groups were introduced into the NEC.

NOTE Divisions were introduced into the NEC in 1947.

After the NEC published the first codified regulations for hazardous locations, UL published the first editions of UL 674(A) and UL 674(B) in 1929 addressing electric motors and generators for use in hazardous locations. These two standards were the first standards for hazardous locations, with UL 674(C) following in 1934 (ultimately, all three become just UL 674 in 1978). This first early decade of HazLoc standards activity was fairly prolific, involving some of the core HazLoc standards that still are used today, such as the first editions of UL 698 in 1930, UL 844 in 1931, and UL 886 in 1931 (with UL 698 and UL 886 later becoming parts of UL 1203).

The four gas Groups, A, B, C, and D, complemented the design of electrical equipment used in hazardous (classified) locations and were defined based on the level of hazard associated with explosion pressures of specific atmospheres and the likelihood that the effects of that explosion could be transmitted outside the enclosure. Group A was defined as atmospheres containing acetylene. Group B was defined as atmospheres containing hydrogen or gas or vapors of equivalent hazard. Group C was defined as atmospheres containing ethyl ether vapor; and Group D was defined as atmospheres containing gasoline, petroleum, naphtha, alcohols, acetone, lacquers solvent vapors, and natural gas.

Despite the fact that the introduction of these Groups was done without standardized testing and without the advantage of today's technological advances or equipment, these definitions have changed little since that time. The first major research testing, in fact, was first conducted in the late 1960s, when engineers at Underwriters Laboratories developed a test apparatus that provided a means to determine how various materials behaved with respect to explosion pressures and transmission, when the specific combustible material was ignited in the test vessel. This apparatus, called the Westerberg Explosion Test Vessel (WETV), provided standardized documentation of a factor called the Maximum Experimental Safe Gap (MESG) and permitted other materials to be "classified by test" into one of the four gas groups. The results of these tests are contained in Underwriter Laboratories (UL) Bulletin No. 58 published in 1969) followed by Bulletin Nos. 58A and 58B (published in 1976 and 1977 respectively). In 1971, the International Electrotechnical Commission (IEC) published IEC 79-1A defining a different type of apparatus for obtaining MESG results without considering explosion pressure. While the two MESG test apparatus are physically different in both size and shape, the results are statistically comparative, although in some cases differences have been observed. A sample of values is shown in Table 1:

Table 1
MESG apparatus comparison

Material	Westerberg apparatus MESG in mm	IEC apparatus MESG in mm
Propane	0.92	0.94
Ethylene	0.69	0.65
Butadiene	0.79	0.79
Diethyl ether	0.30(‡ 0.60)	0.87
Hydrogen	0.08 (‡ 0.23)	0.29

‡ Additional testing on the Westerberg Apparatus has demonstrated that this theory was true, and the MESG value for diethyl ether more than doubled. Further, Westerberg apparatus testing has also shown that the hydrogen MESG value is 0.23 mm.

Papers have been written to attempt to explain the reasons for these differences in the test data. One, by H. Phillips, entitled "Differences Between Determinations of Maximum Experimental Safe Gaps in Europe and U.S.A.," appeared in a 1981 edition of the *Journal of Hazardous Materials* and cited a condition of spontaneous combustion in one portion of the Westerberg Apparatus, which was reflected in materials, like diethyl ether, having low ignition temperatures.

While acetylene remains segregated in Group A because of the high explosion pressure, which results from its very fast flame speed, newer test methodologies have defined other types of protection methods that now consider acetylene and hydrogen to be of equivalent hazard. One such method examines the minimum ignition current required to ignite a specific combustible material. This testing produced more variability when the results of specific combustible materials were compared. However, it was found that the minimum ignition currents of one test could be favorably compared with those of other tests if a ratio value based on methane was applied. This testing has resulted in the generation of MIC Ratio data.

Other testing has been performed by another organization when it was incorrectly assumed that factors called minimum ignition energy (MIE) and auto-ignition temperature (AIT) were related and could be used to place materials into Groups. The fact that these were independent factors resulted in deletion of AITS as a basis for Group determination in the 1971 NEC.

MIEs have been found to exhibit theoretical results, which do not translate into practical designs that can be applied to actual electrical devices with their associated energy levels.

Since the primary concern is to have electrical devices that can safely operate when used in locations classified by Class, Group, and Division, the delineations for the gas groups have been defined on the basis of MESG and MIC ratio.

Further details may be found in NFPA 497.

4.2.2 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 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, some methods of protection permitted in Division 2 and Zone 2 by the National Electrical Code and the Canadian Electrical Code are not yet recognized.

4.2.3 Zone 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 such a high percentage of the time that extraordinary measures should be taken to protect against ignition by electrical equipment. 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 similar in almost all standards, the application of the words to specific industrial situations is different.

4.2.4 Temperature classification

Prior to 1971 the autogenous ignition (or auto-ignition) 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 (320 °F). Hydrogen has an AIT of approximately 520 °C (968 °F). Methane has an AIT of approximately 630 °C (1166 °F). 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 (104 °F) ambient. Those that do not have an alphabetical suffix, i.e., T1-T6, are recognized internationally by the International Electrotechnical Commission (IEC), 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 (212 °F) 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.

Table 2
Temperature class

Maximum Surface Temperature		
Degrees C	**Degrees F**	**Temperature Class**
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

4.2.5 Grouping of materials

4.2.5.1 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.

4.2.5.2 Table 3 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 3 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 3
Comparison of classification of flammable vapors and gases (approx.)

IEC (60079-12)	Europe (ATEX)	North America Zone	North America Division	Base test gas
IIA	IIA	IIA	D	propane, methane
IIB	IIB	IIB	C	Ethylene

Table 3 Continued on Next Page

Table 3 Continued

IEC (60079-12)	Europe (ATEX)	North America Zone	North America Division	Base test gas
			B	Hydrogen
IIC	IIC	IIC		Acetylene, Hydrogen
			A	Acetylene

5 Equipment certification in the United States

5.1 US land-based installations

The Federal requirements for electrical installations in industrial and commercial (non-mining) areas are given in the Code of Federal Regulations (CFR), Title 29 – Labor. The particular requirements for electrical installations in hazardous locations are given in Part 1910, Sub-part S of 29 CFR. This adopts many of the provisions of the National Electrical Code (NEC)* as providing the minimum required levels of safety. Articles 500 to 516 of the NEC, which deal with installations in hazardous locations, are particularly cited as having mandatory application. In Articles 500 to 516 of the NEC it is required as a minimum that electrical equipment for use in hazardous locations shall be 'approved' for use in the particular location concerned. Approved is defined in the NEC as 'acceptable to the authority having jurisdiction'. In many cases, specific sections additionally require the equipment to be 'listed' (tested and certified) by a nationally recognized testing laboratory (NRTL) such as Underwriters Laboratories (UL), FM Approvals (FM) or Intertek Testing Services NA Inc. (Intertek). The NRTL must be recognized by the Occupational Safety and Health Administration (OSHA) to test and evaluate products to specific product safety standards. There are specific applications where only 'listed' equipment is permitted.

5.2 Intro to coal mine explosion hazards and MSHA permissibility

Gas or dust explosions are some of the greatest hazards faced by underground coal mine workers. Methane gas is released during the mining process and accumulates in areas that are not well ventilated. Coal dust can form explosive dust clouds. Coal dust layers may accumulate on equipment or in entries, posing a fire hazard or explosion enhancement hazard should the dust be entrained into the air. Methane ignitions or explosives, for example, can disperse coal dust layers into the atmosphere that subsequently ignite and propagate as powerful explosions.

The Mine Safety and Health Administration (MSHA) requires equipment used in certain locations of underground mines to be "permissible". The term permissible refers to equipment that meets MSHA specifications for the construction and maintenance of such equipment, to assure that such equipment will not cause a mine explosion or fire. The MSHA Approval and Certification Center approves and certifies certain mining products for use in underground coal and gassy underground metal mines. Technical experts evaluate and test equipment, instruments, and materials for compliance with Title 30 of the US Code of Federal Regulations. Products evaluated and tested range from extremely small electronic devices to very large mining systems. Following successful completion of evaluation and testing of a product, a license is issued authorizing a manufacturer to produce and distribute products for use in mines. MSHA provides administrative and technical information for product approval and acceptance programs through the MSHA web site at http://www.msha.gov/.

5.3 US Shipping

Electrical installations in hazardous areas on US inspected vessels (tankers, barges, offshore supply vessels, mobile offshore drilling units, floating offshore facilities, and roll-on roll-off vessels) are regulated in Title 46 Code of Federal Regulations (46 CFR) U.S, Coast Guard, Department of Homeland Security in Subpart 111.105. The installations are required to comply with certain provisions of NEC Articles 500-505, ANSI/ISA-RP12.06.01, NFPA 496, and IEC 60092-502, as applicable; or the incorporated Parts of UL 60079 Series or IEC 60079 Series Publications.

Equipment installations under 46 CFR 111.105-7, -9 and -11 are required to be tested or approved, and listed or certified for use in the hazardous locations by an independent laboratory. Independent laboratory means a laboratory that is accepted by the Commandant of the US Coast Guard under 46 CFR Subpart 159.010. Presently, the list of USCG accepted laboratories can be accessed on-line at https://cgmix.uscg.mil/EQLabs/EQLabsSearch.aspx.

5.4 Comparing USA Zones to IECEx/ATEX Zones

The USA adoption of the IEC Zone System involves US National differences. Compliance with these US National differences are identified by the inclusion of an "AEx" marking on the equipment, instead of the international use of just an "Ex" marking.

Some of the key technical differences reflected by the "AEx" marking include compliance with,

1) US/ANSI general industrial requirements for the risks of fire, electric shock and injury to persons;

2) NEC hazardous locations requirements for wiring methods; and

3) OSHA CFR production audit procedures involving audits four times per year to verify continued compliance.

European ATEX Directive or IECEx System "Ex" markings, on their own, do not address these US National differences.

6 Protection techniques for electrical equipment 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 equipment in hazardous (classified) locations.

6.1 Explosion confinement and flame quenching

6.1.1 Explosionproof

Explosionproof, applicable to Class I, Division 1 and 2, and Class I, Zone 1 and 2 areas, is a specific protection technique in which the ignition source, fuel, and oxygen 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 auto-ignition temperature for the specific gases or vapors involved. The explosionproof technique is gas-group dependent – i.e., an enclosure designed and tested for Class I Group C would not be suitable for use in a Group B atmosphere.

NOTE Refer to UL 1203 or CSA 30 for the applicable ANSI and CAN certification requirements respectively.

6.1.2 Flameproof

Flameproof “da” is for use in Class I, Division 1 and 2, and Zone 0, 1 and 2, areas. Flameproof “db” is for us in Class I, Division 2, and Zone 1 and 2, areas; with flameproof “dc” only for use in Class I Division 2 and Zone 2 areas. These reduced area applications for “db” and “dc” are due to reduced requirements based on their intended application in less explosive atmospheres.

NOTE Refer to UL 60079-1, CSA 60079-1 or IEC 60079-1 for the applicable ANSI, CAN or IEC certification requirements respectively.

6.1.3 Powder filling

Powder filling “q” is for use in Class I, Division 2 and Zone 1 and 2 areas. In powder filled protection, the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by quartz or glass particles to prevent the ignition of an external explosive atmosphere. Note that this type of protection may not prevent the surrounding explosive atmosphere from penetrating into the equipment and Ex components and being ignited by the circuits.

However, due to the small free volumes in the filling material and due to the quenching of a flame which may propagate through the paths in the filling material, an external explosion is prevented. This method of protection is growing in popularity as it allows previously encapsulated equipment to be replaced with powder filled equipment that is easier to recycle or service.

NOTE Refer to UL 60079-5, CSA 60079-5 or IEC 60079-5 for the applicable ANSI, CAN or IEC certification requirements respectively.

6.1.4 Enclosed-Break

Enclosed-break is for use in Class I, Division 2 and Zone 2 areas. Such devices incorporate electrical contacts in a housing that will withstand an internal explosion of the flammable gas or vapor which can enter it without suffering damage and without communicating the internal explosion to the external flammable gas or vapor. The principle differences between enclosed-break devices and explosion-proof/flameproof enclosures involve restrictions in electrical ratings and free internal volume, along with a reduction in the intended area applications based on the involved requirements.

NOTE Refer to UL 121201 or CSA 213 under the Division system and UL 60079-15, CSA 60079-15 or IEC 60079-15 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

6.2 Isolation from flammable atmospheres

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.

6.2.1 Pressurization

Pressurization 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 related.

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.

NOTE Refer to NFPA 496 under the Division system, although this document does not use the term continuous dilution. Also refer to 6.2.2.

6.2.1.1 In North America the pressurization 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.

NOTE Refer to UL 60079-2, CSA 60079-2, IEC 60079-2 and IEC 60079-13 under the Zone system for the applicable ANSI, CAN and IEC requirements respectively.

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

United States and Canada

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

Type Z Pressurization. In the United States and Canada, Type Z pressurization 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.

Zone System

The above concepts of Type X, Type Y and Type Z have been adopted in UL 60079-2, CSA 60079-2 and IEC 60079-2 as px, py and pz respectively. The Zone system requirements are more onerous for Zone 1 such as the minimum internal enclosure pressure is 50 pascals rather than the 25 pascals used in the Division system. Also, for type px, not only must pressure be monitored, but also flow before the purge timer can be initiated. UL 60079-2, CSA 60079-2 and IEC 60079-2 identify significantly different requirements for an internal release that are based upon the containment system and upon the dilution area surrounding the point of release from the containment system.

6.2.1.2 Pressurization for Class II

Pressurization for Class II 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.

6.2.2 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 LFL). 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.

6.2.3 Dust-ignition-proof

Dust-ignition-proof is for use in Class II, Division 1 and 2, and Zone 20, 21 and 22 areas. Such equipment is enclosed in a manner that excludes dusts and does not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

NOTE Refer to UL 1203 and CSA 25 for the applicable ANSI and CAN requirements respectively.

6.2.4 Dusttight

Dusttight is for use in Class II, Division 2, Class III, Division 1 and 2, and Zone 22 areas. These enclosures are constructed so that dust will not enter under specified test conditions.

NOTE Refer to UL 121201 and CSA 213 for the applicable ANSI and CAN requirements respectively.

6.2.5 Dust ignition protection by enclosure

Dust ignition protection by enclosure “ta” is for use in Class I, Division 1 and 2; and Zone 20, 21 and 22, areasthe same areas as Dust-ignition-proof. However, dust ignition protection by enclosure “tb” is only for use in Class II, Division 2 and Zone 21 and 22 areas, with dust ignition protection by enclosure “tc” for use in the same areas as Dusttight. These reduced area applications for “tb” and “tc” are based on their intended application only in these less explosive atmospheres.

NOTE Refer to UL 60079-31, CSA 60079-31 and IEC 60079-31 for the applicable ANSI, CAN and IEC requirements respectively.

Enclosure Types 3, 3S, 3SX, 4, 4A, 5, 6, 6P, 12, 12K, and 13, per NEMA 250 are considered dusttight and suitable for use in Class II, Division 2; Class III, Division 1 and 2; and Zone 22 areas.

6.2.6 Liquid immersion / Oil immersed

Under the Zone system, liquid immersion was formerly known as oil immersion. Under the Division system, it is referred to as oil immersed. Liquid immersion “ob” is for use in Class I, Division 2, Zone 1 and Zone 2 areas. Liquid immersion “oc” and Oil immersed are for use in Class I, Division 2 and Zone 2 areas.

The most common application is of these types of protection are for electrical equipment such as switches, relays, and 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.

NOTE Refer to UL 121201 or CSA 213 under the Division system and UL 60079-6, CSA 60079-6 or IEC 60079-6 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

6.2.7 Sealing (Sealed and Hermetically sealed devices)

Sealed devices and Hermetically Sealed devices (idenified as "nC" under the Zone system) are for use in Class I, Division 2 and Zone 2: Class II, Division 2 and Class III 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.

NOTE Refer to UL 121201 or CSA 213 under the Division system and UL 60079-15, CSA 60079-15 and IEC 60079-15 under the Zone system for the applicable ANSI, CAN and IEC certification requirements respectively.

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.

6.2.8 Encapsulation

Encapsulation “ma” is for use in Division 1 and 2, and Zone 0, 1 and 2, areas. Encapsulation “mb” is for use in Division 2 and Zone 1, Zone 2, Zone 21 and Zone 22, areas, with encapsulation “mc” only for use in Division 2, Zone 2 and Zone 22 areas. These reduced area applications for “mb” and “mc” are due to reduced requirements based on their intended application in less explosive atmospheres.

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.

NOTE Refer to UL 60079-18, CSA 60079-18 and IEC 60079-18 for the applicable ANSI, CAN and IEC certification requirements respectively.

6.2.9 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 6.2.7.

6.2.10 Restricted breathing

Restricted breathing "nR" is for use in Class I, Division 2 and Zone 2 areas. It 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 equipment 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.

NOTE Refer to UL 60079-15, CSA 60079-15 and IEC 60079-15 for the applicable ANSI, CAN and IEC certification requirements respectively.

6.3 Energy release limitation

6.3.1 Intrinsic safety

Intrinsic safety under the Division system is for use in Class I and II, Division 1 and 2 and Class III areas, along with Zone 0, 1, 2, 20, 21 and 22 areas. Under the Zone system, intrinsic safety “ia” is for use in these same areas. Intrinsic safety “ib” is for use in Class I and II, Division 2 and Class III areas, along with Zone 1, 2, 21 and 22 areas. Intrinsic safety “ic” is only for use in Class I and II, Division 2 and Class III and Zone 2 and 22 areas.

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.

NOTE 1 Refer to UL 913 and CSA 157 under the Division system, and UL 60079-11, CSA 60079-11 and IEC 60079-11 under the Zone system, for the applicable ANSI, CAN and IEC requirements respectively.

NOTE 2 For installation information, refer to ANSI/ISA-RP12.06.01 and NEC Article 504.

6.3.2 Nonincendive circuits

Nonincendive circuits are for use in Class I and II, Division 2 and Class III, and Zone 2 and 22, areas. 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.

NOTE Refer to UL 121201 and CSA 213 for the applicable ANSI and CAN requirements respectively.

6.4 Other methods of protection

6.4.1 Increased safety

Increased safety “eb” is for use in Class I, Division 2 and Zones 1 and 2 areas, with increased safety “ec” for use in Class I, Division 2 and Zone 2 areas.

Increased safety is a technique developed in Germany. It has been used for equipment such as terminals, motors, and lighting fixtures. The motors are specially designed to remain below the auto-ignition temperature, even under certain locked rotor conditions, and have special connection facilities designed to prevent loosening even under severe vibration.

NOTE Refer to UL 60079-7, CSA 60079-7 and IEC 60079-7 for the applicable ANSI, CAN and IEC requirements.

6.4.2 Non-sparking

Non-sparking devices are for use in Class I, Division 2 and Zone 2 areas. These devices are constructed to minimize the risk of occurrence of arcs or sparks capable of creating an ignition hazard during conditions of normal operation.

NOTE Refer to UL 121201 and CSA 213 for the applicable ANSI and CAN requirements respectively.

6.4.3 Combustible gas detection system

A combustible gas detection system is a protection technique utilizing stationary gas detectors in industrial establishments.

6.5 Summary of Types of Protection (Gas)

Table 4 provides a summary of various Types of Protection and locations in which they are permissible for flammable gases or vapors-in-air mixtures.

Table 4
Summary of Types of Protection (flammable gases or vapors-in-air mixtures)

Designation	Technique	Zone *
d	Flameproof enclosure	1
db	Flameproof enclosure	1
e	Increased safety	1
eb	Increased safety	1
ia	Intrinsic safety	0
ib	Intrinsic safety	1
ic	Intrinsic safety	2
[ia]	Associated apparatus	Unclassified**
[ib]	Associated apparatus	Unclassified**
[ic]	Associated apparatus	Unclassified**
ma	Encapsulation	0
m	Encapsulation	1

Table 4 Continued on Next Page

Table 4 Continued

Designation	Technique	Zone *
mb	Encapsulation	1
mc	Encapsulation	2
nA	Non-sparking equipment	2
nAc	Non-sparking equipment	2
nC	Sparking equipment in which the contacts are suitably protected other than by restricted breathing enclosure.	2
nCc	Sparking equipment in which the contacts are suitably protected other than by restricted breathing enclosure.	2
nR	Restricted breathing enclosure	2
nRc	Restricted breathing enclosure	2
o	Oil immersion	1
ob	Oil immersion	1
px	Pressurization	1
pxb	Pressurization	1
py	Pressurization	1
pyb	Pressurization	1
pz	Pressurization	2
pzc	Pressurization	2
q	Powder-filled	1
qb	Powder-filled	1
* Does not address use where a combination of techniques is used. **Associated apparatus is permitted to be installed in a hazardous (classified) location if suitably protected using another type of protection.		

For protection techniques (Types of Protection) applicable to Classes I, II, and III; Division 1 and 2, refer to Article 500.7 of the NEC.

6.5.1 Type or Protection “s”

A special protection category, *Type s*, is a technique other than those that have been standardized. When an area is classified Zone 0, it is common in some countries to provide two or more protection techniques, such as pressurizing a flameproof enclosure. *Ex s* has also been applied for Zone 1, where, for example, a transmitting device partly satisfies the increased safety requirements and also partly 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.

NOTE Under the Division system, Type of Protection “s” is comparable to the “Other Protection Techniques” referred to by 500.7(L) of the NEC.

6.5.2 Intrinsic safety

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

6.6 Summary of Types of Protection (Dust)

Table 5 provides a summary of various Types of Protection and locations in which they are permissible for dusts.

Table 5
Summary of Types of Protection (Dust)

Designation	Technique	Zone
iaD	Intrinsic safety	20
ia	Intrinsic safety	20
ibD	Intrinsic safety	21
ib	Intrinsic safety	21
ic	Intrinsic safety	22
[iaD]	Associated apparatus	Unclassified**
ia	Associated apparatus	Unclassified**
[ibD]	Associated apparatus	Unclassified**
ib	Associated apparatus	Unclassified**
ic	Associated apparatus	Unclassified**
maD	Encapsulation	20
ma	Encapsulation	20
mbD	Encapsulation	21
mb	Encapsulation	21
mc	Encapsulation	22
pD	Pressurization	21
p	Pressurization	21
pb	Pressurization	21
tD	Protection by enclosures	21
ta	Protection by enclosures	20
tb	Protection by enclosures	21
tc	Protection by enclosures	22
*Does not address use where a combination of techniques is used.		
**Associated apparatus is permitted to be installed in a hazardous (classified) location if suitably protected using another type of protection.		

7 Wiring methods

For the installation of electrical equipment, three basic installation systems are allowed:

a) Conduit systems (Reference Figure 11, Figure 14, and Figure 16 and Table 6 and Table 7.

b) Cable systems with indirect entry (Reference Figure 5, Figure 6, Figure 12, Figure 13, and Figure 15 and Table 6 and Table 7.

c) Cable systems with direct entry (Reference Figure 7, Figure 8, Figure 9, Figure 12, Figure 13 and Figure 15 and Table 6 and Table 7.

NOTE Intrinsically safe electrical equipment and nonincendive field wiring can be installed with less restrictive wiring methods. See NEC Section 504.20 or 501.10(B)(3), respectively.

NEC Article 501.10(A)(1) allows only a) a conduit system, b) mineral-insulated (Type MI) cables, c) in industrial establishments with restricted public access where the conditions of maintenance and supervision ensure that only qualified persons will service the installation, Type MC-HL cable, listed for use in Class I, Division 1 locations, with a gas/vaportight continuous corrugated aluminum sheath, an overall jacket of suitable polymeric material, separate grounding conductors in accordance with Section 250.122 and provided with termination fittings listed for the application, or d) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type ITC-HL cable, listed for use in Class I, Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material and provided with termination fittings listed for the application.

NEC Article 501.10(B) allows for the use of certain other types of cables in Division 2 areas.

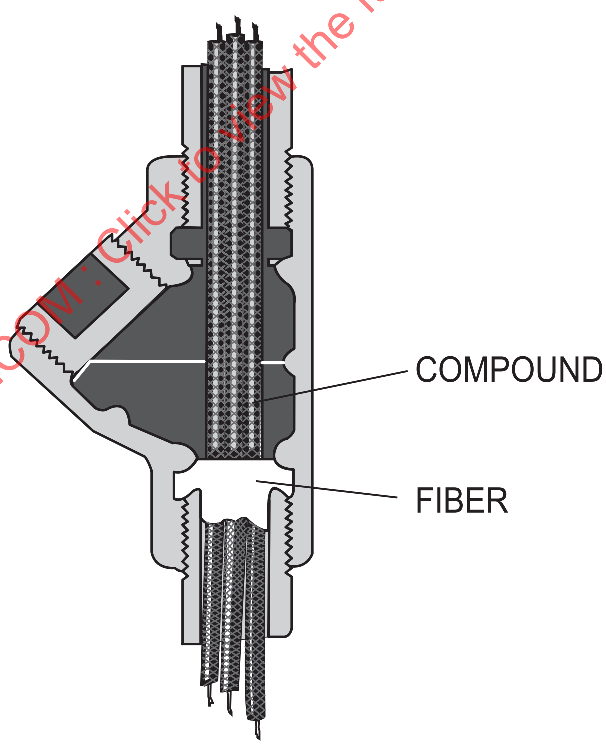
The European harmonized standards, EN 60079-0 through EN 60079-18 permit equipment to be designed that can be installed using one or more of the three installation approaches. The installation requirements, however, are different from country to country.

Wiring requirements for Zones 20, 21 and 22 in the US are defined in 506.15 of NFPA 70.

NOTE All figures referred to in this section are shown below.

Figure 1

Vertical conduit seal



su2032

Figure 2

Conduit drain seal

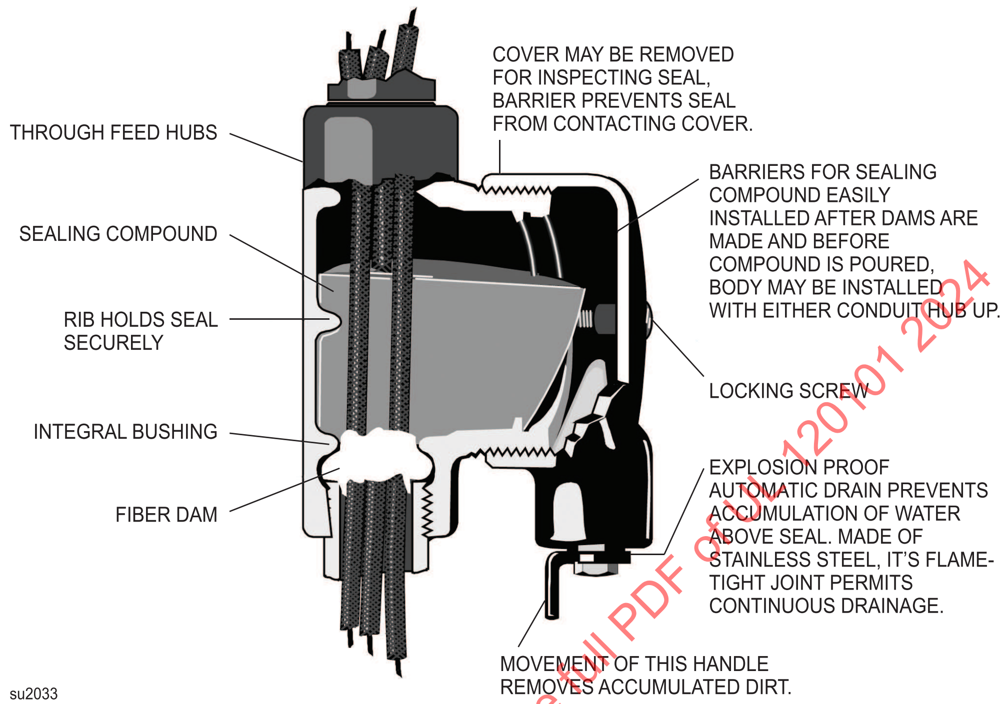


Figure 3

Cable seal

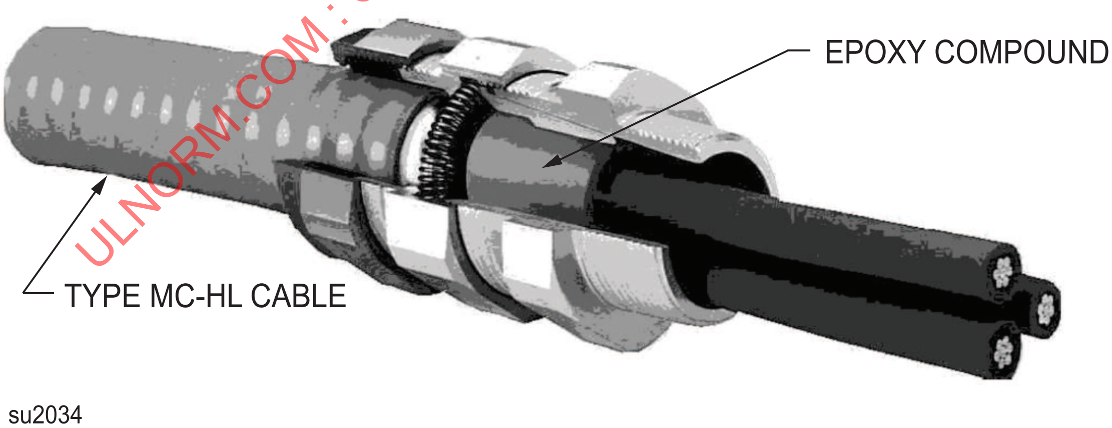
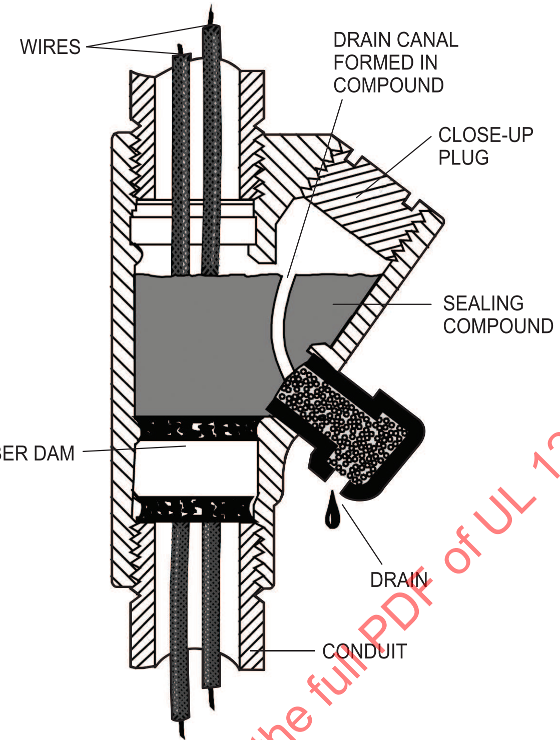


Figure 4

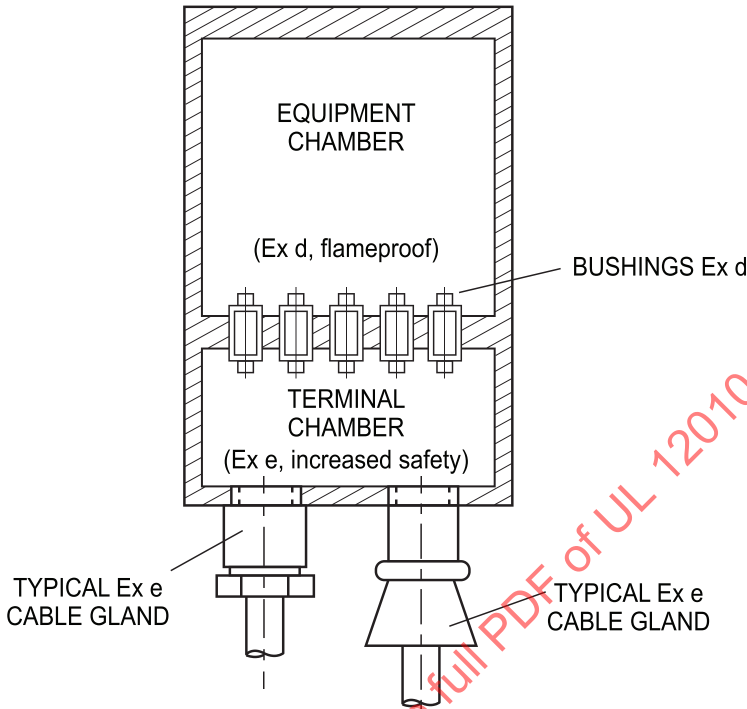
Conduit drain seal



su2035

Figure 5

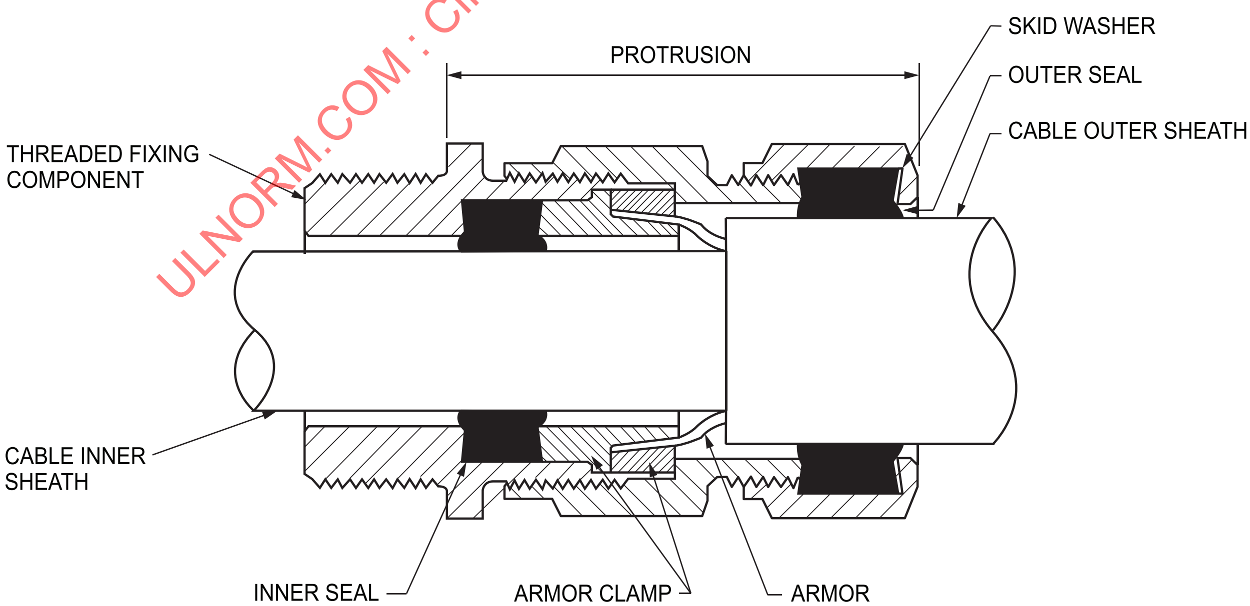
Cable system (indirect entry)



su2036

Figure 6

Cable gland (indirect entry)



su2040

Figure 7

Cable system (direct entry)

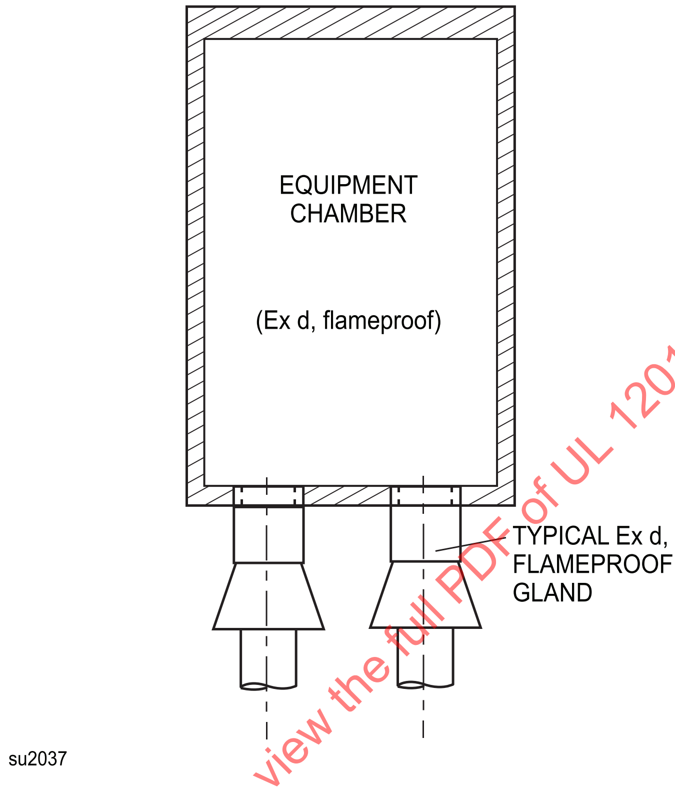


Figure 8

Cable gland (direct entry)

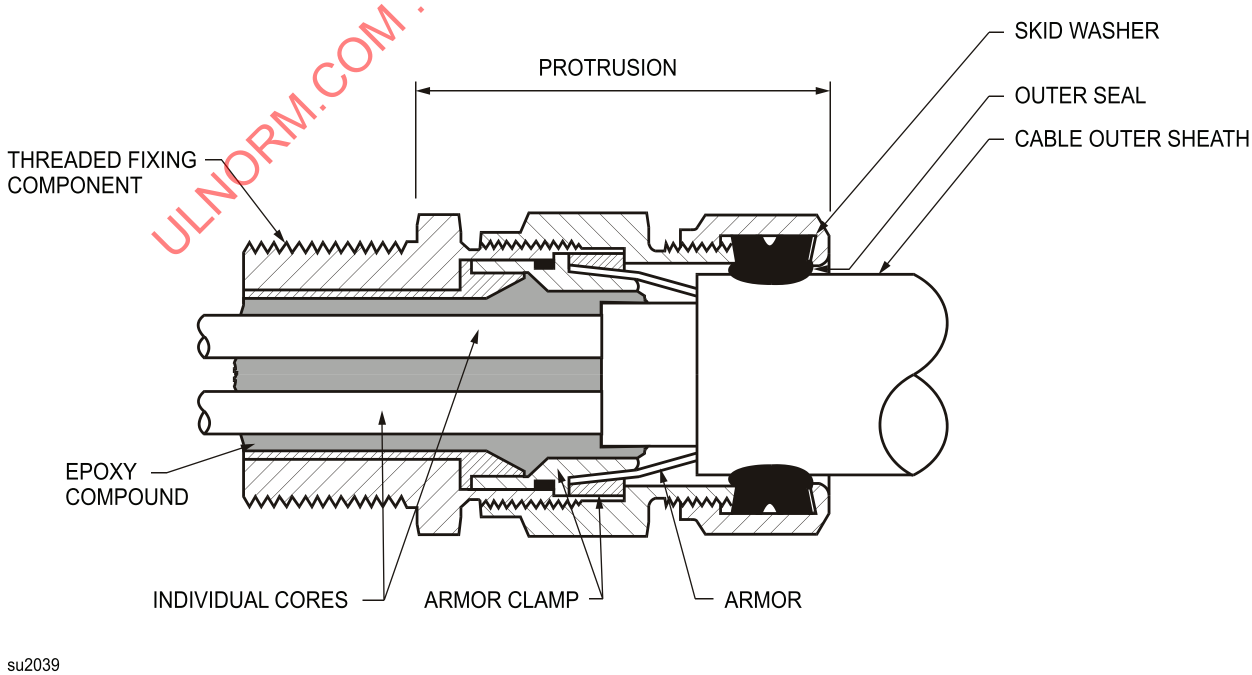
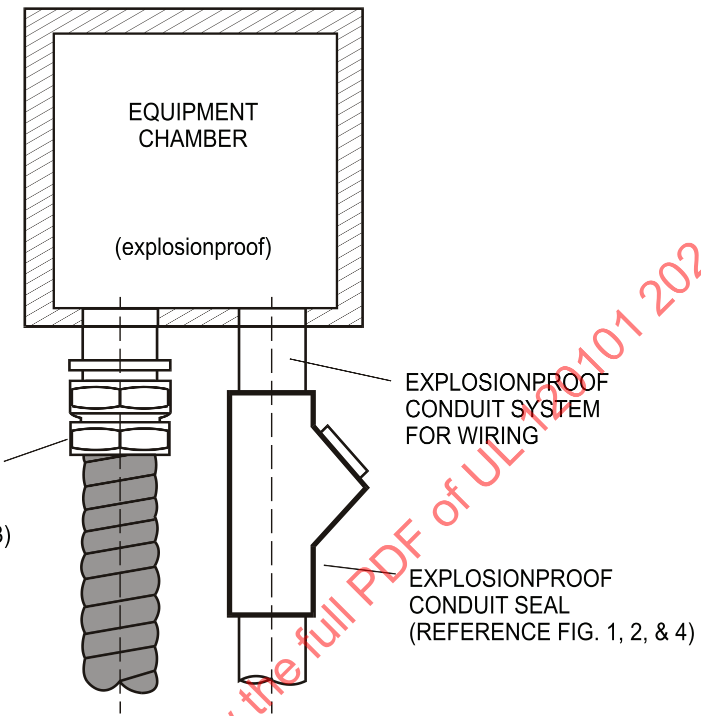


Figure 9

Conduit system (direct entry)



7.1 Conduit system

7.1.1 General

With conduit systems in Class I, Division 1, locations in the United States, the electrical wiring is installed inside closed threaded metal conduit (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. The entire conduit system, including all fittings, is required to be explosionproof and frequently requires an explosionproof 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 I, locations in Canada, one difference is that threaded intermediate metal conduit is not acceptable. In addition, TEK cable is permitted in Class I, Division 1.

In this section all references to *seal* 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 [Figure 1, Figure 2, Figure 3, and Figure 4] (See Article 501 of the NEC.)

7.2 Cable systems

In the United States, in Class I, Division 1, locations, the NEC will allow 1) mineral-insulated Type MI cable, 2) Type MC-HL or Type ITC-HL cable listed for use in Class I, Division 1, locations, with a gas/vaportight continuous corrugated aluminum sheath, an overall jacket of suitable polymeric material, separate grounding conductor in accordance with Section 250, and provided with termination fittings listed for the application (Figure 3), cables used in intrinsically safe systems as permitted by Article 504 of the NEC. For Class I, Division 2 locations, certain cable constructions are allowed. Refer to Table 6.

In the 2014 NEC, non-armored cable TC-ER-HL was introduced for Class I Zone 1 locations and the flexible portion of the circuit in Class I Division 1 locations.

In Canada, the requirements for Zone installations and Division installation are basically identical. Canada allows the use of HL marked TECK cable in Zone 1 and Class I, Division 1 locations however the does not permit the use of TC-ER-HL.

Internationally, openly installed cable systems are common, using heavy-duty sheathed cables (i.e., with an outer sheath of rubber, plastic, or metal). Armored or braided cable is often required in Class I Zone 1 or in areas where damage might occur to unprotected cable. The metal braid or armor is covered by an outer sheath of rubber, plastic, or other synthetics, and the braid or armor 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 IEC standards.

7.2.1 Indirect entry

In Germany, and in many other countries influenced by German technology, only indirect entry (via a terminal chamber that provided increased safety protection) and factory potted and installed flameproof cable entries were allowed.

Cables enter the terminal chambers via cable glands and connect to increased safety terminals (Figure 5 and Figure 6). Then the single conductors enter into the flameproof chamber via post-type bushings or conductor bushings. The installer needs only to open the terminal chamber of increased safety for connection, not the flameproof chamber. Flameproof cable glands are not required.

7.2.2 Direct entry

Cables enter the flameproof chamber directly. For cable gland, suitable flameproof cable glands must be used. (Figure 7 and Figure 8)

7.3 Conduit and cable seals

Seals are installed in conduit and cable systems (except for Type 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;

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 *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.

7.3.1 Seal requirements

7.3.1.1 Enclosure entries

In Division 1 and Division 2 locations, a seal must be installed in every conduit or cable system (reference NEC Article 501.15 for requirements) that enters an enclosure containing arcing, sparking or high temperature equipment 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 multiconductor cable may be treated as a single conductor if the cable end is sealed by an approved means within the enclosure.

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 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, explosionproof 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 (457 mm) from the enclosures to which they are attached. In some cases, enclosure manufacturer’s instructions might require that the seal be installed closer than 18 inches from the enclosure.

7.3.1.2 Process seals

Process-connected equipment is electrical equipment that contains a process seal and is intended for connection to an external system that contains process fluids. This includes, but is not limited to pumps, flow, pressure, temperature, or analysis measurement instruments.

The NEC and CEC require that process seals be installed that 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. Normal conduit seals are intended to reduce pressure piling in the event of an ignition. The need for process seals is not limited to only conduit systems. The NEC and CEC allow single seal and dual-seal devices that are listed or marked as meeting the requirements of UL 122701 to be installed with no additional seals.

7.3.1.3 Classified area boundaries

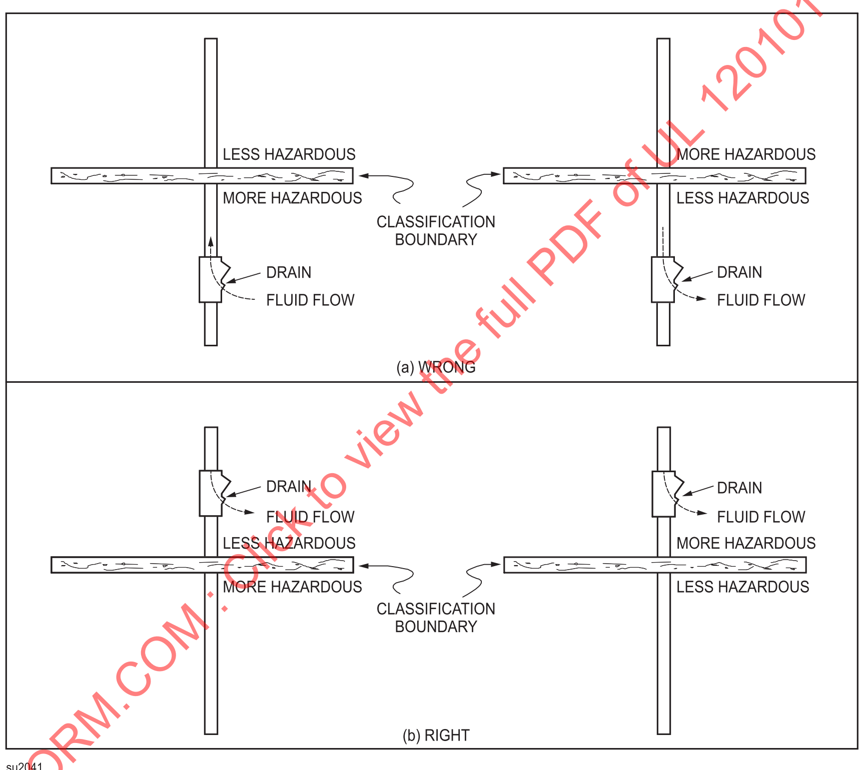
Wherever a conduit run passes from a Division 1 to a Division 2 area, from a Division 2 to an unclassified area, or any other combination thereof, a seal must be placed in the conduit run at the boundary, on either side. The conduit system must not contain any union, coupling, box, or other fitting between 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 (305 mm) beyond each boundary. The same applies for Zones.

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 10.

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 or other means shall be provided to minimize 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.

Figure 10

Placement of drain seals (Reference API RP 14F, Figure 7, Recommended Practice for Design and Installation of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1 and Division 2 Locations)



7.3.1.4 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. Particular attention should be paid to temperature limitations of the sealing compound during installation.

e) No splices or taps are allowed in sealing fittings. Sealing compounds may not be insulation materials and 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 conduit where water or fluids may accumulate in the conduit/system.

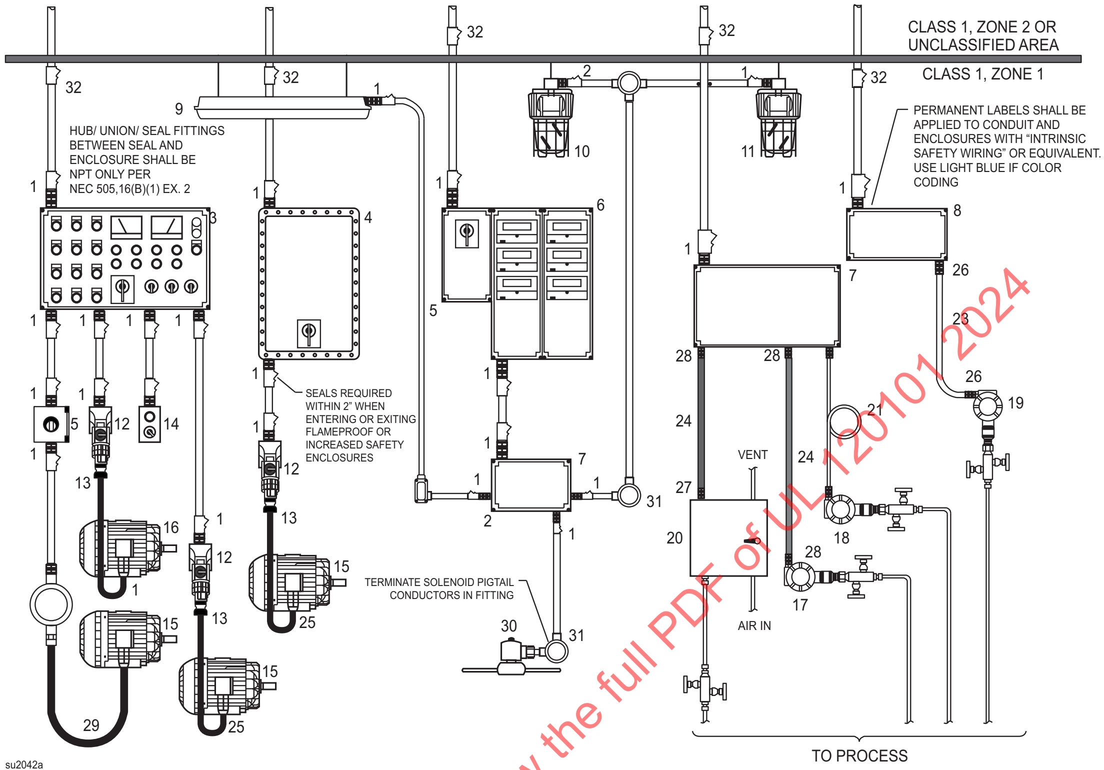
g) Factory-sealed devices such as toggle switches, push buttons, lighting panels, and lighting fixtures eliminate the need for externally sealing those particular devices.

7.4 Comparison of the installation systems

Figure 11 depicts a typical Class I, Zone 1 conduit system installation.

Figure 11

Typical Class I Zone I, Group II conduit system installation



KEY TO NUMERALS:

1 CONDUIT SEAL, INSTALLED WITHIN 2" (50 mm)	12 SWITCHED RECEPTACLE (AEx 'de')	23 INSTRUMENT TRAY CABLE (ITC-ER)
2 CONDUIT SEAL, INSTALLED WITHIN 18" (0.5 mm)	13 PLUG AND CORD (AEx 'de')	24 MC-HL CABLE
3 TERMINAL BOX (AEx 'e') POWER CIRCUITS	14 CONTROL STATION (AEx 'e') W/AEx'de'	25 CABLE GLAND, NON-METALIC CABLE (SEALED)
4 FLAMEPROOF (AEx 'd') / EXPLOSIONPROOF (DIV 1) ENCLOSURE	15 MOTOR-EXPLOSIONPROOF	26 CABLE GLAND, NON-METALIC CABLE (UNSEALED)
5 DISCONNECT SWITCH (AEx 'de')	16 MOTOR – FLAMEPROOF (AEx 'dd')	27 CABLE GLAND, MC-HL CABLE (SEALED CLASS I, DIV 1)
6 PANELBOARD (AEx 'de')	17 INSTRUMENT (AEx 'e')	28 CABLE GLAND, MC-HL CABLE (UNSEALED)
7 TERMINAL BOX (AEx 'e') INSTRUMENT CIRCUITS	18 INSTRUMENT – EXPLOSIONPROOF	29 EXPLOSIONPROOF FLEXIBLE FITTING (SEE NOTE 2)
8 TERMINAL BOX W / IS CIRCUIT	19 INSTRUMENT (I.S.) AEx 'la'/'lb'	30 SOLENOID VALVE (NOT CONNECTED TO PROCESS)
9 FLUORESCENT FIXTURE (AEx 'de')	20 INSTRUMENT AEx "px" (ANALYZER)	31 EXPLOSIONPROOF CONDUIT BODY
10 EXPLOSIONPROOF/FLAMEPROOF FIXTURE (CLASS I, DIVISION 1/AEx'd')	21 MINERAL INSULATED CABLE (MI)	32 CONDUIT SEAL WITHIN 10 FT. OF BOUNDARY
11 FIXTURE (AEx 'e')	22 INSTRUMENT TRAY CABLE (ITC-HL)	

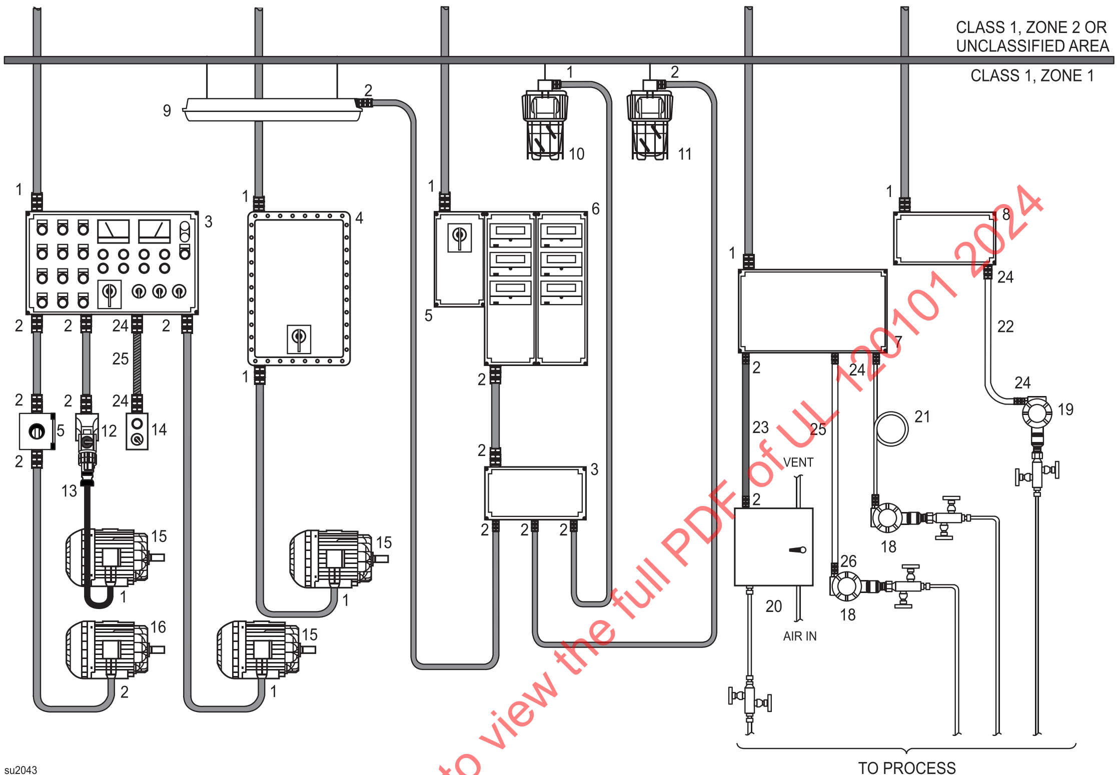
NOTE 1: RIGID METAL OR INTERMEDIATE METAL CONDUIT IS USED THROUGHOUT UNLESS OTHERWISE DESIGNATED.

NOTE 2: EXPLOSION PROOF FLEXIBLE FITTING SHALL NOT EXCEED 36°.

Figure 12 depicts a typical Class I Zone 1, Group II cable system for a similar installation.

Figure 12

Typical Class I Zone 1, Group II cable system installation



KEY TO NUMERALS:

1 MC-HL CABLE GLAND – SEALED (AEx"d" or Class I, Division 1)

2 MC-HL CABLE GLAND – UNSEALED (AEx"e")

3 TERMINAL BOX (AEx 'e') POWER CIRCUITS

4 FLAMEPROOF (AEx 'd') / EXPLOSIONPROOF (DIV 1) ENCLOSURE

5 DISCONNECT SWITCH (AEx 'de')

6 PANELBOARD (AEx 'de')

7 TERMINAL BOX (AEx 'e') INSTRUMENT CIRCUITS

8 TERMINAL BOX W / IS CIRCUIT

9 FLUORESCENT FIXTURE (AEx 'de')

10 EXPLOSIONPROOF/FLAMEPROOF FIXTURE (CLASS I, DIVISION 1/AEx'd')

11 FIXTURE (AEx 'e')

12 SWITCHED RECEPTACLE (AEx 'de')

13 PLUG AND CORD (AEx 'de')

14 CONTROL STATION (AEx 'e') W/AEx'de' COMPONENTS

15 MOTOR-EXPLOSIONPROOF / (AEx 'd')

16 MOTOR – INCREASED SAFETY (AEx 'e')

17 INSTRUMENT (AEx 'e')

18 INSTRUMENT – EXPLOSIONPROOF

19 INSTRUMENT (I.S.) AEx 'ia'/'ib'

20 INSTRUMENT AEx "Px"

21 MINERAL INSULATED CABLE (MI)

22 TRAY CABLE (TC-ER)

23 INSTRUMENT TRAY CABLE (ITC-HL)

24 TC CABLE GLAND FOR NONMETALIC CABLE (UNSEALED)

25 TC-ER-HL CABLE

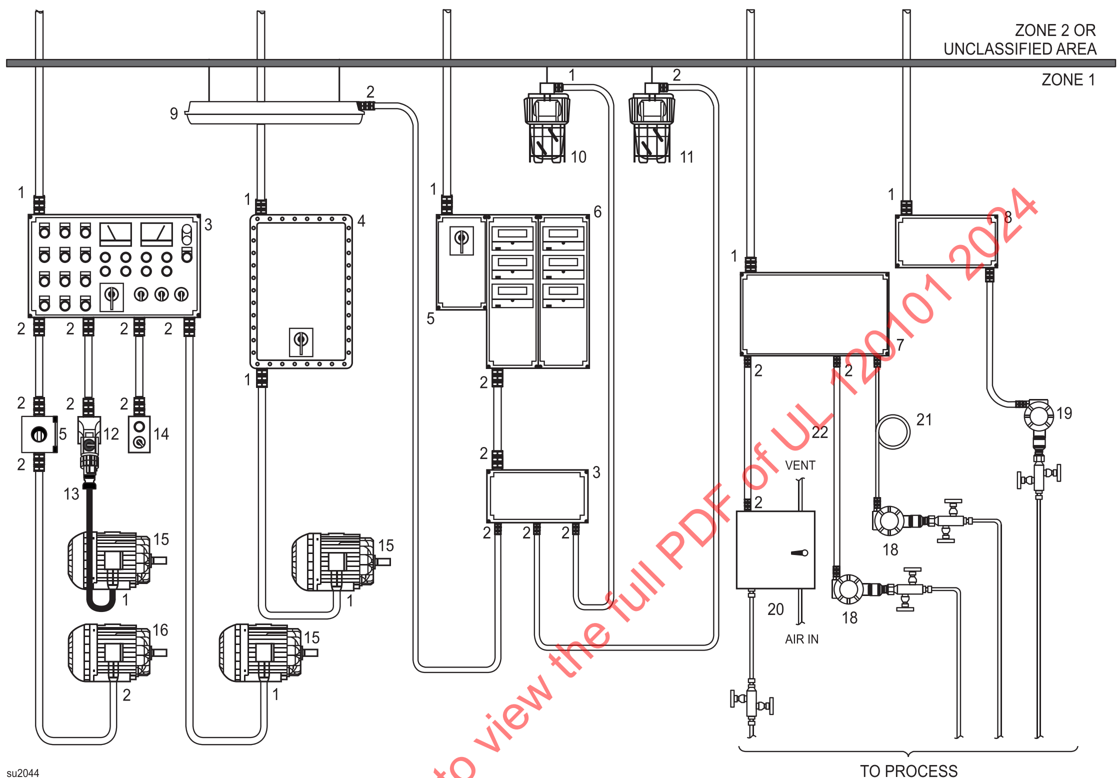
26 TC CABLE GLAND FOR NON METALIC CABLE (SEALED)

NOTE: ALL CABLES ARE MC-HL UNLESS OTHERWISE DESIGNATED

Figure 13 depicts a typical IEC Zone 1, Group II cable system for a similar installation.

Figure 13

Typical IEC Zone 1, Group II cable system installation



KEY TO NUMERALS:

1 CABLE GLAND FOR NONMETALLIC CABLE SEALED (Ex 'd')

2 CABLE GLAND FOR NONMETALLIC CABLE UNSEALED (Ex 'e')

3 TERMINAL BOX (AEx 'e') POWER CIRCUITS

4 FLAMEPROOF (Ex 'd') ENCLOSURE

5 DISCONNECT SWITCH (Ex 'de')

6 PANELBOARD (Ex 'de')

7 TERMINAL BOX (Ex 'e') INSTRUMENT CIRCUITS

8 TERMINAL BOX W / IS CIRCUITS

9 FLUORESCENT FIXTURE (Ex 'de')

10 FLAMEPROOF FIXTURE (Ex'd')

11 FIXTURE (Ex 'e')

12 SWITCHED RECEPTACLE (Ex 'de')

13 PLUG AND CORD (AEx 'de')

14 CONTROL STATION (Ex 'e') W/Ex'de' COMPONENTS

15 MOTOR-FLAMEPROOF (Ex 'd')

16 MOTOR – INCREASED SAFETY (Ex 'e')

17 INSTRUMENT (Ex 'e')

18 INSTRUMENT – FLAMEPROOF (Ex 'd')

19 INSTRUMENT (I.S.) Ex 'ia'/'ib'

20 INSTRUMENT Ex "px"

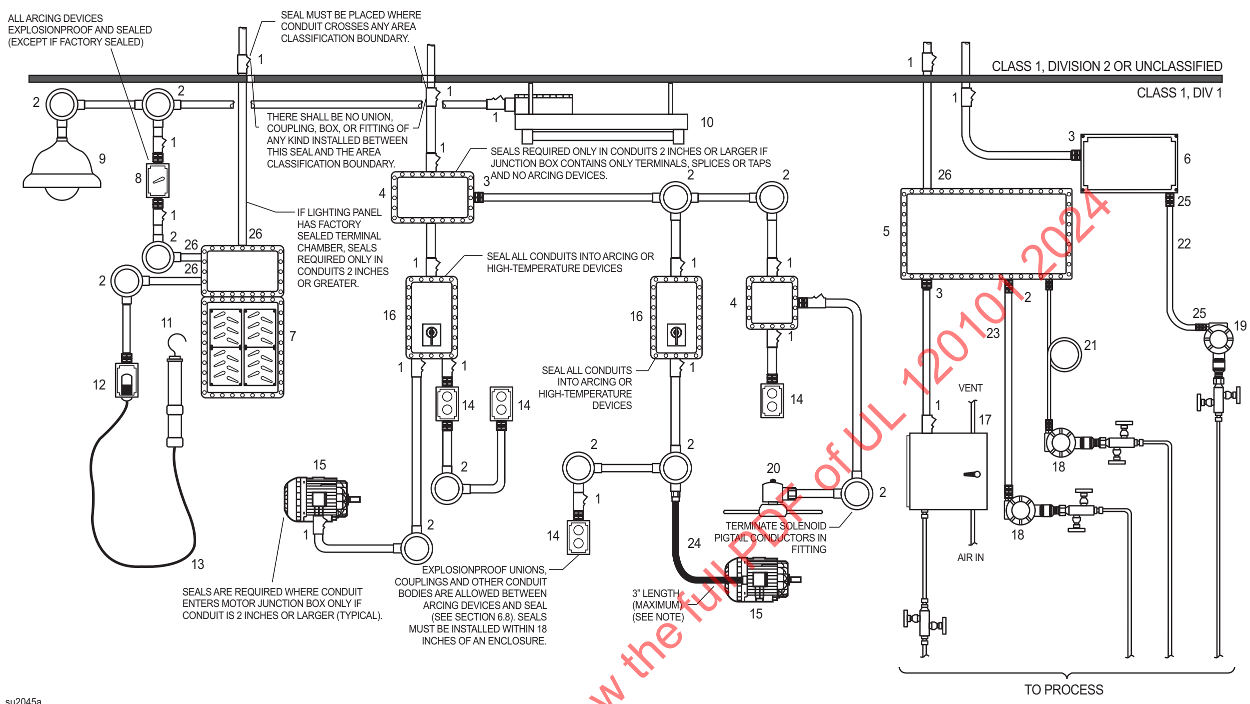
21 MINERAL INSULATED CABLE (MI)

22 INSTRUMENT CABLE

Figure 14 depicts a typical Class I, Division 1 conduit system installation.

Figure 14

Typical Class I, Division 1 conduit system installation



KEY TO NUMERALS:

1 CONDUIT SEAL

2 CONDUIT BODY (EXPLOSIONPROOF)

3 UNION WITH NIPPLE

4 JUNCTION BOX (EXPLOSIONPROOF)

5 TERMINAL BOX EXPLOSIONPROOF (INSTRUMENT CIRCUITS)

6 TERMINAL BOX W / IS CIRCUITS

7 PANELBOARD (EXPLOSIONPROOF)

8 LIGHT SWITCH (EXPLOSIONPROOF)

9 HD LIGHT FIXTURE (EXPLOSIONPROOF)

10 FLUORESCENT FIXTURE (EXPLOSIONPROOF)

11 PORTABLE LIGHT (EXPLOSIONPROOF)

12 SWITCHED RECEPTACLE (EXPLOSIONPROOF)

13 PLUG AND CORD (EXPLOSIONPROOF)

14 CONTROL STATION (EXPLOSIONPROOF)

15 MOTOR (EXPLOSIONPROOF)

16 MOTOR STARTER (EXPLOSIONPROOF)

17 INSTRUMENT (PURGED & PRESSURIZED)

18 INSTRUMENT – EXPLOSIONPROOF

19 INSTRUMENT (INTRINSIC SAFE)

20 SOLENOID VALVE (NOT CONNECTED TO PROCESS)

21 MINERAL INSULATED CABLE (MI)

22 TRAY CABLE (TC-ER)

23 INSTRUMENT TRAY CABLE (TC-ER)

24 EXPLOSIONPROOF FLEXIBLE FITTING

25 CABLE GLAND FOR NONMETALLIC CABLE (UNSEALED)

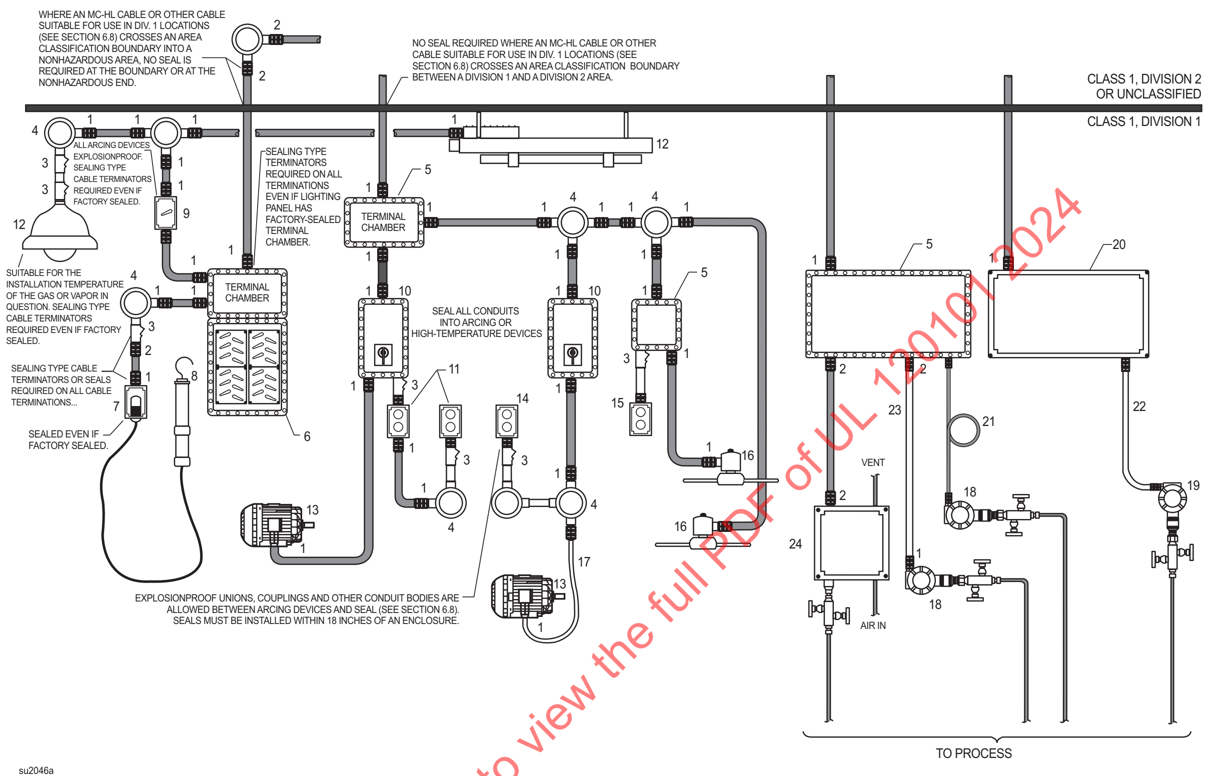
26 DIRECT ENTRY

NOTE: EXPLOSION PROOF FLEXIBLE FITTING SHALL NOT EXCEED 36°.

Figure 15 depicts a typical Class I, Division 1 cable system installation.

Figure 15

Typical Class I, Division 1 cable system installation



KEY TO NUMERALS:

1 CABLE GLAND – SEALED

2 CABLE GLAND – UNSEALED

3 CONDUIT SEAL

4 CONDUIT FITTING (EXPLOSIONPROOF)

5 TERMINAL BOX (EXPLOSIONPROOF)

6 PANELBOARD (EXPLOSIONPROOF)

7 RECEPTACLE (EXPLOSIONPROOF)

8 PORTABLE LIGHTING (EXPLOSIONPROOF)

9 LIGHT SWITCH (EXPLOSIONPROOF / FACTORY SEALED)

10 MOTOR CONTROLLER (EXPLOSIONPROOF)

11 PUSHBUTTON (FACTORY SEALED)

12 LIGHT FIXTURE (EXPLOSIONPROOF)

13 EXPLOSIONPROOF MOTOR

14 CONTROL STATION

15 FACTORY SEALED DEVICE

16 SOLENOID VALVE (NOT CONNECTED TO PROCESS)

17 EXTRA HARD USAGE CORD

18 INSTRUMENT (EXPLOSIONPROOF)

19 INSTRUMENT (INTRINSICALLY SAFE)

20 TERMINAL BOX (TYPE 4)

21 CABLE MI

22 CABLE ITC

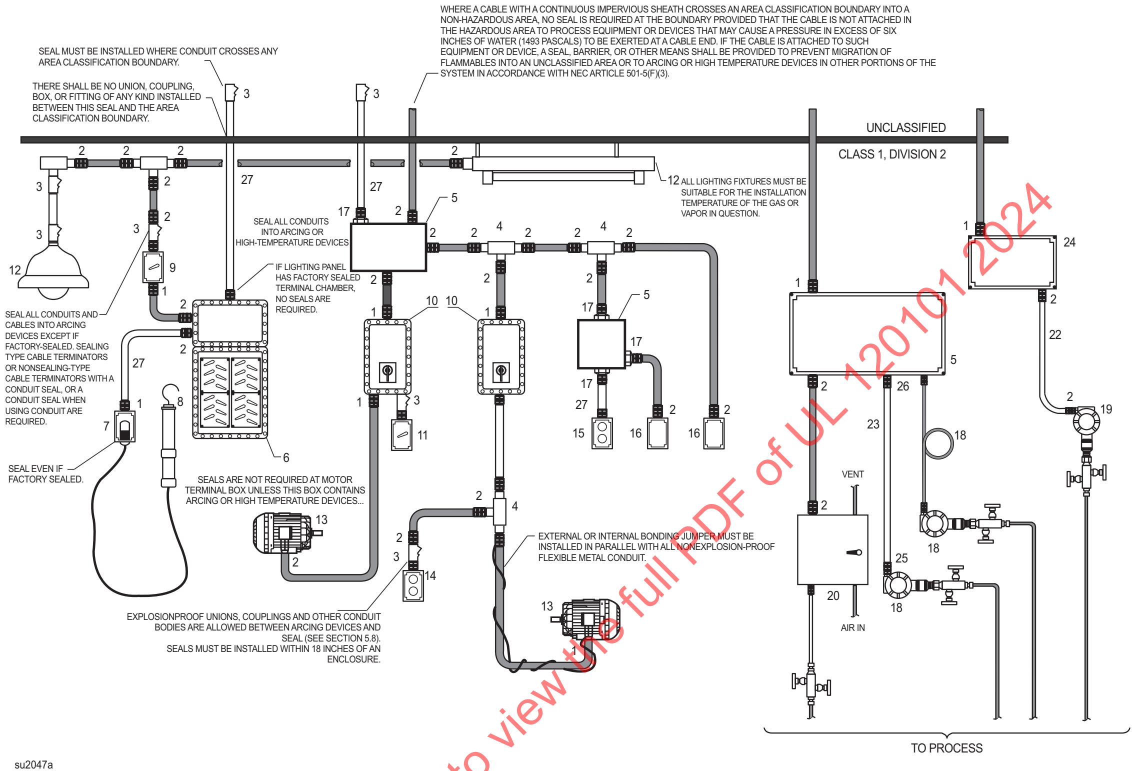
23 CABLE ITC-HL

24 ANALYZER (PURGED & PRESSURIZED)

Figure 16 depicts a typical Class I, Division 2 conduit/cable system installation.

Figure 16

Typical Class I, Division 2 cable/conduit system installation



KEY TO NUMERALS:

1 CABLE GLAND – SEALED

2 CABLE GLAND – UNSEALED

3 CONDUIT SEAL

4 CONDUIT FITTING (STANDARD)

5 TERMINAL BOX (TYPE 4X)

6 PANELBOARD (EXPLOSIONPROOF)

7 RECEPTACLE (EXPLOSIONPROOF)

8 PORTABLE LIGHTING (EXPLOSIONPROOF)

9 LIGHT SWITCH (EXPLOSIONPROOF / FACTORY SEALED)

10 MOTOR CONTROLLER (EXPLOSIONPROOF)

11 SELECTOR SWITCH (FACTORY SEALED)

12 LIGHT FIXTURE (CLASS I, DIV. 2)

13 MOTOR (EXPLOSIONPROOF – 1PH ONLY)

14 CONTROL STATION

15 FACTORY SEALED DEVICE

16 SOLENOID VALVE (NOT CONNECTED TO PROCESS)

17 HUB

18 INSTRUMENT – FLAMEPROOF (Ex'd')

19 INSTRUMENT (I.S)

20 INSTRUMENT (PURGED & PRESSURIZED)

21 CABLE (MI)

22 CABLE (ITC)

23 CABLE (MC-HL)

24 TERMINAL BOX (STANDARD-IS CIRCUITS)22

25 MC-HL CABLE GLAND – SEALED (Class I, Division 1)

26 MC-HL CABLE GLAND – UNSEALED

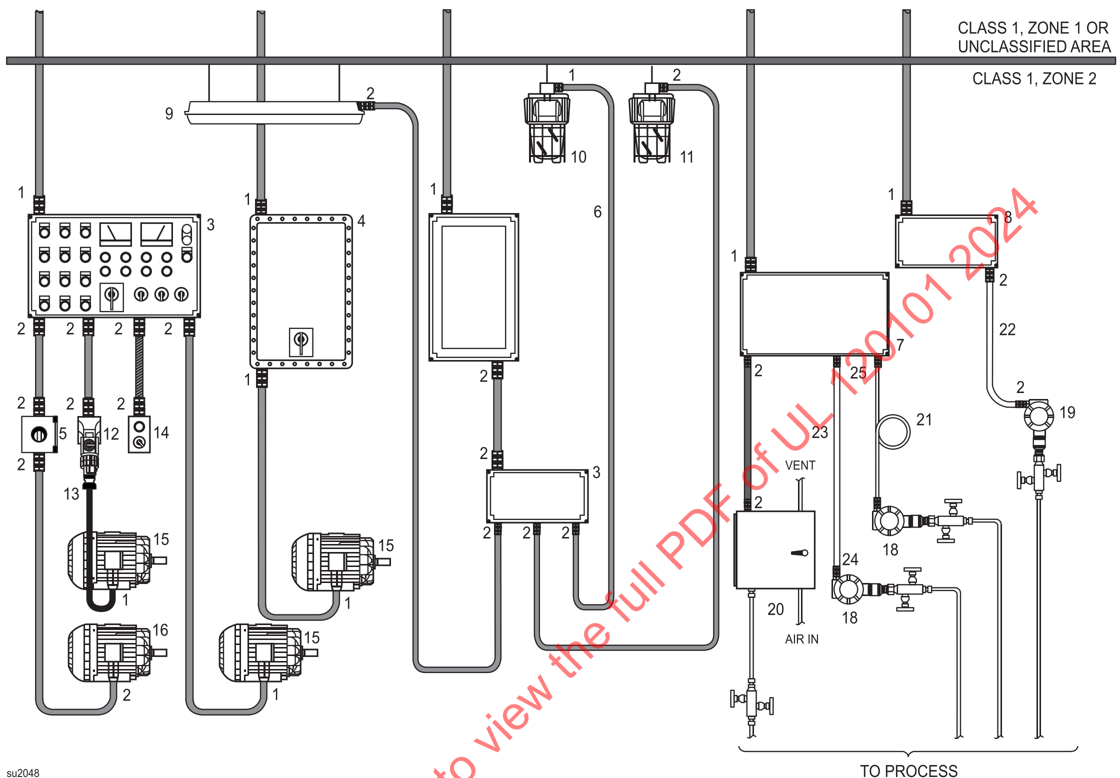
27 CONDUIT

NOTE: ALL CABLE IS TC-ER UNLESS OTHERWISE DESIGNATED

Figure 17 depicts a typical Class I, Zone 2 conduit/cable system installation.

Figure 17

Typical Class I, Zone 2, Group II cable system installation



KEY TO NUMERALS:

1 CABLE GLAND (FOR NONMETALLIC CABLE) – SEALED (AEx "d" or Class I, Division 1)	11 FIXTURE (AEx 'e')	21 MINERAL INSULATED CABLE (MI)
2 CABLE GLAND (FOR NONMETALLIC CABLE) – UNSEALED (AEx "e")	12 SWITCHED RECEPTACLE (AEx 'de')	22 INSTRUMENT TRAY CABLE (ITC)
3 TERMINAL BOX (AEx 'e') POWER CIRCUITS	13 PLUG AND CORD (AEx 'de')	23 TRAY CABLE (MC-HL)
4 FLAMEPROOF (AEx 'd') / EXPLOSIONPROOF (DIV 1) ENCLOSURE	14 CONTROL STATION (AEx 'e') W/AEx 'de' COMPONENTS	24 MC-HL CABLE GLAND – SEALED (AEx "d" or Class I, Division 1)
5 DISCONNECT SWITCH (AEx 'de')	15 MOTOR-EXPLOSIONPROOF / (AEx 'd')	25 MC-HL CABLE GLAND – UNSEALED (AEx "e")
6 PANELBOARD (AEx 'de')	16 MOTOR – INCREASED SAFETY (AEx 'e')	
7 TERMINAL BOX (AEx 'e') INSTRUMENT CIRCUITS	17 INSTRUMENT (AEx 'e')	
8 TERMINAL BOX W / IS CIRCUITS (AEx "ia, ib, ic)	18 INSTRUMENT – EXPLOSIONPROOF	
9 FLUORESCENT FIXTURE (AEx 'de')	19 INSTRUMENT (I.S.) AEx 'ia'/'ib'	
10 EXPLOSIONPROOF / FLAMEPROOF FIXTURE (CLASS I, DIVISION 1 / AEx 'd'	20 INSTRUMENT AEx "px"	

NOTE: ALL CABLES ARE TC-ER UNLESS OTHERWISE DESIGNATED

7.5 Comparisons of wiring methods (see Table 6 and Table 7)

7.5.1 Comparison of cable and conduit systems

Metallic conduit systems have been widely used in the United States and Canada to provide physical and environmental protection to conductors for both hazardous and nonhazardous locations. Conduit systems also prevent the transmission of an internally generated cable or conductor insulation fire within one conduit from spreading to an adjacent conduit, thus offering superior fire resistance. Ferrous metallic conduit can provide substantial magnetic shielding on sensitive circuits. Because conduit systems provide a closed system for the transmission of gases from one area to another, they must rely on properly located and properly installed conduit seals to provide explosionproof system integrity. Conduit systems are 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 and electrical equipment buildings. In some countries, conduit systems are not recognized or accepted.

In many instances, cable systems offer an attractive alternative to conduit systems and are used worldwide. Cable systems may be less labor intensive during the initial installation and in follow-up maintenance. Certain types of cable construction and termination methods offer greater corrosion protection than conduit systems and offer an overall increase in system integrity due to reduced long term corrosion effects. Cable systems provide the benefit that they are visible, which allows for ongoing inspection and simplifies the task of tracing circuits. There are numerous types of cables that are permitted in hazardous areas.

7.5.2 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).

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 a separate terminal chamber that may be type of protection increased safety or flameproof.

7.6 Flexible cords

Flexible cords may be used in Class I and Class II locations where flexibility is needed in permanent installations. In each application where flexible cords are permitted they must be installed with bushings or fittings where they pass through holes in covers, outlet boxes or similar enclosures and must be listed for extra hard usage. In all applications the cord must also have an equipment grounding conductor. For all applications where flexible cords are permitted they are not to be installed if subject to physical damage. Notes c and e of also apply to .

In Class I locations flexible cord is permitted to be installed in industrial establishments where conditions of maintenance and engineering supervision ensure that only qualified person install and service the installation, and where protected by location or by suitable guard from damage

Flexible cord is also permitted between portable lighting or other portable utilization equipment and the fixed portion of the power supply circuit in Class I locations.

Class II, Division 1 and 2 installations are permitted to use hard usage cord between outlet box or fitting and a pendant luminaire.

Table 6
Field wiring in United States Class I locations [a,b]

	Zone 0		Division 1 / Zone 1		Division 2 / Zone 2	
Wiring system	**IS**	**NIS**	**IS**	**NIS**	**IS or Nonincendive**	**NIS**
Threaded rigid metal conduit	A	X	A	A	A	A
Threaded steel intermediate metal conduit	A	X	A	A	A	A
Flexible metal explosionproof fitting	A	X	A	A	A	A
Types MI, MC-HL, TC-ER-HL and ITC-HL cable	A	X	A	A[d]	A	A
Types MC, PLTC, PLTC-ER, MV, ITC, ITC-ER, TC and TC-ER cable	A	X	A	X	A	A
RTRC-XW, Schedule 80 PVC conduit	A	X	A	X	A	A[g]
Flexible metal conduit	A	X	A	X	A	A[c,f]
Liquid-tight, flexible metal conduit	A	X	A	X	A	A[c,f]
Electrical metallic tubing (steel)	A	X	A	X	A	X
Flexible cord (See 6.6)	A	X	A	Note 1 or 3	A	A[c,e] Note 1, 2 or 3
Any other wiring method suitable for nonhazardous locations	A	X	A	X	A	X

[a] Abbreviations: IS = intrinsically safe; NIS = not intrinsically safe; A = acceptable; X = not acceptable.

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

[c] Acceptable only where flexibility is needed.

[d] In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, Type MC-HL and ITC-HL cable, listed for use in Class I, Zone 1, or Division 1 locations, with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, a separate equipment grounding conductor(s) and provided with termination fittings listed for the application. Termination fitting must be marked with AEx d for Zone 1 installations.

For Flexible Connections, in industrial establishments with restricted public access where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600V, nominal or less, and where protected from damage by location or a suitable guard, listed Type TC-ER-HL cable with an overall jacket and a separate equipment grounding conductor in accordance with 250.122 that is terminated with fittings listed for the location.

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

[f] Special bonding/grounding methods are required.

[g] In industrial establishments with restricted public access where the conditions of maintenance and supervision ensure that only qualified persons service the installation and where metallic conduit does not provide sufficient corrosion resistance, reinforced thermosetting resin conduit (RTRC), factory elbows, and associated fittings, all marked with the suffix – XW.

NOTE 1 Acceptable on approved portable equipment where provisions are made for cord replacement, per NEC 501.10(B)(2) and 505.17.

NOTE 2 Acceptable on process control instruments to facilitate replacements, per NEC 501.105(B)(6) and 505.17.

NOTE 3 Acceptable between portable lighting or other portable utilization equipment and fixed portions of circuit. Also permitted for that portion of a circuit where fixed wiring methods will not provide the degree of movement

Table 7
Field wiring in United States Class II and Zone 20, 21 and 22 locations [a,b]

	Zone 20		Division 1 / Zone 21		Division 2 / Zone 22	
Wiring system	IS	NIS	Div1	Zone 21	Div2	Zone 22
Threaded rigid metal conduit	A	A	A	A	A	A
Threaded steel intermediate metal conduit	A	A	A	A	A	A
Type MC	A	X	A[c]	X	A	A
Type MC-HL	A	A	A	A	A	A
Types PLTC, PLTC-ER, ITC, ITC-ER, and TC cable	A	X	X	X	A	A
Type TC-ER	X	X	X	X	X	A
Liquid-tight, Flexible non-metallic conduit [d,e]	A	A	A	A	A	A
Liquid-tight, flexible metal conduit [d,e]	A	A	A	A	A	A
Type MI cable	A	A	A	A	A	A
Electrical metallic tubing (steel)	A	X	X	X	A	A
Flexible cord [d,e]	A	A	A	A	A	A
Nonincendive field wiring	X	X	X	X	A	A

[a] Abbreviations: IS = intrinsically safe; NIS = not intrinsically safe; A = acceptable; X = not acceptable.

[b] See the NEC for description and limitations on the use of these wiring systems.

[c] For flexible connection, interlocked armor Type MC cable having an overall jacket of suitable polymeric material and provided with termination fittings listed for Class II, Division 1 locations.

[d] Acceptable only where flexibility is needed.

[e] Special bonding/grounding methods are required.

8 Grounding and bonding practices

8.1 In the United States and Canada, grounding and bonding practices in hazardous (classified) locations must follow the same standards as grounding and bonding practices in nonhazardous (unclassified) locations. In addition, NEC Article 250-100 requires bonding of all non-current carrying metal parts of equipment, raceways and other enclosures regardless of voltage. The following special precautions must be followed:

a) Locknut bushings and double-locknut bushings must not be used as the only bonding method but must be paralleled with bonding jumpers. Reference NEC 501.30(A).

b) Flexible-metal conduit or liquid-tight flexible-metal conduit must not be used as the only grounding path but must be paralleled with internal or external bonding jumpers. Reference NEC 501.30(B).

c) All conduit must be threaded (NPT standard threads with 3/4 inch taper per foot) and made wrench-tight to prevent sparking when fault current flows through the conduit system. Reference NEC 500.8(D).

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 ANSI/ISA-RP12.06.01)

8.2 Internationally, the term earthed is used instead of grounded, but the same basic practices are followed.

9 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.

9.1 Hazardous location equipment can be repaired only in accordance with the manufacturer's instructions. Some codes of practice require the recording of repairs and the inspection of the completed repair by a second competent person.

9.2 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.

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

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

9.5 Perform only live maintenance permitted by the manufacturer's documentation for intrinsically safe equipment.

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

9.7 Periodic inspections should be made to ensure that intrinsically safe circuits are isolated from non-intrinsically safe circuits.

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

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

10 Practices related to combining third-party assessed products

Assembly of third-party assessed components or equipment does not necessarily result in an assembly that meets all of the requirements for the installation. Ultimately, the acceptance of a combination of such products is the responsibility of the local AHJ. Some AHJs will be willing to make the evaluation of the combination of the components (including wiring methods, etc.), but others will require that evaluation to be done by a third-party test lab or "third-party" certification body. The number of combinations of products and situations varies. It is wise to clarify the end product "third-party" certification requirements with the end user before accepting the order.

In combining third-party assessed products, the integrator must follow the installation instructions provided with the equipment. The overall assembly of the components must be compliant with the NEC, CEC, IEC 60079-14 or equivalent installation standards.

11 Additional practices for authorizing equipment in hazardous locations

There are additional options for gaining authorization of equipment in hazardous locations. Refer to AS/NZS 60079.14 Annex ZD or section 90.4 or NFPA 70 for examples.

Annex A
(informative – per IEC TC31)

Introduction of an alternative risk assessment method encompassing “equipment protection levels” for Ex equipment

A.1 Introduction

This annex provides an explanation of the concept of a risk assessment method encompassing equipment protection levels (EPLs). These EPLs are introduced to enable an alternative approach to current methods of selecting Ex equipment.

A.2 Historical background

Historically, it has been acknowledged that not all types of protection provide the same level of assurance against the possibility of an incendive condition occurring. The installation standard, IEC 60079-14, allocates specific types of protection to specific zones, on the statistical basis that the more likely or frequent the occurrence of an explosive atmosphere, the greater the level of security required against the possibility of an ignition source being active.

Hazardous areas (with the normal exception of coal mining) are divided into zones, according to the degree of hazard. The degree of hazard is defined according to the probability of the occurrence of explosive atmospheres. Generally, no account is taken of the potential consequences of an explosion, nor of other factors such as the toxicity of materials. A true risk assessment would consider all factors.

Acceptance of equipment into each zone is historically based on the type of protection. In some cases the type of protection may be divided into different levels of protection which again historically correlate to zones. For example, intrinsic safety is divided into levels of protection “ia” and “ib”. The encapsulation “m” standard includes two levels of protection “ma” and “mb”.

In the past, the equipment selection standard has provided a solid link between the type of protection for the equipment and the zone in which the equipment can be used. As noted earlier, nowhere in the IEC system of explosion protection is there any account taken of the potential consequences of an explosion, should it occur.

However, plant operators often make intuitive decisions on extending (or restricting) their zones in order to compensate for this omission. A typical example is the installation of "zone 1 type" navigation equipment in zone 2 areas of offshore oil production platforms, so that the navigation equipment can remain functional even in the presence of a totally unexpected prolonged gas release. In the other direction, it is reasonable for the owner of a remote, well secured, small pumping station to drive the pump with a "zone 2 type" motor, even in zone 1, if the total amount of gas available to explode is small and the risk to life and property from such an explosion can be discounted.

The situation became more complex with the publication of the first edition of IEC 60079-26 which introduced additional requirements to be applied for equipment intended to be used in zone 0. Prior to this, Ex ia was considered to be the only technique acceptable in zone 0.

It has been recognized that it is beneficial to identify and mark all products according to their inherent ignition risk. This would make equipment selection easier and provide the ability to better apply a risk assessment approach, where appropriate.

A.3 General

A risk assessment approach for the acceptance of Ex equipment has been introduced as an alternative method to the current prescriptive and relatively inflexible approach linking equipment to zones. To facilitate this, a system of equipment protection levels has been introduced to clearly indicate the inherent ignition risk of equipment, no matter what type of protection is used.

The system of designating these equipment protection levels is as follows.

A.3.1 Group I (equipment that is acceptable for use in coal mining)

A.3.1.1 EPL Ma

Equipment for installation in a coal mine, having a "very high" level of protection, which has sufficient security that it is unlikely to become an ignition source, even when left energized in the presence of an outbreak of gas.

NOTE Typically communications circuits and gas detection equipment will be constructed to meet the Ma requirements, for example an Ex ia telephone circuit.

A.3.1.2 EPL Mb

Equipment for installation in a coal mine, having a "high" level of protection, which has sufficient security that it is unlikely to become a source of ignition in the time span between there being an outbreak of gas and the equipment being de-energized.

NOTE Typically all the coal winning equipment will be constructed to meet the Mb requirements, for example Ex d motors and switchgear.

A.3.2 Group II (equipment that is acceptable for use in above ground applications where the hazard is a gas)

A.3.2.1 EPL Ga

Equipment for explosive gas atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation, expected malfunction faults or when subject to rare faults.

A.3.2.2 EPL Gb

Equipment for explosive gas atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

NOTE The majority of the standard protection concepts bring equipment within this equipment protection level.

A.3.2.3 EPL Gc

Equipment for explosive gas atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).

NOTE Typically, this will be Ex n equipment.

A.3.3 (Group III) (equipment that is acceptable for use in above ground applications where the hazard is an explosive dust atmosphere other than mines susceptible to firedamp)

A.3.3.1 EPL Da

Equipment for combustible dust atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation or when subject to rare faults.

A.3.3.2 EPL Db

Equipment for combustible dust atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

A.3.3.3 EPL Dc

Equipment for explosive dust atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences.

For the majority of situations, with typical potential consequences from a resultant explosion, it is intended that the following would apply for use of the equipment in zones. (This is not directly applicable for coal mining, as the zone concept does not generally apply.) See Table A.1.

Table A.1
Traditional relationship of EPLs to zones (no additional risk assessment)

Equipment protection level	Zone
Ga	0
Gb	1
Gc	2
Da	20
Db	21
Dc	22

A.4 Risk of ignition protection afforded

The various levels of protection of equipment must be capable of functioning in conformity with the operational parameters established by the manufacturer to that level of protection. See Table A.2.

Table A.2
Description of risk of ignition protection provided

Protection afforded	Equipment protection level Group	Performance of protection	Conditions of operation
Very high	Ma Group I	Two independent means of protection or safe even when two faults occur independently of each other	Equipment remains functioning when explosive atmosphere present
Very high	Ga Group II	Two independent means of protection or safe even when two faults occur independently of each other	Equipment remains functioning in Zones 0, 1 and 2
Very high	Da Group III	Two independent means of protection or safe even when two faults occur independently of each other	Equipment remains functioning in Zones 20, 21 and 22
High	Mb Group I	Suitable for normal operation and severe operating conditions	Equipment de-energised when explosive atmosphere present
High	Gb	Suitable for normal operation and frequently occurring disturbances or	Equipment remains functioning in Zones 1 and 2

Table A.2 Continued on Next Page

Table A.2 Continued

Protection afforded	Equipment protection level Group	Performance of protection	Conditions of operation
	Group II	equipment where faults are normally taken into account	
High	Db Group III	Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account	Equipment remains functioning in Zones 21 and 22
Enhanced	Gc Group II	Suitable for normal operation	Equipment remains functioning in Zone 2
Enhanced	Dc Group III	Suitable for normal operation	Equipment remains functioning in Zone 22

A.5 Implementation

The fourth edition of IEC 60079-14 introduced the EPLs to make provision for an extended “risk assessment" approach as an alternative method for the selection of equipment. Reference is also included in the classification standards IEC 60079-10-1 and IEC 60079-10-2.

The general requirements for additional marking and the correlation of the existing types of protection are detailed in IEC 60079-0, with specific requirements detailed in the specific Type of Protection and specific equipment parts of the IEC 60079 series.

Annex B
Acronyms

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

AIT	Auto-ignition Temperature
ABNT	Associação Brasileira de Normas Técnicas (or Brazilian Association of Technical Standards)
ANCE	Asociación Mexicana Nacional de Normalización y Certificación del Sector Electrico (Mexico)
ANSI	American National Standards Institute
API	American Petroleum Institute
AS/NZS	Joint Australian New Zealand Standard
ASTM	American Society for Testing and Materials
ATEX	"Atmosphere Explosible" – European Directive 2014/34/EU 94/9/EC for hazardous location equipment
ATF	Additional Testing Facility under the IECEx System located remotely from an accepted ExTL but under the control of the ExTL
AWG	American Wire Gauge
BASEEFA SGS	Baseefa (UK)
BS	British Standard
BSI	British Standards Institution
BVFA	Bundesversuchs – und Forschungs – Anstalt (Austria)
BvS	Berggewerkschafitliche Versuchsstrecke [now Dekra Exam] (Germany)
CANMET	Canadian Mining and Energy Technology (Canada)
CB Scheme	Scheme under IECEx System responsible for the certification of equipment and systems intended for use in explosive atmospheres
CMC	Certification Management Committee under the IECEE System
CEC	Canadian Electrical Code
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CEPEL	Centro de Pesquisas de Energia Electrica (Brazil)
CERCHAR	Centre d'Etudes et Recherches des Chourbonnage de France [See INERIS] (France)
CESI	Centro Elettrotecnico Sperimentale Italiano (Italy)
CSA	Canadian Standards Association (Canada)
CSIR	Central Mining Research Institute (India)
CTL	Committee of Testing Laboratories under the IECEE System
DIN	Deutsche Institut fur Normung e.V. (Germany)
DIP	Dust-ignitionproof
DNV	Det Norske Veritas (Norway)
DMT	now Dekra Exam (Germany)
EECS	Electrical Equipment Certification Service (UK) (no longer exists)
EMR	Energy Mines and Resources (Canada)
EN	European Norm (Standard)
ERA	Electrical Research Association (UK)
ExCB	Ex Certification Body that is accepted under the IECEx System
ExMC	IECEx Management Committee responsible for management of the overall System
ExTAG	IECEx Testing and Assessment Group responsible for assessment and testing of components and equipment by ExTLs

ExTL	Ex Testing Laboratory that is accepted under the IECEx System
FM Approvals	Factory Mutual Research Corporation (USA)
GOST	Gossudarstwenny Standard (Russia)
HSE	Health and Safety Executive (UK)
IEC	International Electrotechnical Commission
IECEE	IEC System of Conformity Assessment Schemes for Electrotechnical Electrical Equipment and Components
IECEx	International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System)
IECEx ExTR	IECEx Test Report that is issued by an ExTL and endorsed by an ExCB
IECEx CoC	IECEx Certificate of Conformity that is approved for issuing by an EXCB
IECEx QAR	IECEx Quality Assessment Report that is issued by an ExCB
IEEE	Institute of Electrical and Electronics Engineers
IEV	International Electrotechnical Vocabulary (IEC 60050)
INIEX	Institut National des Industries Extractives [See ISSeP] (Belgium)
INERIS	Institut National de L'Environnement Industriel et des Risques (France)
INMETRO	Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (or National Institute of Metrology, Quality and Technology)
INSEMEX	Institutul National Pentru Securitate Miniera si Protectie Antiexploziva (Romania)
IP	Institute of Petroleum (UK)
IP	Ingress Protection per IEC 60529
ISA	A global, nonprofit organization for automation (formerly Instrument Society of America) (ISA is no longer active in HazLoc standards development)
ISSeP	Institute Scientific des Service Public [was INIEX] (Belgium)
ISO	International Organization for Standardization
ITS	Intertek
JIS	Japan Industry Standards (Japan)
KEMA	Keuring van Elektrotechnische Materialen (The Netherlands)
KGS	Korea Gas Safety Corporation
KOSHA	Korea Occupational Safety and Health Agency
KTL	Korea Testing Laboratory
LCIE	Laboratoire Central Des Industries Electriques (France)
LEL	Lower Explosive Limit (Lower Flammable Limit)
LFL	Lower Flammable Limit (Lower Explosive Limit)
LOM	Laboratorio Oficial Madariaga (Spain)
LOSC	Londonderry Occupational Safety Centre – Work Cover Authority (Australia)
MECS	Mining Equipment Certification Service – Part of EECS (UK) that no longer exists
MESG	Maximum Experimental Safe Gap
MIC	Minimum Igniting Current
MIE	Minimum Ignition Energy
MMS	Minerals Management Service, U.S. Department of the Interior
MSHA	Mine Safety and Health Administration
NAMUR	Normenarbeitsgemeinschaft fur Mess-und Regelungstechnik in der Chemischen Industrie (German)
NANIO CCVE	Certification Centre of Explosion-proof and Mine Electrical Equipment
NAS	National Academy of Science
NCB	National Certification Body that is accepted under the IECEE System
NEC	National Electrical Code (ANSI/NFPA 70)

NEMA	National Electrical Manufacturers Association
NEMKO	Norges Elektriske Materiellkontroll (Norway)
NEPSI	National Supervision and Inspection Centre for Explosion Protection and Safety of Instrumentation (China)
NFPA	National Fire Protection Association
NRC	National Research Council
NRTL	Nationally Recognized Testing Laboratory
NMX	Voluntary Standards (Mexico)
NOM	Norma Official Mexicana (Mexico)
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)
SCS	Sira Certification Service (UK)
SEV	Schweizerischer Elektrotechnischer Verein (Switzerland)
SIMTARS	Safety in Mines Testing and Research Station (Australia)
SIPAI	Shanghai Institute of Process Automation Instrumentation (China)
SNZ	Standards New Zealand
SMRE	Safety in Mines Research Establishment – Operation Suspended (UK)
SP	Sveriges Provnings – och Forskningsinstitut trans: Swedish National Testing and Research Institute (Sweden)
TIIS	Technical Institute of Industrial Safety (Japan)
TUV-A	Technischer Uberwachungsverein Austria (Austria)
UEL	Upper Explosive Limit (Upper Flammable Limit)
UFL	Upper Flammable Limit (Upper Explosive Limit)
UK	United Kingdom
UL	UL LLC or Underwriters Laboratories Inc. (USA)
UL DEMKO	UL International Demko A/S (Denmark)
ULC	Underwriters' Laboratories of Canada (Canada)
USA	United States of America
USCG	United States Coast Guard
USBM	*Former* United States Bureau of Mines
VTT	Vaition Tekmillinen Tutkimuslaitos (Finland)
XP	Explosionproof