ELECTRICAL EQUIPMENT IN HAZARDOUS (CLASSIFIED) LOCATIONS

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1.0 SCOPE

This loss prevention data sheet provides recommendations for preventing electrical systems or equipment from igniting flammable gases, flammable vapors and combustible dusts that may be released into the atmosphere, or that may be normally present in or near processing equipment.

The following FM Global loss prevention data sheets should be consulted for specific guidance at specific occupancies: Data Sheet 7-1, *Fire Protection for Textile Mills* (locations involving combustible fibers or flyings in textile processes); Data Sheet 7-9, *Dip Tanks, Flow and Roll Coaters and Oil Cookers*; Data Sheet 7-13, *Mechanical Refrigeration*; Data Sheet 7-27, *Spray Application of Flammable and Combustible Materials;* Data Sheet 7-32, *Ignitable Liquid Operations*; Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*.

This data sheet does not address Class III (easily ignitable fibers and flyings) hazardous locations.

1.1 Changes

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Referenced NFPA or International and National Standards

2.1.1.1 Although recommendations in this data sheet are primarily based on the NEC, there are exceptions and additions. If an application is not covered in the data sheet, refer to one of the following NFPA or corresponding international and national standards:

NFPA 70, Articles 500 and 505, *National Electrical Code*, 1999.

IEC 60079-10:1995 or EN 60079-10:1996, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas.*

IEC 61241-3:1997, *Electrical apparatus for use in the presence of combustible dust — Part 3: Classification of areas where combustible dusts are or may be present.*

NFPA 496, *Purged and Pressurized Enclosures for Electrical Equipment*, 1998.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 1997.

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 1997.

CSA Standard C22.1-98, *Canadian Electrical Code, Part 1.*

2.1.2 Exceptions to Application of Data Sheet 5-1

2.1.2.1 The NEC or other corresponding international and national standards do not make any explicit exceptions to the use of hazardous location electrical equipment in areas where only small amounts of flammable material are handled. However, it is reasonable to conclude that in many cases where only small amounts of ignitable materials are involved, the cost of providing FM Approved (see Appendix A for definition)or listed electrical equipment would not be justified.

Note: Reference to other corresponding international and national standards within this guideline is primarily intended to mean IEC (International Electrotechnical Commission) or CENELEC (European Committee for Electrotechnical Standardization) standards, but not exclude other national standards that typically are based on these standards or occasionally the NEC with national deviations.

Because the result of a fire ignited by electrical sources will vary depending on site specific circumstances, no all-encompassing guidance will be provided here to distinguish the specific cases when ordinary electrical equipment would be acceptable in an area that might theoretically be considered a hazardous (classified) location. However, to help in the application of engineering judgement, a few examples will be given of cases where Approved or listed equipment may not be required.

Example 1:

Small quantities of low flash point ignitable liquids are handled in equipment or containers such that the maximum ignitable quantity in the event of electrical ignition would not exceed 5 gallons (19 liters), and the ignition of that quantity would not cause a rapid escalation of fire events. Approved containers should be used where transporting or dispensing of the liquid is involved.

Example 2:

Small quantities of flammable gas are used on a regular basis in a given area, such as in a 1 lb (0.5 kg) cylinder of propane used in a workshop brazing torch.

Example 3:

Larger quantities of flammable gas are used as fuel for mobile equipment, such as propane or natural gas to power a forklift truck, or as part of a portable acetylene welding kit. The mobile equipment may be brought to areas that would not normally require hazardous location electrical equipment.

Example 4:

Fine combustible dust is produced and accumulates, but in relatively small quantities, and without producing a potential explosion hazard, such as at a sanding machine in a woodworking shop.

2.2 Occupancy

2.2.1 Classification of Hazardous Locations: Class I and Class II Hazardous Locations

Note: The following definitions and application guidelines are primarily based on the historical ''division'' classification method as traditionally used within the United States (U.S.) and covered by Article 500 of the NEC. The 1996 Edition of the NEC (Article 505) introduced an alternative classification method, the so-called ''zone'' classification method for Class I (i.e., flammable gas or vapor) atmospheres only, which is consistent with the approach essentially used throughout the rest of the world. Only one of these classification methods may be used within the U.S. for a specific location (i.e., cannot mix methods) and implementation of Article 505 must be under the supervision of a qualified registered professional engineer. The Canadian Electrical Code, which had been similar to the NEC, now requires the zone classification method for Class I atmospheres be used for new installations. For equivalency purposes, see Table 1 for a comparison of the Class I hazardous area classification methods as covered by the NEC and the corresponding IEC or CENELEC standard (i.e., IEC 60079-10 or EN 60079-10) for areas where flammable gases or vapors are or can be present.

Table 1. Area Classification of Locations Containing Flammable Gas or Vapor Atmospheres (Class I)

Standards Organizations		*Flammable Material Present Continuously*	*Flammable Material Present Intermittently*	*Flammable Material Present Abnormally*
IEC/CENELEC		Zone 0	Zone 1	Zone 2
NFPA	NEC Article 505	Zone 0	Zone 1	Zone 2
	NEC Article 500	Division 1		Division 2

Note: The IEC and CENELEC do not use the Class I designation for areas where flammable gases or vapors may be present. That is, the corresponding area designations would be Class I, Zone 1 (NEC Article 505) and simply Zone 1 (IEC/CENELEC) for example.

2.2.1.1 Class I Hazardous Locations

2.2.1.1.1 Locations in which flammable gases or vapors are or may be present should be classified as Class I, Division 1 hazardous locations if the following conditions exist: 1) ignitible concentrations of flammable gases or vapors can exist under normal operating conditions; or 2) ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or 3) breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

Note: The definition for a Class I, Zone 1 hazardous location is the same as for a Class I, Division 1 except for an additional condition. The additional condition for a Class I, Zone 1 hazardous location is (4) if adjacent to a Class I, Zone 0 hazardous location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive ventilation from a source of clean air and effective safeguards against ventilation failure are provided. Locations where flammable gases or vapors are present continuously or for long periods of time (i.e., typically 1000 hours or more per year) are considered Class I, Zone 0 hazardous locations. See C.2.1 for examples of Class I, Zone 0 hazardous locations.

2.2.1.1.2 Locations in which flammable gases or vapors are or may be present should be classified as Class I, Division 2 hazardous locations if the following conditions exist: 1) ignitable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapors or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; 2) ignitible concentrations of gases or 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 are adjacent to a Class I, Division 1 location, and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. The definition for a Class I, Zone 2 hazardous location is essentially identical to the above definition for a Class I, Division 2 hazardous location (i.e., simply replace the word ‘‘Division’’ with the word ‘‘Zone’’).

2.2.1.1.3 Figure 1 should be used to determine the degree of hazard at various distances from a typical indoor vapor source expected to have a Division 1 area (e.g., open equipment or process). Figure 1 should assist in the selection and location of equipment in Class I areas. When other applicable FM Global data sheets provide distances for classified (hazardous) areas related to specific hazards and occupancies, refer to them rather than to Figure 1.

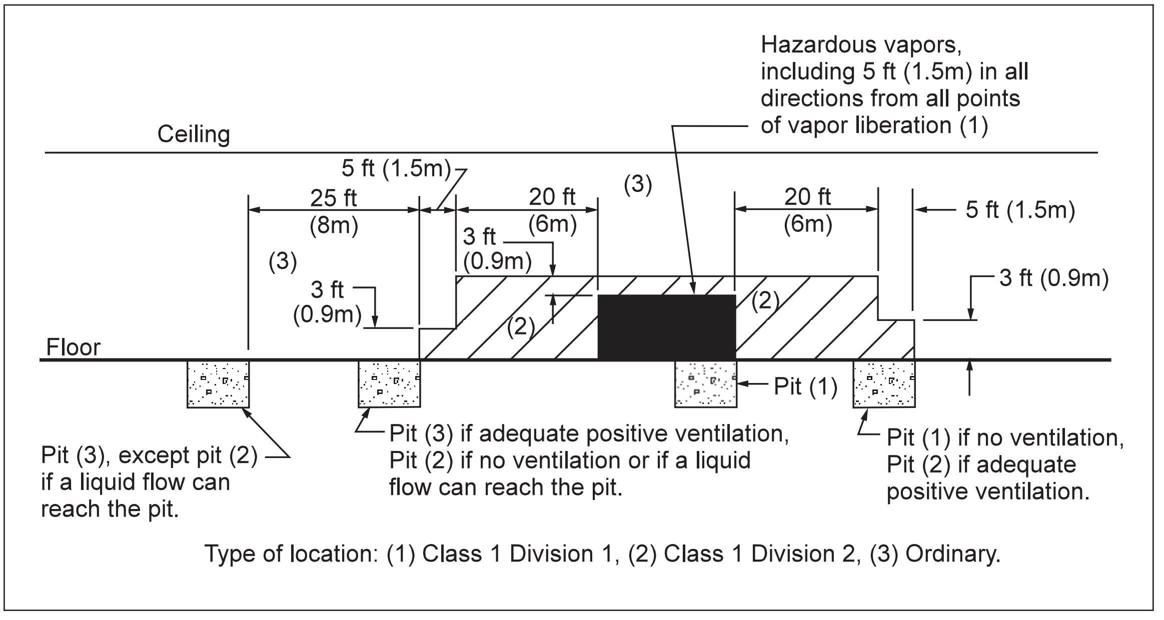

Fig. 1. Areas near indoor hazardous processes or equipment handling heavier than air vapors where special types of electrical equipment are needed.

2.2.1.1.4 Figures in NFPA 497 may be used to help determine the extent of a Class I, Division 2 or Zone 2 area for leakage sources located outdoors, in closed containers or systems (e.g., pipes, process equipment) with or without adequate ventilation or in other closed installations that are not expected to have Division I or Zone 1 areas. Since NFPA documents normally recommend what are considered minimum criteria, considerable judgement may still be needed in the evaluation of a specific situation.

2.2.1.1.5 Adequate mechanical ventilation may be provided to reduce the extent of a hazardous location or to reduce the classification level. A ventilation system can significantly reduce or even eliminate a Division 1 or Zone 1 area. Exceptions to completely eliminating a Division 1 or Zone 1 area would include the immediate vicinities where the release of ignitable concentrations of vapor are expected under normal conditions. (See Appendix C for examples.) Adequate ventilation requires a ventilation rate of 1 $ft^3/min/ft^2$

($0.3\ m^3/min/m^2$) of room or process area to ensure that flammable vapor concentrations do not exceed 25% of the lower explosive limit. In addition, effective safeguards against the failure of the ventilation system should be provided.

2.2.1.2 Class II Hazardous Locations

2.2.1.2.1 Locations in which combustible dusts are or may be present should be classified as Class II, Division 1 hazardous locations if the following conditions exist: 1) combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures; 2) 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 electric equipment, operation of protection devices, or from other causes; or 3) where combustible dusts of an electrically conductive nature may be present in hazardous quantities.

2.2.1.2.2 Locations in which combustible dusts are or may be present should be classified as Class II, Division 2 hazardous locations if the following conditions exist: 1) locations where combustible dust is not normally in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electric equipment or other apparatus, but combustible dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment; and 2) where combustible dust accumulations on, in, or in the vicinity of the electrical equipment may be sufficient to interfere with the safe dissipation of heat from electrical equipment or may be ignitible by abnormal operation or failure of electrical equipment.

2.2.1.2.3 The classification guidelines shown in Table 2 may be used, based on a maximum total accumulation between cleanings on the major portions of horizontal surfaces.

Table 2. Classification Guidelines Based on Depth of Dust Accumulations

Dust Layer Thickness	*Division*
>⅛ in. (3.2 mm)	1
<⅛ in. (3.2 mm) but surface color not discernible or surface color discernible, but a hazardous quantity of dust may be released as a result of infrequent malfunctioning of handling or processing equipment	2
Surface color discernible and a hazardous quantity of dust cannot foreseeably be released as a result of infrequent malfunctioning of handling or processing equipment.	Nonclassified

Based on these accumulations, good housekeeping can reduce the classification from Division 1 to Division 2. However, housekeeping should not be used as a primary method of dust control but should rather be used to supplement control and elimination of dust at its source.

2.2.1.2.4 Guidelines in NFPA 499 may be used as an aid in applying judgement to determine the extent of Division 1 and Division 2 areas for a Class II location. Since NFPA documents normally recommend what are considered minimum criteria, considerable judgement may still be needed in the evaluation of a specific situation.

Note: Paragraph A-3-1.2 of NFPA 499-1997 with dust layer thickness criteria based on a 24-hour accumulation period should not be used. It could lead to underclassifying areas that may be hazardous.

2.3 Equipment and Processes

2.3.1 General

2.3.1.1 If available, Approved equipment should be recommended. When Approved equipment is not available, equipment listed, labeled, or approved by another recognized testing laboratory is acceptable.

Note: FM Approvals can conduct testing to satisfy both the ‘‘Division’’ and ‘‘Zone’’ hazardous location classification methods, and also has reciprocal interlaboratory testing agreements with other testing agencies worldwide.

2.3.2 Specific Electrical Wiring and Equipment Requirements

2.3.2.1 Class I Hazardous Locations

2.3.2.1.1 In Class I or comparable hazardous locations per IEC or CENELEC standards (i.e., IEC 60079-10 or EN 60079-10), electrical equipment should be one of or a combination of the protected types as shown in Table 3. See C.2.4 through C.2.9 for further explanation of the various protection concepts used with this electrical equipment.

Table 3. Protected Types of Electrical Equipment for Class I Locations per the NEC or Comparable Hazardous Locations per IEC or CENELEC Standards

Method of Protection	*Code*	*Permitted Use*	*Standard*	*Protection Principle*
Increased Safety	AEx e EEx e Ex e	Class I, Zone 1, 2 Zone 1, 2 Zone 1, 2	FM 3619*(ISA S12.16.01) EN 50119 IEC 79-7	No arcs, sparks or hot surfaces
Non-Incendive	(NI)	Class I, Division 2	FM 3611	
Non-Sparking	Ex nA	Zone 2	IEC 79-15	
Explosionproof	(XP)	Class I, Division 1, 2	FM 3615	Contain the explosion and quench the flame
Flameproof	AEx d EEx d Ex d	Class I, Zone 1, 2 Zone 1, 2 Zone 1, 2	FM 3618*(ISA S12.22.01) EN 50018 IEC 79-1	
Powder Filled	AEx q EEx q Ex q	Class I, Zone 1, 2 Zone 1, 2 Zone 1, 2	FM 3622*(ISA S12.25.01) EN 50017 IEC 79-5	
Enclosed Break	Ex nC	Zone 2	IEC 79-15	
Intrinsic Safety	(IS) AEx ia AEx ib EEx ia EEx ib Ex ia Ex ib	Class I, Division 1, 2 Class I, Zone 0,1, 2 Class I, Zone 1, 2 Zone 0, 1, 2 Zone 1, 2 Zone 0, 1, 2 Zone 1, 2	FM 3610** FM 3610** FM 3610** EN 50020/39 EN 50020/39 IEC 79-11 IEC 79-11	Limit energy of sparks and surface temperature
Limited Energy	Ex nA	Zone 2	IEC 79-15	
Pressurized	Type X Type Y Type Z EEx p Ex p	Class I, Division 1 Class I, Division 1 Class I, Division 2 Zone 1 Zone 1	FM 3620 FM 3620 FM 3620 EN 50016 IEC 79-2	Keep flammable gas out
Restricted Breathing	Ex nR	Zone 2	IEC 79-15	
Encapsulation	AEx m EEx m Ex m	Class I, Zone 1, 2 Zone 1, 2 Zone 1, 2	FM 3614*(ISA S12.26.01) EN 50028 IEC 79-18	
Oil Immersion	AEx o EEx o Ex o	Class I, Zone 1, 2 Zone 1, 2 Zone 1, 2	FM 3621*(ISA S12.26.01) EN 50015 IEC 79-15	

*Also shall comply with ISA S12.0.01
**Based on ISA S12.2.01

Note: Where non-incendive electrical equipment is provided in Class I, Division 2 hazardous locations, a special enclosure is not needed, just a general purpose enclosure.

2.3.2.1.2 Equipment approved and used in Class I hazardous locations also should be approved for the specific group (A, B, C or D per NEC Article 500) or (IIC, IIB or IIA per NEC Article 505 or the corresponding IEC or CENELEC standard) of the gas or vapor that will be present.

Note: Needed electrical equipment protective features are based on the degree or severity of hazard exposure. Different flammable gases and vapors represent such a wide range of degree or severity of hazard that further grouping (subdivision) is necessary to facilitate testing and approving/listing of appropriately designed hazardous location electrical equipment. See Section C.3 for further explanation of group classifications.

2.3.2.1.3 Heat producing equipment (i.e., motors and lighting fixtures but not equipment such as junction boxes, conduit and electric wiring fittings) should be marked to show the class, group and operating temperature. Temperature identification numbers (T codes) marked on the equipment should be in accordance with Table 4 below. The surface temperature of the equipment (see Table 4) should not exceed the ignition temperature of the specific gas or vapor to be encountered. Ignition temperatures for many gases and vapors are provided in NFPA 497.

Table 4. T Codes (Temperature Identification Numbers)

Maximum Surface Temperature	*NFPA (NEC Article 500)*	*NFPA (NEC Article 505) IEC CENELEC*
450°C (842°F)	T1	T1
300°C (572°F)	T2	T2
280°C (536°F)	T2A	
260°C (500°F)	T2B	
230°C (446°F)	T2C	
215°C (419°F)	T2D	
200°C (392°F)	T3	T3
180°C (356°F)	T3A	
165°C (329°F)	T3B	
160°C (320°F)	T3C	
135°C (275°F)	T4	T4
120°C (248°F)	T4A	
100°C (212°F)	T5	T5
85°C (185°F)	T6	T6

The ignition temperature for which existing equipment was approved in past years (prior to the establishment of T codes in NFPA 70 — 1971) should be assumed to be as follows:

Group A, B, D: 280°C (536°F)
Group C: 180°C (356°F)

2.3.2.1.4 Where unclassified areas exist at elevations directly above a Division 1 or Zone 1 area, and ordinary electrical equipment is located within that unclassified area, provisions should be made to ensure that failure or foreseeable mechanical damage to that equipment would not allow parts or fragments hot enough to cause ignition to fall into the Division 1 or Zone 1 area.

Example 1: Metal halide or mercury lamps, which are known to rupture in the event of a defect, should be located within a fixture able to contain fragments of hot quartz or glass.

Example 2: Ordinary incandescent light bulbs, which are easily broken by impact, should be enclosed within substantial guards or globes.

2.3.2.1.5 Electrical equipment and wiring recommended for locations containing flammable vapors or gases should be provided per Table 5. Refer to Article 501 of the NEC or IEC 60079-14 Ed. 2.0: *Electrical apparatus for explosive gas atmospheres — Part 14: Electrical installations in hazardous areas (other than mines)*, for additional requirements.

*Table 5. Equipment Recommended for Locations Containing Flammable Gases or Vapors (Class I)**

	Division 1	*Division 2*
Wiring	Threaded rigid metal conduit or Type MI cable. Explosionproof boxes and fittings. Use seals to prevent passage of gases, vapors, or flames through conduit from one portion of electrical installation to another. Threaded joints must have at least 5 threads engaged. Avoid tensile stress at termination fittings. Use approved flexible fittings for Class I locations.	Threaded rigid metal conduit, threaded steel intermediate metal conduit, enclosed gasketed wireways, enclosed gasketed busways, or Type MI, MC, PLTC, MV, TC, or SNM cable. No seals required except where explosionproof equipment is necessary and conduit leaves hazardous area. Wiring, which under normal conditions cannot release sufficient energy to ignite a specific hazardous atmospheric mixture, can be accepted using any of the methods suitable for wiring in ordinary locations.
Switches, circuit breakers, and motor controllers	Install in an enclosure approved as a complete assembly for Class I, Division 1 locations. (Enclosures approved for Class I, Division 1 locations include explosionproof and purged and pressurized enclosures.)	Same as Division 1, unless general enclosures are provided and the interruption of current occurs in hermetically sealed chambers, the contacts are oil-immersed, or interruption occurs in an approved explosionproof chamber. (General-purpose enclosures are acceptable for isolating or disconnecting switches without fuses and not intended to interrupt current.)
Fuses	Install in an enclosure approved as a complete assembly for Class I, Division 1 locations. (Enclosures approved for Class I, Division 1 locations include explosionproof and purged and pressurized enclosures.)	Install in an enclosure approved for Class I, Division 1 locations, for fuses protecting motors, appliances, and portable lamps. General purpose enclosures are acceptable for these fuses if the operating element of the fuse is oil-immersed or in hermetically sealed chamber. (General-purpose enclosures are acceptable for fuses on circuits to fixed lamps.)
Receptacles and attachment plugs	Polarized type approved for Class I locations, having provision for connection to grounding conductor of flexible cord.	Same as Division 1.
Motors and generators	Approved for Class I locations, or totally enclosed type supplied with positive pressure ventilation from a source of clean air, or totally enclosed inert gas filled type supplied with a source of inert gas to pressurize the enclosure, or a type designed to be submerged in a liquid that is ignitable only when vaporized and mixed with air. The different types should be arranged to automatically de-energize the equipment when the supply of liquid, gas or vapor fails.	Enclosure approved for Class I locations for rotating electrical machines employing sliding contacts, centrifugal or other switches or integral resistors, unless such contacts, switches, and resistors have enclosures approved for Class I, Division 1 locations. Open polyphase squirrel-cage induction motors without brushes or switches are acceptable. (Enclosed polyphase squirrel-cage induction motors are preferable for new installations.)

	Division 1	*Division 2*
Lighting fixtures	Fixed and portable units approved as complete assembly for Class I, Division 1 locations. Fixtures should have guards surrounding the globes or be located so as not to be subject to physical damage. Pendant fixtures should be suspended by threaded rigid metal conduit or threaded steel intermediate conduit stems or by other approved means. Supports should be approved for Class I locations.	Fixed enclosed gasketed globes or other effective protective means where (a) ignitable liquids are in the open, or (b) sparks or hot metal from lamps or fixtures might ignite local concentrations of flammable vapors or gases. Use lamps of a size or type that do not reach surface temperatures in excess of 80 of the ignition temperature (°C) of the gas or vapor involved; or use fixed fixtures approved as complete assembly for Class I, Division 1 locations. Other fixed lighting units may be ordinary open type without switches, starters, or control equipment. Fixtures for fixed lighting should have guards or be located so as not to be subject to physical damage. Portable lamps to be approved as complete assembly for Class I, Division 1 locations. Pendent fixtures per Division 1.
Transformers and capacitors	Install units containing either ignitable or nonignitable liquid in approved vaults having no openings to hazardous areas.** Use units approved for Class I locations for those that do not contain a liquid that will burn.	Install according to rules of sections 450-21 to 450-27 of NEC for nonhazardous locations.
Meters, relays, and instruments	Provide enclosure approved for Class I, Division 1 locations, or intrinsically safe equipment. (Enclosures approved for Class I, Division 1 locations include explosionproof and purged and pressurized enclosures.)	Equipment containing make-and-break contacts should have enclosures approved for Class I, Division 1 locations. General purpose enclosures are acceptable if current-interrupting contacts are (a) oil-immersed, or (b) hermetically sealed, or (c) in circuits that under normal conditions do not release sufficient energy to ignite a specific hazardous atmospheric mixture, i.e., are non-incendive. Equipment such as transformer windings, solenoids, and other windings that do not contain sliding or make-and-break contacts is acceptable in general purpose enclosures.

* Wherever possible, locate electrical equipment outside of hazardous areas. More specific details are given in Article 501 of the NEC. Also see Article 501 of the NEC for details on equipment not covered in Table 5.

** Units containing ignitable liquid must have ample ventilation, vent openings or ducts leading to a safe location outside the building and vents and ducts of sufficient area for explosion relief. Ducts within buildings shall be of reinforced concrete construction.

2.3.2.2 Class II Hazardous Locations

2.3.2.2.1 In Class II hazardous locations electrical equipment should be of one or a combination of the following types:

a) dust-ignitionproof (See C.2.8)

b) intrinsically safe (See C.2.5)

c) non-incendive (See C.2.6)

d) pressurized (See C.2.4 and C.2.9)

2.3.2.2.2 Equipment approved for Class II hazardous locations also should be approved for the specific group (E, F or G) of dust that will be present.

Note: There are no comparable dust groups in IEC or CENELEC standards.

2.3.2.2.3 The surface temperature markings in Table 4 should be less than the ignition temperature of the specific dust encountered. Ignition temperatures of many common dusts are provided in NFPA 499. The ignition temperature for which existing equipment was approved in past years (prior to the establishment of T codes in NFPA 70-1971) should be assumed to be as shown in Table 6.

Table 6. Surface Temperature Limits

	Equipment Not Subject To Overloading		*Equipment That May Be Overloaded*			
			Normal Operation		*Abnormal Operation*	
Class II Group	*°F*	*°C*	*°F*	*°C*	*°F*	*°C*
E	392	200	392	200	392	200
F	392	200	302	150	392	200
G	329	165	248	120	329	165

2.3.2.2.4 Electrical equipment and wiring recommended for locations containing combustible dusts should be provided per Table 7. Refer to Article 502 of the NEC or IEC 61241-1-1 Ed. 1.0: *Electrical apparatus for use in the presence of combustible dust — Part 1: Electrical apparatus protected by enclosures — Section 1: Specifications for apparatus*, and IEC 61241-1-2 Ed. 1.0: *Electrical apparatus for use in the presence of combustible dust — Part 1: Electrical apparatus protected by enclosures — Section 2: Selection, installation and maintenance*, for additional requirements.

*Table 7. Equipment Recommended for Locations Containing Combustible Dusts (Class II)**

	Division 1	*Division 2*
Wiring	Threaded rigid metal conduit, threaded steel intermediate metal conduit or Type MI cable with termination fittings. Use units approved for Class II locations for boxes or fittings containing taps, joints, or terminal connections, or in locations where dusts are combustible and electrically conducting. Seals are needed in conduit connecting dust-ignitionproof and non-dust-ignitionproof enclosures.	Rigid metal conduit, electric metallic tubing, intermediate metal conduit, dust-tight wireways or Type MI, MC, SNM cable with approved termination fittings, or Type MC, PLTC or TC cable in ventilated channel type cable trays in a single layer with a space not less than the larger cable diameter between the two adjacent cables. Same as Division 1 for sealing.
Switches, circuit breakers, and motor controllers	Install in an enclosure approved as a complete assembly for Class II, Division 1 locations for devices that normally interrupt current or where dusts are combustible and electrically conducting. (Enclosures approved for Class II, Division 1 locations include dust-ignitionproof and purged and pressurized enclosures.) Isolating or disconnecting switches without fuses and not subject to the above conditions should have tight metal enclosures and covers to minimize entrance of dust, and to prevent escape of sparks or burning material. Locations having metal dusts should have approved enclosures.	Install in a tight metal enclosure with close fitting cover to minimize entrance of dust, and to prevent escape of sparks or burning material.
Fuses	Same as for other spark-producing devices above.	Same as for other spark-producing devices above.
Receptacles and attachment plugs	Polarized type approved for Class II locations, having provision for connection to grounding conductor of flexible cord.	Polarized type with grounding connection and so designed that connection to the supply circuit cannot be made or broken while live parts are exposed.

	Division 1	*Division 2*
Motors and generators	Approved for Class II locations or totally enclosed pipe ventilated meeting any temperature limitations.	Totally enclosed nonventilated, totally enclosed fan cooled, dust-ignitionproof or totally enclosed pipe ventilated, for which maximum surface temperature does not exceed the ignition temperature of the specific dust (see Table 4) and shall have no external openings. Where moderate accumulations of nonconducting nonabrasive dust occur and equipment is accessible for cleaning, it is acceptable to use (a) self-cleaning textile-type squirrel-cage motors, or (b) standard open motors without sliding contacts, switches, or resistance devices or (c) with contacts, switches or resistance devices, enclosed in dust tight housings.
Lighting fixtures	Fixed and portable units approved as complete assembly for Class II, Division 1 locations. Provide guards or locate to prevent physical damage. Pendant fixtures should be suspended by threaded rigid metal conduit or intermediate metal conduit stems or by other approved means. Supports should be approved for Class II locations.	For fixed lights, provide enclosures to minimize dust deposits, prevent escape of sparks or burning material, and maintain exposed surface temperature less than the ignition temperature of the specific dust. Provide guards or locate to prevent physical damage. Portable units approved for Class II, Division 1 locations. Pendent fixtures as in Division 1.
*Capacitors and transformers	Install units containing ignitable liquid in approved vaults. Any openings to hazardous areas should be protected by double, tight-fitting, self-closing fire doors. Ventilating and pressure-relief openings should communicate only to outside air. Install units that do not contain a liquid that will burn in approved vaults, or use those approved as a complete assembly for Class II locations. Transformers/capacitors may not be installed in locations containing metal dusts	Install units containing ignitable liquid in approved vaults. Install dry-type transformers in vaults or tight metal housings without openings, and do not operate at voltages above 600 volts. Install askarel transformers rated in excess of 25 kVA in accordance with rules for nonhazardous locations. Locate these transformers so that there is an air space of not less than 6 in. (15.2 cm) between the transformer cases and any adjacent combustible material. Transformers should be provided with pressure-relief vents and have means of absorbing any gases inside the case or venting gases to outside the building.
Meters, relays, and instruments	Enclosure approved for Class II, Division 1 locations, or intrinsically safe equipment. (Enclosures approved for Class II, Division 1 locations include dust-ignitionproof and purged and pressurized enclosures.)	Tight metal enclosures and covers to minimize entrance of dust, and prevent escape of sparks and burning material.

* Wherever possible, locate electrical equipment outside of hazardous areas. More specific details are given in Article 502 of the NEC. Also see Article 502 of the NEC for details on equipment not covered in Table 7.

2.3.3 Purged and Pressurized Enclosures for Electrical Equipment in Class I and Class II Hazardous (Classified) Locations

2.3.3.1 General Requirements for Pressurized Enclosures

NOTE: The following design requirements for pressurized enclosures are not all inclusive. The recommendations in Section 2.3.3 present only those basic requirements that are expected to have the greatest impact on loss history. For exceptions and additions see NFPA 496, *Purged and Pressurized Enclosures for Electrical Equipment*. The 1998 Edition of NFPA 496 also recognizes the ‘‘zone’’ approach for Class I hazardous (classified) locations. Therefore, Zone 1 and Zone 2 locations may be equated to Division 1 and Division 2 locations, respectively within Section 2.3.3 for Class I locations only.

2.3.3.1.1 Pressurized enclosures may be used to locate electrical equipment in hazardous locations for which the equipment would otherwise be unsuitable. The three types of pressurization generally used for electrical equipment enclosures are Types X, Y, and Z. Type X pressurizing should be used to reduce the classification inside the protected enclosure from Division 1 to nonclassified. Type Y pressurizing should be used to reduce the classification within the protected enclosure from Division 1 to Division 2. Type Z pressurizing should be used to reduce the classification inside the protected enclosure from Division 2 to nonclassified.

2.3.3.1.2 During operation of the protected equipment, the protected enclosure should be maintained at a positive pressure of not less than 25 Pa (0.1 in. water) above the surrounding atmosphere.

2.3.3.1.3 An alarm should be provided to indicate the loss of the protective gas supply. However, an alarm on the supply is unnecessary if individual alarms are provided for each protected enclosure, or if Type X pressurization is used. Alarms on either the gas supply or protected enclosures should sound at a constantly attended location.

2.3.3.1.4 Acceptable protective gases include air of normal instrument quality, nitrogen or other nonflammable gases. Compressed air is acceptable if the compressor intake is located in a nonclassified location.

2.3.3.1.5 The protective gas should be discharged from the enclosure to a nonclassified location.

2.3.3.1.6 Temperatures or T codes should be marked on the enclosures, and should indicate the highest of the following: a) the hottest external surface temperature, b) the hottest internal component surface, or c) the temperature of the protective gas leaving the enclosure. The T code marking is not necessary if the hottest temperatures cannot exceed 100°C (212°F).

2.3.3.1.7 A permanent label should be mounted on the purged and pressurized enclosure and should state that the enclosure should not be opened unless the area is known to be nonhazardous or unless power has been removed from devices in the enclosure.

2.3.3.1.8 The area classification for the enclosure and pressurization type should be marked on the enclosure.

2.3.3.1.9 Type Z Pressurization

a) An alarm or indicator should be provided to detect the loss of positive pressure in individually protected enclosures. The protected equipment does not need to be de-energized.

b) If provided, an indicator should be located for convenient viewing and should indicate pressure or flow.

2.3.3.1.10 Type Y Pressurization

a) The features indicated for Type Z pressurizing systems should be provided.

b) Equipment inside the enclosure should be Approved for Division 2 locations.

c) Where the flow of protective gas provides needed equipment cooling as well as pressurization, the equipment should be interlocked to de-energize when the flow of gas is stopped.

2.3.3.1.11 Type X Pressurization

a) Circuits should be de-energized automatically using a flow or pressure actuated cutoff switch upon failure of the protective gas supply.

b) Equipment that could be overloaded (e.g., motors, transformers) should be provided with temperature measurement devices, and should be interlocked to automatically de-energize upon detection of any increase in temperature beyond the equipment design limits. Alternatively, the flow rate of protective gas should provide sufficient cooling even during overload conditions.

2.3.3.2 Specific Requirements for Pressurized Enclosures in Class I Locations

2.3.3.2.1 The enclosure should be purged if it has been opened or if the protective gas supply has failed to maintain the required positive pressure.

2.3.3.2.2 Pressurized equipment should not be energized until at least four enclosure volumes of protected gas (ten volumes for motors) have passed through the enclosure while maintaining an internal pressure of at least 25 Pa (0.1 in. water). For Type X pressurization, a timing device should be used to prevent energizing of electrical equipment prior to the required purging.

2.3.3.3 Specific Requirements for Pressurized Enclosures in Class II Locations

2.3.3.3.1 Accumulated combustible dust should be removed from the enclosure before pressurization.

2.3.3.3.2 The pressure required inside the protected enclosure should be increased to 125 Pa (0.5 in. water)(rather than the normally required 25 Pa (0.1 in. water) if the particle density of the dust is 130 lb/ft^3 (2083 kg/m^3) or greater.

2.3.3.3.3 Maximum surface temperatures should not exceed those stated in 2.3.2.2.3 if the ignition temperature of the dust is unknown.

2.3.3.3.4 For Type X pressurization a cutoff switch as in 2.3.3.1.11 is not required if an alarm is provided at a constantly attended location, and the enclosure is tightly sealed to prevent the entrance of dust.

2.3.3.4 FM Approved vs Non Approved Equipment

2.3.3.4.1 Equipment that is Approved or listed as Purged and Pressurized will be so labeled, and can be accepted for use within the area Class and Divisions or Zones as marked. Equipment that is not Approved or listed may be accepted if it meets the requirements detailed in Section 2.3.3. Additional detailed requirements of NFPA 496 should also be met where Code compliance is sought.

2.4 Operation and Maintenance

2.4.1 Maintain electrical equipment in accordance with the manufacturer's guidelines and NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*. Care should be taken during maintenance of hazardous (classified) location electrical equipment to ensure the continued integrity of protection for such equipment.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

Following the recommendations in this loss prevention data sheet is needed to minimize the potential for electrical ignition of flammable gases, flamable vapors and combustible dusts within areas or equipment where they are handled.

4.0 REFERENCES

4.1 FM Global

Data Sheet 7-1, *Fire Protection for Textile Mills.*
Data Sheet 7-9, *Dip Tanks, Flow Coaters and Roll Coaters*.
Data Sheet 7-13, *Mechanical Refrigeration*.
Data Sheet 7-27, *Spray Application of Flammable and Combustible Materials*.
Data Sheet 7-32, *Ignitable Liquid Operations*.
Data Sheet 7-55, *Liquefied Petroleum Gas (LPG) in Stationary Installations*.

4.2 NFPA Standards

NFPA 70, *National Electrical Code*.

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.

NFPA 496, *Purged and Pressurized Enclosures for Electrical Equipment*.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

4.3 Others

CSA Standard C22.1-98, *Canadian Electrical Code, Part 1.*

IEC 60079-10:1995 or EN 60079-10:1996, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas.*

IEC 60079-14 Ed. 2.0: *Electrical apparatus for explosive gas atmospheres — Part 14: Electrical installations in hazardous areas (other than mines)*.

IEC 61241-1-1 Ed. 1.0: *Electrical apparatus for use in the presence of combustible dust — Part 1: Electrical apparatus protected by enclosures — Section 1: Specifications for apparatus*.

IEC 61241-1-2 Ed. 1.0: *Electrical apparatus for use in the presence of combustible dust — Part 1: Electrical apparatus protected by enclosures — Section 2: Selection, installation and maintenance*.

IEC 61241-3:1997, *Electrical apparatus for use in the presence of combustible dust — Part 3: Classification of areas where combustible dusts are or may be present.*

LeBlanc, J. A. and Lawrence, W. G., ''The Three-Zone Classification System and the National Electric Code,'' Paper 5b, presented at AIChE 34th Annual Loss Prevention Symposium, Atlanta (March 5–9, 2000).

APPENDIX A GLOSSARY OF TERMS

Approved: references to ''Approved'' in this data sheet means the product and services have satisfied the criteria for FM Approval. Refer to the *Approval Guide*, a publication of FM Approvals, for a complete listing of products and services that are FM Approved.

See Appendix C, Section C.2 for an explanation of some common hazardous location electrical equipment terms, including the various protected types of electrical equipment.

APPENDIX B DOCUMENT REVISION HISTORY

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

September 2006. Added information on the acceptability of portable electronic products to Appendix C.

January 2002. Added reference paper under Appendix E entitled ''The Three-Zone Classification System and the National Electric Code'' for further guidance in the application of the ''Zone'' classification method as covered by Article 505 of NFPA 70, *National Electric Code.*

September 2000. This revision of the document has been reorganized to provide a consistent format.

APPENDIX C SUPPLEMENTARY INFORMATION

C.1 General

The NEC divides hazardous locations into three ''classes'' according to the nature of the hazard: Class I, Class II, and Class III. The locations in each of these classes are further classified by ''divisions'' (or ''zones'' for Class I locations only) according to the degree of hazard. Class I and II locations and their divisions (or zones for Class I locations) are described in Section C.2 of this appendix.

It is sometimes possible to avoid the use of special hazardous location electrical equipment and wiring by locating the equipment and wiring outside the hazardous location. For example, lights may be located outside a room, illuminating the inside through transparent panels. Motors may be located outside hazardous locations with properly sealed shafts extending into the hazardous location to drive mechanical equipment. Power equipment and control instruments may be located in remote, nonhazardous locations or in pressurized rooms that are suitable for general purpose equipment.

Considerable judgement is required to properly classify an area as a hazardous location. Unnecessarily expensive installations can be avoided by not over-classifying an area or by using expensive, explosionproof equipment that is sometimes rated for a higher classification.

C.2 Explanatory Material

The basic descriptions of Class I and II hazardous locations, nonclassified locations and pressurized enclosures for Class I and II locations are contained in the NEC, Articles 500 and 505, as well as NFPA Nos. 496, 497 and 499.

C.2.1 Class I Hazardous Locations

Class I Locations. Class I locations are those in which volatile flammable gases or vapors are or may be present in air in quantities sufficient to produce ignitible mixtures. These locations often include processes where volatile ignitable liquids are used. Per recent consultations with NEC specialists, Class I locations also include those where ignitible mists are normally present where the liquid has a flash point above 100°F (38°C) and is not heated above its flash point.

Volatile Ignitable Liquid. Volatile ignitable liquids are defined as liquids that have (a) a closed cup flash point below 100°F (38°C) or (b) a closed cup flash point of 100°F (38°C) and above if heated higher than their flash point.

The design of electrical equipment for Division 1 locations is based on a flammable atmosphere being continuously present, as this is the worst case situation.

Examples of Class I, Zone 0 locations include areas inside vented tanks or vessels containing volatile ignitable liquids; areas inside inadequately ventilated spraying or coating enclosures where volatile ignitable liquids are used; the area between the inner and outer roof sections of a floating roof tank containing volatile ignitable liquids; areas inside open vessels, tanks and pits containing volatile ignitable liquids; the interior of an exhaust duct that is used to vent ignitable concentrations of gases or vapors; and areas inside inadequately ventilated enclosures containing normally venting instruments utilizing or analyzing ignitable liquids and venting to the inside of the enclosures.

Examples of Class I, Division 1 or Zone 1 locations include areas where volatile ignitable liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile ignitable solvents are used; locations containing open tanks or vats of volatile ignitable liquids; drying rooms or compartments for the evaporation of ignitable solvents; locations containing fat and oil extraction equipment using volatile ignitable solvents; portions of cleaning and dyeing plants where ignitable liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile ignitable liquids; the interiors of refrigerators and freezers in which volatile flammable or ignitable materials are stored in open, lightly stoppered, or easily ruptured containers; and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations but are not classified Zone 0.

Electrical installations in Class I, Division 1 or Zone 1 locations are designed so that normal operation or failure of any part of the electrical system will not release flame, sparks, or hot gases, nor will it result in surface temperatures high enough to ignite the surrounding atmosphere.

Protection systems for Division 2 or Zone 2 locations are not as stringent as they are for Division 1 or Zone 0 and Zone 1 locations since flammable gases and vapors are not present under normal conditions, and are likely to be present only for relatively short periods under abnormal conditions.

Installations for Class I, Division 2 or Zone 2 locations are designed and arranged so that normal operation of the electrical system does not provide a source of ignition. Protection against ignition during electrical breakdown is not provided. However, electrical breakdowns are sufficiently rare that the likelihood of one occurring simultaneously with accidental release of an ignitible mixture is extremely remote. Arcing and sparking devices are permitted only if suitably enclosed or if the sparks are of insufficient energy to ignite the mixture.

Adequate mechanical ventilation can be used to reclassify a location from Division 1 to Division 2 or Zone 1 to Zone 2 or in some instances even result in reclassification as nonhazardous and avoid costly Division 2 or Zone 2 wiring. Typical examples where adequate ventilation would not reduce the classification level include: within 3 ft (0.9 m) of the fill opening of an indoor ignitable liquid drum, locations under and adjacent to open kettles, mixers or dip tanks (and their drainboards) containing volatile ignitable liquids, the immediate vicinity of continuous cleaning operations where exposed ignitable liquids are used, the immediate vicinity of open filter presses processing volatile ignitable liquids and in the immediate vicinity of normally closed equipment that is frequently opened and that contains volatile ignitable liquids or flammable vapors or gases.

C.2.2 Class II Hazardous Locations

Class II Locations. Class II locations are locations that are hazardous because combustible dusts are or may be present.

Examples of typical Class II, Division 1 locations include the working areas of grain handling and storage plants; rooms containing such equipment as grinders, pulverizers, open conveyors, or similar dust producing machinery in plants processing grain, malt, starch, sugar, wood, flour, or similar materials; starch-handling areas in candy plants; coal pulverizing plants (except where the pulverizing equipment is essentially dust tight); areas where metal dusts and powders are produced, handled, or stored (except in tight containers); and other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce ignitible mixtures.

Dusts containing magnesium or aluminum are particularly hazardous and extreme caution is necessary to avoid ignition or explosion.

Examples of typical Class II, Division 2 locations include those containing only closed conveyors, closed bins, or machines from which appreciable quantities of dust would escape under abnormal operating conditions; rooms adjacent to Class II, Division 1 locations into which ignitible concentrations of suspended dust might be communicated only under abnormal operating conditions; or rooms where ignitible concentrations of suspended dust are normally prevented by effective dust control equipment.

Electrical installations in Class II, Division 1 locations are designed and enclosed in a manner that will exclude ignitible amounts of dusts and will not permit arcs, sparks, or heat generated or liberated inside the enclosures to cause ignition of exterior dust accumulations on the enclosure or of atmospheric dust suspensions in the vicinity of the enclosure.

Electrical installations in Class II, Division 2 locations may be designed with dust-tight enclosures or other equipment enclosures as specified in Article 502 of the NEC.

C.2.3 Nonclassified Locations

Experience has shown that the release of ignitible mixtures or dust suspensions from some operations and apparatus is so infrequent that area classification is not necessary. For example, it usually is not necessary to classify the following locations where combustible mixtures or ground up solids are processed, stored or handled:

a) Locations that are adequately ventilated, where combustible materials are contained within suitable, well maintained, closed piping systems.

b) Locations that are not adequately ventilated but where piping systems are without valves, fittings, flanges, and similar accessories that may be prone to leaks.

c) Locations where combustible dusts are stored in sealed containers (bags, drums, fiber packs)are palletized or racked.

d) Locations where combustible dusts are transported in well maintained closed piping systems.

e) Locations where palletized materials with minimal dust are handled or used.

f) Locations where mechanical dust collection systems on equipment prevent visual dust clouds and layer accumulations that make surface colors indiscernible, and where appreciable quantities of dust are not likely to escape under abnormal operating conditions.

g) Locations where excellent housekeeping is maintained and there are no visual dust suspensions or layer accumulations that make surface colors indiscernible, and where appreciable quantities of dust are not likely to escape under abnormal operating conditions.

The area directly adjacent to a normally present and unavoidable ignition source also is considered to be a nonclassified location. Examples include areas adjacent to: fuel-fired equipment burners; hot exposed surfaces that normally are above the autoignition temperature of gases, vapors or dusts that may be released; and gas turbines. The use of classified area electrical equipment next to obvious ignition sources is unwarranted due to the fact that the use of the special electrical equipment is not likely to significantly reduce the probability of ignition of an accidental release of combustible material. It is not possible to provide fixed guidelines regarding how far away from these ignition sources hazardous location electrical equipment should be used again. Factors to consider in exercising judgment include the magnitude and location of potential material releases or accumulations, as well as the potential distances that the released material may drift

C.2.4 Purged and Pressurized Enclosures as covered by NFPA 496

Note: The 1998 Edition of NFPA 496 equates Class I, Zone 1 and Zone 2 locations to Class I, Division 1 and Division 2 locations, respectively as referenced below within this section.

C.2.4.1 Terminology

Purging: the process of supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable gas or vapor initially present to an acceptably safe level.

Pressurization: the process of supplying an enclosure with a protective gas with or without continuous flow at sufficient pressure to prevent the entrance of a flammable gas or vapor, a combustible dust or an ignitible fiber.

Protective Gas: the gas used to maintain pressurization or to dilute a flammable gas or vapor.

Protective Gas Supply: the compressor, blower, or compressed gas container that provides the protective gas at a positive pressure. The supply includes inlet (suction) pipes or ducts, pressure regulators, outlet pipes or ducts, and any supply valves not adjacent to the pressurized enclosure.

C.2.4.2 Purged and Pressurized Enclosures for Class I Locations

Type X Pressurization reduces the classification within an enclosure from Division 1 to nonhazardous. Because the probability of a hazardous atmosphere external to the enclosure is high and the enclosure normally contains a source of ignition, it is essential that any interruption of the purging results in de-energizing of the equipment. It is essential that the enclosure also be tight enough to prevent escape of molten metal particles or sparks.

Type Y Pressurization reduces the classification within an enclosure from Division 1 to Division 2. Equipment and devices within the enclosure must be suitable for Division 2. This requires that the enclosure not normally contain an ignition source. Thus, a hazard is created within the enclosure only upon simultaneous failure of the purge system and of the equipment within the enclosure. Due to the very low probability of this occurring, it is not considered essential to de-energize the equipment upon the failure of the pressurization system.

Type Z Pressurization reduces the classification within an enclosure from Division 2 to nonhazardous. With Type Z Pressurization, a hazard is created only if the purge system fails at the same time that the normally nonhazardous area becomes hazardous. Due to the low probability of this occurring, it is not considered essential to de-energize the equipment upon failure of the pressurization system.

C.2.4.3 Purged and Pressurized Enclosures for Class II Locations

A hazard is created within an enclosure only after the pressure has failed and enough dust to be explosive penetrates into the enclosure. This takes an appreciable length of time with any normally tight enclosure. Because of this, it is not always considered essential to de-energize the equipment automatically upon failure of the pressurization. It is necessary only to provide an adequate warning so that operations will not continue indefinitely without pressurization. It is essential that the enclosure be tight enough to prevent escape of sparks or burning material.

C.2.5 Intrinsically Safe Electrical Equipment

Intrinsically safe (''IS'' per NEC Article 500 or ''ia'' for Zones 0, 1 and 2 or ''ib'' for Zones 1 and 2 per NEC Article 505 — see Table 3) equipment and wiring are designed to be incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to ignite a specific hazardous atmospheric mixture in its most easily ignited concentration. Intrinsically safe apparatus is suitable for use in Class I, Division 1 and/or Class II, Division 1 hazardous locations, depending on the type of environment for which it has been tested and Approved (listed).

The NEC and other corresponding IEC and CENELEC standards recognize intrinsically safe electrical equipment and its wiring. The intrinsically safe apparatus is safe for use in the specified atmosphere without the special enclosures or physical protection that would otherwise be needed.

Industrial applications of intrinsically safe electric circuits are increasing considerably. There is a greater use of intrinsic safety to supplement or substitute for the other forms of protection in hazardous locations. Overall, the principal of intrinsically safe equipment and circuits can be considered for any equipment that operates at very low voltages and very low amperages. Intrinsically safe equipment is thus ideal for process monitoring or controlling applications in chemical plants and petroleum refineries.

The ability of an electrical circuit or equipment to produce ignition is determined by the energy available and the manner in which such energy is released. The energy may be released by arcing (a spark), by high temperature, or by a combination of arcing and temperature. The energy released by an arc or spark discharge can be by: a) the discharge of a capacitive circuit, b) the interruption of current in an inductive circuit, c) the make-and-break of a resistive circuit, or d) a combination of these three mechanisms.

FM Global Research and other recognized laboratories examine electrical devices to determine, by analysis and/or actual tests, the ignition capability of the particular equipment. The laboratories determine whether or not the device is intrinsically safe for a specific hazardous location. Electrical equipment approved as intrinsically safe is listed in the *Approval Guide*.

C.2.6 Non-Incendive Electrical Equipment

Non-incendive ‘‘(NI)’’ equipment and wiring are incapable of releasing sufficient electrical or thermal energy, during normal operating conditions, to ignite a specific hazardous atmosphere mixture. Such non-incendive equipment is safe for use in Class I, Division 2 or Class II, Division 2 hazardous locations, depending on the type of environment for which it has been tested and approved (listed). A special enclosure or other physical safeguard for the equipment is not needed.

Electrical equipment approved as non-incendive is listed in the *Approval Guide.*

C.2.7 Explosionproof Equipment

The term explosionproof ‘‘(XP)’’ means that the device has an enclosure that is capable of withstanding an internal explosion of a specified gas or vapor without igniting a similar external mixture. In addition, the maximum external surface temperatures are below the ignition temperature of the materials to which the enclosure may be exposed. Explosionproof equipment is suitable for Class I, Division 1 locations.

C.2.8 Dust-ignitionproof Equipment

The term dust-ignitionproof ‘‘(DIP)’’ means that the device has an enclosure that will exclude ignitible amounts of dust. In addition, the enclosure will not permit arcs, sparks, or heat generated inside the enclosure to ignite exterior accumulations of dust. This is the type of design most frequently used for Class II, Division 1 equipment.

C.2.9 Other Protected Types of Electrical Equipment

Flameproof ‘‘d’’ is a type of protection of electrical equipment in which the enclosure will withstand an internal explosion of a flammable mixture that 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 mixture consisting of one or more of the gases or vapors for which it is designed.

Pressurized ‘‘p’’ is a type of protection of electrical equipment that guards against the ingress of the external atmosphere, which may be explosive, into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere.

Type of Protection ‘‘n’’ is a type of protection applied to electrical equipment such that, in normal operation, the electrical equipment is not capable of igniting a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur. Type of protection ‘‘n’’ is further subdivided into nA (non-sparking equipment), nC (sparking equipment in which the contacts are suitably protected other than by restricted breathing enclosure) and nR (sparking equipment that has restricted breathing enclosure).

Oil Immersion ''o'' is a 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 that may be above the liquid or outside the enclosure cannot be ignited.

Increased Safety ''e'' is a type of protection applied to electrical equipment that does not produce arcs or sparks in normal service and under specified abnormal conditions, 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.

Encapsulation ''m'' is 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.

Powder Filling ''q'' is a type of protection in which the parts capable of igniting an explosive atmosphere are fixed in position and completely surrounded by filling material (glass or quartz powder) to prevent the ignition of an external explosive atmosphere.

C.3 Group Classification

The atmosphere created by flammable vapors, gases or dusts makes them more or less hazardous around specific electrical equipment. Atmospheric mixtures using the ''Division'' hazardous area classification method per NEC Article 500 are further classified into seven groups (A through G) for purposes of testing and approving pieces of electrical equipment for their suitability for various atmospheres.

Groups A, B, C and D per the ''Division'' approach or corresponding Groups IIC, IIB and IIA per the ''Zone'' approach consist of flammable gases or vapors as further explained in Table 8. They are classified according to either (1) their ability to propagate flame through a flanged joint (MESG value — maximum experimental safe gap value), or (2) their minimum igniting current (MIC) ratio, or both. See C.6.1 for further clarification.

Groups E through G consist of combustible dusts and are further explained in Table 9. They are classified according to (1) their ability to penetrate joints, (2) their blanketing effect, (3) their ignition temperatures, and (4) their electrical conductivity.

Refer to either NFPA 497 (gases and vapors) or NFPA 499 (dusts) for a comprehensive list of materials including their group classification.

Table 8. Group Classifications for Flammable Gas and Vapor Atmospheres

Typical Flammable Gas or Vapor Atmosphere	*NEC Article 500*	*NEC Article 505 or IEC/CENELEC*
Acetylene	Group A	Group IIC MESG value ≤ 0.50 mm or MIC ratio ≤ 0.45
Hydrogen	Group B MESG value ≤ 0.45 mm or MIC ratio ≤ 0.40	
Ethylene	Group C MESG value > 0.45 mm and ≤ 0.75 mm or MIC ratio > 0.40 and ≤ 0.80	Group IIB MESG value > 0.50 mm and ≤ 0.90 mm or MIC ratio > 0.45 and ≤ 0.80
Propane	Group D MESG value > 0.75 mm or MIC ratio > 0.80	Group IIA MESG value > 0.90 mm or MIC ratio > 0.80

Note: MESG values or MIC ratio criteria for group classification purposes were added to NFPA 497 (1997) and also incorporated into the 1999 edition of the NEC for consistency. Refer to C.6.1 for further explanation of MESG values and MIC ratios.

Table 9. Group Classifications of Dust Atmospheres per NEC Article 500

Dust Atmosphere	*Group*
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.	Group E
Atmospheres containing combustible carbonaceous dusts, including carbon black, charcoal, coal, or dusts that have been sensitized by other materials so that they present an explosion hazard.	Group F
Atmospheres containing combustible dusts not included in Group E or F, including flour, grain, wood, plastic, and chemicals.	Group G

Note: Where Group E dusts may be present in hazardous quantities, there are Division 1 locations only (i.e., no Division 2 locations). This is because the release of conductive dust also can cause a simultaneous failure of the electrical equipment.

C.4 NEMA Classifications for Enclosures for Electrical Equipment

The following enclosure type numbers are assigned by NEMA (National Electrical Manufacturers Association) to identify enclosures for some hazardous location electrical equipment.

Type 7. Enclosures constructed for indoor use in hazardous locations classified as Class I, Division I, Groups A, B, C or D, as defined in the NEC.

Type 8. Enclosures constructed for either indoor or outdoor use in hazardous locations classified as Class I, Division I, Groups A, B, C or D, as defined in the NEC.

Type 9. Enclosures constructed for indoor use in hazardous locations classified as Class II, Division I, Groups E, F or G, as defined in the NEC.

Type 10. Enclosures constructed to meet the requirements of the Mine Safety and Health Administration, 30 CFR, Part 18.

These designations alone are not sufficient to determine suitability for use in a specific hazardous location. These designations are historical terms approaching obsolescence and are not referenced by the NEC when specifying the requirements for equipment selection. FM Global Research recommends that all hazardous location electrical equipment be Approved or listed and labeled as specified in Section C.5. This may include these type designations, but they must be supplemented by all of the marking requirements of the NEC.

C.5 FM Approvals

Electrical equipment is Approved by FM Approvals for either Class I or Class II locations, or both, and for one or more atmosphere groups (A, B, C, D or IIC, IIB, IIA) for Class I hazardous locations or (E, F, or G) for Class II hazardous locations. Surface temperatures of Approved equipment do not exceed the ignition temperature of the specific gas, vapor, or dust for which the equipment is Approved. Electrical equipment is marked to show the class, division or zone, group as applicable, and operating temperature or temperature range for which it is Approved. Electrical equipment also can be specifically Approved and marked for Division 1 and 2 or Zone 0, 1 and 2 applications or for Division 2 or Zone 2 only. Electrical equipment that has been Approved for a Division 1 or Zone 0 and Zone 1 location may be permitted in a Division 2 or Zone 2 location of the same class and group as applicable.

There are types of electrical equipment which the NEC allows to be used in Class I, or II, Division 1 or 2 classified locations that do not require any special protection mechanisms, special markings or specific listings. This type of equipment is commonly referred to as ‘‘nonsparking’’. Tables 5 and 7 (Section 2.3.2) indicate many of the specific equipment types that need not be Approved or listed to be acceptable. Some examples of frequently used non-Approved equipment include:

1. Some attachment plugs and receptacles which are not completely explosionproof and yet have been tested and designed to be safe for use in Class I, Division 1 locations.

2. Electrical lighting fixtures in Class I, Division 2 locations with the exception of portable lighting equipment. (Note that it must still be ensured that surface temperatures will not exceed 80% of the autoignition temperature of the gas or vapor involved.)

3. Open squirrel cage or totally enclosed motors, fan cooled or not, are acceptable in Class I, Division 2 locations provided that they do not produce ignition-capable sparks or arcs under normal equipment operating conditions.

4. Dust-tight enclosures in Class II, Division 2 locations are permitted for fuses, switches, motor controllers, circuit breakers, push buttons, solenoids, control transformers, relays and other small devices. (See Section C.4 for an enumeration of enclosures considered to be dust tight.)

5. Totally enclosed, pipe-ventilated motors for Class II, Division 2 locations.

6. ‘‘Simple apparatus’’ which will neither generate nor store more than 1.2 volts, 0.1 amps, 25 milliwatts or 20 microjoules need not be approved (e.g., thermocouple, LED).

There are various kinds of general purpose equipment that can be used in hazardous locations. The above is just a guide and not a complete listing. The many exceptions can be found in the NEC.

C.6 Theoretical Background Information

C.6.1 General

The required energy for ignition of any flammable gas or vapor mixture primarily depends on the flammable material, its concentration in air, its temperature and pressure just prior to ignition, and the prevailing electric circuit ignition characteristics. Each vapor air mixture has a minimum value of energy that is required for ignition. The minimum amounts of energy required to ignite some common flammable gases (i.e., Minimum Ignition Energy or MIE at their most easily ignitable concentration) are given in Table 10 below. Below this minimum, ignition of the mixture does not occur.

Electric spark ignition energy may be expressed in joules or millijoules. In a capacitive circuit, the energy of a spark may be expressed as $W = \frac{1}{2} CV^2$. W is the energy available in joules, C is the effective capacitance in farads, V is the capacitance voltage in volts. MIE values for specific gases or vapors are determined using a capacitive spark discharge. In an inductive current, $W = \frac{1}{2}LI^2$. W is the energy available in joules, L is the effective inductance in henrys and I is the inductive current in amperes. MIC (Minimum Igniting Current) values are determined using an inductive spark discharge. The MIC ratio is the ratio of the MIC value for the specific gas or vapor of concern compared to the MIC value for methane when evaluated in the same test apparatus. MIC values for Groups A through D and corresponding Groups IIC, IIB and IIA are given in Table 8. MIC values for many other flammable gases and vapors are also provided in NFPA 497.

Table 10. Ignition Characteristics of Selected Gases

Flammable Gas	*Minimum Ignition Energy (millijoules)*	*MESG (mm)*
Acetylene	0.017	0.25
Hydrogen	0.019	0.28
Ethylene	0.07	0.65
Propane	0.25	0.97
Methane	0.28	1.12
Ammonia	680	3.17

The Maximum Experimental Safe Gap (MESG) assumes the basic principle that ignition of a flammable atmosphere can be prevented by separating an unburned flammable atmosphere from an ignition source by a slit, screen or gauze material with very small openings. In general, the more ignitable a gas, the smaller the openings are required to prevent a flame (or explosion) from passing through. Using this principle, electrical equipment such as motors with commutators and switches can be made non-incendive by enclosing the equipment in such a way that openings for shaft and switch operating mechanisms are very small.

Flat joints having a very small gap between mating surfaces in comparison to their width, present a flame path along which an explosive mixture could travel. A flammable mixture ignited inside the enclosure would be prevented from propagating flame through the gap to the outside of the enclosure. The amount of heat absorbed from the hot gases by the flame path is dependent on the length of the flame path and the tightness of the joint. The MESG for Groups A through D and corresponding groups IIC, IIB and IIA are given in Table 8. Typical values of the MESG for a 25 mm wide flame path that will not propagate an explosion through a flameproof joint also are given for some flammable gases in Table 10. MESG values for many other flammable gases and vapors also are also in NFPA 497.

The minimum ignition energy of most flammable gases and vapors as shown in Table 10 and NFPA 497 is typically less than 1 mJ. In comparison, the minimum ignition energy for combustible dusts is considerably higher, as illustrated by the few representative values shown in Table 11. On the other hand, the autoignition temperatures (AITs) of many typical hydrocarbon solvent vapors are in the 450-500°C (850-950°F) range, whereas the AITs of some typical dusts are below 250°C (500°F). The AIT ignition hazard of dusts is further increased by the accumulation of deposits on equipment, leading to the possibility of smoldering due to thermal instability. For this reason, the surface temperature requirements of equipment suitable for Class II locations are based not only on the dust cloud ignition temperature, but also the dust layer ignition temperature. Layer or cloud ignition temperatures for many common dusts are given in NFPA 499.

The practical implication of the comparison between dust and gas ignition properties is that the risk of ignition from hot surfaces is much greater for dusts, while the risk of ignition from sparks is much greater for gases and vapors. These very different ignition properties result in different designs for Class I and Class II equipment. Unless Approved or listed for both classes, equipment Approved or listed for one class should be assumed to be inappropriate for the other class.

Table 11. Minimum Ignition Energy of Selected Dusts[1]

Combustible Dusts	*Minimum Ignition Energy (millijoules)*
Aluminum	15
Magnesium	40
Grain	240
Coffee	160
Coal	60
Sulfur	15

[1] Because the minimum ignition energies for dusts are dependent on particle size and shape, the values in the table should be considered as illustrative only. The values should not be assumed to be correct for all individual situations involving the same materials.

C.6.2 Intrinsically Safe Equipment

Intrinsically safe equipment must meet two special conditions:

a) The energy available must be incapable of igniting the specified fuel-air mixture under ''normal'' operating conditions. ''Normal'' conditions include operations at maximum line supply voltage and the environmental conditions that fall within the ratings given for the apparatus.

b) The energy available also must be incapable of igniting the specified fuel-air mixture under ''abnormal'' operating conditions. ''Abnormal'' or fault conditions include operations with any combination of two independent mechanical or electrical faults occurring at the same time. If a defect or breakdown leads to defects or breakdowns in other components, the primary and subsequent failures are considered to be a single fault.

Intrinsically safe equipment involves relatively low levels of energy and is therefore limited to low voltage, low current signal circuits. Typical equipment includes circuits for signaling, telephones and monitoring equipment in hazardous locations.

C.7 Requirements in Countries Outside of the United States

Area classification in most countries as previously noted in Section 2.2 is based on ''zones'' rather than ''divisions'' which is now also recognized by NEC Article 505 for Class I locations. Although somewhat similar approaches in concept, one important exception is that NEC Article 505 and the corresponding IEC/CENELEC standards subdivide what are considered Division 1 areas by NEC Article 500 into two distinct zones: Zone 0 and Zone 1. Zone 0 is defined as an area where the combustible mixture is continuously present, or present for long periods (e.g., inside of an ignitable liquid storage tank). Zone 1 is defined as an area where the combustible mixture is likely to occur in normal operation (e.g., next to a periodically opened access opening in an ignitable liquids mix tank).

There are various markings for hazardous location electrical equipment, depending on the country of equipment manufacture and intended use. However, one commonality in a great many countries are the markings **Ex** (IEC) and **EEx** (CENELEC) to indicate equipment suitable for hazardous locations. The United States uses the marking **AEx** for electrical equipment meeting NEC Article 505 using American National Standards (ANSI test standards).

Testing and certification of equipment in all countries of Western Europe are performed to CENELEC standards. EC member countries issue Certificates of Conformity to these standards and accept products and systems certified by other members. Other countries either work to their own standards based on IEC standards (e.g., Australia, Brazil, Japan, Russia) or accept products and systems certified to European and/or American standards. Table 3 references the applicable test standards for the respective electrical equipment protection concept employed by FM Approvals and other test/certification organizations to satisfy the governing jurisdiction.

The system of marking applied to electrical apparatus satisfying NEC Article 505 or the corresponding IEC/CENELEC area classification standard includes the following:

1. The symbol **AEx**, **Ex** or **EEx** which indicates that the electrical equipment corresponds to the applicable ANSI, IEC or CENELEC test standards as noted in Table 3.

2. The sign to identify the method of protection:

o — oil immersion
p — pressurized apparatus
q — powder filling
d — flameproof enclosure
e — increased safety
ia — intrinsic safety, category a
ib — intrinsic safety, category b
m — encapsulation

3. The symbol of the group of the electrical apparatus: I (IEC and CENELEC only) for electrical apparatus for mines susceptible to firedamp (gas mixture primarily methane) and II, IIA, IIB or IIC for electrical apparatus for locations with a potentially explosive atmosphere other than mines susceptible to firedamp. The chemical formula or name of the gas will follow the symbol II when the electrical apparatus is certified for use in only a particular gas.

4. For Group II electrical apparatus, the symbol indicating the temperature class (i.e., T codes given in Table 4) or the maximum surface temperature in °C, or both. The temperature class will be given last in parenthesis if the marking includes both. For Group II electrical apparatus where the maximum surface temperature is greater than 450°C, only an inscription of the temperature will appear.

The order of the markings will correspond to the order in which they are given above. Some examples of markings are as follows:

- electrical apparatus in flameproof enclosure for Group IIC:

  AEx d IIC (NEC Article 505)
  Ex d IIC (IEC)
  EEx d IIC (CENELEC)

Note: See Code column in Table 3 for other examples of different methods of protection.

- electrical apparatus in flameproof enclosure for Groups IIC, temperature class T3:

  AEx or Ex or EEx d IIC T3

- increased safety electrical apparatus and a pressurized enclosure for group II with a maximum surface temperature of 125°C:

  AEx or Ex or EEx ep II 125°C (T4) or
  AEx or Ex or EEx ep II 125°C

- flameproof enclosure for ammonia:

  AEx or Ex or EEx d II(NH_3)

C.8 NFPA Standards

There are no conflicts between this data sheet and the NEC with one exception. FM Global Research defines volatile ignitable liquids (C.2.1) as liquids having (a) a closed cup flash point below 100°F (38°C) or (b) a close cup fresh point of 100°F (38°C) and above if heated higher than their flash point, while the NEC includes only ignitable liquids with flash points at or above 100°F (38°C) and below 140°F (60°C) that are heated above their flash point. Some guidelines for the application of judgement when establishing area classification are different in this data sheet as compared to NFPA 497 and 499. Overall, guidelines in this data sheet are less broadly sweeping, so as not to underclassify certain types of areas and occupancies.

C.9 Portable Electronic Products

All electrical equipment, including portable, low-voltage, battery-operated devices such as pages and cellular phones, are considered as potential ignition sources in Class I or II, Division 1 or Zone 0 or 1 hazardous locations unless specifically tested and FM Approved or listed for such use.

Portable, low-voltage, battery-operated devices meeting the requirements of ISA (The Instrumentation, Systems and Automation Society) recommended practice (RP) 12.12.03 - 2002, can be used in Class I or II, Division 2 or Zone 2 hazardous locations where FM Approved or listed devices are not available.

APPENDIX D BIBLIOGRAPHY

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6. NFPA 496 (1998), *Purged and Pressurized Enclosures for Electrical Equipment*, National Fire Protection Association, Quincy, MA.

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APPENDIX E THE THREE-ZONE CLASSIFICATION SYSTEM AND THE NATIONAL ELECTRIC CODE

The following paper was presented at the American Institute of Chemical Engineers 34th Loss Prevention Symposium, Atlanta, March 5–9, 2000. This paper provides a description of the ‘‘Zone’’ classification system, compares the ‘‘Zone’’ system to the traditional ‘‘Division’’ system and provides some discussion on the application of the ‘‘Zone’’ system.

The Three-Zone Classification System and the National Electric Code®

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Prepared for Presentation at

American Institute of Chemical Engineers
34th Loss Prevention Symposium
Atlanta, GA

March 5-9, 2000

Date: November 1999

The Three-Zone Classification System and the National Electric Code®

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ABSTRACT

The National Electric Code® (NEC®), ANSI/NFPA 70, published by the National Fire Protection Association (NFPA) allows two distinct approaches to classifying and installing electrical equipment in hazardous (classified) locations. The 1996 edition of the NEC® provided the initial framework for the development of the product standards for a three-Zone classification system based on the International Electrotechnical Commission (IEC) 60079 series of standards. US deviations were introduced to align those standards with NEC® and US practice. The 1999 edition of the NEC® has further refined the new "Zone" system. Electrical equipment *listed* in accordance with the new "Zone" system is now available in the US. An understanding of the similarities and differences between "Division" equipment and "Zone" equipment is needed to effectively use these classification systems to protect facilities against unwanted electrical ignition sources in hazardous (classified) locations.

The traditional US approach utilizes the two-Division classification system for hazardous locations. This system has been in use since 1947 and is generally well understood. The new "Zone" system has been used in much of the world for many years but has only limited acceptance in the US. The lack of acceptance is largely based on a lack of understanding and the requirements of the NEC®. The NEC® requires that hazardous locations be classified under either the traditional "Division" system or the new "Zone" system. Since many existing installations were based on the "Division" system, "Zone" designed equipment could generally not be introduced in those locations. The NEC® does, however, permit the use of "Division" classified equipment in similar "Zone" areas. Reclassifying an area using the "Zone" system increases the number of available options since both "Zone" and "Division" classified equipment may be used.

This paper will provide a description of the "Zone" classification system, compare the new "Zone" system to the traditional "Division" system and provide some discussion on the application of the "Zone" system.

INTRODUCTION

The National Electrical Code® (NEC®), ANSI/NFPA 70, published by the National Fire Protection Association (NFPA) is a set of uniform electrical installation rules written in a form that can be adopted into law. The federal Occupational Safety and Health Administration (OSHA), all fifty states, and many local jurisdictions have adopted, at least in part, the NEC® for electrical installation requirements. In addition to its applicability to ordinary locations (unclassified), the NEC® provides the framework for approval, by jurisdictions, of electrical equipment installations in hazardous (classified) locations and serves as the basis for the product standards used by Nationally Recognized Testing Laboratories (NRTLs) to *list* equipment for approval by jurisdictions.

The NEC® allows two distinct approaches to classifying and installing electrical equipment in hazardous locations containing flammable gases and vapors, and ignitable liquids. The original approach utilized the two-Division classification system for hazardous locations. That system has been in use for many years and is generally well understood. The 1996 edition of the NEC® provided the framework for the introduction of a three-Zone classification system based on the International Electrotechnical Commission (IEC) 60079 series of standards. This classification system only applied to flammable gases and vapors, and ignitable liquids. US deviations were introduced into the appropriate product standards to align these IEC standards with NEC® and US practice. The 1999 edition of the NEC® further refined the new "Zone" system.

The "Zone" system has been used in much of the world for many years Electrical equipment *listed* in accordance with the new "Zone" system is now available in the US but availability remains limited. The lack of acceptance is based on a lack of understanding and the requirements of the NEC®. The NEC® requires that hazardous areas must be classified under either the "Division" system or the new "Zone" system. Since many existing installations were based on the "Division" system, "Zone" designed equipment could not be introduced. The NEC® does, however, permit the use of "Division" equipment in similar "Zone" areas. Reclassifying an area using the "Zone" system increases the number of available options since both "Zone" and "Division" equipment may be used. An understanding of the similarities and differences between "Division" equipment and "Zone" equipment is needed to effectively use these systems to protect facilities against unwanted electrical ignition sources.

DIVISION SYSTEM OVERVIEW

Under the “Division” system, flammable, combustible, and ignitable materials are first classified into three Classes of materials.

Class I hazardous materials include gases, vapors and liquids that can burn or explode. Class II materials include combustible dust, such as flour, sugar, aluminum magnesium. Class III materials include ignitable fibers or ”flyings”, such as cotton lint.

Each of these three classes is further subdivided into two “Divisions”, with Division 1 encompassing hazards that are continuously, intermittently, or periodically present in the atmosphere. Division 2 includes hazards that can exist only under ”abnormal” circumstances. In other words, under this scheme, an area classified as Class 1, Division 1 would represent the most hazardous area within its class.

The last subdivision within the “Division” classification system is the Group. Seven Groups are used to categorize materials by similar physical characteristics. Groups A, B, C and D apply to Class I areas only. Group A includes only acetylene. Group B includes gases such as hydrogen. Group C contains gases or vapors such as ethyl ether, diethyl ether, ethylene, and ethylene oxide. Group D contains gases or vapors such as propane, methane, gasoline, acetone, ethyl alcohol, hexane, butane, and ammonia.

Groups E, F, and G are the last three Groups and apply only to Class II areas where combustible dusts may be found. Group E includes metals dusts such as magnesium. Group F contains the carbonaceous dusts such as coal and coke dust. Group G includes the agricultural dusts such as flour. There are no groups defined for Class III locations.

INTRODUCTION OF THE “ZONE” SYSTEM TO THE NEC®

Since the introduction of the two-Division area classification system in the 1947 NEC®, areas containing potentially flammable gas atmospheres have been classified and apparatus has been designed to be applied in Class I, Division 1 or Class I, Division 2 locations. With the introduction of the three-Zone area classification into the IEC in the late 1960’s, there were informal discussions in the US concerning the introduction of the system into US codes. The first proposals were prepared for the 1971 NEC®, but were rejected at that time. For the next 25 years “Zone” proposals in various forms continued to be considered. Finally in 1996 a new Article 505 was adopted which provided only the barest framework for the introduction of the “Zone” area classification system. The definitions were included, but details such as marking and references to the apparatus standards were not.

The possible introduction of the “Zone” area classification system into the 1996 NEC® provided the impetus for the development of the US apparatus standards for the “Zone” types of protection. In 1994, one of the American National Standards Institute (ANSI) Standards Developing Organizations, ISA – The International Society for Measurement and Control, began development of a series of US standards based on the IEC 60079 series of standards, but with US deviations introduced to align with the NEC® and US practices. The types of electrical equipment protection schemes that were included in the US standards are the same as those defined in IEC 60079-0 and also in the similar European standard EN 50 014. The development effort was completed with the issue of a series of standards in 1998. A second ANSI Standards Developing Organization began a parallel effort in late 1995. They issued their standard in 1996. This standard did not include the IEC text; it only provided the US deviations. It also did not include many of the US deviations considered necessary to align with NEC® and US practices. There is now an ANSI mandated effort underway to harmonize those two standards development efforts. The resulting standards are expected to be very close to the current ISA standards and will be jointly published by both organizations.

“ZONE” SYSTEM OVERVIEW

In the US, the “Zone” system only applies to Class I locations. There is no equivalent “Zone” system for Class II or III locations. There are three “Zone” classifications, Zone 0, Zone 1 and Zone 2. As shown in Table 1, the “Zone” and “Division” classification systems defined by the NEC® are closely related. The table also includes the “Zone” system that is used internationally. As should be expected, the US and IEC “Zone” systems are, on the surface, identical. However, keep in mind that the IEC “Zone” system was only used as guide for developing what was adopted in the NEC®. Numerous differences do exist between the US and IEC “Zone” systems and electrical equipment *listed* in one system cannot be used by the other system without an additional listing.

Table 1. Comparison of “Division” and “Zone” Area Classification Systems

<table>
<tr><th colspan="2">Standards Organization</th><th>Flammable Material Present Continuously or for Long Periods of Time</th><th>Flammable Material Present Intermittently During Normal Operations</th><th>Flammable Material Present Only During Abnormal Operations</th></tr>
<tr><td colspan="2">IEC/CENELEC*</td><td>Zone 0</td><td>Zone 1</td><td>Zone 2</td></tr>
<tr><td rowspan="2">NFPA</td><td>NEC® Article 505 “Zone” System</td><td>Zone 0</td><td>Zone 1</td><td>Zone 2</td></tr>
<tr><td>NEC® Article 500 “Division” System</td><td colspan="2">Division 1</td><td>Division 2</td></tr>
</table>

*CENELEC: European Committee for Electrotechnical Standardization

COMPARISON OF “ZONE” SYSTEM AND “DIVISION” SYSTEM

Under the “Zone” classification system, Zone 2 is an area in which an explosive gas-air mixture is not likely to occur under normal conditions and, if it does occur, will exist only for a short time. Class I, Zone 2 is essentially the equivalent of Class I, Division 2. Even though there are minor differences in the various protection techniques, the two classifications are handled interchangeably by the NEC®. The same is not true for Class I Division 1 locations and Class I Zone 1 locations.

Class I, Division 1 can be considered to be subdivided into Zone 0 and Zone 1. Zone 0 defines those locations in which an explosive gas-air mixture is present continuously or for long periods during normal operation. An example of Zone 0 is the vapor space of a closed, but atmospherically vented, process vessel or storage tank containing flammable or ignitable material. By isolating the worst explosion hazards within Zone 0 classifications, designers are free to use less restrictive and less costly systems in the remainder of Division 1 areas defined as Zone 1, while limiting the type of protection permitted to Intrinsic Safety only in the more hazardous Zone 0 areas.

The full definitions for each “Zone” in the “Zone” classification system are provided in Table 2. Since prior to 1996, all existing facilities in the US were classified using the “Division” classification system, the table also provides a comparison of the two “Divisions” with the three “Zones”. Although the definitions provided in the NEC® for the “Zone” system are more detailed, they do match up very well with the more generic “Division” system definitions. The NEC® does however apply the two area classification systems differently. Some of the key differences are listed below:

1. Classification of areas, selection of equipment and wiring methods, and installations using the “Zone” classification system are required to be under the supervision of a qualified ‘Registered Professional Engineer’ (PE). This is not the case for areas classified under the “Division” classification system or any other electrical installation covered by the NEC®.

2. With few exceptions, the two area classification systems cannot be intermixed. A Class I, Zone 2 location is permitted to abut, but not overlap, a Class I, Division 2 location. A Class I, Zone 0 or Zone 1 location is not permitted to abut a Class I, Division 1 or Division 2 location.

3. Any location that is currently classified using the “Division” system can be reclassified as a Class I, Zone 0, Zone 1, or Zone 2 location provided all the space that is classified, because of a single flammable gas or vapor source, is reclassified under the requirements of NEC® Article 505. Because of the potential cost of reclassification, the introduction of the “Zone” classification system remains limited to new installations and major revisions.

Table 2. NEC® Definitions of "Zone" and "Division" Classified Areas

Corresponding Division	*Zone*	*Definition/Examples of Use Area*
1	0	Definition: 1) Areas in which ignitable concentrations of flammable gases of vapors are present continuously; or 2) Areas in which ignitable concentrations of flammable gases or vapors are present for long periods of time.
		Examples: 1) Inside vented tanks or vessels that contain volatile ignitable liquids; 2) Inside inadequately vented spraying or coating enclosures, where volatile ignitable solvents are used; 3) Between the inner and outer roof sections of a floating roof tank containing volatile ignitable liquids; 4) Inside open vessels, tanks and pits containing volatile ignitable liquids; 5) Interior of an exhaust duct that is used to vent ignitable concentration of gases or vapors; 6) Inside inadequately ventilated enclosures that contain normally venting instruments utilizing or analyzing ignitable fluids and venting to the inside of the enclosure
	1	Definition: 1) Areas in which ignitable concentrations of flammable gases of vapors are likely to exist under normal operating conditions; or 2) Areas in which ignitable concentrations of flammable gases or vapors may exist frequently because of repair of maintenance operations or because of leakage; or 3) Areas 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) Areas that are adjacent to a Zone 0 location from which ignitable concentration of gases or 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. (applies to Zone 1)
		Examples: 1) Locations where volatile ignitable liquid or liquefied flammable gases are transferred from one container to another; 2) In the vicinity of spraying and painting operation where ignitable solvents are used; 3) Adequately ventilated drying rooms or compartments for evaporation of ignitable solvents; 4) Adequately ventilated gas generator rooms; 5) Inadequately ventilated pump rooms for flammable gas or volatile ignitable liquids
2	2	Definition: 1) Areas in which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and if the do occur will exist only for a short period; or 2) Areas in which volatile ignitable 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 container or system, or as a result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or 3) Areas in which ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as a result of failure or abnormal operation of the ventilation equipment; or 4) Areas adjacent to Zone 1/Division 1 locations, from which ignitable concentration of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation form a source of clean air, and effective safeguards against ventilation failure are provided.

Protection Techniques

The specific rules for applying the “Division” and “Zone” classification systems must be clearly understood. The differences in application are driven by the differences in protection techniques used on the electrical equipment. Table 3 provides a listing of the allowed protection techniques for both systems. They each have their own methodology for accomplishing the general equipment protection principle. In many cases, the methodologies differ significantly and cannot be directly compared.

Intrinsic Safety.

Electrical equipment that is built using intrinsic safety is designed to be unable to ignite a flammable atmosphere, even under specific fault conditions. This is accomplished by limiting the amount of electrical energy used by or delivered to the device. Only equipment that uses the intrinsic safety protection scheme is permitted in Zone 0 areas. However, caution must be used since there are two levels of intrinsic safety that can be used. Electrical equipment that is specifically intended and tested for Zone 0 areas is identified by using the letter “a” in the type of protection code for intrinsic safety (i.e., “ia”). Electrical equipment that is specifically intended and tested for Zone 1 areas is identified by using the letter “b” in the type of protection code for intrinsic safety (i.e., “ib”).

Flameproof.

“Flameproof” is a protection technique in the “Zone” system that is similar to “Explosionproof” under the “Division” system. Equipment that is designed to be flameproof will resist an internal deflagration of a flammable atmosphere without causing the ignition of an external flammable atmosphere. The ability to contain an explosion and prevent ignition of a surrounding flammable atmosphere depends on the ability to extinguish or cool an escaping flame front before it exits the equipment. Flame extinction is accomplished by cooling the burning gases. The equipment designs to accomplish this cooling of the flame are tied to specific flammable gases or vapors or ignitable liquids. As discussed in the next section of this paper, flammable vapors and gases, and ignitable liquids are subdivided into Groups. “Zone” *listed* equipment is always marked with the acceptable Group.

Increased Safety.

The increased safety protection technique was developed in Germany. It focuses on eliminating the potential sources of ignition such as sparking, arcing or hot surfaces. The increased safety protection approach is not directly comparable to any of the “Division” system protection schemes. Increased safety employs increased creepage and clearance for electrical insulation, generously dimensioned contact surfaces, and highly reliable connections to greatly reduce the likelihood of an ignition capable spark occurring. All increased safety connections must be protected by an enclosure to reduce the possibility of contamination of the electrical insulation that could result in a failure of the insulation. The enclosure must have a minimum degree of protection of IP54 per IEC 60529 which provides a dust tight and water tight enclosure. This protection is most commonly employed for connection terminals but also has applications in motor windings.

A Benefit of “Zone” *Listed* Equipment.

The combination of Zone 1 protection techniques allows the construction of small, light-weight, electrical devices that can be readily combined into control panels without the need for the entire panel to be flameproof. This allows the use of the best engineering approach to protect against any potential ignition source.

An example of how this approach can benefit an end user follows:

A Class I Division 1 fluorescent light fixture designed to be explosionproof has all of the electrical components enclosed in an explosionproof case. A Class 1 Zone 1, fluorescent light fixture has each of its electrical components individually protected using one of the “Zone” types of protection. The ballast is housed in its own flameproof case with its wire terminals increased safety. The isolation switch is also flameproof with its wire terminals increased safety. The bi-pin fluorescent lamps are connected using special sockets that meet the requirements for increased safety. All of the fixture components are housed in a lightweight shatterproof plastic case that provides degree of protection IP54 to reduce the likelihood of contamination of the electrical insulation. This example demonstrates the significant reduction in the size and cost of electrical equipment possible for Zone 1 locations in contrast to that required for Division 1 locations.

Table 3. Electrical Protection Techniques for the "Division" and "Zone" Systems

Protection Technique	*Designation*	*Permitted Zone/ Division*	*Standard*	*Protection Principle*
General Requirements	AEx	Zone 0, 1, & 2	ANSI/ISA S12.0.01	
		Division 1, 2	FM 3600	
Explosion Proof	(XP)	Division 1, 2	FM 3615	Contain the explosion and quench the flame
Flameproof	d	Zone 1, 2	ANSI/ISA S12.22.01	
Powder Filling	q	Zone 1, 2	ANSI/ISA S12.26.01	
Increased Safety	e	Zone 1, 2	ANSI/ISA S12.16.01	No arcs, sparks, or hot surfaces
Non-sparking Equipment	nA	Zone 2	ISA S12.12.01	
Sparking Equipment w/protected contacts	nC	Zone 2	ISA S12.12.01	
Non-Incendive	(NI)	Division 2	FM 3611	
Intrinsic Safety	ia	Zone 0, 1, 2	ISA S12.2.01	Limit energy of sparks and surface temperature
Intrinsic Safety	ib	Zone 1, 2	ISA S12.2.01	
Intrinsically Safe Associated Apparatus	[ia]	Non-Hazardous	ISA S12.2.01	
Intrinsically Safe Associated Apparatus	[ib]	Non-Hazardous	ISA S12.2.01	
Intrinsic Safety	(IS)	Division 1, 2	FM 3610 (based on ISA S12.2.01)	
Restricted Breathing Enclosure	nR	Zone 2	ISA S12.12.01	Keep flammable gas or vapor out.
Purged or Pressurized	p Type X, Y, Z	Zone 1, 2 Division 1, 2	ANSI/NFPA 496	
Oil Immersion	o	Zone 1	ANSI/ISA S12.25.01	
Encapsulation	m	Zone 1	ANSI/ISA S12.23.01	

Group

There are other similarities between the two classification systems. Both systems provide an additional rating that subdivides flammable gases and vapors into several Groups. Table 4 lists the "Zone" and "Division" system Groups. As shown in Table 4, the Groups are quite similar in how the various gases or vapors are subdivided. The largest difference is how acetylene and hydrogen are handled. Under the "Division" system, each gas has its own Group, acetylene is in Group A, and hydrogen is in Group B. In the IEC "Zone" system, both gases are in the same Group, acetylene and hydrogen are in Group IIC. In addition to the grouping difference, Group IIC does not allow the use of flanged joints in flameproof equipment where as Group B explosion proof equipment allows the use of flanged joints. In order to resolve these differences and continue to allow the use of flanged joints, Group IIB equipment is also tested with hydrogen. This permits its use in Group IIB atmospheres and also in hydrogen atmospheres. This equipment is marked IIB+H_2.

Table 4. Comparison of "Division" and "Zone" Apparatus Grouping

Typical Gas or Vapor	*NEC® Article 505 "Zone" Groups**	*NEC® Article 500 "Division" Groups*
Acetylene	Group IIC	Group A
Hydrogen	(Group IIB + H_2)**	Group B
Ethyl ether, diethyl ether, ethylene, and ethylene oxide	Group IIB	Group C
Propane, methane, gasoline, acetone, ethyl alcohol, hexane, butane, and ammonia	Group IIA	Group D

** Group I applies to environments found in underground mines which are not covered by the NEC®*

*** It should be noted that IIB + H_2 is not a 'Group'. Since the US has traditionally separated Acetylene and Hydrogen into two different Groups, Group A and Group B; the closest approximation in the "Zone" system is to mark apparatus that is suitable for Hydrogen application as suitable for IIB + H_2. This is a common marking for flameproof apparatus that employs flanged joints not permitted in Group IIC.*

Temperature Class

The last electrical equipment rating is temperature class. A comparison of the “Zone” and “Division” temperature classes is presented in Table 5. The only real difference between the temperature classes in the two systems is that the “Division” system allows for additional subdivision of temperatures.

Table 5. Temperature Class

Maximum Surface Temperature	*NEC® Article 500*	*NEC® Article 505*
450°C (842°F)	T1	T1
300°C (572°F)	T2	T2
280°C (536°F)	T2A	
260°C (500°F)	T2B	
230°C (446°F)	T2C	
215°C (419°F)	T2D	
200°C (392°F)	T3	T3
180°C (356°F)	T3A	
165°C (329°F)	T3B	
160°C (320°F)	T3C	
135°C (275°F)	T4	T4
120°C (248°F)	T4A	
100°C (212°F)	T5	T5
85°C (185°F)	T6	T6

Equipment Use

The use of electrical equipment in a “Zone” classified location is more limited by the NEC® than the equipment for application in a “Division” classified location. Under the traditional “Division” system, apparatus only has to be *approved*. Under the “Zone” system, apparatus has to be *listed* although there are exceptions for Zone 2 to allow the apparatus to be *approved* instead of *listed*. The NEC® differences between *approved* and *listed* are important to understand.

The NEC® defines *Approved* as follows:

Approved — Acceptable to the authority having jurisdiction.

The NEC® defines *Listed* as follows:

Listed — Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of *listed* equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for a specified purpose.

With few areas classified using the “Zone” system, the market for apparatus using the IEC-based types of protection in “Zone” classified areas remains limited and apparatus manufacturers continue to focus on the “Division” system types of protection. In reality, the NEC® rules should not be a major limitation for apparatus manufacturers or users. The NEC® permits “Division” apparatus to be used in similar “Zone” areas (see Table 6). Intrinsically Safe apparatus *listed* for Division 1 is permitted in Zone 0 locations, apparatus *approved* for Division 1 is permitted in Zone 1 locations, and apparatus *approved* for Division 2 is permitted in Zone 2 locations. The requirement here for *listed* Intrinsically Safe Apparatus is not a penalty as almost all Intrinsically Safe apparatus is indeed *listed*.

Table 6. Acceptable Use of Hazardous Location Electrical Equipment

Classified Location	*Acceptable Listed* Equipment	*Acceptable Approved* Equipment
Zone 0	Zone 0, Division 1 (intrinsically safe)	None
Zone 1	Zone 0, Zone 1	Division 1
Zone 2	Zone 0, Zone 1, Zone 2	Division 1, Division 2
Division 1	Division 1 (intrinsically safe)	Division 1
Division 2	Zone 0, Zone 1, Zone 2	Division 1, Division 2

This allowance provides additional equipment options for users if they reclassify existing hazardous (classified) locations using the “Zone” system. In addition to having additional equipment choices, electrical equipment that was designed using the Increased Safety “e” and Powder Filling “q” protection techniques can offer significant size, weight, and cost reductions. These newly available “Zone” protection techniques cannot be used in “Division” classified locations.

Marking Hazardous Area Electrical Equipment

Because of the potential for confusion with the introduction of the alternate “Zone” area classification system, some changes were made to the marking detailed in IEC 60079-0 for use in the NEC®. The driving force is that under the traditional “Division” system, the apparatus marking advises the installer which areas the equipment can be installed in. A typical “Division” system apparatus marking is provided in Figure 1. Under the IEC-based “Zone” system, the apparatus marking advises the installer what the type of protection is, but does not detail where it can be used. The marking requirements introduced in Article 505 of the NEC® combine the two methods of marking. In addition to the IEC-based marking, which is modified with the addition of an “A” prefix before the “Ex” marking, the permitted Class and Zone are also added. A typical NEC®-based “Zone” apparatus marking is provided in Figure 2.

Since “Division” apparatus is permitted in areas classified using the “Zone” classification system, a supplemental “Zone” marking was also allowed. The marking consisted of the Class, Zone, Group, and temperature class (T-Code) corresponding to the Class, Division, Group, and temperature class (T-Code) of the “Division” system. The difference is the absence of the AEx and type of protection marking.

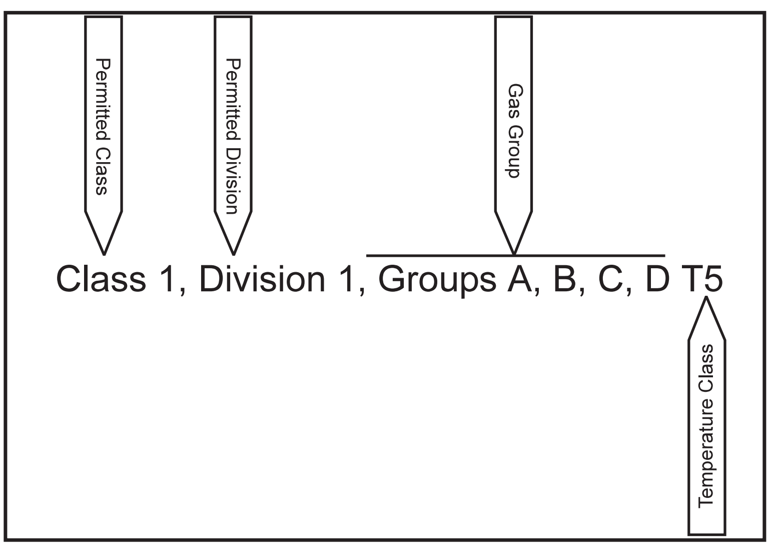

Figure 1 Marking Explanation for Division Classified Equipment

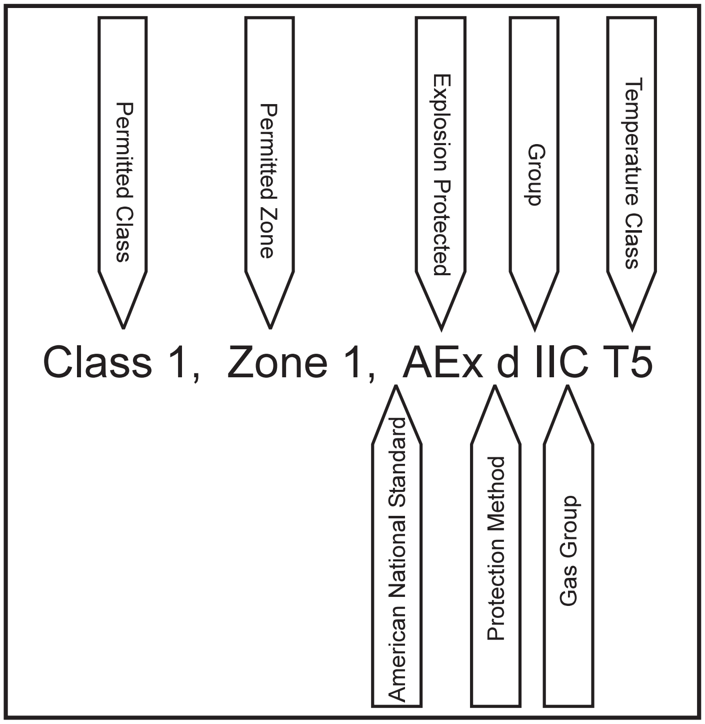

Figure 2 Marking Explanation for Zone Classified Equipment

Wiring Methods

Although the IEC types of protection for electrical equipment have been introduced into the US, it is critical to note that the wiring methods permitted for this equipment remains the traditional US wiring method of conduit with some limited application of cable. Many of the deviations introduced into the apparatus standards are directly related to the need to interconnect with these traditional US wiring methods.

For wiring in NEC®-based Zone 0 locations, any of the wiring methods permitted for ordinary locations may be used. Typical wiring methods employed are various types of non-armored cable, not unlike those used in Europe. The apparent lack of requirements for Zone 0 wiring is based on the fact that all Zone 0 equipment is intrinsically safe (i.e., low energy).

Beginning with the 1996 NEC®, some limited cable wiring methods were introduced for Division 1/Zone 1 locations. Metal-clad cable, Type MC, and Instrument Tray Cable, Type ITC, are both *armored* cable designs with limited flexibility. However, they represent the first US application of other than conduit in a Division 1/ Zone 1 fixed applications.

For wiring in Division 2/Zone 2 locations, there are again some types of non-armored cable used, but for most applications, the traditional conduit system is the most common wiring method.

CONCLUSION

Using the "Zone" system to classify hazardous areas increases the choices of electrical equipment available for use in hazardous (classified) locations since both "Zone" and "Division" *listed* equipment is acceptable. The added choices will can also reduce the overall cost of electrical installations in hazardous (classified) locations since the protection techniques allowed in the "Zone" system can permit smaller, lighter, and less costly equipment designs. The only way to utilize the advantages of the "Zone" system is to reclassify existing hazardous (classified) locations in accordance with Article 505 of the NEC®.

As more areas are classified using the “Zone” system and more electrical equipment is certified to meet the US requirements for IEC-based “Zone” types of protection, US apparatus and installations will migrate towards the IEC-based “Zone” system. As the users prepare by classifying new installations and reclassifying existing installations to take advantage of the new “Zone” apparatus, the manufacturers are also preparing. Most of the major US companies manufacturing or marketing hazardous area electrical apparatus have 1)international operations producing IEC-based “Zone” apparatus, 2) alliances with international companies producing IEC-based “Zone” apparatus, or 3) have purchased international operations to provide a source of IEC-based “Zone” electrical apparatus. Unfortunately, moving to the “Zone” classification system will not provide compatibility of equipment from other countries also using the IEC-based “Zone” system. There are still numerous differences between the US system and the IEC systems for equipment. Because of all the legal ramifications involved in national certifications, equipment that is certified to meet the IEC-based requirements of other countries will need to be re-certified to meet the US requirements.

ADDITIONAL READING

1. ANSI/NFPA 70, “National Electrical Code®,” National Fire Protection Association, 1999 Edition

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3. NFPA 497, “Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas,” National Fire Protection Association, 1997 Edition.

4. API Recommended Practice 500 (RP500), “Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 or Division 2,” American Petroleum Institute, November 1997, Second Edition.

5. ANSI/API RP505, “Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 or Zone 2,” American Petroleum Institute, 1998, First Edition.

6. FM Global Property Loss Prevention Data Sheet 5-1, “Electrical Equipment in Hazardous (Classified) Locations.”

7. “Approved Product News — In the Zone with FMRC,” Factory Mutual, 1998, Volume 14, Number 3. http://www.fmglobal.com/pdfs/apn14_3.pdf

8. “Approved Product News – Interlaboratory Agreements – International Hazardous Location Standards,” FM Global, 1999, Volume 15, Number 3. http://www.fmglobal.com/pdfs/apn15_3.pdf

Approved Product News

Volume 15 • Number 3 • 1999

Interlaboratory Agreements

International Hazardous Location Standards

FM Global

Approved Product News

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On the Cover: Factory Mutual Research's interlaboratory agreements can help shorten your products' paths to international markets.

Editor: Amy Costa

Published three times a year by Factory Mutual Research.

New subscriptions/change of address: Send your name, address and phone number *(including area code)* to:

Approved Product News
Customer Services
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P.O. Box 9102 • Norwood, MA 02062
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Interlaboratory Agreements—Helping Customers Avoid the "Three-Ring Circus" of International Certification

"Without certification, you don't have a product," begins Richard Allen, principal engineer for product safety and approvals engineering in Honeywell's Industrial Automation & Control (IAC) division, Fort Washington, Pennsylvania, USA.

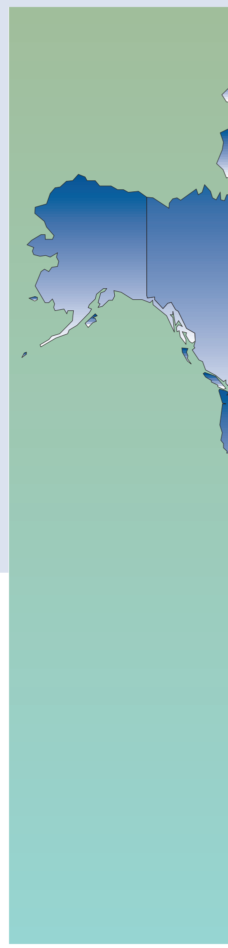
"We send about 80 percent of our division's products to Factory Mutual Research for testing and Approval," Allen continues. "Most of those products are also evaluated for foreign markets under the interlaboratory agreements that Factory Mutual Research maintains. Without those agreements, we would have to deal directly with every country. With multiple products and multiple countries, it can become a three-ring circus in a hurry!"

Global Marketing Made Easier

As the line from the famous song says, "If you can make it here, you'll make it anywhere!" The same can be said for manufacturers wishing to certify their products for foreign markets. Rather than brave the gauntlet of varied international standards and certifications alone, many U.S. manufacturers call upon Factory Mutual Research and its interlaboratory agreements program **(see chart page 11)** to help them reduce time-to-market ... and reduce stress.

"We can provide an enormous speed-to-market advantage," affirms John Rennie, vice president, Factory Mutual Research Approvals, "Not only are our test reports accepted in most major global markets, but we have multiple agreements in several markets, which gives our customers the flexibility to go with the agency with the shortest backlog at any given time."

"Let's say a company wants to market a product in Europe," explains Frank McGowan, Factory Mutual Research, Instrumentation Section manager. "They want the certification done by a European lab, but they don't want the expense or to take the risk in shipping the product overseas to have the testing done. In many cases, those companies come to Factory Mutual Research. It's easier and less costly for us to do the testing and send a test report to the European lab with which we have an agreement. In some



Factory Mutual Research participates with testing laboratories on all most every continent of the world.

> "Factory Mutual Research evaluates our products to the most conservative standards and the most recent requirements."

cases, it may not even be for an Approval, but just testing to European standards."

According to McGowan, this approach saves a manufacturer shipping costs, improves time-to-market, and can eliminate multiple ship-test-fail-retest cycles. "You take our test report to a foreign agency and you should be all set," McGowan notes. "You don't have to redo any analyses because we have an established relationship with that foreign lab through our interlaboratory agreements."

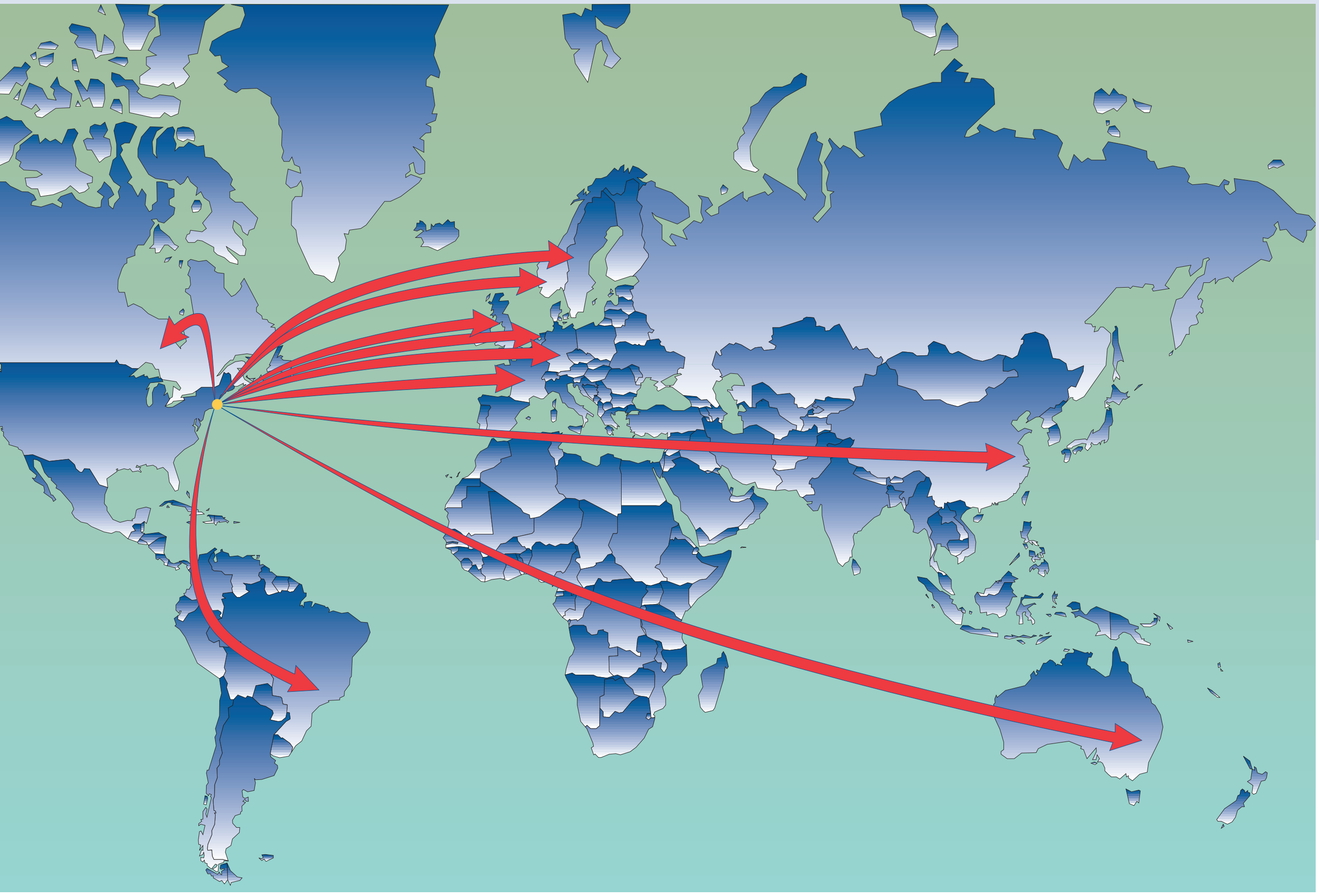
The Agreement

The interlaboratory agreement is a formal document that is signed by the cooperating laboratories. The language of this agreement is careful to avoid a discussion of payment, except to say: "The parties agree to independently bear the total financial burden for implementation of this agreement. There shall be no monetary exchange between the parties unless covered under a separate agreement."

"There is a base fee that has been agreed to in advance," McGowan explains. "As much as possible, we want to maintain the highest level of impartiality."

In addition to a formal written agreement to cooperate, laboratories also must agree to be inspected and audited by the cooperating lab. "It's a confidence building exercise," McGowan explains. "By auditing the other lab, we get a feel for how they conduct their testing and the competence of their staff and other resources. Participating testing labs must meet the requirements of International Organization for Standardization (ISO) Guide 25 and Guide 65, which set general guidelines for product certification systems and labs."

To learn how the interlaboratory agreement program benefits manufacturers, we contacted three Factory Mutual Research customers with a long history of international marketing experience.



Honeywell IAC

As noted earlier, Honeywell's Industrial Automation & Control division is a long-time Factory Mutual Research client. IAC and the Sensing and Control Products group make up Honeywell's Industrial Control business unit, which accounts for over 30 percent of the company's total sales. IAC provides systems, products, and services for a wide range of process industries, including petrochemical, pharmaceutical, pulp and paper, and food.

According to Honeywell's Allen, the IAC division seeks Approval for nearly all of its products. "Time is money," Allen stresses. "That's what it comes down to. We are always looking to have a singular examination performed and cover all our bases at one time. That's why we rely on Factory Mutual Research. We go for an Approval, and we specify where we plan to market a particular product and what our priorities are for issuing test reports. In that way, Factory Mutual Research can design their testing program to ensure we cover all the applicable international standards."

According to Allen, once an Approval has been obtained, Honeywell typically requests that Factory Mutual Research prepare assessment reports for each foreign market by order of market size or based on special requests. "Sometimes, a product will be specifically designed for a particular market. That country or market will be the next on the list following Approval. We save time by conducting a single battery of tests that will cover all the markets we're interested in."

"We have used Factory Mutual Research's interlaboratory agreements to gain certification at many different labs in Europe, including KEMA in The Netherlands, Sira in the U.K., and LCIE in France," Allen says. "Because European Community members that participate in CENELEC will accept certification by any other member, our main criteria in selecting a European lab is their backlog. How long will it take to gain certification? Factory Mutual Research engineers often know which labs have the shortest backlogs. Sometimes we get a specific request to have a product certified by a particular lab and we do that, but usually it's based on a quick turnaround."

On a couple of occasions, Allen says he has run into a backlog at Factory

Factory Mutual Research helps companies get their products certified for sale in major international markets.

Approvals testing verifies design acceptability.

Printed circuit boards are an example of a product where mere functionality is not always adequate for certification.

Mutual Research and used the interlaboratory agreement program in reverse. "We have gone to CSA and had them conduct their certification tests and include the tests needed by Factory Mutual Research. CSA issues an assessment report that Factory Mutual Research then reviews, and an Approval was issued based on that report. Again, it's a time-is-money situation and the interlaboratory agreement works both ways."

Reduces Time-to-Market

Allen emphasized that while time-to-market—representing a time savings of at least 25 percent or more—is one of the most important reasons for working with Factory Mutual Research, there are many other benefits provided by the interlaboratory agreements program, including:

- testing generally requires only a single product sample
- testing requires only one set of product documentation
- single "worst-case" product examinations are applicable in multiple international markets
- testing verifies design acceptability
- if product changes are required, they only need to be made once

"We are a global company, selling in markets worldwide," Allen explains. "While we are very active on many standards committees and groups, we cannot keep track of all the changes that are taking place. We rely on Factory Mutual Research to help us do this. Through its interlaboratory agreements, the organization is able to stay abreast of changes at other testing agencies."

Allen gave examples of two types of products his company offers and how Factory Mutual Research's guidance in the area of international standards helps the company avoid problems.

"Our pressure transmitters, for instance, are used in many process industries to measure many types of process pressures such as gauge pressure, differential pressure, and absolute pressure," Allen says. "From the engineering perspective, sometimes it is difficult to balance the functional requirements of a product with the approval requirements for various markets."

"We work with them to come up with a design for a part that will be suitable for hazardous locations worldwide," Allen continues. "One area that is easy to overlook is component ratings. A part may be designed to perform correctly from a functional perspective, but does it meet the requirements of an intrinsically safe system? Maybe not. Component rating requirements can differ between countries in some cases. You may have revise the circuitry in order to achieve a hazardous locations rating."

Printed circuit boards are another example of a product where mere functionality is not always adequate for certification. "There are varying requirements for the layout of the conductor traces on printed circuit boards from agency to agency," Allen explains. "While one thickness or width may be adequate for normal operation, it may not be enough for intrinsic safety. Layouts for circuit boards can get very costly, so we need to know in advance about any special requirements. Factory Mutual Research evaluates our products to the most conservative standards and the most recent requirements."

The Foxboro Company

Founded in 1908 in Foxboro, Massachusetts, USA, The Foxboro Company was acquired in 1990 by Siebe plc of Windsor, England. Siebe merged this year with BTR to form Invensys plc. Foxboro, with 5,500 employees worldwide, is now the cornerstone of the U.S.-based Invensys Intelligent Automaton division.

The flagship of Foxboro's product offerings is the I/A Series of open industrial process control systems. The I/A Series provides measurement, control, and real-time information for process control applications such as chemical, oil and gas, pulp and paper, metals, mining, foods, and pharmaceuticals.

"Almost all of our I/A products go through the Approval process," says Al Stafford, a 27-year Foxboro veteran and the company's principal engineer for codes and standards. "Factory Mutual Research interlaboratory agreements give me a sort of one-stop testing arrangement or process. I can provide one sample product, one set of documents, and I do not have to go to all of the other testing agencies and deal with them directly, which is very time-consuming. With new products, getting samples for testing is tough, so this process makes it easier."

"We probably save at least one month in each market by going through Factory Mutual Research," Stafford notes. "Even in going to Canada, which is a friendly market for us, I have had products held up at customs because they didn't have the right paperwork or something relatively minor was amiss."

"If we really did have one world standard, that would make our jobs much

> We probably save at least one month in each market by going through Factory Mutual Research.

easier, but we don't," Stafford stresses. "That means in order to go into all of the international markets we focus on, we need Factory Mutual Research to perform an extra 10 to 20 percent more testing. The firm can then use data from these tests to write reports for the various foreign agencies. The alternative would be to have each agency run a complete set of tests."

Stafford noted that almost all of Foxboro's I/A field products must be certified for use in hazardous locations where safety is paramount. The company designs its I/A products using internationally-recognized protection principles such as Intrinsic Safety (Ex ia & ib), Explosionproof (Ex d), and Nonincendive (Ex n). New Foxboro products will likely take advantage of the new zone classification system in North America by using the Increased Safety (AEx e) and other new types of protection.

Weidmüller U.K.

The German-based Weidmüller Interface GmbH and Company is one of the world's leading suppliers of terminal blocks, printed circuit board terminals and connectors, electronic interface modules and related products. Weidmüller has about 3,500 employees worldwide, with a presence in 75 countries.

At Weidmüller's United Kingdom facility in Kent, England, David Conquer is the company's international marketing manager and "point man" on international standards and interlaboratory agreements.

"I've changed the way we approach certifications and approvals over the last 15 months or so," Conquer explains. "We used to first go directly to BASEEFA, our local testing house here in the U.K. We would get their certification mark for the European Community countries, and then we'd go to Factory Mutual Research for an Approval, followed by CSA (Canadian Standards Association)."

> "The time lag for CSA to even pick up a project can be 20 weeks. When we go through Factory Mutual Research, that time gets cut down to 6-8 weeks."

"Now, we use Factory Mutual Research for all our North American Approvals," Conquer says. "Their interlaboratory agreement with CSA is very good. The ease of communication between them and CSA has a lot to do with them being in the same time zone and speaking the same language. It's much faster to go through Factory Mutual Research for CSA certification. The time lag for CSA to even pick up a project can be 20 weeks. When we go through Factory Mutual Research, that time gets cut down to 6-8 weeks. For Europe, we still go directly to BASEEFA ourselves, and we submit to Factory Mutual Research simultaneously to save time and to allow the testing agencies to work out any anomalies concurrently. It's easy for us to submit to BASEEFA since they're right here."

According to Conquer and Honeywell's Rich Allen, the Australian market has been a tough one to deal with due to lengthy laboratory backlogs and the difference in time zones. "Australia has been a bit of a disaster in terms of certifications," Conquer notes. "They seem to be following a different song sheet when it comes to standards. In some areas they are following some old British standards. It's not really anyone's fault in particular, just the interpretation of the existing published standards. The sooner we get on with the IEC and start singing from the same hymn sheet, the better. That level of standardization would free our local Weidmüller representatives from having to answer technical queries, which they have to pass back to our U.K. office anyway."

According to Allen, the 14-hour average time difference between the United States and Australia makes voice communications difficult. "We have tried to go direct to Australian labs in the past by using our local Australian sales representatives as go-betweens," Allen explains. "It didn't make any difference. The backlog at Australian labs was just too great. It's actually faster to have Factory Mutual Research do the testing and write a report for the Australian laboratory with which they have an interlaboratory agreement. Taking that route probably reduces the turnaround time for Australian certification by 50 percent or so."

Interlaboratory agreements not only help manufacturers accelerate time-to-market, they also facilitate global standards harmonization. "The fundamental basis for our agreements with other labs is the technical exchange it fosters," says Rennie. "Two groups—two labs—with like interests reach an understanding and work together. Everyone benefits."

To Learn More...

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Factory Mutual Research
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email: roger.lutfy@fmglobal.com

A World of Change—Making Sense of International Hazardous Location Standards

"Any company out there that is successful is constantly trying to innovate," explains Al Stafford, The Foxboro Company's principal engineer for codes and standards. "We often use Factory Mutual Research to advise us during the product development stage on how developments in international standards may impact a new product. If it's something new, we try to have them make an initial judgement. They have the contacts and knowledge to actually bounce ideas off foreign agencies to determine whether something will be accepted overseas."

"We are singularly a very strong body of knowledge on the subject of hazardous locations and the effort to achieve global standards harmonization," states John Rennie, vice president of Factory Mutual Research Approvals. One of the most important ways that Factory Mutual Research plays a role in setting standards for hazardous locations is by encouraging its engineers to serve on international and domestic standardization bodies, such as the IEC (International Electrotechnical Commission), the ISA (the international society for measurement and control), and the National Fire Protection Association (NFPA).

Rennie, for instance, serves as the U.S. technical advisor (TA) for the IEC's main technical committee (TC) on hazardous locations standards, TC 31. There are numerous subcommittees (SC) and working groups (WG) under this main committee, each studying and developing different hazardous location standards.

Factory Mutual Research is also represented on many of these IEC subcommittees and working groups. For instance, Frank McGowan, Instrumentation Section manager, is the TA for SC 31A (flameproof enclosures) and 31G (intrinsic safety). McGowan also chairs the ISA committee SP12, which coordinates and manages all of the organization's activities relating to electrical equipment used in hazardous locations.

Robert Menot, Instrumentation Section project engineer, serves on the IEC Technical Advisory Group (TAG) for SC 31L (combustible gas detection). Bill Lawrence, Electrical Section senior engineer, is a member of the IEC TAG's for TC31, SC31A, and SC31J and serves as a U.S. National Expert on WG10 (pressurization) and WG13 (increased safety). On the domestic side, Lawrence serves on the NFPA Code Making Panel (CMP) 14 for the National Electric Code®. CMP 14 is responsible for Articles 500-517 which detail the hazardous location installation requirements. Nick Ludlam, an Instrumentation Section senior engineer, serves as a U.S. National Expert on WG12 (type "n" apparatus).

The work done by Factory Mutual Research and other committee members on ISA and IEC standards committees often translates directly into Approval standards. For example, the company recently introduced two revised Approval standards addressing the hazardous location protection methods: intrinsic safety and nonincendive equipment.

Both of these draft Approval standards are currently out for comment by reviewers. While Approval Standard 3611 on Nonincendive Electrical Equipment is primarily a clarification of an earlier standard, Standard 3610 on Intrinsically Safe Apparatus addresses the use of international zone classifications in the United States. This revised Approval standard is based directly on ISA and IEC standards.

An article on the introduction of the international zone hazardous area

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classification system into the 1996 National Electric Code® (NEC®) can be found in *Approved Product News,* Volume 14, Number 3, 1998, which is available online at: http://www.fmglobal.com/education_resources/online_catalog/apn.html

Ludlam, who chairs one ISA standards subcommittee, believes that eventually the world will rely on a single intrinsic safety standard, but we're not quite there yet. "There are still significant differences between how intrinsic safety is interpreted in Europe and in the U.S.," Ludlam stresses. "For instance, when we look at simple apparatus, we at Factory Mutual Research take a much more conservative approach to it. We do not believe that simple apparatus should not include more than a single, simple component for instance a switch, or an LED. In Europe, a simple apparatus can include several components including batteries and semiconductors. That's not a simple apparatus anymore, in our view."

Confidence Building

"Factory Mutual Research is heavily involved in the IEC (International Electrotechnical Commission)," Stafford says. "The IEC standards are usually adopted word-for-word by CENELEC (European Committee for Electrotechnical Standardization). Knowing that the folks at Factory Mutual Research sit on or even head various standards committees does give you a certain level of confidence. I certainly appreciate the amount of work it takes to keep up on global developments."

According to Rich Allen, the principal engineer for product safety and approvals engineering in Honeywell's Industrial Automation & Control division, "In order to operate as an international authority, Factory Mutual Research has to participate on these international standards groups.

"I sit on several ISA subcommittees in the U.S. along with representatives from Factory Mutual Research. I can tell you that the input we get from Factory Mutual Research as a result of their work with international standards groups like the IEC has been invaluable. You need that. As a manufacturer, the same is true. Factory Mutual Research acts as a consultant to us, advising us on what's coming down the pike in the area of international standards."

Factory Mutual Research's Frank McGowan is careful to point out that the standards development and refinement process takes patience. "It's important to recognize that this process takes years and years. We worked on zone classification standards in ISA subcommittees for at least four years. Our standards on gas detectors took 12 years to put into place."

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Factory Mutual Research participates with testing laboratories on almost every continent of the world. The number of signed agreements continues to grow; here is a current list of international laboratories with whom Factory Mutual Research has reciprocal agreements.

TESTING LAB	TYPE OF EQUIPMENT		TESTED TO	CONTACT
Canadian Standards Association (CSA International) CANADA	Intrinsically safe Intrinsically safe, Ex i Explosion proof Non-incendive Purged and pressurized Encapsulated, Ex m	Flameproof, Ex d Type n, Ex nA, nC, nR Increased safety, Ex e Pressurized, Ex p Oil immersed, Ex o Powder filled, Ex q	CSA standards	Frank McGowan (781) 255-4840
Centro de Pesquisas de Energia Elétrica (CEPEL) BRAZIL	Intrinsically safe, Ex i Flameproof, Ex d Type n, Ex nA, nC, nR Pressurized, Ex p	Increased safety, Ex e Encapsulated, Ex m Oil immersed, Ex o Powder filled, Ex q	IEC standards	Frank McGowan (781) 255-4840
China National Quality Supervision and Test Center of Explosion Protected Electrical Products (CQSTEx) CHINA	Flameproof, Ex d Encapsulated, Ex m Pressurized, Ex p Intrinsically safe, Ex i	Type n, Ex nA, nC, nR Increased safety, Ex e Oil immersed, Ex o Powder filled, Ex q	Chinese standards	Roger Lufty (781) 255-4820
Deutsche Montan Technologie (BVS/DMT) GERMANY	Intrinsically safe, EEx i Encapsulated, EEx m Pressurized, EEx p Flameproof, EEx d	Type n, EEx nA, nC, nR Increased safety, EExe Oil immersed, EEx o Powder filled, EEx q	European norms	Frank McGowan (781) 255-4840
Electrical Equipment Certification Services (EECS/BASEEFA/MECS) UNITED KINGDOM	Intrinsically safe, EEx i Flameproof, EEx d Pressurized, EEx p Encapsulated, EEx m	Type n, EEx N, nA, nC, nR Increased safety, EEx e Oil immersed, EEx o Powder filled, EEx q	European norms	Frank McGowan (781) 255-4840
Hurricane Engineering & Testing Inc. (HETI) UNITED STATES	Fenestrations		Impact resistance testing for windblown debris	George Smith (781) 255-4870
Institut National de l'Environnement Industriel et des Risques (INERIS) FRANCE	Flameproof, EEx d Pressurized, EEx p Encapsulated, EEx m Intrinsically safe, EEx i	Type n, EEx nA, nC, nR Increased safety, EEx e Oil immersed, EEx o Powder filled, EEx q	European standards	Frank McGowan (781) 255-4840
Intertek Testing Services NA Inc. (ITS) UNITED STATES	Fenestrations		Impact resistance testing for windblown debris	George Smith (781) 255-4870
KEMA Registered Quality Nederland BV (KEMA) NETHERLANDS	Flameproof, EEx d Encapsulated, EEx m Pressurized, EEx p Intrinsically safe, EEx i	Type n, EEx nA, nC, nR Increased safety, EEx e Oil immersed, EEx o Powder filled, EEx q	European norms	Frank McGowan (781) 255-4840
Laboratoire Central des Industries Electriques (LCIE) FRANCE	Flameproof, EEx d Pressurized, EEx p Encapsulated, EEx m Powder filled, EEx q	Type n, EEx nA, nC, nR Increased safety, EEx e Oil immersed, EEx o	European standards	Frank McGowan (781) 255-4840
Le Centre National de Prevention et de Protection (CNPP) FRANCE	Fire and intrusion detection, alarm signaling, manual and automatic extinguishing systems		Standards acceptable to both labs and/or EN54	Bob Elliott (781) 255-4832
Norges Elektriske Materiellkontroll (NEMKO) NORWAY	Flameproof, EEx d Encapsulated, EEx m Pressurized, EEx p Intrinsically safe, EEx i	Type n, EEx nA, nC, nR Increased safety, EEx e Oil immersed, EEx o Powder filled, EEx q	EN 50 014 through 50 020; IEC 79-15	Frank McGowan (781) 255-4840
Physikalisch-Technische Bundesanstalt (PTB) GERMANY	Flameproof, EEx d Encapsulated, EEx m Pressurized, EEx p Intrinsically safe, EEx i	Type n, Ex nA, nC, nR Increased safety, EEx e Oil immersed, EEx o Powder filled, Ex q	European norms	Frank McGowan (781) 255-4840
Quest Engineering Solutions UNITED STATES	Electrical Equipment that must comply with specific EMC limits		FCC Part 15, Subpart J and all standards to conform to EU directives	Tony Nikolassy (781) 255-4819
Safety in Mines Testing and Research Station (SIMTARS) AUSTRALIA	Flameproof, Ex d Encapsulated, Ex m Pressurized, Ex p Intrinsically safe, Ex i	Type n, Ex nA, nC, nR Increased safety, Ex e Oil immersed, Ex o Powder filled, Ex q	Australian standards	Frank McGowan (781) 255-4840
Scientific Services Laboratory (SSL) AUSTRALIA	Sprinkler heads, sprinkler alarm valves, sprinkler pipe hangers, sprinkler pipe couplings	and fittings, water flow switches, carbon dioxide (low pressure) systems	Australian standards	Bob Martell (781) 255-4850
Shanghai Institute of Process Automation (NEPSI/SIPAI) CHINA	Flameproof, Ex d Type n, Ex nA, nC, nR Increased safety, Ex e	Intrinsically safe, Ex i Pressurized, Ex p	Chinese standards	Frank McGowan (781) 255-4840
Sira Certification Service (SCS) UNITED KINGDOM	Flameproof, EEx d Encapsulated, EEx m Pressurized, EEx p Intrinsically safe, EEx i	Type n, EEx N, nA, nC, nR Increased safety, EEx e Oil immersed, EEx o Powder filled, EEx q	European norms	Frank McGowan (781) 255-4840
Swedish National Testing Institute (SP) SWEDEN	Building materials		UBC 17-5, 14-2 ISO 9705 room tests	George Smith (781) 255-4870
TestSafe Australia (formerly LOSC) AUSTRALIA	Flameproof, Ex d Encapsulated, Ex m Pressurized, Ex p Intrinsically safe, Ex i	Type n, Ex nA, nC, nR Increased safety, Ex e Oil immersed, Ex o Powder filled, Ex q	Australian standards	Frank McGowan (781) 255-4840
TÜV Product Service GERMANY	Safety system components PLCs and sensors		Functional safety assessment and certification to ANSI/ISA S84.01 and IEC 61508	Paris Stavrianidis (781) 255-4983
Underwriters Laboratories Inc. (UL) UNITED STATES	ISO 9000 co-registration		ISO 9000 standards	John Hill (781) 255-4972
Verband der Sachversicherer (VdS Schadenverhutung) GERMANY	Pipe hangers, couplings, right-angle gear drives,	ESFR sprinklers	European norms	Roger Allard (401) 567-0590
Vouching Technical Inspection Ltd. (VTI) CHINA	ISO 9000 co-registration		ISO 9000 standards	John Hill (781) 255-4972

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Do you have a safety system based on electric, electronic or programmable electronic (E/E/PE) technology? If so, you may be subject to the standards IEC 61508, or ANSI/ISA S84.01.

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ANSI/ISA S84.01, "Application of Safety Instrumented Systems for the Process Industries" and IEC 61508, "Functional Safety of E/E/PE Safety Related Systems" are performance-based standards that consider the entire safety life cycle of the industrial process. Factory Mutual Research participated in the development of these standards and is in an excellent position to provide third-party testing and certification for safety system components and specific industrial applications.

If you have questions about how the Reliability Certification Program can help you, please contact Factory Mutual Research.

Call Paris Stavrianidis at (781) 255-4983, or write to:

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