A COMPARATIVE REVIEW OF NEC VERSUS IEC CONCEPTS AND PRACTICES

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Abstract: New Article 505 of the 1996 National Electrical Code ©[NEC] introduces a concept of Zone electrical area classification similar to that of the International Electrotechnical Commission's [IEC] Standard 79-10 [79-10] . This tutorial paper comparatively reviews the most common electrical installation concepts and practices in classified locations as defined by NEC Divisions and IEC Zones. In addition, it makes a comparative review of sections in Articles 500 and 501 to show that the concepts of Zone classified installations were already recognized in earlier editions of the NEC for locations classified by Division.

Introduction

Article 505 of the 1996 National Electrical Code © [NEC] is the first concrete introduction of the International Electrotechnical Commission's (IEC) Zone concept of electrical area classification and classified location installations in the NEC. That Article along with several minor additions to Articles 500 and 501 are the basis for recognizing a method of electrical area classification and installation practices that are different from those historically used in the United States. These new practices are actually an "Americanized" hybrid of IEC concepts that have been adjusted to make them more familiar and acceptable to the U.S. market.

This paper is a comparative review of many NEC versus IEC practices and concepts; however it is not exhaustive. It cannot be. Since the IEC is an international body it's standards can only be enforced through local, regional or national adoption. There is also some degree of latitude given to the enforcing jurisdictions to modify the IEC standards during their adoption. This paper generally reflects the CENELEC implementation of IEC standards. CENELEC is the European Economic Community's (EEC) clearing house for unifying electrical standards among the member nations. Although the IEC is the universally accepted CENELEC base standard, the individual member nations must enact legislation to adopt the standards and may have minor variations in them. This paper also reflects experience of IEC classified location applications in Eastern Europe, Africa, and the Indian sub-continent. It should not be too surprising that there are variations in practice among the various IEC jurisdictions just as NEC regional practices vary in the United States. Nevertheless, most IEC conceptual applications are broadly consistent across the jurisdictions even as NEC concepts are in the United States. Some of the general statements made in this paper are certainly debatable since there are, of course, exceptions. A few are significant but most are minor. The authors still believe the generalizations to be accurate for the tutorial purposes of this paper. The most significant exceptions tend to be where generalizations are made about cultural or legal practices.

However, since the laws of physics and chemistry are the same in all jurisdictions there are many similarities between the IEC and NEC concepts and practices. In order to both appreciate the differences and to show that IEC practices are not too alien for those familiar with the NEC, the authors have also found it useful, for tutorial purposes, to review some of the similarities.

This paper is divided into four major sections. The first directly compares the similarities and differences between NEC and IEC practices in classified locations. It is fairly broad and goes beyond the review of enclosure types or area classification techniques and definitions that have been competently discussed in other papers. Those topics are only briefly discussed in this paper for review purposes. Occasionally there may be minor differences in the "similarities"; for example, both systems require "T" ratings for equipment, but the NEC has more sub-divisions than the IEC. Conversely, what is called a "difference" may still have points of similarity. A wiring method (rigid metal conduit for example) may be available to both systems but is much more common in one system than the other. For the purpose of this paper, "system" refers to the set of self-consistent concepts and installation practices that allow the appropriate application, investigation, design, operation, and equipment and material selection to an identified classified location.

The second section reviews methods of protection that are often considered to be IEC but have historical precedence in the NEC. It is an assertion of this paper that virtually every method of protection commonly used in IEC installations is already recognized in the NEC.

The third section reviews methods of protection that would appear to be unique to the IEC. It includes a discussion of the potential safety and economical consequences of introducing them to the U.S. market.

The final section deals with the current status of Article 505 as the NEC is preparing for the 1999 revision. It considers the potential of unification of the two systems as the U.S. becomes more familiar with the application of Article 505. It also discusses the status of the International Society for Measurement and Control's (ISA) and Underwriters Laboratories' (UL) independent development of standards for listing or labeling of equipment designed for use in locations classified under Article 505.

NEC versus IEC Classified Location Comparisons

Unless otherwise indicated, discussion of NEC concepts and practices in this section generally refer to the U.S. domestic application of Articles 500 and especially 501. Likewise IEC discussion generally refers to CENELEC application of Standard 79-10.

The principal approach of this section is to compare the fundamental more rigorously than the apparent. For example, the NEC lists the ignitable gas and vapor Groups in alphabetical order, Group A being the most volatile. The IEC lists the Groups in inverse alphabetical order, Group A being the *least* volatile. This is an apparent difference only since both systems recognize various levels of volatility and it would not affect the ultimate installation. However, a fundamental difference is that the NEC recognizes four Groups and the IEC only three. Here there is a potential that an ignitable gas or vapor would be associated with a different volatility collection (Group) from one system to the other. A prime example: hydrogen is considered to be in the second most volatile group by the NEC, but in the most volatile group by the IEC. Since the level of volatility of the gas or vapor involved is essential in selecting the appropriate material and equipment for a classified location, the placement of a gas of vapor in a specific group has the potential of changing the installation. The apparent differences then are discussed only as they amplify or clarify the fundamental.

Occasionally it is useful to state the obvious in order to clarify the subtle. The NEC and IEC systems recognize that certain locations need additional attention to electrical installations that have the potential to ignite various mixtures of gases and vapors. However the two systems diverge in determining the "what, where, when, why and how" of classified area installations. In fact, even the "who" of classified area construction has some subtle differences

Area Classifications

Similarities

Type and Degrees of Hazard

Both systems recognize that ignitable mixtures of gases and vapors are incompatible with the arcs, sparks, and high surface temperatures associated with some electrical equipment. They also agree that the degree of hazard is not a fixed value. The degree of hazard is a function of the frequency of the presence of the ignitable gas or vapor. That is, the more often the ignitable gas or vapor is present the greater the degree of hazard and the more rigorous the electrical installation indicated for a classified location.. The NEC calls the type of hazard for gases and vapors "Class I", the IEC calls it "Class II". This is an insignificant difference. Before the 1996 NEC the degrees of hazard for the NEC and IEC were called "Divisions" and "Zones" respectively. Article 505 of the 1996 NEC has adopted a "Zone" system similar to the IEC. In all cases the greater hazard is indicated by the lower designation number; that is Division 1 is the most hazardous division and Zone 0 is the most hazardous zone. While the difference in the names of the designations is not fundamentally significant, it is important to use them properly to clarify which NEC Article applies.

Grouping of Gases and Vapors

Both systems recognize that some gases and vapors are more volatile than others and the explosion pressures created and Maximum Experimental Safe Gaps (MESG) can vary greatly. This principally affects equipment that is designed to contain an internal explosion.

"T" ratings

Some equipment specifically designed to be installed in classified locations are evaluated to determine the maximum operating temperature they will reach under specified ambient temperatures. This maximum operating temperature is required to be indicated on the equipment. Both systems allow using an identification number rather than the actual temperature measured. This identification number, often called the "T" rating, indicates a maximum range of temperature. The basic "T" rating ranges of both systems are identical; however the NEC subdivides several of the ranges.

Ventilation

Whether it is natural or forced both systems recognize that ventilation may affect the classification of an area.

External Standards

While both NEC Article 500 and IEC 79-10 define various terms they give only the most primitive electrical area classification guidance. Except in limited applications, such as NEC Article 514 for service stations, a location's electrical area classification cannot be fully determined by direct application of the NEC. Some external standard such as API RP-500 or ISA 12-24 must usually be consulted to actually determine an area's classification. The appendices of IEC Standard 79-10 give substantially more information than the NEC. They may often be adequate to classify a simple installation; however, the appendices are "informative", namely, they are like Fine Print Notes in the NEC, they are not an enforceable part of the standard. It is common practice in IEC jurisdictions to use an auxiliary standard, such as the British Institute of Petroleum's IP-15 [IP-15] as the actual analysis document.

Differences

Degrees of Hazard: Two Divisions—Three Zones

One of the most obvious and significant differences in the two systems is the number of degrees of hazard recognized. The NEC uses two Divisions, the IEC three Zones. The correlation of the two systems is not clear-cut. Often, Division 2 and Zone 2 are directly equated and Division 1 is equated to the combination of Zones 0 and 1. The model commonly used for this correlation is shown as **Figure 1.** It is a good first start but it is not entirely accurate and can be misleading.

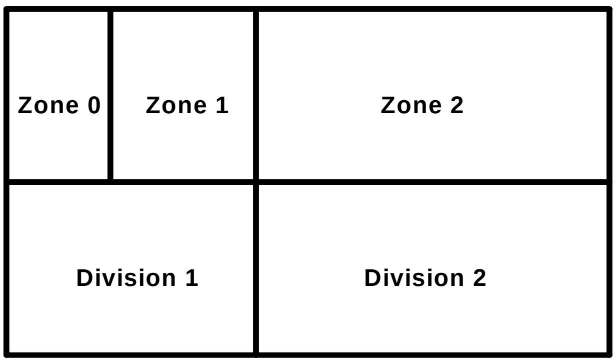

FIGURE 1. The common model for NEC / IEC comparisons

A simple comparison of the same location classified by both API RP-500 and IP-15 would indicate a significant potential overlap of Division 2 and Zone 1. This is indicated by a more accurate model for comparison of the degrees of hazard as shown in **Figure 2.**

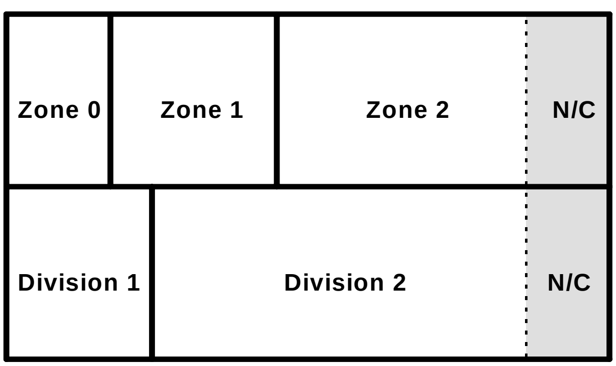

FIGURE 2. A model for comparing Divisions and Zones by area classification practice.

The second model indicates that a location classified as Zone 0 by IEC would definitely be classified as Division 1 and Division 1 locations could be classified as either Zone 0 or Zone 1 as the "common model" indicates; however, a location classified as Zone 1 could very likely be classified as Division 2. In addition, at the low end is a "gray area." A location classified as Zone 2 by the IEC system my be non-classified by the NEC. The reverse is also true. This is largely due to the "shape and size" of the appropriate hazard radius each system uses, but may also reflect the evaluation of the equipment involved.

Method of Protection	Zone 0	Zone 1	Zone 2	Division 1	Division 2
ia	x	x	x	x	x
ib		x	x	x	x
d		x	x	x	x
p		x	x	x	x
e		x	x		?
s		x	x		?
m		x	x		x
o			x		x
q			x		x
n			x		?
GP					Some Allowed

FIGURE 3. A model for comparing Divisions and Zones by acceptable installation practice.

The Third model (**Figure 3**) compares the various area classification designations with installation practices that are acceptable in them. Again from the model it can be seen that Division 1 more closely, but not exactly, equates to Zone 0 with some Zone 1. On the other hand, Division 2 generally encompasses most of Zones 1 and 2. This also is not exact since, as shown on the model, certain installations acceptable in Division 2 are not acceptable in either Zones 1 or 2. The next two major sections "IEC Concepts Already in Articles 500 and 501" and "New Concepts" more fully develop these comparisons and rationalize their application in the U.S. domestic market.

Four Versus Three Volatility Groups

The NEC recognizes Four volatility groups, The IEC system only three. Acetylene and Hydrogen, Groups A and B respectively in the NEC system, comprise a single Group IIC in the IEC. The other two groups generally correspond directly to each other. IEC Group IIA corresponds to NEC Group D and IEC Group IIB to NEC Group C. It should be noted that there are some "mavericks." Because IEC test methods for gases and vapors differ slightly from the UL methods, some of the border line gases and vapors will be classified differently in the two systems. NOTE: There is a potential problem with NEC Article 505 here. Section 505-20(b) states:

> Zone 1. In Class I, Zone 1 locations, only equipment specifically listed and marked as suitable for the location shall be permitted.
>
> *Exception: Equipment approved for use in Class I, Division 1 or Class I, Zone 0 locations of the same gas group and with similar temperature marking, if any, shall be permitted.*

A similar rule, and exception, is made about Zone 2 in Section 505-20(c). Since the gas groups are not entirely identical there may be some minor application problems.

Group IIB plus Hydrogen

Another interesting feature somewhat unique to IEC practice is the occasional inclusion of hydrogen in a volatility group lower than its principal grouping. In general, IEC considers hydrogen and acetylene to be in a common volatility group. However, the manufacturing construction tolerances for acetylene enclosures are so severe that applying them to equipment not intended to actually be installed in an acetylene environment is generally cost prohibitive. IEC recognizes a hybrid manufacturing standard that allows some products to be labeled for "Group IIB plus hydrogen." This classification is most commonly used for motors, but there are other applications.

Definitions—Possible Versus Probable

It is critically important to understand this fundamental difference in the two systems. It is necessary to compare the definitions of Divisions and Zones in the root documents to fully appreciate that the NEC system defines Divisions in terms of possibility and the IEC system defines them in terms of probability.

Section 500-5(a) of the NEC defines Division 1 as a location:

> ... (1) in which ignitible concentrations of flammable gases or vapors ***can*** exist under normal operating conditions; or (2) in which ignitible concentrations of such gases or vapors ***may*** exist frequently because of repair or maintenance operations or because of leakage; or (3) in which breakdown or faulty operation of equipment or processes ***might*** release ignitible concentrations of flammable gases or vapors, and ***might*** also cause simultaneous failure of electric equipment. [***Emphasis*** added]

Likewise Division 2 is defined in Section 500-5(b) as a location:

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

IEC Standard 79-10 defines Zone 0 as:

> An area in which an explosive gas atmosphere ***is present*** continuously or for long periods. [***Emphasis*** added]

Zone 1 is:

> An area in which an explosive atmosphere ***is likely*** to occur in normal operation. [***Emphasis*** added]

Zone 2 is:

> An area in which an explosive atmosphere ***is not likely*** to occur in normal operation and, if it does occur, ***is likely*** to do so only infrequently and will exist for a short period only. [***Emphasis*** added]

It is clear from the delimiting terms that Divisions are defined by the possibility of a hazard existing and Zones are defined by its probability. NOTE: NEC Article 505 is a synthesis of the two systems and mixes the delimiting terms.

Most local practices consider "likely" and "unlikely" to be too imprecise. The following quote from the British Institute of Petroleum's IP-15 Section 1.5.5.2 indicates that, in at least one IEC/CENELEC culture, area classification is analyzed on a statistical probability basis:

> ... as a rule-of-thumb guide and for continuously operated plant [sic] it has been recommended that a release should be regarded as *continuous* if it is likely to be present for more than 1000 hours per year and *primary* if it is likely to be present for 10 hours or more but less than 1000 hours. A release likely to be present for less than 10 hours per year and for short periods only should be regarded as *secondary.*

There is a strong, but not absolute, correlation between grades of release and Zones. More discussion will follow.

As another example, The Netherlands code P182: *"Classification of hazardous areas with respect to gas explosion hazard*", maintains the following relation for outdoor situations:

	rate of release (g/sec)	zone dimension (m)
small hazardous source:	max. 1	radius = 1
large hazardous source:	max. 10	radius = 7

Moreover, for closed or partially closed buildings, the zone dimensions depend of the method of ventilation.

From the experience of the authors, local practice for area classification in some other IEC cultures follows a logarithmic scale, i.e., locations expected to be hazardous more than 100 hours per year or roughly 1% of the time are considered to be Zone 0, less than 100 hours but more than 10 are Zone 1, and less than 10 hours are Zone 2. Where the likelihood of hazard is less than 1 hour per year there is some ambivalence. Some more conservative analysts will consider *any* probability to be Zone 2. This is consistent with the root definition but leads to the creating extremely large Zone 2 areas. Others take the view that a probability of less than an hour a year indicates a situation that could not be normal and must be a catastrophic event for which extraordinary measures must be taken.

Definition of "normal operation"

Another significant definition to compare is the definition of *normal operation*. IEC 79-10 Section 2.8 defines it as "The situation when the equipment is operating within its design parameters." It then adds the two following notes:

> 1 Minor releases of flammable material may be part of normal operation. For. Example, releases from seals which rely on wetting by the fluid which is being pumped are considered to be minor releases.
>
> 2 Failures(such as the breakdown of pump seals, flanges gaskets or spillages caused by accidents)

which involve urgent repair or shut-down are not considered to be part of normal operation.

There is no formal definition of *normal operation* or *normal* in the NEC, but the IEC definition would satisfy most people conducting an analysis of a classified area. However, Section 500-3(c) states: “Unless otherwise specified, normal operating conditions for motors shall be assumed to be rated full-load steady conditions”. In other words, starting a motor is not normal. This has implications that are discussed in more detail later.

Grades of Release

This topic is relatively unique to the IEC. While the concepts are not alien to U.S. domestic practice they are not formally defined in the NEC. Standard 79-10 Section 2.6 defines three grades of release “...in order of decreasing likelihood of the explosive gas atmosphere being present.” The specific definitions are:

> continuous – A release which is continuous or is expected to occur for long periods.
>
> primary – A release which can be expected to occur periodically or occasionally during normal operation.
>
> secondary – A release which is not expected to occur in normal operation and if it does occur, is likely to do so only infrequently and for short periods.

A casual review of the definition of zones would lead to the conclusion that each grade of release directly corresponds to a specific Zone. In general, this is true; however they are not synonymous. As IP 15 Section 1.5.5.4 states:

> Although *continuous*, *primary* and *secondary grade releases* will normally result in *Zones 0*, *1* and *2* respectively, this is not always true. For example, poor *ventilation* may result in a more stringent zone while, with high *ventilation*, the converse will be true.

The same IP-15 Section notes that a certain source may be, in fact, a dual grade of release . The example given is a pump seal which may be a small continuous or primary source but a large secondary source.

Lack of Required Transition Regions

The preceding subsection leads to another significant difference between NEC and IEC practice. There is no requirement for transition zones surrounding Zones 0 or 1. As shown in **Figure 4** taken from 79-10 each zone may be considered as stand alone.

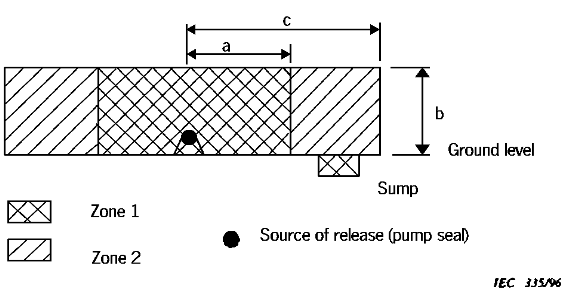

FIGURE 4. Taken from IEC 79-10 Example 2. Pg. 71 (CORRIGENDUM)

NOTE: NEC Article 505 definitely departs from this; transition zones are specifically required in Sections 505-7(b) and (c).

Application

Similarities

Equipment Selection

The principal reason for area classification is to determine the appropriate electrical equipment and methods of installation in an area. This is common to both systems.

Differences

Non-Electrical Equipment

While electrical area classification has been used for the selection of non-electrical equipment in NEC jurisdictions, the “official” documents on the subject, i.e. the NEC Article 500, NFPA 496, API RP500, etc. all specifically state that their application is exclusive to the selection of electrical equipment and installations. When non-electrical sources of ignition are identified in the NEC system they are often used as the basis for reducing or even eliminating the area classification of a location because the electrical equipment involved is not likely to be the source of ignition.

In the CENELEC system area classification is not limited to electrical installations

In Note 4 of Section 1.1, IEC 79-10 states:

> In any process plant, irrespective of size, there may be numerous sources of ignition apart from those associated with electrical apparatus. ... This standard may be used with judgment for other ignition sources.

In IEC cultures when preparing a plant area classification, the following non-electrical ignition sources are also analyzed for their impact:

- non-electrical hot surfaces ('hot' is being equal or above the auto-ignition temperature of the explosive gas/air mixture); e.g.: flanges, walls of process equipment, combustion engines, etc.

  > Note: Completion of this assessment may actually result in changes to the plant layout.

- Ionization and optical sources: e.g. radio active and laser instrumentation, photoflash light or stroboscopes.
- friction and sparks generated by equipment such as manual and electric hoists, sliding doors, elevators.
- static electricity which can generate sparks, e.g. during transport of liquid, granulate, powder or gas.

IP-15 Section 8.1, second paragraph, states:

> ... this chapter provides additional guidance for the use of the *area classification* approach to aid the location and control of non-electrical *sources of ignition*. The term 'control' should in this context be regarded as

extending to the training of personnel for safe working in such areas, including *work permit* control

The next section lists the various sources of ignition, such as fired heaters, hot work, the access of non-approved vehicles, bridge crane wheels and similar items. Area classification has also been used to determine the fire-proofing and fire rating requirements of structures.

No General Purpose in IEC

As stated in the section on the definitions of “normal operation,” motor starting is not considered normal in the NEC system but it is in the IEC. Virtually all motors have thermal switches in them to prevent over heating under stalled or locked rotor conditions -- even in Zone 2. There are no “general purpose” motors allowed in the IEC system.

In fact, with the exception of a few enclosures, there is virtually no general purpose electrical equipment at all in the IEC system. In the IEC system, terminals are considered to be potential sources of ignition and are required to have some form of design that renders them incapable of vibrating free. The design is labeled Type “Ex e” to indicate that they are appropriate in a classified location. General purpose terminals would otherwise be required to be installed in the IEC equivalent of an explosion-proof enclosure (Ex d) -- even in Zone 2. It should be noted that many terminals commonly used in U.S. domestic construction already meet this standard; however, one very common type does not - the twist-on type connector.

No 80% Temperature Limit Requirements

The “upside” of all this is that, with potential “arching, sparking and high surface temperatures” virtually eliminated in the IEC system, the full 100% “T” ratings of equipment is allowed in Zones 1 and 2. The 80% in degrees in Celsius of the “T” rating limit that is common in NEC Division 2 installations is considered unnecessary.

Labeling

Similarities

Limits of Use

Both systems use a method of labeling that indicates the limits of use of equipment relative to their application in a classified area. Common to both systems is a general requirement to note the Class, Group and ,where appropriate, the operating temperature or range (“T” rating).

Differences

Identified for Division Use Versus Methods of Protection

In most cases the Class, Group and temperature requirements noted above are all that the NEC requires on the equipment marking to identify its suitability for installation in a classified area. It is to be assumed that equipment so marked is acceptable in either Division 1 or 2. Equipment marked for Class, Group and temperature but suitable only for Division 2 must be so marked. (See Section 500-3(d) and its FPN).

The IEC approach is slightly different. In addition to the general information required the equipment must also identify the method of protection that the equipment provides. In theory it would be like requiring a marking of “explosion-proof,” “hermetically sealed,” “sand-filled” or something similar on the equipment. The IEC has a shorthand nomenclature for these methods of protection. The characters “Ex” , which indicates that the equipment is suitable for installation in a classified area, are appended with a single letter which designates the method of protection the equipment offers.

A typical CENELEC labeling example would be:

EEx ia II C T4

The first 'E' means: Certified to the CENELEC standard.

'Ex' means: Explosion protected.

'ia' means: The protection method, in this case intrinsically safe.

'II C' means: The gas group

'T 4' means: The temperature classification.

None of these markings alone indicate what Zone a piece of equipment may be used in. While it may be inferred that the “Ex” indicates acceptability in Zone 2, the user must know which methods of protection are appropriate for Zones 1 and 0. **Table 1** indicates the relationship between methods of protection and the Zones in which they are acceptable.

TABLE 1

IEC Symbol	Method of Protection	Acceptable Zone(s)
Ex i1	Intrinsically safe - 2 level	0,1,2
Ex i2	Intrinsically safe - 1 level	1,2
Ex d	Flameproof enclosure	1,2
Ex p	Pressurized enclosure	1,2
Ex e	Increased safety design	1,2
Ex s	Special Protection	1,2
Ex m	Encapsulation	1,2
Ex o	Oil Immersed	2
Ex q	Powder Filling	2
Ex n	Non-sparking design	2

NOTE: NEC Article 505 uses a modified approach of the “identified for division” marking system. For equipment manufactured to IEC standards, in addition to the general IEC marking requirements, the equipment must also be marked for the Zones in which they are appropriate. Presently the “Ex” marking is meaningless. However, a “Class I” marking does have meaning since equipment acceptable in Class I, Division 1 (which is implied by the

“Class I” marking) is acceptable in Article 505 Zones 1 and 2. (See Section 505-20 (b) and (c) *Exceptions)*

Third Party Approvals

Similarities

NRTLs/European CENELEC Equivalents

Each system has a method of authenticating that equipment is appropriate for installation in a classified area. In the NEC system a Nationally Recognized Testing Laboratory (NRTL), such as UL or FM, uses a “recognized American Safety Standard” as the basis for investigating the equipment. The CENELEC implementation of the IEC system is similar. Several recognized testing authorities, such as BASEEFA in Great Britain, PTB in Germany and LCIE in France, perform a similar function to the U.S. NRTLs using CENELEC standards

Differences

Construction Versus Performance Standards

The differences here tend to be a matter of emphasis rather than absolute. Most “recognized American Safety Standards” tend to emphasize the methods and materials of construction for equipment and then test the equipment for conformance. For example UL Standard 1203 specifies the minimum length of the flame-path across a ground surface of explosion proof equipment. The equipment is further tested to insure that it meets other anti-ignition physical requirements.

The IEC testing authorities predominately use a performance based approach. If the product meets the test performance criteria it is acceptable. Specific manufacturing requirements or equipment or materials of construction are rarely mentioned.

Inspections

Similarities

Operating Liabilities

In both systems the owner of a facility containing a classified location is responsible for providing reasonable safeguards for establishing public and employee safety. Should an accident occur whether through equipment failure, operator error, poor maintenance or improper installation, the owner holds first-line liability both civilly and criminally. Under further investigation the facilities designer (design engineer or architect), the original installer or maintainer (contractor), and the equipment manufacturer may also incur those liabilities. Occasionally a standards writing body may also be subject to civil liability. Rarely is a non-managerial or non-supervisory employee held civilly liable even for operator error.

A quotation from the *City of Los Angeles Electrical Code* indicates another important similarity:

> Neither the City of Los Angeles, nor any department, board, commission, officer or employee thereof shall be held liable or responsible for any damage or injury by or resulting from the issuance of any permit or any inspection or approval made under the provisions of this Code. [SEC 93.0315. NONRESPONSIBILITY OF CITY]

This statement is similar to the charters of governmental inspection agencies worldwide. Technically, incompetent inspection incurs no civil liability to the agency or its employees. An inspector can only be held liable if he fails to appear for an inspection or is involved with a criminal activity such as accepting a bribe.

Differences

The Authority Having Jurisdiction

The relationship of enforcement to design and installation is different in the IEC world from that of the NEC. Generally, the function of inspection is to inspect and inform rather than enforce. That is, where an inspector detects a deviation from appropriate design or installation practices, his principal role is to notify the design professional of the discrepancy. The design professional then makes the determination of the seriousness of the deficiency and may, by the use of engineering judgment, rule that the design, installation, or equipment meets the intent of the code or standard. This is because the inspecting agency carries no actual liability in the installation.

Wiring Methods

Similarities

Cable Tray

Multiconductor cables in cable tray is common in both systems for distribution of power, control, lighting and instrumentation circuits.

Differences

The most common methods in the U.S. other than cable tray is rigid metallic conduits for aboveground installations and concrete encased ductbanks for underground distribution. The ductbanks commonly use rigid metallic or non-metallic conduits.

Wiring methods common to IEC installations:

- Open conduit. The conduits are not necessarily coupled and only provide mechanical protection to multiconductor cables
- Direct buried armored cables (served wire or belted steel).
- Above ground armored cables.
- Use of cable glands.

Note: Unarmored cables are used mostly in above ground applications, but must be mechanically protected by open conduit, covered cable trays or ducts. Unarmored cables underground are only used where it is technically not possible to use armored cables, e.g. single conductor power cables

Lighting Methods

In the U.S. various forms of High Intensity Discharge (HID) lighting using fixtures specifically approved for the location is most common. In the CENELEC system fluorescent lighting is most common, mercury vapor (HID) is used for 'highbay lighting, plant street lighting and area floodlighting

IEC "Methods of Protection" concepts already recognized in the NEC

In a major rewrite of Section 500-2 the NEC introduced in sub-section (a) the term "Protection Techniques." A comparative review of this Section and a few other Code Sections will show that virtually every IEC Method of Protection is already recognized by the NEC. (See also **Figure 1B)**

Type "Ex d" - Flameproof Enclosure

This method of protection is virtually identical with Explosionproof Apparatus identified in NEC 500-2 (a)(1). The general concept is to be able to contain an internal explosion without propagating an external emission capable of igniting a surrounding ignitable atmosphere. This method of protection is acceptable in IEC Zones 1 and 2. It is not acceptable in Zone 0. The corresponding protection technique, Explosionproof Apparatus," is acceptable in all NEC Divisions and Zones 1 and 2.

Type "Ex p" - Pressurization or Continuous Dilution

This method of protection is very similar in concept with "Purged and Pressurized" identified in NEC 500-2 (a)(3). The principal is to either exclude an external explosive atmosphere from an enclosure or prevent an internal source from reaching its lower flammable limit. It is generally an accepted technique in all NEC Divisions and Zones and in IEC Zones 1 and 2.

Type "Ex i" - Intrinsic Safety

Again this is similar to "Intrinsically Safe Systems" described in NEC 500-2(a)(4) and Article 504. The general concept is that the equipment identified cannot release enough energy to ignite a surrounding atmosphere *even when the system is damaged*. The IEC recognizes two levels. One where no amount of damage or improper operation can create a possibility of ignition. This is acceptable in all IEC Zones and all NEC Divisions and Zones. The second level recognizes the energy is limited under "normal" conditions or that a single fault may occur where other appropriate safeguards are taken. This concept is similar to "Nonincendive Circuits" and "Nonincendive Component" described in NEC Sections 500-2(a)(5) and (6). The technique is acceptable in IEC Zones 1 and 2 and in NEC Division 2 (See 501-4(b) *Exception)* and Zone 2. Note: It is not clear from Article 505 whether the technique is acceptable in Zone 1 but because it is acceptable in Division 2 it is acceptable in Zone 2.

Type "Ex o" - Oil Immersion Protection

Section 500-2(a)(7) "Oil Immersion" recognizes this form of protection. Under normal conditions an arc is contained within a oil-filled chamber that prevents it from direct contact with an ignitable atmosphere. Section 501-6(b)(1)(2) is the primary application for this technique; however, the FPN to 500-2(a)(7) also refers the reader to Sections 501-3(b)(1), Exception a.; 501-5(a)(1), Exception b., 501-6(b)(1); 501-14(b)(1), Exception . The protection technique is acceptable in IEC Zone 2 and NEC Division 2 and Zone 2.

Types "Ex m" - Moulding (Encapsulation)

This method of protection has taken two forms. The common concept is to enclose an arc-making device in a material or shell that prohibits contact with an ignitable atmosphere. The most common is an epoxy filled chamber. Another common method is a "Hermetically Sealed" chamber similar to that described in NEC 500-2(a)(8). In some IEC countries hermetic sealing is referred to as method of protection type "Ex h". In any case the protection technique is acceptable in IEC Zones 1 and 2 and NEC Division 2 and Zone 2. Again it is uncertain from Article 505 if it is acceptable in NEC Zone 1.

Type "Ex q" - Powder Filling

This type of protection is not listed in NEC Section 500-2(a); however the concept is found in 501-6(b)(3) where it is used to recognize that non-expulsion type sand filled fuses are acceptable in Division 2 . The general technique is to enclose a potential arc-making device in a finely granulated material that prevents the ignition of a surrounding atmosphere. This method is limited to NEC Division 2 and Zone 2 and IEC Zone 2.

"Methods of Protection" Unique to the IEC

The following methods of protection are relatively unique to the IEC. However it should be noted that, with the exception of type "Ex e", the other methods do not have universal acceptance.

Type "Ex e" - Increased Safety

Increased safety is a rather broad concept, however it may be stated relatively simply as equipment constructions that give additional attention to preventing arcs, sparks and high temperatures during "normal" operation. This includes the concept of vibration-proof terminals, non-sparking motor fans, additional clearances in terminal blocks etc. Many products commonly used in the U.S. already give such protections but they are not required to be used. There are potential safety and economical advantages of a listed or labeled method of termination and other non-sparking equipment in Division 2. In the IEC the method is generally acceptable in Zones 1 and 2. Some authorities restrict its use to Zone 2 only.

Type "Ex n"

This type of protection is generally applied in the United Kingdom. IP-15 describes it as "A *type of protection* that in normal operation within its rated duty it will not ignite a surrounding *flammable atmosphere*, and a fault capable of ignition is unlikely to occur." It then subdivides into the following categories: Selected industrial, Non-incendive, and Restricted Breathing. "Selected industrial" is discussed in the following section and "Non-incendive has already been discussed. "Restricted breathing" has several application restrictions, however it is in fairly common use in the UK and bears discussion. It is essentially a "vapor tight" construction that prevents the ingress of an ignitable atmosphere. The method cannot be used in areas of limited natural ventilation or where gases with high diffusion rates, such as hydrogen or acetylene, are used. In any case The type of protection is generally limited to IEC Zone 2.

Type "Ex s" - Special Protection

This category is a "catch all." It applies to something that cannot be specifically categorized in any other method of protection but by test or otherwise can be shown to be safe. In theory it could apply to any Zone but generally it applies to Zones 1 and 2. Most "selected industrial" equipment fall in this category.

Where do we go from here?

Product Standards.

Many people refer to the IEC 79 Series of Standards when referring to product certification, however, products outside the United States and Canada are certified to the "EN" Standards of CENELEC. Countries outside the European Community trying to achieve international harmonization of standards are forced to looking to the International Electrotechnical Commission (IEC), since they can participate in that system and are barred from participating in the system of the European Community.

During the 1993 NEC cycle, one of the reasons used by the opponents of the Zone system in trying to prevent the adoption of that system into the NEC was that there were no ANSI Standards for the protection techniques of the IEC System. They also argued that there was no reason to work on these standards since even when the standards were completed, they would not be able to be used since the protection techniques were not recognized by the NEC.

While no other organization in the United States seemed interested in trying to develop product standards harmonized to the IEC 79 Series, the Instrument Society of America (ISA) under its SP12 Committee for Hazardous Locations, established subcommittees for all protection techniques. These subcommittees then, began the task of developing standards for the United States that are harmonized as close as practical to the IEC Standards while reflecting US practice.

About the time the ISA harmonized versions of the 79 Series were entering the ANSI Canvas phase, Underwriters Laboratories decided to develop their own version of these standards. Even though the ISA had been issued the right from ANSI to develop these standards, when UL applied to ANSI for circulation of their version of standards harmonized to the IEC Standards for canvas, ANSI let UL proceed.

There is quite a contrast to the method used by the two organizations to arrive at "harmonized" standards. The ISA has broad representation on their subcommittees, and balance on their SP12 Committee. Harmonization is achieved by balloting drafts of the proposed document, and addresses the comments received during the balloting process at open meetings. UL on the other hand used their "experts" to develop their version of the "harmonized" standard.

Both organizations subjected their version of the "harmonized" standard to the ANSI canvas procedure. There was quite a contrast though between the process used by the two organizations. The ISA version of the "harmonized" standard used a process where changes to the IEC document are represented by strike throughs, and additions are represented by underlined text. An informative Annex is provided that includes the reasons for major deviations. The UL version of the harmonized standard is UL 2279. It includes only the deviations to the IEC Standards. Participants in the UL, ANSI Canvas process received only UL 2279 without the corresponding IEC Standards. Unless these reviewers happened to have all of these IEC standards, it is not understood how they could arrive at a valid technical conclusion concerning UL 2279.

The method use by the two organizations of resolving comments and negative ballots from the ANSI process is also quite different. The ISA uses open meetings, while UL reviews the issues and responds to each participant. The unfortunate part of this process is that there are not many checks and balances in place at ANSI. For example, even though UL arrives at their conclusion about technical issues in a "closed" process, no-one arbitrates technical issues, all that is required is two thirds approval by those canvassed.

While many in the United States are trying to achieve international harmonization, this effort by UL is viewed to be counterproductive and detrimental to the efforts of the United States when trying to resolve issues in the IEC System. Many are of the opinion that it is better to have a United States harmonized standard based on broad categories of interest rather than a standard that reflects the views of one certification agency and its customers, the manufacturers. It isn't clear what the outcome of this effort will be. At this point virtually all of the ISA versions of the IEC standards are in the process of ANSI canvas and the ISA harmonized version of the standard for Increased Safety has been submitted to the IEC as a new work proposal with the IEC being the convenor of the working group.

Conclusion

It is important to remember that neither system is superior to the other; both have long and distinguished histories. There are significant differences, but most are easy to understand and none are incomprehensible. As application of Article 505 develops the similarities should, in fact, begin to outweigh the differences. For those who are already comfortable with the NEC concepts, the IEC concepts should not be difficult to use.

References

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