# Chapter – 22 Electrical Codes for Refrigeration Equipment and System



The major electrical codes which are applicable to refrigeration system are NEC and IEC for equipment and NEMA and IP for enclosures. All the electrical including motors, enclosures of starters, control panels, and control devices; electrical wirings and conduits use for refrigeration system are under the jurisdiction of these codes and all are to be designed and constructed accordingly with the code requirements. The codes cover all hazardous and non-hazardous, indoor and outdoor locations application.

## NEC Code

NEC (National Electric Code) is the highest code for electrical standard in USA. If the refrigeration system is for hazardous location, the system must be designed and constructed in accordance with the Article 500 of the NEC code.

Article 500 of the NEC Code defines the hazardous environment and degree of protection requirements by three categorizations as the following:

“Class” – This category is to define the atmospheres that the refrigeration equipment is to be located.

“Group” – This category is to define the hazardous characteristics of the atmosphere.

“Division” – This category is to define the degree of the hazardous concentration and degree of protection.

When a refrigeration system is to be designed and constructed in accordance with NEC code for hazardous application, all three categories of “Class”, “Group” and “Division” are to be indicated. An example of the description of the NEC for a hazardous application is shown in Figure 22-1. The full description for this example defines the type of atmosphere where the equipment is located; type of gas or vapor that the equipment is exposed to; type of protection is required and the maximum surface temperature for the equipment.

Further details of the definition for “Class”, “Group” and “Division” are outlined as the following:

“Class” is the hazardous atmosphere where the equipment is to be located:

Class I: Atmosphere is with gas or vapor.

Class II: Atmosphere is with combustible dusts.

Class III: Atmosphere is with flammable fibers or flyings.

"Group" is to identify various hazardous chemical substances in the atmosphere:

Group A: Acetylene.

Group B: Hydrogen or equivalent.

Group C: Ethyl ether, ethylene, cyclo-propane and etc.

Group D: Gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzyl, lacquer solvent, natural gas and etc.

Group E: Dusts of aluminum, magnesium and etc.

Group F: Dusts of carbon black, charcoal, coal or coke and etc.

Group G: Containing flour, starch or grain dust.

"Division" is to identify the probability existing of the hazardous chemical concentration and degree of protection required for the equipment.

Division I: Location in which the hazardous concentrations in the air exists continuously, intermittently or periodically under normal operating conditions or during maintenance.

Division II: Location in which the hazardous concentrations are only under abnormal or unusual conditions (breaking of a pipe, for instance)

If the industrial refrigeration system is used for hydrocarbon processing, the atmosphere shall be gas and vapor and the gases exposed are hydrocarbon gases; therefore, the installation area is "Class I" and the chemical exposure is "Group D". The degree of protection of either "Division I" or "Division II" shall be determined by the process engineer of the user.

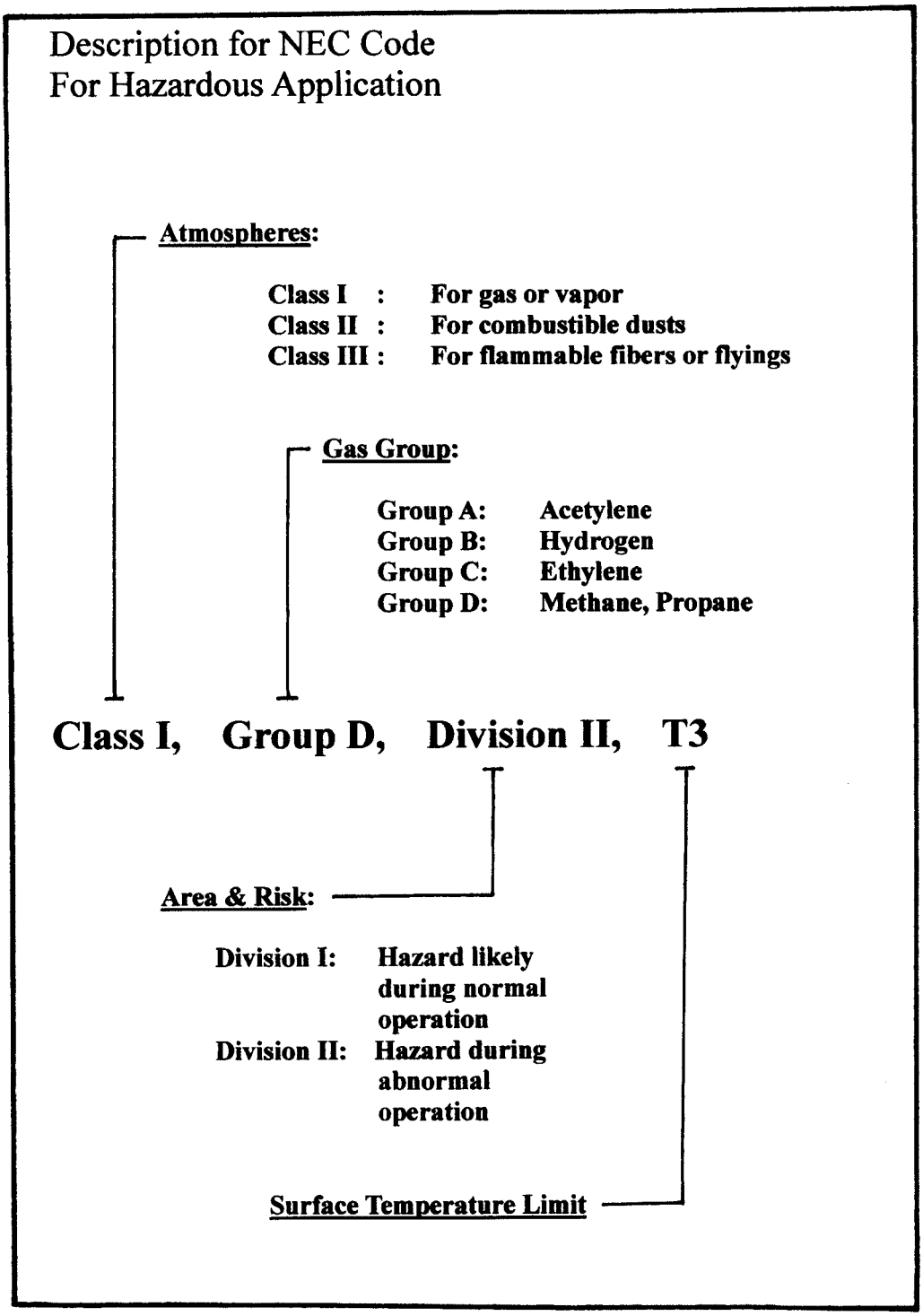


Figure 22-1 Expression for NEC for Hazardous Application

Beside of Class, Group and Division, NEC also defines the maximum surface operating temperature. The temperature identification numbers list by NEC 500-2(b) are as the following:

Table 22.1 Maximum Temperature

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

## IEC Code

IEC (International Electric Code) is used by European countries. Some countries in Asia Pacific are having electric code closely resembling to IEC code. Similar to NEC code, the IEC code also have hazardous identification in three categories. An example of the description for hazardous application expression for the IEC code is shown in Figure 22-2.

The symbols denote the type of protection or enclosure is (Ex)e, (Ex)d, (Ex)f and (Ex)i as indicated. The degree of protection is outlined as the following:

(Ex)e – This refers to Increased Safety Design. This type of enclosure is used for all items of electrical equipment which do not produce sparks in normal operation.

(Ex)d – This refers to Flameproof Enclosure. All the parts of the item of electrical equipment where igniting arcs or sparks may be produced are housed in a flameproof enclosure. The sealing faces, cable entries, shaft glands, etc., are made with comparatively large gap length and limited gap clearances to prevent the transmission of flames or particles which might ignite the surrounding explosive atmosphere. During operation, explosive gas-air mixtures penetrate only seldom into the interior of the enclosure. Should an internal explosion occur, however, it is prevented from spreading to the mixture in the ambient atmosphere.

(Ex)p – This refers to Pressurized Enclosure. Those parts of the item of electrical equipment which may become a source of explosion, or the unit itself, are artificially ventilated with fresh air or and inert gas to produce a pressure above atmospheric inside the enclosure, thus preventing any explosive mixtures contained in the surrounding atmosphere from reaching the parts which may become the source of an explosion.

(Ex)i – This refers to Intrinsically Safe Construction. Generation of electric arcs (and of unduly high temperatures) which may ignite an explosive mixture is prevented by appropriately limiting the current and voltage as a function of inductance, capacitance and resistance. The power rating of the circuit is smaller than the minimum ignition power of 20 $\mu$ Ws.

IEC code lists the classification of hazardous areas into three zones according to the degree of hazard as the following:

Zone 0 – That is a zone in which an explosive gas and air mixture is continuously present or present for long periods.

Zone 1 – That is a zone in which an explosive gas and air mixture is likely to occur in normal operation.

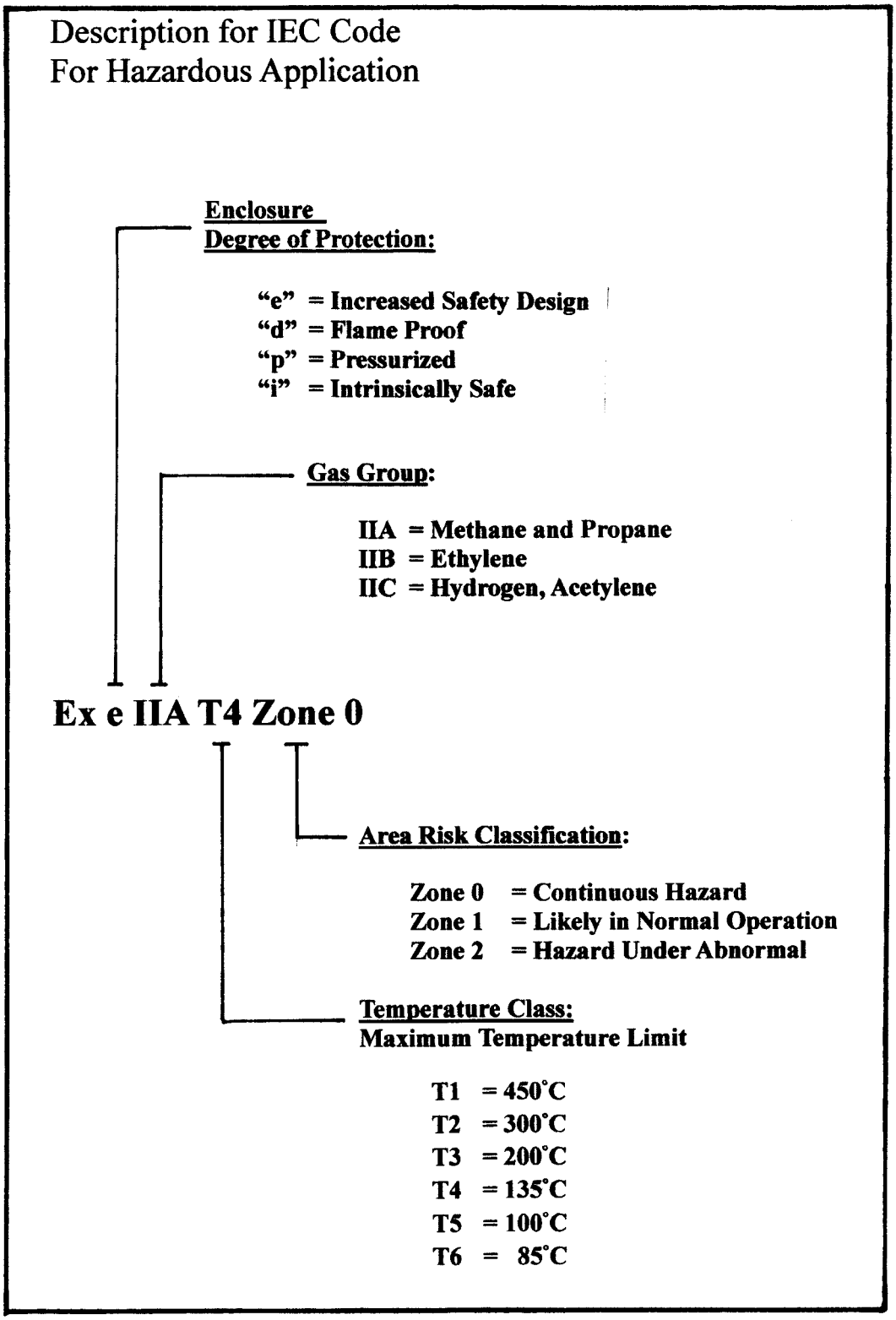


Figure 22-2 Expression for IEC for Hazardous Application

Zone 2 – That is a zone in which an explosive gas and air mixture is not likely to occur, and if it occurs it will only exist for a short time.

Temperature Classification under IEC

There are six temperature classes for the grouping of gases relative to ignition temperature and for designing the maximum surface temperature for electrical equipment for use in hazardous area under IEC as shown in Table 22-2.

Table 22.2 Maximum Temperature Class (IEC)

| Temperature Class | Maximum Surface Temperature |
|---|---|
| T1 | 450˚C |
| T2 | 300˚C |
| T3 | 200˚C |
| T4 | 135˚C |
| T5 | 100˚C |
| T6 | 85˚C |

## Classification Equivalent between IEC and NEC

The grouping of gases under IEC is similar but not identical to NEC. Although there are exceptions, the following comparisons are generally applied:

Table 22.3 Classification of Gases

| IEC Code | NEC Code |
|---|---|
| Group IIA | Group D |
| Group IIB | Group C |
| Group IIC | Group B |

The area classification, enclosure and degree of protection for IEC and NEC equivalent are as the following:

Table 22.4 Area and Enclosure

| IEC Code | NEC Code |
|---|---|
| Group II, Zone 0 | Class I, Division 1 |
| Group II, Zone 1 | Class I, Division 1 |
| Group II, Zone 2 | Class I, Division 2 |

### Electrical Codes for Enclosures & Control Devices

### NEMA Code

All enclosures of electrical apparatus should be designed and constructed in accordance with the NEC or NEMA (National Electrical Manufacturers Association)

whichever is applicable or specified for the area of applications either hazardous or non-hazardous as defined by NEMA or NEC. Various enclosures which are classified by NEMA are outlined as the following:

**NEMA-1** General Purpose

A general purpose enclosure is intended primarily to prevent accidental contact with the enclosed apparatus. It is suitable for general purpose applications indoors where it is not exposed to unusual service conditions.

**NEMA-2** Drip-Tight

A drip-tight enclosure is intended primarily to prevent accidental contact with the enclosed apparatus and, in addition, is so constructed as to exclude falling moistures or dirt.

**NEMA-3** Weatherproof (Weather-Resistant)

A weatherproof enclosure is intended to provide suitable protection against specified weather hazards. It is suitable for use outdoors.

**NEMA-3R** Rain-Tight

A rain-tight enclosure is intended primarily to meet the requirements for rain-tight apparatus. It is suitable for general applications outdoors where sleet-proof construction is not required.

**NEMA-4** Water-Tight

A watertight enclosure is designed to exclude water applied in the form of hose stream. It is suitable for application where the apparatus may be subjected to a stream of water during cleaning operations.

**NEMA-5** Dust-Tight

A dust-tight enclosure is so constructed as to exclude dust.

**NEMA-6** Submersible

A submersible enclosure is intended to permit the enclosed apparatus to operate successfully when submerged in water under specified conditions of pressure and time.

**NEMA-7** (A, B, C or D) Hazardous Location – Class I –Air Break

The enclosures are designed to meet the application requirements of Group A, B, C or D of the NEC code for Class I hazardous location which may be in effect from time to time that the circuit interruption occurs in air.

**NEMA-8** (A, B, C, or D) Hazardous Location – Class I – Oil Immersed

The enclosures are designed to meet the application requirements of the NEC code for Class I hazardous locations which may be in effect from time to time that the apparatus is immersed in coil.

**NEMA-9** (E, F or G) Hazardous Location – Class II

These enclosures are designed to meet the application requirements of the NEC code for Class II hazardous locations.

**NEMA-10** Bureau of Mines – Explosion Proof

This enclosure is designed to meet the explosion proof requirements of the U.S. Bureau of Mines. It is suitable for use in gassy coal mines.

**NEMA-11** Acid or Fume-Resistant – Oil Immersed

This enclosure provides for the immersion of the apparatus in oil such that it is suitable for application where the equipment is subject to acid or other corrosive fumes.

**NEMA-12** Industrial Use

An industrial use enclosure is designed for use in those industries where it is desired to exclude such materials as dust, line, fibers and flyings, oil seepage or coolant seepage.

**NEMA-13** Dust-Proof

A dust-proof enclosure is intended primarily to prevent accidental contact with the enclosed apparatus, and in addition, is so constructed that dust which may enter will not interfere with the operation of the apparatus. The construction of the enclosure can be defined only in relation to the apparatus and to the amount and kin of dust present.

## IP (Ingress Protection) Code

IP code is described in IEC and is generally used in Europe and some Asia Pacific countries. IP code is to define the degrees of protection of enclosures.

The expression of IP code is for example IP 21. The first characteristic numeral defines Protection against Contact and Ingress of Foreign Bodies; the second characteristic numeral defines Protection against Ingress of Liquid. The classifications for the degrees of protection of enclosures are as shown in Table 22.5.

Table 22.5 Classifications for the Degrees of Protection

| First Characteristic Numeral | Second Characteristic Numeral | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 0 | IP 00 | - | - | - | - | - | - | - | - |
| 1 | IP 10 | IP 11 | IP 12 | - | - | - | - | - | - |
| 2 | IP 20 | IP 21 | IP 22 | IP 23 | - | - | - | - | - |
| 3 | IP 30 | IP 31 | IP 32 | IP 33 | IP 34 | - | - | - | - |
| 4 | IP 40 | IP 41 | IP 42 | IP 43 | IP 44 | - | - | - | - |
| 5 | IP 50 | - | - | - | IP 54 | IP 55 | - | - | - |
| 6 | IP 60 | - | - | - | - | - | IP 66 | IP 67 | IP 68 |

The brief definition for the First Digit Numeral (Protection against Contact and Ingress of Foreign Bodies) is as the following:

( 0 ) No protection of equipment against ingress of sold foreign bodies.

( 1 ) Protection against ingress of large solid foreign bodies.

( 2 ) Protection against ingress of medium size sold foreign bodies.

( 3 ) Protection against ingress of small solid foreign bodies greater in thickness than 2.5 mm.

( 4 ) Protection against ingress of small solid foreign bodies greater in thickness than 1 mm.

( 5 ) Protection against the ingress of dust in an amount sufficient to interfere with satisfactory operation of the equipment enclosed.

( 6 ) Complete protection against ingress of dust.

The brief definition for the Second Digit Numeral (Protection against Ingress of Liquid) is as the following:

[ 0 ] No protection of equipment against ingress of sold foreign bodies.

[ 1 ] Protection against drops of condensed water.

[ 2 ] Protection against drops of liquid falling at any angle up to 15° from the vertical.

[ 3 ] Protection against drops of rain falling at any angle up to 60° from the vertical. .

[ 4 ] Protection against splashing. Liquid splashed from any direction shall have no harmful effect.

[ 5 ] Protection against water projected by a nozzle from any direction.

[ 6 ] Protection against conditions of ship’s decks.

[ 7 ] Protection against immersion in water.

[ 8 ] Protection against indefinite immersion in water.

Both NEMA and IP codes are also applicable for the design and construction of enclosures for electric motors and starters, see Chapter 23 for details.

## Purged and Pressurized Enclosures

NFPA-496 is a standard for purged and pressurized enclosures for electrical equipment if the layout of the electrical installation of the plant is so ingeniously arranged. NFPA-496 is not for the purpose of replace NEC NFPA-70, it is to provide

information for the design of purged enclosure for the purpose of eliminating or reducing within the enclosure a Class I hazardous location classification as defined in Article 500 of National Electrical Code. By this means, equipment which is not otherwise acceptable for hazardous location may be utilized in accordance with the NEC. The enclosure with type “Z” purge meets Division II classification and the type “X” purging is to reduce the classification of Division I to non-hazardous.

## Intrinsically Safe Devices

Intrinsically safe devices are allowed to be used for hazardous location for which it is approved under NEC 500-1. By definition, intrinsically safe equipment or device and its wiring are incapable, under normal or reasonably abnormal operating conditions, of igniting a specified hazardous material, or any in a group of hazardous materials. Normal operating conditions assume maximum supply voltage and environmental factors within the rated extremes given for the equipment. Abnormal operating conditions assume any two independent electrical faults occurring in combination. In other words, intrinsically safe equipment is incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most ignited concentration. Intrinsically safe electrical equipment and wiring may be installed in any hazardous location of any Group classification for which it is accepted without requiring NEMA-7 enclosure.