SCALE INSTALLATIONS IN HAZARDOUS ENVIRONMENTS

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Electronic equipment is capable of generating and releasing electrical and thermal energy during normal and abnormal operating conditions. If this energy is above the explosion causing level of the hazardous atmosphere, severe damage to equipment and personal injury can occur. For these reasons, weighing systems are oftentimes installed in “safe” environments that are costly, inconvenient and/or time consuming to use. By adhering to established standards, guidelines, and recommended practices, many weighing systems can be modified to be utilized in hazardous environments.

Systems can be designed to be intrinsically safe or repackaged in explosion proof or purged and pressurized to render them safe in hazardous environments. Installation of hazardous area equipment must be performed by certified electricians. The installation must be inspected and approved by an authority having jurisdiction over the hazardous area. The key to safe hazardous environment weighing operations is a concentrated team effort with close interaction between the scale professional, plant safety engineer, plant insurance carrier and licensed electrician.

These standards, codes and recommended practices are national in scope. Local, state, country and city agencies may enforce codes, which are more stringent. Often, insurance carriers and/or local authorities see the need to offer more stringent protection as local conditions warrant. Since local officials are more closely involved with issues surrounding their jurisdiction, they may be in a better position to determine if the national codes adequately protect equipment and lives for specific local conditions. Some of these documents have made provisions allowing specific requirements to be waived by the authority having jurisdiction, or permit alternate methods where it is assured that equivalent objectives can be achieved by establishing and maintaining safety.

Local electricians and engineers should be familiar with the national and local regulations governing their installations. The National Fire Protection Association (NFPA), Underwriters Laboratories (UL), Factory Mutual Global Technologies (FM) and the Instrument Society of America (ISA) publish guidelines for proper electrical installations.

The National Electrical Code (NEC) Handbook is a nationally accepted guide for the safe installation of electrical conductors and equipment. It is the basis for all electrical codes used in the United States. This handbook is periodically revised to reflect new information and/or available equipment. Articles 500 through 504 cover the requirements for electrical equipment and wiring for all voltages in locations where fire or explosion hazards may exist. These hazards include flammable gases or vapors, flammable liquids, combustible dust or ignitable fibers or flyings. Further information regarding fire or explosion hazards can be found on the National Fire Protection Association’s website at www.nfpa.org.

HAZARDOUS LOCATIONS

To be adequately defined, hazardous locations must be categorized as to their Class, Division and Group.

Class

Class defines the type of hazard present in the locations.

1. Class I Locations: Flammable gases or vapors are or may be present in the air in the quantities sufficient to produce explosive or ignitable mixtures.
2. Class II Locations: Combustible dust is present.
3. Class III Locations: Easily ignitable fibers or flyings are present. However, fibers or flyings are not likely to be in suspension in the area in quantities sufficient to produce ignitable mixtures.

Division

A Division defines the hazardous locations as the conditions under which the hazard exists. A Division is a subcategory of a Class. Each Class is categorized into two divisions.

Division 1

1. Exists under normal conditions
2. May exist because of repair or maintenance operations or leakage
3. Released concentration because of breakdown of equipment or process, faulty operation of equipment or of process which cause simultaneous failure of electrical equipment

Division 2

1. Liquids and gases in closed containers or systems are handled, processed, or used.
2. Concentrations normally prevented by positive mechanical ventilation
3. Adjacent to a Class I, Division 1 location

Group

A group narrows the hazardous location to the specific material or type of material present. Class I locations are categorized into Groups A, B, C and D. Group A materials provide more of an explosion hazard than Group B materials. Class II locations are categorized into Group E, F and G. Again, Group E environments are more explosive than Group G environments. Class III locations are not grouped.

- Group A: atmospheres containing acetylene
- Group B: atmospheres containing hydrogen, fuel and combustible process gases containing more than 30 percent hydrogen by volume, or gases or vapors or equivalent hazard such as butadiene, ethylene oxide, Propylene oxide, and acrolein.
- Group C: atmospheres such as cyclopropane, ethyl ether, ethylene, or gas or vapors or equivalent hazard.
- Group D: atmospheres such as acetone, ammonia, benzene, benzol, butane, gasoline, ethanol, methane, hexane, naphta, natural gas, propane or gas or vapors of equivalent hazard.

CATEGORIZATION

The best way to illustrate the categorization of locations into Class, Division and Group is to understand the applications where these hazards may exist.

Typical Class I Locations

- Petroleum refining facilities
- Dip tanks containing flammable or combustible liquids
- Dry cleaning plants
- Plants manufacturing organic coatings
- Spray finishing areas (residue must be considered)
- Petroleum dispensing areas
- Plants manufacturing or using pyroxylin-(nitro-cellulose) type and other plastics
- Locations where inhalation anesthetics are used
- Utility gas plants
- Operations involving storage and handling or liquefied petroleum and natural gas
- Aircraft hangers and fuel servicing areas

Typical Class II Locations

- Grain elevators and bulk handling facilities
- Magnesium manufacturing and storage
- Starch manufacturing and storage
- Fireworks manufacturing and storage
- Flour and feed mills
- Pulverized sugar and cocoa packaging and handling
- Coal preparation plants and handling
- Spice grinding plants and Confectionery manufacturing plants

Typical Class III Locations

- Wood-working plants
- Textile mills
- Cotton gins and cotton seed mills
- Flax-producing plants
- Figure 2 and Figure 3 on the following pages.

Zone

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

- Zone 0 (IEC): An area in which an explosive gas atmosphere is present continuously or for long periods.
- Zone 0 (NEC): A Class I, Zone 0 location is a location (1) in which ignitable concentrations of flammable gases or vapors are present continuously; or (2) in which ignitable concentrations of flammable gases or vapors are present for long periods of time. (NEC Section 505-9(a)
- Zone 1 (IEC): An area in which an explosive gas atmosphere is likely to occur in normal operation.
- Zone 1 (NEC): A Class I, Zone 1 location is a location (1) in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or (2) in which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which equipment is operated or processes are carried on of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or (4) that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided. (NEC Section 505-9(b)).
- Zone 2 (IEC): An area in which an explosive gas 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.
- Zone 2 (NEC): A Class I, Zone 2 location is a location (1) in which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and, if they do occur, will exist only for a short period; or (2) in which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors normally are confined within closed containers or closed systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as the result of abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or (3) in which ignitable concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as the result of failure or abnormal operation of the ventilation equipment; or (4) that is adjacent to a Class I, Zone 1 location, from which ignitable concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. (NEC Section 505-9(c))
- Zone 21 (IEC): An area not classified as Zone 20 in which combustible dust, as a cloud, is likely to occur during normal operation, in sufficient quantity to be capable of producing an explosible concentration of combustible dust in mixture with air. This zone can include, among others, areas in the immediate vicinity of powder filling or emptying points and areas where dust layers occur and are likely in normal operation to give rise to an explosible concentration of combustible dust in mixture with air.
- Zone 22 (IEC): An area not classified as Zone 21 in which combustible dust, as a cloud, can occur infrequently, and persist only for a short period, or in which accumulations or layers of combustible dust can give rise to an explosive concentration of combustible dust in mixture with air. This zone can include, among others, areas in the vicinity of equipment containing dust, which dust can escape from leaks and form deposits (e.g. milling rooms in which dust can escape from the mills and then settle).

Class 1
Flammable Gases or Vapors

Division 1

1. Exists under normal conditions
2. May exist because of:
   - repair operations
   - maintenance operations
   - leakage
3. Released concentration because of
   - breakdown of equipment
   - breakdown of process
   - faulty operation of equipment
   - faulty operation of process which cause simultaneous failure of electrical equipment

Division 2

1. Liquids and gases in closed containers or systems are
   - handled
   - processed
   - used
2. Concentrations normally prevented by positive mechanical ventilation
3. Adjacent to Class I, Division 1 location

Group A: atmospheres containing acetylene

Group B: atmospheres containing hydrogen, fuel and combustible process gases containing more that 30 percent hydrogen by volume, or gases or vapors of equivalent hazard such as *butadiene, **ethylene oxide, and **acrolein

Group C: atmospheres such as cyclopropane, ethel ether, ethylene, or gas or vapors of equivalent hazard.

Group D: atmospheres such as acetone, ***ammonia, benzene, benzol, butane, gasoline, ethanol, methanol, methane, hexane, naphta, natural gas, propane, or gas or vapors of equivalent hazard.

Figure 1: Class I

*Group D equipment may be used for this atmosphere if such equipment is isolated in accordance with NEC Section 501-5(a) by sealing all conduit 1/2-inch size or larger.

**Group C equipment may be used for this atmosphere if such equipment is isolated in accordance with NEC Section 501-5(a) by sealing all conduit 1/2-inch size or larger.

***For classification of areas involving ammonia atmospheres, see ANSI/ASHRAE 15, “Safety Code for Mechanical Refrigeration” and ANSI/CGA G 2.1, “Safety Requirements for the Storage and Handling of Anhydrous Ammonia.”

CLASS II
Combustible Dusts

Division 1

1. In air under normal conditions
2. Ignitable mixture produced by:
   - mechanical failure of machinery
   - mechanical failure of equipment
   - abnormal operation of equipment and provide source of ignition from:
     - simultaneous failure of electrical equipment
     - simultaneous failure of operation of protection devices
     - other causes
3. Electrically conductive dusts may be present in hazardous quantities

Division 2

1. Not normally in the air
2. Accumulations normally insufficient to interfere with normal operation of electrical equipment or other apparatus
3. In air as a result of malfunctioning:
   - handling equipment
   - processing equipment
4. Accumulations sufficient to interfere with safe dissipation of heat from electrical equipment
5. Accumulations may be ignitable by abnormal operation or failure of electrical equipment

Group E: atmospheres containing combustibles

- Metal dusts regardless of resistivity
- Other combustible dusts of similarily hazardous characteristics having resistivity of less than 100 ohm-centimeter

Group F: atmospheres containing:

- Carbon black, charcoal, coal or coal dusts which have more than 8 percent total volatile material
- These dusts sensitized so that they present an explosion hazard and having resistivity greater than 100 ohm-centimeter or less than 100,000,000 ohm-centimeter

Group G: atmospheres containing combustible dusts having resistivity of 100,000,000 ohm-centimeter or greater

Figure 2: Class II

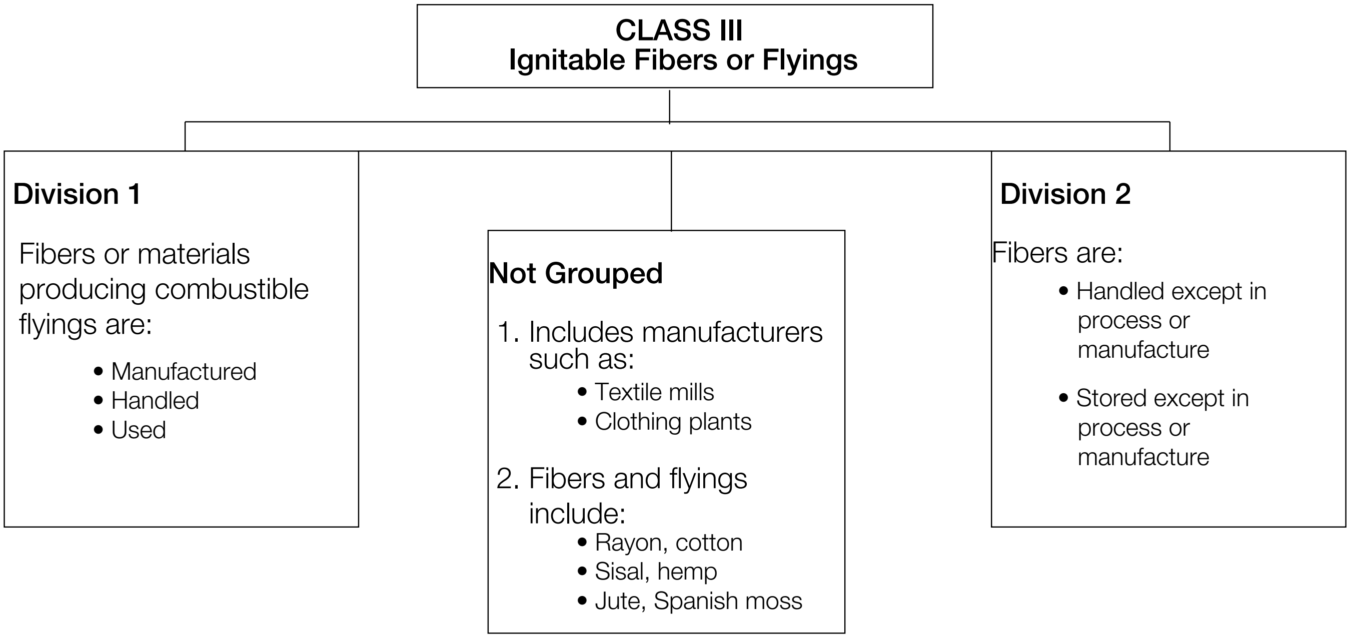

Figure 3: Class III

Let's take an example of an atmosphere containing natural gas. Since we are dealing with a gas, we can determine from the charts that the correct class is Class I, Flammable gases or vapors. We will say that the natural gas may be present in our atmosphere because of leakage. Again, referring to our charts, we see that the possibility of a flammable gas being in the atmosphere because of leakage would place our location in Division 1. Now looking further into the chart, we see the natural gas is part of Group D, to fully define our hazardous location we would say that it is a Class I, Division 1, Group D hazardous location.

Caution Just because a particular material does not appear in the preceding charts does not necessarily mean it does not pose a hazard.

Always consult the plant safety engineer, maintenance personnel or whomever the "authority having jurisdiction" is to determine the degree of hazard they need to assign to the location. It is essential that you become familiar with hazardous locations, but as the scale professional, do not put yourself in the position to make the final decision when categorizing hazardous atmospheres. The responsibility falls with the safety engineer, insurance underwriter or whoever is the authority having jurisdiction.

For a complete list noting properties of flammable liquids, gases and solids, see NFPA 497M, "Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations.

3.5 TEMPERATURE

Prior to the 1971 National Electric Code, the auto ignition temperature (AIT) of a hazardous area was part of the group classification process. Because of low ignition temperatures of some materials, they were not able to be classified. This led to the removal of ignition temperatures consideration when grouping hazardous areas. This does not mean that ignition temperatures can be ignored. In fact, they are taken into consideration as a separate, but just as important, identify from normal categorization of hazardous areas.

A system of marking equipment to identify the external surface temperature was initiated. Equipment can be used in locations where the ignition temperature is higher than the marked external surface temperature of the equipment. The system employs identification numbers to identify specific temperatures or temperature ranges. These numbers range from T1 through T6, where the maximum equipment surface temperature allowed for the hazardous location is highest for T1 identified equipment and lowest T6 equipment. Sub-identification are provided for identification are provided for identification numbers T2, T3 and T4.

The following chart provides the identification numbers and their maximum temperature ranges.

Maximum Temperature		Identification Number
° C	° F	
450	842	T2
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

NFPA 497M provides information on ignition temperatures for Class I and Class II materials. Equipment that has the ignition temperature marked on it has been tested and the operating temperature is known.

INTRINSIC SAFETY

The principle of combustion describes a minimum ignition energy that must be introduced into a specific flammable or combustible mixture before it can become a self-propagating combustion wave called an explosion. If energy less than the minimum ignition energy is supplied, the combustion wave will die out before the self-propagation process begins. That is the purpose of intrinsic safety design—to limit electrical and thermal energy to a level below that required to ignite a specific hazardous atmospheric mixture. Intrinsic safety design is applied to Class I, II, and III, Division 1 hazardous locations.

Intrinsically safe equipment and wiring must not be capable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of specific flammable or combustible atmospheric mixture in its most easily ignitable concentration.

Intrinsic safety is an energy concept. Besides voltage and current levels, other issues are considered. These include:

- Sources of spark ignition from discharge of capacitive circuits
- Interruption of inductive circuits
- Intermittent making and breaking of resistive circuits
- Hot-wire fusing is considered

Sources of thermal ignition considered include heating of small-gauge wire strands, glowing of a filament and high component surface temperatures. Voltages and current levels sent to the hazardous location are very important. For each combination of voltage and current parameters, there is a maximum value of capacitance and inductance that may be connected to the system for it to remain intrinsically safe. These values or current, voltage, capacitance and inductance that may be present in a hazardous location are shown on ignition curves. The length of the cable that is connected to these circuits affects the capacitance and inductance present in the system. Consult the manufacturer's data as to proper wire size and length when wiring intrinsically safe systems. The authority having jurisdiction over the hazardous area must be consulted to certify that the intrinsically safe system is truly safe for the environment in which it is located. This is done before the system is put into operation and after all service and maintenance actions have been completed. Requirements for intrinsically safe systems do not include evaluating risk related to mechanical sparking, electrostatic sparking, chemical action, radio waves or lightning strikes. However, protection against such events may need to be employed. There are number of ways to design intrinsically safe circuits from non-intrinsically safe circuits. It is this isolation that allows limits to be placed on energy entering a hazardous location.

Factory Mutual Global Technologies must approve all components and/or systems used in a hazardous location. This approval is referred to as FM approval. A main concern is the combination of load cells, junction boxes, scale bases and indicators. Two methods of combining devices are: entity approval and system approval.

Individual components which carry entity approval may be interconnected with other entity-approved components. The entity approval concept allows interconnection of intrinsically safe components to associated components not specifically examined in combination with each other. The criteria for interconnecting equipment is that the voltage and current which intrinsically safe apparatus can receive and remain intrinsically safe, considering faults, must be equal to or greater than the voltage and current levels which can be sent to that apparatus by the associated apparatus, considering its faults. In addition, the maximum unprotected capacitance and inductance of the intrinsically safe apparatus, including interconnecting wiring, must be equal to or less than the capacitance and inductance, which can be safely connected to the associated apparatus. If these criteria are met, the Factory Mutual entity approved combination may be connected, regardless who manufactures the individual components.

Some barriers, junction boxes, load cells, indicators and scale bases are Factory Mutual approved as a system. When these intrinsically safe components were approved for use in hazardous locations, they were tested and approved as a system and intended to be used together as a system. They are not tested as individual entities and are not approved to be used in conjunction with other components that have or have not been entity approved.

Refer to FM and UL inspection standards for further information. When installing a system, the end user and the authority having jurisdiction over the hazardous location must take the specific responsibility for the determination equipment suitability being interfaced in a specific location. The authority may be the fire marshal, plant safety engineer, insurance underwriter, owner or other agent. Electrical systems in hazardous environments require vast knowledge to design, install and maintain.

Temperature tests may be required on components likely to exceed the ignition temperature test of the gas or vapor involved. For very small components where component temperature may exceed the known ignition temperature of the gas or vapor involved, actual ignition testing is permitted. Small heated surfaces can exceed the ignition temperature without causing ignition of turbulence at the heated surface.

In the United States, the National Fire Protection Agency (NFPA) in NEC Article 504 writes the standards by which intrinsic safety is implemented. Intrinsically safe products are tested and approved or listed by Factory Mutual Research Corporation (FM) or Underwriters Laboratories Inc. (UL).

The Canadian Standards Association (CSA) is the predominant approval authority of Canada. The standards used by CSA are very similar in concept to their American counterparts, although slightly different methods are used to match a barrier to a hazardous area instrument.

There are many international standards for intrinsic safety in use throughout the world. The most important are those used for the European Committee for Electrotechnical Standardization (CENELEC). The CENELEC standards are a single set of standards agreed upon by all of the member nations of Western Europe. There are several test laboratories authorized to issue approvals of intrinsic safety equipment to the CENELEC standards. Some of the more prominent of these are: BASEEFA (Great Britain), PTB (Germany), CESI (Italy), LCIE (France), and INIEX (Belgium).

REFERENCE MATERIALS

NFPA 70 “National Electrical Code (NEC) Handbook”

NFPA 497M “Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous Locations”

NFP 325M “Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids”

ANSI/UL 913 “Standard for Intrinsically Safe Apparatus and Associated

Apparatus for use in Class I, II, and III, Division 1 Hazardous Locations”

ANSI/ISA RP 12.6 “Installation of Intrinsically Safe Instrument Systems for Hazardous (Classified) Locations”

FM Approval Standard 3610 “Approval Standard, Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, II, and III, Division 1 Hazardous Locations”

FM Approval Standard 3615, “Approval Standard, Explosive Proof Electrical Equipment”

NFPA “Electrical Installations in Hazardous Locations”