Explosive Environment Review

Version 3.0

A Comprehensive Guide to Electronic Weighing Equipment and Hazardous Environments

RICE LAKE
WEIGHING SYSTEMS

‘To be the best by every measure’
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1.0 Introduction

As we are all aware, electronic equipment is capable of generating and releasing electrical and thermal energy during both 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, a weighing system can be made safe to be utilized in hazardous environments.

Systems can be made explosion proof, intrinsically safe or purged and pressurized to render them safe to use in hazardous environments. This guide is not intended to take the place of the established standards, guidelines and practices, but to point them out to you and “guide” you on the path to safe hazardous environment weighing operations.

There is no substitute for experience. 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 and licensed electrician

⚠️ Caution

Do not use these guidelines as your only references for scale installations. While performing maintenance refer to the manufacturer's manual for procedures that are peculiar to the equipment being serviced. It is important to be familiar with all standards, recommended practices and codes that apply to your installation.
2.0 Standards

OBJECTIVE: Familiarization with codes, standards and recommended practices.

These standards, codes and recommended practices are national in scope. Local, state, county and city agencies may enforce codes which are more stringent. Often, local authorities see the need to offer more stringent protection as local conditions warrant. Since local officials are closer to their specific locale, 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 to allow some 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 effective safety. The documents are not intended as a design specification nor as an instruction manual for untrained persons. They are intended for use by capable engineers, contractors and inspectors who are fully acquainted with the principles for which the standard is written. 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 (FM) and the Instrument Society of America (ISA) publish guidelines for proper electrical installations. We will identify these publications that are applicable to hazardous environment equipment installations. (See Appendix “A” for organizational addresses.)

2.1 NFPA 70, “National Electrical Code (NEC) Handbook”

The 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. The “National Electrical Code Handbook” is periodically revised to reflect new information and/or available equipment. It is important to ensure your handbook is the current one. NFPA 70 contains an agenda for the meetings to compile the next handbook. You can use this to obtain an idea as to when the next NFPA 70 revision will occur, thus keeping your handbook up-to-date.

Articles 500 through 504 cover the requirements for electrical equipment and wiring for all voltages in locations where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust or ignitable fibers or flyings.

The address for the National Fire Protection Association is 1 Batterymarch Park, Quincy, MA 02269-9990.

2.2 NFPA 496, “Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations”

NFPA 496 governs purged enclosures for electrical equipment in Class I locations, and pressurized enclosures for electrical equipment in Class II locations.

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

NFPA 497M contains the properties of flammable liquids, gases and solids.

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

NFPA 325M is a compilation of basic fire protection properties of various materials. The “General” section of 325M provides information such as definitions of fire hazard properties, extinguishing methods, health hazard ratings, flammability hazard ratings, and reactivity hazard rating. The “Properties” section includes flash point, ignition temperature, upper and lower flammable limits, specific gravity and boiling point.
2.5 ANSI/UL 913 “Standard for Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, II and III, Division 1 Hazardous Locations”

ANSI/UL 913 provides requirements for the construction and testing of electrical apparatus or parts of such apparatus, in which circuits themselves are incapable of causing ignition in Class I, II, or III, Division 1 locations, in accordance with Article 500 of the NEC.

The address of Underwriters Laboratories is 333 Pfingsten Road, Northbrook, IL 60062.

2.6 ANSI/ISA RP 12.06.01 “Installation of Intrinsically Safe Instrument Systems for Hazardous (Classified) Locations”

ANSI/ISA RP 12.6 is a recommended practice (RP) prepared by the Instrument Society of America (ISA) to promote the uniform installation of intrinsically safe systems for hazardous (classified) locations. This RP should be used in conjunction with the NEC. It is not intended to include guidance for equipment design, testing, maintenance, repair nor apply to the use of portable equipment.

The address of the Instrument Society of America is 67 Alexander Drive, Research Triangle Park, NC 27709.

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

This standard serves as the basis for Factory Mutual Approval of intrinsically safe apparatus and associated apparatus. It also provides requirements for the construction and testing of electrical apparatus or parts of such apparatus whose circuits are incapable of causing ignition in Division 1 hazardous locations as defined in Article 500 of the NEC.

The address of Factory Mutual Global is 1151 Boston-Providence Turnpike, Norwood, MA 02062.

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

FM Approval Standard 3615 is used by Factory Mutual to evaluate and approve electrical equipment for use in hazardous (classified) locations. Areas evaluated are the product suitability, operation, performance, durability and reliability.

2.9 “Electrical Installations in Hazardous Locations”

“Electrical Installations in Hazardous Locations” is published by the National Fire Protection Association. It has not been processed in accordance with the NFPA Regulations Governing Committee Projects. The material in this publication should not be considered as the official position of the NFPA. The intent of the publication is to advise people who are unfamiliar with, or who occasionally become involved in, electrical installations in hazardous locations. It does not take the place of official documents about hazardous locations. It is a guide to steer you in the direction of official documents. The currency of these documents should be checked by obtaining a copy from the specific organization responsible for the document’s publication. This publication is a good general source of hazardous location information which gives excellent general information to steer you to the correct official document for your application.
1. Place the letter from the title next to its corresponding publication.

____1. ANSI/UL 913
____2. NFPA 496
____3. NFPA 70
____4. ANSI/ISA RP 12.06.01
____5. NFPA 497M

A. “Installation of Intrinsically Safe Instrument Systems in Class I Hazardous Location”

B. “Standard for Intrinsically Safe Apparatus and As-associated Apparatus for use in Class I, II and III, Division 1 Hazardous Locations”

C. “Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations”

D. “National Electrical Code Handbook”

E. “Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations”

See Appendix C for answers to Review Exercises.
3.0 Hazardous Locations

OBJECTIVE: Define hazardous locations and categorize them as to their Class, Division and Group.

To be adequately defined, hazardous locations must be categorized as to their Class, Division and Group. We will define the meaning of Class, Division and Group plus see what type of locations falls under each heading.

3.1 Class

Class defines the type of hazard present in the locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Class II locations are those that are hazardous because of the presence of combustible dust.

Class III locations are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the area, in quantities sufficient to produce ignitable mixtures.

3.2 Division

A Division defines the hazardous locations as to the conditions under which the hazard exists. A Division is a sub-category of a Class. Each Class is categorized into Division 1 and Division 2. Division 1 and Division 2 conditions vary for each class of material.

3.3 Group

A Group narrows the hazardous location down to the specific material or type of material present. Class I locations are categorized into Groups A, B, C and D where Group A materials provide more of an explosion hazard than Group B materials.

Class II locations are categorized into Groups E, F and G. Again, Group E environments are more explosive than Group G environments.

Class III locations are not grouped.

3.4 Categorization

The easiest way to illustrate the categorization of locations into Class, Division and Group is to study the charts in Figures 3-1, 3-2 and 3-3 on the following pages.
Hazardous (Classified) Locations
(In accordance with Article 500, National Electrical Code-1990)

CLASS I
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 than 30 percent hydrogen by volume, or gases or vapors of equivalent hazard such as butadiene*, ethylene oxide**, Propylene oxide**, and acrolein**.

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

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

Figure 3-1. NEC 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.

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 of:
   - handling & 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 combustible
- metal dusts regardless of resistivity
- other combustible dusts of similarly hazardous characteristics having resistivity of less than 100 ohm-centimeter

Group F: atmospheres containing
- carbon black, charcoal, coal or coke 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 3-2. NEC Class II

Hazardous Locations
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 that natural gas is part of Group D. So to fully define our hazardous location we would say that it is a Class I, Division 1, Group D hazardous location.

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. That 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 temperature 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, identity 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 for T6 equipment. Sub-identification are provided for identification numbers T2, T3 and T4. The following chart provides the identification numbers and their maximum temperature ratings.

**External Surface Temperature Identification Numbers**

<table>
<thead>
<tr>
<th>°C</th>
<th>°F</th>
<th>Identification Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>842</td>
<td>T1</td>
</tr>
<tr>
<td>300</td>
<td>572</td>
<td>T2</td>
</tr>
<tr>
<td>280</td>
<td>536</td>
<td>T2A</td>
</tr>
<tr>
<td>260</td>
<td>500</td>
<td>T2B</td>
</tr>
<tr>
<td>230</td>
<td>446</td>
<td>T2C</td>
</tr>
<tr>
<td>215</td>
<td>419</td>
<td>T2D</td>
</tr>
<tr>
<td>200</td>
<td>392</td>
<td>T3</td>
</tr>
<tr>
<td>180</td>
<td>356</td>
<td>T3A</td>
</tr>
<tr>
<td>165</td>
<td>329</td>
<td>T3B</td>
</tr>
<tr>
<td>160</td>
<td>320</td>
<td>T3C</td>
</tr>
<tr>
<td>135</td>
<td>275</td>
<td>T4</td>
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<td>120</td>
<td>248</td>
<td>T4A</td>
</tr>
<tr>
<td>100</td>
<td>212</td>
<td>T5</td>
</tr>
<tr>
<td>85</td>
<td>185</td>
<td>T6</td>
</tr>
</tbody>
</table>

*Table 3-1. External Surface Temperature ID Numbers*

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.
I. Classify each environment below according to Class, Division and Group.

1. Location where fibers that produce combustible flyings are handled.

2. A location containing gasoline which is processed in a closed system.

3. A location where ethylene oxide gas may exist during maintenance operations.

4. A location where coal dust is sensitized to present an explosion hazard and having a resistivity of 1000 ohm-centimeter during normal conditions.

5. A location where combustible dusts having a resistivity of 100,000,000 ohm-centimeter are in the air as a result of infrequent malfunctioning of handling equipment.

6. A location where ethylene gas is released because of faulty equipment operation.

7. A location adjacent to a Class I, Division 1 location where manufactured gas containing 33% hydrogen by volume is present.

See Appendix C for answers to Review Exercises
4.0 Product Review

OBJECTIVES: Identify explosion proof, intrinsically safe, purged and pressurized systems and their purposes. Identify specific Rice Lake Weighing Systems explosive environment equipment and their purposes.

4.1 Explosion Proof Systems

The design of an explosion proof system does not totally contain the explosion, but it does control the explosion, so it does not ignite the atmosphere external to the system. It is impractical to hermetically seal all electric equipment from the explosive atmosphere. The enclosure may have switches, circuit breakers and other moveable parts that must be operated through the enclosing case. Because there are paths between the inside of the enclosure and the hazardous area, certain manufacturing and installation techniques must be employed to retain the enclosure’s explosion proof integrity.

An explosion proof container is constructed with flanges (see Figure 4-1 and Figure 4-2). Opposite sides of the flange are sealed by a gasket and bolts. The faces of the flange are machined so there is a slope formed so the opening is larger at the outside of the flange than at the inside of the flange. This gradual slope allows for gradual escape of the exploded gases. As the gas is forced from the inside of the container to the outside, the volume of the gas is increased by the slope of the flange and the temperature is thereby decreased to a level that is below the explosive limit of the hazardous environment.

Figure 4-1. Explosion Proof Container
A normal flange slope is typically .0015"/inch, i.e., for every inch of outward travel along the flange, the slope becomes greater by .0015 inches. The distance between the inside of the enclosure and the gasket is called the flame path. When the explosion occurs, the distance or clearance between the flange will be increased somewhat. The amount of increase caused by the explosion depends on the “stiffness” of the enclosure parts, the size, strength and spacing of the bolts and the explosive pressure. Since the escaping gases need to be cooled slowly, a large increase in the flange clearance would be unacceptable as gases would escape too quickly and not be sufficiently cooled. Simply measuring the flange or joint width and clearance when there are no internal pressures will not indicate what the clearances will be under dynamic conditions of an explosion. Therefore, actual explosion tests are needed to demonstrate design acceptability.

Push buttons, rotary switches and sealing fittings are attached to the enclosure by the use of drilled and tapped holes. Just as the flange controls the flame path, so do the threads of these tapped holes. As the threads are long as compared to their width, the gas will cool as it travels to the outside environment. For use in Class I, Division 1, Group C locations, there must be at least five full threads of engagement between the threads tapped into the enclosure and the threaded device screwed into the enclosure (See Figure 4-3 and Figure 4-4).
Explosion proof enclosures are rated for the category of the hazardous location in which they can be used. The enclosure must not emit gases that are hot enough to ignite the hazardous atmosphere in which they are used. Adherence to the Underwriters Laboratories and Factory Mutual ratings is mandatory. Again, the hazardous area must be categorized to its Class, Division and Group by the proper authority having jurisdiction over the area.

It is necessary for all explosion proof enclosures to be accurately installed according to the National Electrical Code. There are chemical environments where aluminum or cast iron cannot be used without coatings such as vinyl organisol or special lubricants. Unless specified at the time of purchase, explosion proof enclosures are not suitable for outdoor use. Condensation can be a real problem without adequate drain fittings. Most enclosures can be ordered with machined gaskets if outdoor installation or washdown is required.

### 4.1.1 Explosion Proof Equipment Tests

In addition to the tests required for the enclosures if they were to be used in non-hazardous locations, the explosion proof enclosure must pass explosion tests, temperature tests and hydrostatic tests.

#### Explosion Test

The explosion test is conducted to determine pressure to be used for the hydrostatic test and to determine if the construction of the enclosure is such that it will prevent ignition under actual explosion conditions. In some products the explosion test also determines that the enclosed device (circuit breaker for example) will perform its function under the severe condition of flame and turbulence inside the enclosure.
The following gases are normally used as test gases for each Hazardous Group:

- Group A - Acetylene
- Group B - Hydrogen
- Group C - Ethylene of Ethyl Ether
- Group D - Propane

NOTE: Explosion testing using acetylene can also be used to represent Groups C & D but NOT Group B. Acetylene-air mixture produces higher explosion pressures than hydrogen-air mixtures but it takes less energy to ignite hydrogen. The thermal energy released through the joints is a potential ignition source. Explosion tests are conducted with lengths of conduit attached to the enclosure to represent installation with or without conduit seals, depending on the size of conduit likely to be used and the type of equipment to be enclosed.

Point of ignition is varied based on the testing experience of the lab. Besides ignition at the end of the length of conduit, tests would be conducted with ignition close to joints and with ignition caused by the switching device inside the enclosure. Equipment that houses a switching device may be operated under anticipated load making and breaking conditions. A motor controller, for example, would be tested with ignition resulting from a circuit designed to simulate stalled rotor conditions. A circuit breaker is tested to represent a short-circuit or ground fault.

It may be necessary to test the adequacy of switches, controllers and circuit breakers in an ionized environment. Flames caused by an explosion may ionize the air in the enclosure. The spacing between switch contacts may not be sufficient to interrupt the circuit in an ionized atmosphere but may be adequate in a non hazardous area.

A circuit breaker must perform its function in the atmosphere it is placed. An explosion may cause the molded case of a breaker to explode thus keeping it from doing its job. This device needs to be tested under hazardous conditions.

The product being tested is placed in a chamber to surround it with flammable mixture. The device under test is filled with the flammable mixture by passing the mixture through the device under test and then to the surrounding chamber or by piping the mixture into both the product under test and the test chamber simultaneously.

The flammable mixture is pumped into the testing arrangement until the mixture for the preceding tests is purged from the system. The mixture then is ignited. Pressures are measured with transducers at critical points. Usually 10-20 tests are conducted.

**Temperature Tests**

Temperature tests are conducted to determine not only that the product meets non-hazardous location equipment temperature requirements for temperatures of various parts, but also to determine that the operating temperature marking is appropriate.

Temperatures are taken on the outside of the enclosure to determine the external surface operating temperature in a 40°C (104°F) ambient temperature.

Tests are conducted under anticipated abnormal conditions, such as overload, single phasing, and stalled motor rotor and blocked armature for solenoid valves.

**Hydrostatic Pressure Test**

Hydrostatic pressure tests determine that the strength of the enclosure is adequate to withstand the explosion with a safety factor.

The enclosure is filled with water so that all air is eliminated from inside the enclosure. A pressure of 100 to 600 PSIG per minute is applied until the required internal pressure is reached. Water is used instead of air for safety in case of a test failure. The enclosure is required to withstand the specified pressure for one minute, without rupture or permanent distortion.
4.1.2 Dust Ignition Proof Equipment Tests
Dust penetration tests are conducted to determine that the equipment is dust-tight. The equipment is placed in a chamber in which a cloud of dust is circulated. The dust is very finely ground to a consistency of powder. The requirements specify the sieve size through which the dust must pass if it is to be used in the test.

The equipment under test is cycled on and off several times. The dust then is removed from the test chamber and the enclosure under test is opened to see if any dust has entered the enclosure. Usually prior to opening the enclosure the dust-blanketing temperature test is conducted.

The dust-blanketing temperature test is to determine that the external surface temperature does not exceed the marked operating temperature. It is also used to assign the correct marked operating temperature. It also determines that the equipment inside the enclosure operates within the prescribed temperature limits with the thermal blanket of dust which reduces heat transfer.
1. Explain how the explosion proof enclosure flange and thread design prevent hazardous area explosions.

See Appendix C for answers to Review Exercises.
4.2 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 maximum 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 a specific flammable or combustible atmospheric mixture in its most easily ignitable concentration.

Intrinsically safe circuits always operate below minimum ignition energy levels. It is not possible to make all electrical circuits intrinsically safe. The power requirements of some circuits are well above the minimum ignition levels of the hazardous location specified. In these cases, other engineering means, such as explosion proofing, must be considered.

Intrinsically safe equipment and wiring is a system concept. Any piece of equipment that is connected or can be connected to the system is part of the system. This does not include self-contained battery operated equipment that is not connected to any other equipment or apparatus.

Intrinsic safety is an energy concept. Besides voltage and current levels, sources of spark ignition from discharge of capacitive circuits, interruption of inductive circuits, intermittent making and breaking of resistive circuits and hot-wire fusing are considered. Sources of thermal ignition considered are heating of small-gage wire strands, glowing of a filament and high component surface temperatures. Remember that the voltage and current levels sent to the hazardous location are very important, but also 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 of current, voltage, capacitance and inductance that may be present in a hazardous location are shown on ignition curves. These curves are published in most intrinsic safety standards, including Factory Mutual Standard 3610 and UL 913. The length of the cable that is connected to these circuits affects the capacitance and inductance present in the system. Be sure to 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, before the system is put into operation and after all service and maintenance actions.

Requirements for intrinsically safe systems does 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 a number of ways to design an intrinsically safe system. However, the common objective is to isolate the intrinsically safe circuits from the non-intrinsically safe circuits. It is this isolation that allows limits to be placed on energy entering a hazardous location.

4.2.1 System Compatibility

All components and/or systems used in a hazardous location must be approved by Factory Mutual Global. This approval is referred to as FM approval. As scale professionals, your main concern will be the combination of load cells, junction boxes, scale bases and indicators. Two methods of combining devices will be discussed. These methods are entity approval and system approval.
Entity Approval
Individual components which carry entity approval may be interconnected with other components which also are entity approved. 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 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, then the Factory Mutual entity approved combination may be connected, no matter who manufactures the individual components.

System Approval
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, to be used together as a system. They are not tested as individual entities and are not approved to be used independently of one another in a hazardous location. They also are not to be used in conjunction with other components that have or have not been entity approved. An example of this type of system is the WS900 IS Intrinsically Safe Digital Weight Indicator and its associated equipment.

4.2.2 Intrinsically Safe Equipment Tests
This section is not intended to illustrate all the testing procedures used by Factory Mutual (FM) and Underwriters Laboratories (UL) for testing intrinsically safe equipment, but to give you a short overview and idea as to some of the tests performed. Refer to FM and UL inspection standards if more information is required.

When installing a system, the specific responsibility for determination of suitability of equipment being interfaced in a specific location must be made by the end user and the authority having jurisdiction over the hazardous 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. If you are unsure of anything pertaining to hazardous locations, ask questions before committing to a system that may not work or may cause damage and/or injury. Remember, it is the customer’s responsibility to determine what he and his insurance underwriter will accept. Be familiar with the NEC and other pertinent publications.

Temperature Test
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 because of turbulence at the heated surface.

Spark Ignition Test
The spark ignition test determines whether or not after consideration of protective components and the application of a variety of safety factors, the circuit is capable of ignition.
The test apparatus is agreed to by the International Electrotechnical Commission. The explosion chamber has a volume of 15.25 cubic inches. The test chamber must withstand 213 psi or have suitable pressure relief.
The circuit making and breaking arcs are produced in a test gas which represents the hazard location group involved. The contact arrangement is made up of a cadmium disc with two slots. The disc is mounted on a spindle. Another spindle contains four tungsten wires. The two spindles rotate in opposite directions. The tungsten wires slide over the cadmium disc causing a spark. The two spindles are isolated from the housing and from each other.
A tin disc can replace the cadmium disc if cadmium, zinc, or magnesium is not present in the circuit being tested. During high current tests, copper may replace the tungsten wires.

Gas mixtures used in spark ignition tests are:

- 5.25 ±0.25% propane in air for Group D
- 7.8 ±0.5% ethylene in air for Group C
- 21 ±2% hydrogen in air for Groups A & B

Oxygen is substituted for or added to the air if the test is for apparatus for use in oxygen enriched atmospheres. The spark tester sensitivity is checked before and after each test using a 25 VDC circuit containing a 0.095 henry air-core coil.

There is a considerable amount of data available on minimum igniting currents for various circuits using a standardized test apparatus. This data is in the form of curves and comparison to this data is permitted so actual spark testing is not necessary on some circuits. The following are examples of some of the curves that are used to evaluate intrinsically safe equipment for use in various Hazardous Location Groups.

Determination as to whether the curves can be used to eliminate actual spark testing is limited to those circuits that can be readily assessed in terms of elementary circuits represented by the curves.

Complex electronic equipment offers a challenge to the testing agencies. It is difficult to determine worst-case faults in this complex equipment. A complete fault analysis of the equipment may be required. To simplify the evaluation sometimes all capacitors are treated as being in parallel and all inductors treated as if in series.
Figure 4-5. Resistance Circuits (Cadmium)

RESISTANCE CIRCUITS (LE5µ H)
IGNITING CURRENTS APPLICABLE TO ALL CIRCUITS CONTAINING ALUMINUM, CADMIUM, MAGNESIUM OR ZINC.

METHANE
PROPADE Gp D
ETHYLENE Gp C
HYDROGEN Gp A and B
Figure 4-6. Resistance Circuits (Tin)

IGNITING CURRENTS APPLICABLE TO CIRCUITS WHERE ALUMINUM, CADMIUM, MAGNESIUM OR ZINC CAN BE EXCLUDED.
Figure 4-7. Inductance Circuits (Cadmium)

Inductive circuits igniting currents are 24 volts applicable only to circuits where aluminum, cadmium, magnesium or zinc may be present.

- Methane
- Propane Gp D
- Ethylene Gp C
- Hydrogen Gp A and B
Figure 4-8. Inductance Circuits (Tin)

INDUCTIVE CIRCUITS
IGNITING CURRENTS ARE 24 VOLTS APPLICABLE ONLY TO CIRCUITS WHERE ALUMINUM, CADMIUM, MAGNESIUM AND ZINC CAN BE EXCLUDED.

METHANE
PROPAZ D
ETHYLENE Gp C

HYDROGEN
Gp A and B

IGNITING CURRENTS ARE 24 VOLTS APPLICABLE ONLY TO CIRCUITS WHERE ALUMINUM, CadMUm, MAGNESIUM AND ZINC CAN BE EXCLUDED.
Figure 4-9. Inductance Circuits (Cadmium)

INDUCTANCE CIRCUITS
IGNITING CURRENTS FOR VARIOUS VOLTAGES IN GROUP B. APPLICABLE TO ALL CIRCUITS CONTAINING ALUMINUM, CADMIUM, MAGNESIUM OR ZINC.
Figure 4-10. Inductance Circuits (Cadmium)

- **Inductance Circuits**
- Igniting currents for various voltages in methane and applicable to all circuits containing aluminum, cadmium, magnesium or zinc.
Figure 4-11. Capacitance Circuits (Methane)

Igniting voltages in methane. The curves correspond to values of current-limiting resistance as indicated. The curve marked Sn is applicable only where aluminum, cadmium, magnesium and zinc can be excluded.
Figure 4-12. Capacitance Circuits (Groups A & B)

IGNITING VOLTAGES IN GROUPS A AND B. THE CURVES CORRESPOND TO VALUES OF CURRENT LIMITING RESISTANCE AS INDICATED. THE CURVE MARKED Sn IS APPLICABLE ONLY WHERE ALUMINUM, CADMIUM, MAGNESIUM AND ZINC CAN BE EXCLUDED.
Other Tests
- Dielectric Withstand Test: Performed on blocking capacitors to determine whether they can be considered protective components, therefore not subject to faults.
- Transformer Tests: To determine if the transformer can be considered a protective component.
- Mechanical Tests of Partitions
- Battery Ejection Drop Test From portable hand-held battery-operated apparatus.

4.2.3 Approval Authority
All equipment intended for use in a hazardous environment must first be approved by the predominant approval authority in the United States, Canada or internationally.

United States
The standards by which intrinsic safety is implemented are written by the National Fire Protection Agency (NFPA). Intrinsically safe products are tested and approved or listed by Factory Mutual Global (FM) or Underwriters Laboratories Inc. (UL).

Canada
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.

International
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)
- INIEX (Belgium)
A CENELEC approval issued by any authorized test laboratory is valid in all of the CENELEC member nations.
REVIEW EXERCISE - INTRINSIC SAFETY

1. What is the purpose of intrinsically safe circuitry?

2. For the following statements, circle “T” if the statement is true and circle “F” if the statement is false.

   T / F Intrinsically safe circuits always operate below minimum ignition energy levels.

   T / F Intrinsic safety design is applied to Class I, II, and III, Division 1 hazardous locations.

   T / F The length of cable connected to intrinsically safe circuits has no bearing on its energy producing effects.

   T / F If circuit power requirements are above the minimum ignition levels of the hazardous location, engineering means other than intrinsic safety need to be employed.

   T / F Intrinsic safety systems designed for Class II hazardous locations are suitable for use in Class I hazardous locations of the same group.

See Appendix C for answers to Review Exercises.
4.3 Purged Systems

Purged enclosures are designed to keep the hazardous environment out of the instrument enclosure by maintaining a slightly positive pressure inside the enclosure. Purged enclosures are thoroughly discussed in NFPA 496, “Purged and Pressurized Enclosures for Electrical Equipment.” The purging medium can be clean air or an inert gas. Purged enclosures must be properly designed and maintained to be effective. Normally purged enclosures are made from NEMA 4 type basic enclosures and are not designed to contain an explosion. Purged equipment must be designed and approved on an individual basis to be considered rated by Factory Mutual.

Purged enclosures do not make load cells or peripheral equipment explosion proof or intrinsically safe.

We will now look at three different types of purged enclosures. The types discussed here are taking into consideration enclosures of 10 cubic feet of volume or less. NFPA 496 further explains the purged enclosure types, including enclosures larger than 10 cubic feet as well as purged control rooms.

4.3.1 Type “Z”

Type “Z” purging systems reduce the classification within an enclosure from Division 2 to non-hazardous. An alarm or indicator to detect failure of an individual enclosure purge is required. However, safety interlocks to de-energize the electrical system, if the enclosure is opened, are not required. A warning name plate must be mounted on the enclosure in a prominent location so that it is visible before the enclosure can be opened. The plate shall contain the following or equivalent statement:

Enclosures shall not be opened unless the area is known to be non-hazardous or unless all devices within have been de-energized. Power shall not be restored after the enclosure has been opened until enclosure has been purged for ______ minutes.

The manufacturer must recommend purge conditions and flow rate necessary to pass at least four enclosure volumes of purge gas in the time period specified on the label. Other specific requirements for Type “Z” purging are found in NFPA 496.

4.3.2 Type “Y”

Type “Y” purging systems reduce the classification within an enclosure from Division 1 to Division 2. All requirements of Type “Z” systems apply to Type “Y” systems. Also, all equipment and devices within the enclosure must conform to the requirements for Division 2 locations as outlined in NFPA 496.

4.3.3 Type “X”

Type “X” purging systems reduce the classification within an enclosure from Division 1 to a non-hazardous. Since type “X” systems reduce from the most critical division all the way to a non-hazardous environment, there are more stringent system requirements than with Type “Z” and Type “Y” purged enclosures. This is not to minimize the requirements for Type “Z” and Type “Y” purged enclosures, as these requirements must be adhered to in order to ensure Type “Z” and Type “Y” integrity.

In Type “X” environments, a timing device must be used to prevent energizing of electrical equipment within the enclosure until at least four volumes of purge gas have passed through the enclosure while maintaining an internal pressure of at least .0036 PSI. The purge conditions and flow rate necessary to pass four enclosure volumes in the stated time must be determined. A cutoff switch must be used to remove power automatically from all circuits within the enclosure not suitable for Division 1 upon failure of the purge system. If the enclosure can be easily opened without the use of a key or tools, an interlock will be provided to immediately de-energize all circuits within the enclosure that are not suitable for Division 1 locations when the enclosure is open.
A warning plate must be affixed to the enclosure in a prominent location so it is visible before the enclosure can be opened. The plate will contain the following, or equivalent, statement:

Enclosures shall not be opened or any cover removed unless the area is known to be non-hazardous or unless all devices within have been de-energized. Power shall not be restored after the enclosure has been opened until the enclosure has been purged for ______ minutes.

The manufacturer shall recommend purge conditions and flow rate necessary to pass at least four enclosure volumes of purge gas in the time specified on the label. Remember to consult the current NFPA 496 to obtain current requirements for purged systems.
1. What is the purpose of purged systems as they pertain to hazardous environments?

See Appendix C for answers to Review exercises.
4.4 Pressurized Systems

Pressurized systems are explained in detail in NFPA 496. They are designed to be used in Class II locations to prevent dust from entering the enclosure. Here is a review of pressurization as it applies to enclosures with a gross internal volume not exceeding 10 cubic feet. The pressurizing supply must be free from dusts and liquids that can plug small openings. Air of normal instrument quality is considered acceptable for pressurizing as are other suitable supplies such as inert gas. Ordinary plant compressed air is usually not suitable for pressurizing systems due to contaminants that may cause equipment to malfunction.

Before the equipment in the enclosure is energized, the enclosure interior must be dust free. If combustible dusts have collected within the enclosure, it must be opened and the dust removed before pressurization. The enclosure must be maintained under a positive pressure of greater than or equal to 0.1 inches of water if the specific particle density of dust is less than or equal to 130 pounds per cubic foot, or greater than or equal to .5 inches of water if the specific particle density of dust is greater than 130 pounds per cubic foot.

In Class II, Division 1 locations, a door switch must be provided on the enclosure to de-energize all circuits within the enclosure that are not suitable for Division 1, if the enclosure can be readily opened without the use of a key or tools. A door switch is not required for Division 2 locations.

A warning plate must be mounted on the enclosure and visible before the enclosure can be opened. The plate must contain the following or equivalent.

Enclosures shall not be opened unless the area is known to be non-hazardous or unless all devices within have been de-energized. Power shall not be restored after the enclosure has been opened until combustible dusts have been removed and the enclosure repressurized.

Under normal operating conditions, neither the temperature of the external enclosure surface nor the temperature of the gas exiting the enclosure can exceed 80% of the layer ignition temperature (in degrees Celsius) of the combustible dust involved, and in all cases will be at least 25°C (77°F) below the ignition temperature.

Class II equipment must be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of any organic dust deposits that may occur.

An alarm must be installed to indicate pressurizing system failure. The alarm may be mechanically, pneumatically or electrically actuated and may be visual or audible. The alarm must be placed so it is readily seen or heard. The alarm actuator must take its signal from the enclosure and must not be installed between the enclosure and the pressurizing air/gas supply. There must be no valves installed between the alarm actuator and the enclosure.

The above information is provided as an overview of pressurized systems in Class II locations. It is by no means a complete, detailed description of pressurized systems. The requirements for pressurized systems in hazardous locations are found in NFPA 70 “National Electrical Code Handbook” and NFPA 496 “Purged and Pressurized Enclosures for Electrical Equipment.”
4.5 Enclosure NEMA Ratings

An enclosure is a surrounding case constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specific environmental conditions. Enclosures for hazardous locations are designed to control an internal explosion without causing an external hazard, prevent combustion through the use of oil-immersed equipment, or prevent the ignition of combustible dust. Descriptions, features and test criteria of enclosures for both non-hazardous and hazardous locations are provided in NEMA (National Electrical Manufacturers Association) Standards Publication No. 250. Let’s look at some enclosures designed for hazardous locations.

4.5.1 NEMA Type 4 Enclosures

Type 4 enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against wind blown dust and rain, splashing water and hose directed water. They are also intended to be undamaged by the formation of ice on the enclosure. They shall meet hose-down, external icing and rust-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

When completely and properly installed, Type 4 enclosures:

- Exclude water under test conditions which are intended to simulate a hose-down condition.
- Will be undamaged after being encased in ice under test conditions.
- Will be permitted to have conduit hub or equivalent provisions to exclude water at the conduit entrance.
- Will have mounting means external to the equipment cavity, if these means are to be provided.
- Will have suitable corrosion protection.

4.5.2 NEMA Type 7 Enclosures

Type 7 enclosures are for indoor use in locations classified as Class I, Groups A, B, C or D. Type 7 enclosures will be capable of withstanding the pressures resulting from an internal explosion of specified gases and contain this explosion sufficiently so as not to ignite the atmosphere surrounding the enclosure.

When completely and properly installed, Type 7 enclosures:

- Provide a degree of protection to a hazardous gas environment from an internal explosion or from operation of internal equipment.
- Do not develop surface temperatures which exceed prescribed limits for the specific gas corresponding to the atmospheres for which the enclosure is intended when internal equipment is operated at rated load.
- Withstand a series of explosion design tests which determine the maximum pressure effects of the gas mixture and propagation effects of the gas mixtures.
- Withstand, without rupture or permanent distortion, an internal hydro-static design test based on the maximum internal pressure obtained during explosion tests and on a specified safety factor.
- Are marked with the appropriate Class and Group(s) for which they have been qualified.

4.5.3 NEMA Type 8 Enclosures

Type 8 enclosures are for indoor or outdoor use in locations classified as Class I, Groups A, B, C and D. Type 8 enclosures are arranged so all arcing contacts, connections and so forth are immersed in oil. Arcing is confined under the oil so it will not ignite an explosive mixture of the specified gases in internal spaces above the oil or in the atmosphere surrounding the enclosure. The enclosed heat-generating equipment shall not cause external surfaces to reach temperatures capable of igniting explosive mixtures in the surrounding atmosphere. Type 8 enclosures must meet operation and temperature design tests. Enclosures intended for outdoor use shall meet the rain test outlined in Section 6.4 of NEMA Standard Publication No. 250.
When completely and properly installed, Type 8 enclosures:

- Provide, by oil immersion, a degree of protection to a hazardous gas environment from operation of internal equipment.
- Do not develop surface temperatures which exceed prescribed limits for the specific gas corresponding to the atmospheres for which the enclosures is intended when internal equipment is at rated load.
- Withstand a series of operation design tests, with oil levels arbitrarily reduced and with flammable gas-air mixtures introduced above the oil.
- When intended for installation outdoors, exclude water when subjected to a water spray design test simulating a beating rain.
- Are marked with the appropriate class and group(s) for which they have been qualified.

4.5.4 NEMA Type 9 Enclosures

Type 9 enclosures are intended for indoor use in locations classified as Class II, Groups E, F or G. Type 9 enclosures must be capable of preventing the entrance of dust. Enclosed heat generating devices shall not cause external surfaces to reach temperatures capable of igniting or discoloring dust on the enclosure or igniting dust-air mixtures in the surrounding atmosphere. Type 9 enclosures must meet dust penetration and temperature design tests.

When completely and properly installed, Type 9 enclosures:

- Provide a degree of protection to a hazardous dust environment from operation of internal equipment.
- Do not develop surface temperatures which exceed prescribed limits for the groups corresponding to the atmospheres for which the enclosure is intended, when internal equipment is operated at rated load.
- Withstand a series of operation design tests while exposed to a circulating dust-air mixture to determine that dust does not enter the enclosure and that operation of devices does not cause ignition of the surrounding area.
- Are marked with the appropriate Class and Group(s) for which they have been qualified.

4.5.5 Other Suitable Enclosures

Enclosures rated for non-hazardous locations which have met the requirements for the dust test described in Section 6.5 of NEMA Standard No. 250 may be used in Class II, Division 2, Group G and Class III, Division 1 and 2 locations.

Hazards may be reduced or eliminated and equipment installed in enclosures suitable for non-hazardous locations by adequate positive pressure ventilation from a source of clean air in conjunction with effective safeguards against ventilation failure (See Section 4.3—Purged Systems and Section 4.4—Pressurized Systems in this guide. Also, refer to NFPA 496 “Purged and Pressurized Enclosures for Electrical Equipment.”)
I. Place the letter of the description in Column B next to its corresponding enclosure “Type” in Column A.

____1. Type 8
____2. Type 7
____3. Type 9
____4. Type 4

A. Use in Class I, Groups A, B, C & D, indoor use only.

B. Use in indoor and/or outdoor applications. Excludes water under test conditions.
   Non-hazardous design.

C. Use in Class I, Groups A, B, C & D, indoor and/or outdoor applications.

D. Use in Class II, Groups E, F or G, indoor use only.

II. Describe when non-hazardous designed enclosures may be used in hazardous locations.

See Appendix C for answers to Review Exercises.
4.6 Products and Applications

This review of explicit products available from Rice Lake Weighing Systems will emphasize the explosion proof and/or intrinsically safe aspects. The equipment operates the same as the non-hazardous environment versions. Explosion proof versions of all of our equipment are substantially heavier than the standard versions. Make sure your mounting structure is capable of supporting this heavier weight. Intrinsic safety barriers mentioned with these products are explained in more detail in section 4.7 of this guide.

4.6.1 IQ plus® 310 XPCD Explosion Proof Digital Weight Indicator

The IQ plus 310 XPCD is designed for use in hazardous locations falling under NEC classifications (Class I, Division 1 & 2, Groups C & D; Class II, Division 1 & 2, Groups E, F and G, and Class III). It is encased in a cast aluminum enclosure rated NEMA 4, 7 and 9. It has four external control buttons; Gross/Net, Tare, Zero and Print. Intrinsic safety barriers are included to isolate the hazardous and safe areas. Connection of the remote sense lines is required. The weight of this indicator is approximately 44 pounds. The standard non-explosion proof indicator operates with an excitation voltage of 10 VDC. Since intrinsic safety barriers must be used the excitation voltage drops from 10 VDC to 8.5 VDC when exciting a single 350 ohm load cell and 5.88 VDC when exciting 4 350-ohm load cells.

Figure 4-13. IQ Plus 310 XPCD

4.6.2 IQ plus® 810 XPCD Explosion Proof Digital Weight Indicator

The IQ plus 810 XPCD is designed for use in hazardous locations falling under NEC classifications (Class I, Division 1 & 2, Groups C & D; Class II, Division 1 & 2, Groups E, F and G, and Class III). It is encased in a cast aluminum enclosure rated NEMA 4, 7 and 9. There are 27 externally mounted buttons for setpoint control, fixed tare entry and Gross/Net, Tare, Units and Print functions. The IQ plus 810 is capable of driving 4 350-ohm load cells with an excitation voltage of 5.88 VDC.

Figure 4-14. IQ Plus 810 XPCD

4.6.3 IQ plus® 810 Purged/Pressurized Hazardous Environment Indicator

The IQ Plus Purged/Pressurized indicator is designed for use in hazardous environments under NEC classifications (Class I, Divisions 1 & 2, Groups C & D, Class II, Divisions 1 & 2, Groups E - G, and Class III). The indicator is manufactured to the American National Standards Institute/National Fire Protection Association (ANSI/NFPA) Article 496 guidelines for purged and pressurized enclosures. The wall mount is encased in a stainless steel enclosure rated NEMA 4X. The indicator has a full keyboard for setpoint or fixed tare entry and front panel control switches for Zero, Gross/Net, Tare, Units, Print, Disp Accum, Disp R.O.C., Disp Tare, Time/Date, New ID, Base #, Setpoint, and Clear.

Figure 4-15. IQ Plus 810 Purged/Pressurized
4.6.4 **EL232 XPCD Explosion Proof Remote Serial Display**

The EL232 XPCD is an explosion proof remote display that meets NEC Class I, Division 1, Groups C and D and Class II, Division 1, Groups F and G hazardous environment criteria. It can be operated with 20 mA current loop or RS-232C inputs.

It is compatible with all Rice Lake Weighing Systems IQ plus XPCD indicators. It can operate with indicators at baud rates of 1200, 2400, 4800 and 9600. BCD interface option is available. It is enclosed in a NEMA Type 4, Type 7 and Type 9 enclosure.

*Figure 4-16. EL232 XPCD*

4.6.5 **320IS Intrinsically Safe Digital Weight Indicator**

The 320IS is designed for use in hazardous locations falling under NEC classifications (Class I, Division 1, Groups A-D; Class II, Division 1, Groups E-G and Class III). It is encased in NEMA 4X/IP66-rated stainless steel sealed case. It has six external control buttons; Zero, Gross/Net, Tare, Print, Units and Power. The weight of this indicator is approximately 6.1 lb. The 320IS is capable of driving 4 350¾ load cells or 8 700¾ load cells with an excitation voltage of 7.9 VDC or 5.8 VDC.

*Figure 4-17. 320IS*

4.6.6 **IQ700IS Intrinsically Safe Digital Weight Indicator**

The IQ700IS is designed for use in hazardous locations and meets NEC classifications (Classes I, II, and II, Divisions 1 and 2, and Groups A-G). It is encased in a NEMA 4X-rated stainless steel enclosure. The approximate weight of the IQ 700IS is 9.5 lbs. The indicator front panel consists of a 21-button keypad, six seven-segment display digits and 11 LED annunciators. The indicator is capable of driving up to 4 350¾ load cells at 5 VDC.

*Figure 4-18. IQ 700IS*

4.6.7 **Condec™ UMC 600IS Hazardous Environment Indicator**

The Condec UMC 600IS is designed and approved to operate as an intrinsically safe system in hazardous locations that meets NEC classifications (Classes I, II, and III, Divisions 1 and 2, and Groups A-G). It is housed in a NEMA 4X-rated polished stainless steel enclosure. The indicator front-panel control switches consist of Zero, Gross/Net, Tare, Tare Recall, Print, and lb/kg Conversion with 0 - 9 keys, ENT (Enter) and CE (Clear), SP1, SP2, and On/Off keys. The UMC 600IS is capable of excitation voltage of up to 5 VDC when exciting 4 350¾ load cells.

*Figure 4-19. Condec UMC 600IS*
4.7 Intrinsically Safe Barriers
The objective of an intrinsically safe system is to isolate the intrinsically safe circuits from those that are non-intrinsically safe. Intrinsic safety barriers have been designed to limit electrical energy to the intrinsically safe apparatus. Barriers are protective assemblies which interface between the apparatus in the hazardous location and the apparatus in the non-hazardous location. Barriers allow electrical signals under normal conditions to flow in proper directions in a circuit. However, under faulty conditions, the electrical energy to the hazardous location is limited to a level incapable of causing ignition of a specific flammable or combustible mixture. Barriers are installed in safe areas. An explosion proof enclosure is considered a safe area.

4.7.1 DC Resistive Barriers
One type of barrier is shown in Fig. 4-20. This barrier is a fused, shunt diode direct current barrier. Its output is positive with respect to ground. The barrier includes both voltage and current limiting components. During normal conditions, the zener diodes (D1 and D2) are not conducting, allowing the electrical signals to travel to the hazardous area.

![Figure 4-20. Fused, Shunt Diode Direct Current Barrier](image)

When abnormal conditions occur, D1 senses a high voltage. When the voltage reaches the conduction point of D1, it turns on or conducts, directing the input to ground. Thus, the higher energy fault signal does not reach the hazardous area. D2 is in parallel with D1 and is a redundant component which will offer circuit protection in case D1 fails.

Resistor R2 is a series protective component which limits the current to the hazardous area. Resistor R1 is indirectly related to intrinsic safety. Its purpose is to offer a means of checking D1 and D2 to ensure they are intact. Fuse F1 is selected so it will open before the zener diodes open if they are overloaded. If F1 failed to open under fault conditions and D1 and D2 opened, the high level of energy would be sent to the hazardous area.

A barrier with a negative output as referenced to ground is illustrated in Fig. 4-21. Notice the only difference is the polarity of the zener diodes. The negative output barrier operates with the same principle as the positive output barrier.
4.7.2 DC Resistive Barrier - Signal Return

Examples of Direct Current Resistive barriers for signal returns are shown in Figure 4-22. Notice the input from the hazardous area. The signal from the load cells will be routed through this type of barrier. The signal return barrier is comparable to the previous barriers discussed.

Diodes D3 and D4 are added in parallel with R2. During normal operation, D3 and D4 are conducting and drop about 1.2 volts (.6 volts each). The signal is readily passed through the diodes, R1, F1 and R0 to the output. Let’s say that a very high positive fault voltage is applied to the output side of the barrier in Figure 4-22. This should cause D3 and D4 to stop conducting. Now the barrier works like the one in Figure 4-19. A fault path to ground is provided by D1 (D2 if D1 should fail). Current limiting is then provided by R2. When we refer to R2 as a current limiter, we mean R2 will limit the current to the hazardous area only up to the voltage ratings of the zener diodes. If the voltage ratings of the zener diodes is exceeded, the current limiting capability of R2 may be exceeded and pass high current to the hazardous area. This should not happen unless both zener diodes fail and F1 does not open, an unlikely occurrence.
4.7.3 Alternating Current Resistive Barriers

AC Resistive barriers are designed to pass alternating current (see Fig. 4-23 and Fig. 4-24). The barrier in Fig. 4-23 uses back-to-back redundant zener diodes to clamp the voltage available to the hazardous location. If the positive half-cycle of the AC signal exceeds the zener diode rated voltage, D1 will conduct. Since D2 is placed with its anode away from ground, it will act as a near short to positive voltages above .6 volts. If the negative half-cycle should exceed the rated zener diode voltage, D2 will conduct. Since the cathode of D1 is connected to the output side of the barrier, it will be forward biased during the negative half-cycle. Thus, an amount of negative voltage above the rated zener voltages will cause a path to ground to be provided through the conductor of D1 and D2. Diodes D3 and D4 are redundant diodes and operate if D1 and/or D2 should open.

![Figure 4-23. Back to Back Redundant Zener Diodes](image)

The AC barrier shown in Fig. 4-24 operates comparably to the barrier in Fig. 4-23. Since these diodes are not zener diodes, but normal signal diodes, they will conduct on both the positive and negative half cycles of the AC signal when the signal exceeds approximately 1 volt.

**This type of barrier can only be used with signals that are less than 1 volt in magnitude.**

![Figure 4-24. Normal Signal Diode](image)
5.0 Specifying Hazardous Environment Equipment

OBJECTIVES: Identify who is responsible for determining the hazardous location classification. Calculate system output signal sensitivity including barrier voltage drops.

5.1 Classification Determination
As previously discussed, each hazardous environment must be categorized as to its Class, Division and Group. Each of these three parts must be defined in order to completely describe the hazardous location. Class III locations are not categorized into groups. Class and Division adequately describe a Class III location. NFPA 497M “Manual for Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations” contains information on specific flammable gases, flammable and combustible liquids and combustible dusts. The relevant combustion properties of these gases, liquids and dusts have been identified sufficiently to allow their classification into groups established by the NEC. NFPA 497M assists the engineer in the selection of special electrical equipment for hazardous areas. NFPA 497M is not an all inclusive list. It does contain definitions of flammable and combustible liquids to aid the engineer in determining if a hazard may be present.

⚠️ Caution The authority having jurisdiction over the area is the final authority when categorizing a hazardous location. Under no circumstances should a scale professional define a hazardous area classification.

5.2 Hazardous Area Classification Liability
Specifying, installing and servicing equipment designed for hazardous locations involves coordination between the manufacturer, distributor, installer, servicing agency and the authority having jurisdiction over the hazardous area. Attention to detail is a must! Rice Lake Weighing Systems has developed a Hazardous Area Classification form which will help you specify your hazardous area application. This form is a record of the Class, Division and Group of the hazardous location for which the system is to be specified. The signature of the individual who classified the location also must be on the form in case questions arise about the hazardous location and the system. The end user’s company name is also required so we all have a record of where our hazardous location designed equipment is located. After you have completely annotated this form, retain a completed copy for your records. Any distributor that is interested in quoting and selling our line of explosive environment equipment must first attend one of our Explosive Environment Product Reviews.
Hazardous Area Classification

For assistance in selecting hazardous Area Control Equipment for your application requirements, please complete this form and submit, along with a description of the application to:

Rice Lake Weighing Systems
Attn: Hazardous Environment Dept.
230 W. Coleman Street
Rice Lake, WI 54868
Telephone: 715-234-9171
Fax: 715-234-6967

| RLWS File #: ______________________ | Date: ______________________ |
| Sales Order #: ____________________ | Checked By: ____________________ |
| Equipment PN(s) & Serial #(s) _______ | _______ |
| Factory Mutual Not Applicable ________ | (International Orders Only) ________ |

RLWS CUSTOMER INFORMATION:

| RLWS Customer Name: ______________________ | Customer Number: ______________________ |
| Address: ______________________ City: ______________________ State: ______ Zip: ______ |
| Telephone: (_____ ) ______________________ Fax: (_____ ) ______________________ |
| Contact Name: ______________________ (Print Name) (Signature) (Date) |
| Authorized Signature: ______________________ (Print Name) (Signature) (Date) |

End User Information:

| End User Company Name: ______________________ |
| Address: ______________________ City: ______________________ State: ______ Zip: ______ |
| Telephone: (_____ ) ______________________ Fax: (_____ ) ______________________ |
| Contact Name: ______________________ (Print Name) Title: ______________________ |
| Authorized Signature: ______________________ (Print Name) (Signature) (Date) |

(The following information is to be defined and completed by the END USER’S Plant Safety Engineer or other authorized party)

| Hazardous Area Classification: Class: __________, Division: __________, Group: __________ |
| Specific Hazard/Material (please print): ______________________ |
| Defining Individual: ______________________ (Print Name) (Signature) (Date) |
| Defining Authority (Title): ______________________ |

PLEASE USE THIS PAGE AS A MASTER, MAKE PHOTOCOPIES TO FILL OUT AND RETURN

Please retain a copy of this completed form for your records
5.3 Calculate System Load Cell Output Sensitivity (µV/Grad)

When specifying equipment, it is important that the load cell output not be smaller than the indicator can accept. Output sensitivity is expressed in microvolts/graduation (µV/grad). Some indicators can accept a signal as small as .8 µV/grad. This means it takes an input signal of at least .8 µV to change the display one graduation. Anything less (more sensitive) than .8 µV will cause erratic and inaccurate indicator operation.

When calculating load cell output sensitivity with intrinsic safety barriers involved, we must also take the voltage drop introduced by the barriers into consideration. The barriers decrease the excitation voltage available to the load cells to an acceptable hazardous location level. By decreasing the excitation voltage, the load cell output signal is also decreased. Therefore, it is imperative to factor in barrier voltage drops during the stages of specifying an intrinsically safe weighing system. You wouldn’t want to install a system to find out there isn’t sufficient signal available to drive the indicator.

Before we look at a particular scale application, let’s look at the barrier system and see how the barrier decreases the available load cell excitation voltage. Refer to the barrier system used in Figures 5-1 and Tables 5-1 & 5-2. You will notice with 10 volts applied to one 350Ω load cell through the barrier system only 8.5 volts of excitation voltage reaches the load cell. Less excitation means less output signal strength.

![Figure 5-1. Barrier System](image-url)
Figure 5-2 is an equivalent circuit of the excitation circuit of our barrier system shown in Fig. 5-1. The 10 volt battery is the excitation voltage applied to the system. $R_{exc}$ is the internal resistance of the +Excitation barrier (30.5Ω) and the -Excitation barrier (30.5Ω). This gives us a total excitation barrier resistance of 61Ω. $R_L$ is the load cell resistance. The total circuit resistance is 411Ω (61Ω + 350Ω). Using Ohm’s Law, we can figure total circuit current ($I_T$) and use the current to figure the voltage drops across the barrier ($E_{exc}$) and the load cell ($E_L$).

Figure 5-2. Equivalent Circuit of the Excitation Circuit
\[ I_T = \frac{E_T}{R_T} \]
\[ = \frac{10V}{411\Omega} \]
\[ = .0243 \text{ amps or 24.3 mA (milliamps)} \]

\[ E_{LC} = R_{LC} (I_T) \]
\[ = 350\Omega \cdot (.0243A) \]
\[ = 8.50 \text{ volts} \]

\[ E_{EXC} = R_{EXC} (I_T) \]
\[ = 61\Omega \cdot (.0243A) \]
\[ = 1.48 \text{ volts} \]

The two voltage drops should add up to 10 volts. (There may be a few hundredths of a volt difference because of where we choose to round-off our calculations). For our purposes, we will use 8.50 volts of excitation voltage that the load cell actually sees.

Let’s look at an application using three 350Ω load cells.

\[ R_{LCT} = \frac{R_{LC1} \text{ or } R_{LC2} \text{ or } R_{LC3}}{3} \]
\[ = \frac{350\Omega}{3} \]
\[ = 117\Omega \]

Figure 5-3 is an equivalent circuit of the excitation circuit. \( R_{EXC} \) is the internal resistance of the excitation barrier. The \( R_{LC} \) values are the load cell resistances. The first thing to look at is the total load cell resistance (\( R_{LCT} \)) that is seen by the 10 volt excitation voltage.

\[ I_T = \frac{E_T}{R_T} \]
\[ = 10V \div 178\Omega \]
\[ = .056A \text{ or 56mA} \]

\[ E_{LCT} = R_{LCT} (I_T) \]
\[ = 117\Omega \cdot (.056A) \]
\[ = 6.55V \]

\[ E_{EXC} = R_{EXC} (I_T) \]
\[ = 61\Omega \cdot (.056A) \]
\[ = 3.42V \]
Again, depending on how you round off your calculations, the values of voltage drops across the load cells and the excitation barriers should equal the total excitation voltage.

Also, notice that the more load cells you place in parallel, the lower the excitation voltage across the load cell. Looking back at Table 5-2, you can see that by placing 4-350Ω load cells in parallel causes a 50% decrease in load cell excitation. You can also see that by using 700Ω load cells, the excitation voltage decrease across the load cells is not as much.

5.3.1 Hazardous Area Application

We will discuss a weighing application utilizing a hopper scale and three 350Ω load cells. Our indicator has a sensitivity of 1 µV/grad. The excitation voltage is bipolar, that is the negative excitation voltage is -7.5VDC as referenced to ground. The positive excitation voltage is +7.5VDC as referenced to ground. This yields a potential difference of 15 volts between the positive and negative excitation terminals. The safety barriers used for this application have an internal resistance of 335Ω each or 670Ω for the total excitation circuit barrier resistance.

Other system parameters are as follows:

- Dead Load—300 lbs
- Live Load—6000 lbs
- Scale Capacity = 6000 lbs x 1 lb

The total system load will equal the dead load plus the live load or in our case, 6300 lbs. The 6300 lbs is shared by all three load cells or 2100 lbs each. The next larger load cell capacity available is 2500 lbs. So we will select 3 2500-lb load cells for our applications, giving us a total system capacity of 7500 lbs.

To determine what percentage of load cell output is used for the live load, we divide the live load by the total load cell capacity, or:

\[
\frac{\text{Live Load}}{\text{Cell Capacity}} = \frac{6000 \text{ lbs}}{7500 \text{ lbs}} = 80\%
\]

Normally, to determine the millivolt output of our load cells, we would multiply the excitation voltage (15VDC) by the load cell full scale output (3.0mV/V) and come up with a load cell output at full load. In this case, without figuring in the barrier voltage drop, the load cells would see an excitation voltage of 45mV at full scale. However, with our barrier application, we must figure in the barrier voltage drop.

Figure 5-5 represents our 3 load cells and barrier resistance combination. As previously stated, our barrier internal resistance is 670Ω. From the example in Fig. 5-5, we know the total resistance of 3-350Ω parallel load cells is 117Ω. (Fig. 5-5)

Using Ohm’s Law:

\[
I_T = \frac{E_T}{R_T} = \frac{15V}{787\Omega} = .019A \text{ or } 19mA
\]

\[
E_{\text{LCT}} = R_{\text{LC}} (I_T) = 117\Omega (.019A) = 2.22 \text{ volts}
\]

\[
E_{\text{EXC}} = R_{\text{EXC}} (I_T) = 670\Omega (.019A) = 12.73 \text{ V}
\]
You can see the high resistance excitation barrier has dropped 12.73 volts leaving only 2.22 volts excitation for our load cells. Instead of 45mV output at full load, the load cells only put out 2.22V (3mV/V) or 6.66mV.

As previously calculated, the 6000 lbs live load only represents 80% of our scale capacity. So, at 6000 lbs, the load cell is only using 80% of its full scale output or in our case, 6.66mV (.8) = 5.33mV.

To figure the µV/grad sensitivity of our load cell outputs, we divide the mV output caused by our live load (5.33mV) by the resolution desired (6000 graduations).

\[
\text{Sensitivity} = \frac{5.33 \text{mV}}{6000 \text{grads}} = 0.89 \mu\text{V/grad}
\]

Remember, the sensitivity of our indicator is 1 µV/grad. As you can see, our indicator is not sensitive enough to accurately measure our load.

Now let’s look at the same example except we will use 700Ω load cells in place of the 350Ω load cells. All other parameters will stay the same.

Figure 5-6. Load Cell & Barrier Resistance Combination

Figure 5-6 represents our load cell/barrier resistances. Three 700Ω load cells in parallel equals 233Ω total equivalent load cells resistance (700Ω/3 = 233Ω). Refer back to Ohm’s Law to calculate total current, barrier and load cells voltage drops (Fig. 5-6)

\[
I_T = \frac{E_{EXC}}{R_{EXC}} = \frac{15V}{670\Omega} = 0.0166 \text{ A or 16.6mA}
\]

\[
E_{LC} = R_{LC} (I_T) = 233\Omega \times (0.0166A) = 3.87 \text{ volt}
\]

\[
E_{EXC} = R_{EXC} (I_T) = 670\Omega \times (0.0166A) = 11.12 \text{ volts}
\]

You can see that the 700Ω load cells have more excitation voltage available than the 350Ω load cells. With the 3mV/V full scale output, our load cell output at full load is 11.61mV.

Again, going back to our original system configuration, the 6000 lbs live load represents only 80% of our total load cell capacity. At full scale, our load cell is outputting 11.61mV (.8) or 9.29mV.

Again, calculating the sensitivity:

\[
\text{Sensitivity} = \frac{9.29 \text{mV}}{6000 \text{grads}} \approx 1.55 \mu\text{V/grad}
\]

Our indicator is sensitive enough (1 µV/grad) to measure this signal.
1. Who is responsible for classifying hazardous environments?

2. Determine the system output sensitivity for the following scale:

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead load</td>
<td>50 lbs</td>
</tr>
<tr>
<td>Live Load</td>
<td>500 lbs</td>
</tr>
<tr>
<td>Scale Cap.</td>
<td>500 lbs x .05 lbs</td>
</tr>
<tr>
<td>Load Cell Size</td>
<td>1000 lbs/350Ω</td>
</tr>
<tr>
<td>F.S.O.</td>
<td>3mV/V</td>
</tr>
<tr>
<td>Excitation Voltage</td>
<td>10V</td>
</tr>
<tr>
<td>+Excitation Barrier Resistance</td>
<td>40Ω</td>
</tr>
<tr>
<td>-Excitation Barrier Resistance</td>
<td>65Ω</td>
</tr>
</tbody>
</table>

3. Determine the system output sensitivity for the following system:

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead load</td>
<td>1000 lbs</td>
</tr>
<tr>
<td>Live Load</td>
<td>6000 lbs</td>
</tr>
<tr>
<td>Scale Cap.</td>
<td>6000 lbs x 1 lb</td>
</tr>
<tr>
<td>Load Cell Size</td>
<td>4000 lbs/700Ω</td>
</tr>
<tr>
<td>F.S.O.</td>
<td>3mV/V</td>
</tr>
<tr>
<td>Excitation Voltage</td>
<td>15VDC</td>
</tr>
<tr>
<td>+Excitation Barrier Resistance</td>
<td>50Ω</td>
</tr>
<tr>
<td>-Excitation Barrier Resistance</td>
<td>75Ω</td>
</tr>
</tbody>
</table>

See Appendix c for answers to Review Exercises.
5.4 Communication Interface

Communication data interface techniques for hazardous environments are handled like other wiring schemes for the Class, Division and Group where the equipment is located. Any communications equipment that does not have Factory Mutual Approval cannot be used inside the hazardous location. The use of intrinsically safe barriers to reduce data transmission energy levels eliminates the necessity to employ explosion proof protection techniques. Generally, each single conductor used for communications purposes will have a single barrier terminal associated with it. A separate terminal is used for the ground connection. The ground lead must be connected to true earth ground and have a resistance no greater than one ohm. The barriers must be able to handle the signal current and voltage levels. RS-232C voltage levels are normally in the ±12 volt range but may be as high as ±15 volts. As with all intrinsically safe wiring, communications wiring must be provided with a means to prevent transmission of gases and/or vapors. For sealing cables and raceways containing intrinsically safe circuits, ordinary conduit fittings for sealing can be used. Non-explosion proof seals are appropriate.
6.0 Installation

OBJECTIVE: Identify correct installation procedures for explosion proof, intrinsically safe, and dust ignition proof systems.

6.1 Correct Procedures and Responsibilities

When installing weighing systems in hazardous locations, the scale professional, certified electrician and authority having jurisdiction over the area must work together as a team. The more each one of these individuals knows about the others’ responsibilities, the smoother the installation will proceed. If you have questions about your area of responsibility, be sure to ask the questions and have it answered thoroughly before you proceed any further in the installation process. Also, if you have questions about the other parties’ responsibilities and techniques, bring those questions up to them. By double checking and being sure of your and others’ responsibilities, a safe, efficient system can be installed. Correct installation procedures are found in the National Electrical Code Handbook and ANSI/ISA RP 12.06.01 “Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations.”

6.2 Explosion Proof Systems

The design of an explosion proof system does not contain the explosion, but it does control it. Because there are paths between the inside of the enclosure and the hazardous area, certain installation techniques must be employed to retain the enclosures explosion proof integrity.

6.2.1 Wiring Methods

NOTE: See Class I and Class II wiring charts in Appendix D.

Class I, Division 1

Protection of energized conductors is just as important as the protection of other energized parts. The most common wiring method is the use of rigid metal conduit, either steel, aluminum or bronze. Also, threaded steel intermediate metal conduit is used. These conditions must be met:

• A minimum of 5 fully engaged threads made wrench tight to provide adequate conduit system joints
• Enclosure connections shall always be threaded
• Knockouts with lock nut and bushing connections are not acceptable
• Explosion proof flexible connections and fittings are allowed if approved for Class I locations
• All boxes and fittings are to be marked with their hazardous location class and group for which they are designed. Threaded couplings provided as part of the conduit need not be marked.
• Conduit bends and threaded nipples made from conduit are permitted.

Class I, Division 2

The following wiring methods are permitted:

• All acceptable Class I, Division 1 methods
• Enclosed and gasketed busways and wireways
• Flexible metal fittings and conduit
• Liquid tight flexible metal conduit
• Extra hard service flexible cord
• Non-hazardous locations outlets and junction boxes, conduit and cable fittings.

If flexible conduit or liquid tight flexible metal conduit is used, the conduit should not be used as the equipment grounding path. The circuit should contain an equipment grounding conductor or there should be a bonding conductor around the conduit. The bonding conductor should not be wrapped around the raceway as this will cause greater inductance in the circuit.
6.2.2  Seals
Seals are made for either horizontal or vertical installation. A vertical seal is not to be used in a horizontal application and vice versa.

Class I, Division 1
Seals are required to complete the explosion proof enclosures. Rigid metal conduits are considered explosion proof enclosures. Flammable gases can be transmitted from one location to another simply by pressure differentials at the ends of horizontal conduit runs as a result of air movement outside the conduit. However, gases and vapors can move through non-hazardous runs without any pressure differential. Seals are used to minimize this passage of gases, vapors and/or flames from one portion of the electrical installation to another through the conduit system.

Seals are required:
- In each conduit run leaving the Division 1 location whether the conduit run is entering a Division 2 or non-hazardous location
- Within 18" of explosion proof enclosures housing parts that are ignition sources under normal operating condition, such as switches, circuit breakers and/or high temperature parts.
- Within 18" of each enclosure for conduits larger than 1 1/2".

Sealing of conduits, regardless of size, will permit use of more readily available and lower cost explosion proof equipment than would be required if all conduits were sealed in accordance with minimum requirements of the NEC.

Class II, Division 2
The requirements for seals in Division 2 locations are somewhat more complex than Division 1 locations because more cable wiring types are permitted. Consideration must therefore be given to cable in conduit and cable not in conduit.

When conductors in a conduit are sealed, the sealing compound is poured around the conductor insulation. Spaces between each strand of a stranded conductor (called interstices, see Figure 6-1) are not sealed by a conduit seal. In large conductors (larger the #2 AWG), strand interstices may permit passage of gas and even weak explosions. In critical situations, these small passages of gas should be taken into consideration. The strands can be sealed by using compression-type connectors and tape between the end of the connector and the end of the conductor insulation.

Figure 6-1. Single Insulated Conductor Cross-section

Multiconductor cables can be considered similar to insulated conductors in a conduit. There may be space between the individual insulated cable conductors and the outer jacket. This space is called the cable core (see Figure 6-2). Some cable cores contain fillers which act as gas blockers (see Figure 6-2). If a cable is constructed so it blocks gases or is installed so the core of the cable is equivalent to a conduit seal, the cable is considered a gas-blocking cable. Some cables are specifically designed and listed as gas-blocking cables.
Figure 6-2. Cable Types

If your cable is in conduit, use Division 1 sealing procedures. Sealing procedures for cables not in conduit vary, depending on the cable type.

For cables with gas/vapor tight continuous sheathes, a seal is not required at the boundary of the Division 2 and non-hazardous location if the cable is sealed at the enclosure (see Figure 6-3). The enclosure seal may be a Division 2 approved cable sealing fitting or a combination conduit nipple and seal.

Figure 6-3. Seal Not Required

If the cable does not have a gas/vapor tight continuous sheath, a seal is required at the boundary of the Division 2 and non-hazardous location. A seal is also required at the enclosure (see Figure 6-4). If any cable enters the explosion proof enclosure and is not in conduit, its jacket must be removed and the individual insulated cable conductors must be sealed.
Special Precautions
The mounting and installation of explosion proof equipment is different from that of a standard unit. The explosion proof enclosure is substantially heavier than the standard enclosure. The mounting structure must be capable of supporting this weight.

All joint surfaces should be protected so they are not scratched or damaged. If equipment is to be painted after installation, care should be taken to ensure that the paint does not get on joint surfaces.

Bolts and nuts should be drawn up tightly. If a torque is specified by the manufacturer, that torque should be used. (35-45 ft./lbs for Rice Lake Weighing Systems enclosures.) Bolts left out or not tightened can reduce or destroy the explosion proof enclosure effectiveness. Conduit should be tightened wrench tight. Threaded covers, plugs, etc. must be securely tool tightened. Hand tightening is not adequate.

Care should be taken to determine that various components of the explosion proof system are compatible with each other. Conduit fittings for sealing are tested based on the use of specified materials. Only these sealing materials should be used. A sealing compound made by Manufacturer A should not be used with a sealing fitting made by Manufacturer B. Although it may appear to be the identical compound, sealing compounds have additives often unique to the particular manufacturer that cause the compound to expand during the drying process. This expansion could result in large mechanical forces on the fitting itself and could crack or otherwise damage the fitting if it is not designed for that particular compound. Too little expansion can reduce the seal effectiveness.

Some enclosures use high strength bolts. Substitution of an equivalent size bolt of a different strength can reduce enclosure effectiveness.

6.2.3 Intrinsically Safe Systems
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 a specific flammable or combustible atmospheric mixture in its most easily ignitable concentration.
**Wiring Methods**

Article 504 of the NEC covers the installation of intrinsically safe apparatus and wiring in Class I, II and III locations. Also, refer to ANSI/ISA RP 12.06.01. Intrinsically safe apparatus, associated apparatus and other equipment will be installed in accordance with the control drawing(s) provided by the manufacturer of the intrinsically safe or associated apparatus.

Conductors and cables of intrinsically safe circuits not in raceways or cable trays must be separated by at least 2" and secured from conductors and cables of any non-intrinsically safe circuits. Two inches should also be maintained between intrinsically safe conductors and non-intrinsically safe conductors when placed in any raceway or cable tray unless these circuits are separated by a grounded metal partition or an approved insulating partition. It is also permissible to place intrinsically safe conductors in raceways or cable trays with non-intrinsically safe conductors where either group of conductors are in grounded metal-sheathed or metal clad cables where sheathing or cladding is capable of carrying fault current to ground. Different intrinsically safe circuits shall be in separate cables or will be separated from each other by placing conductors of each circuit within a grounded metal shield or by ensuring each conductor has insulation with a minimum of 0.01".

Conductors of intrinsically safe circuits within enclosures shall be separated by at least 2" from non-intrinsically safe circuits. All conductors will be secured so that any conductor that might come loose from a terminal cannot come in contact with another terminal. The use of separate wiring compartments for the intrinsically safe and non-intrinsically safe terminals is the preferred method of complying with this requirement. Physical barriers such as grounded metal partitions or approved insulating partitions can be used to help ensure the required wire separation.

Remember, wiring has inductance and capacitance associated with it. Inductive and capacitive elements store energy. Consult the manufacturer’s specifications as to the maximum cable length permitted for your specific installation.

**Identification**

Intrinsically safe circuits must be identified at terminal and junction locations to prevent unintentional interference with the circuits during testing and servicing. Raceways, cable trays and open wiring for intrinsically safe wiring must be identified with permanently fixed labels with the wording “Intrinsically Safe.” The labels will be located so they are visible, after installation, and placed so they may be readily traced through the entire length of the installation. Spacing between labels will not be more than 25 ft. Color coding may be used to identify intrinsically safe circuits if the color used is light blue and no other conductors are colored blue.

**Barrier Locations**

Intrinsic safety barriers are usually installed and grounded in non-hazardous locations. They should be located as close as possible to the hazardous location to prevent the connection of high energy circuitry onto the intrinsically safe side of the safety barrier. There are some applications where it is necessary to install the barriers in a hazardous location. If this is the case, then the barriers must be in a suitable enclosure, such as a purged or explosion proof enclosure.

**Barrier Grounding**

To ensure the voltage limiting section of the barrier is working properly, the barriers must be properly grounded. The grounding path resistance from the farthest barrier to the designated ground electrode must not exceed 1Ω. The barrier ground conductor must be capable of carrying the maximum fault current (#8 AWG is recommended). In any case, the ground conductor cannot be any smaller than #12 AWG. Shake proof terminals must be used to connect the ground conductor to the barrier ground bus. All ground path connections will be secure, permanent, visible and accessible. The safety of the entire installation is ensured by proper grounding. The total ground assembly must be maintained and routinely inspected.
6.3 Class II. Division 1

6.3.1 Dust Ignition Proofing
Since the wiring methods in Class II, Division 1 environments need not be designed to withstand the pressures of explosions, the requirements are not as stringent as they are in Class I, Division 1 hazardous locations.

Wiring Method
Fittings and boxes in which taps, joints or terminal connections are made and are used in locations where dusts of a combustible electrically conductive nature are used are required to be approved for Class II locations, which means they must be dust ignition proof or pressurized. However, if the boss or fitting does not include taps, joints or terminal connections, the fittings and boxes are not required to be dust ignition proof or pressurized. However, these boxes must be provided with threaded bosses for connection to threaded conduit or cable terminations, and to have close-fitting covers with no openings through which dust might enter or through which sparks or burning material might escape.

Seals
Seals in Class II, Division 1 locations must prevent dust from entering an otherwise dust-tight enclosure. There are several acceptable methods to prevent dust from entering a dust ignition proof enclosure from one that is not dust ignition proof. A permanent and effective seal may be placed in the raceway. A horizontal raceway not less than 10 feet long or a vertical raceway not less than 5 feet long and extending downward from the dust ignition proof enclosure may be used. These 5 feet and 10 feet raceways are considered being long enough to permit any dust which enters the raceway to settle out of the air before it reaches the dust ignition proof enclosure.

Special Precautions
Precautions for dust ignition proof equipment are essentially the same as for explosion proof equipment. The joints and gaskets should be protected during installation. All bolts and nuts must be properly torqued and threaded conduit systems made wrench tight. Grounding and bonding is just as important in Class II locations as it is in Class I locations. Faults within the equipment must be cleared quickly to maintain the dust ignition proof properties of the enclosure and prevent excessive surface temperatures that could ignite a dust layer.

6.3.2 Intrinsically Safe Systems
Intrinsically safe has exactly the same meaning in Class II locations as it does in Class I locations. Because the ignition temperatures of dusts are generally below the ignition temperatures of gases and vapors, intrinsically safe equipment in Class II locations is limited to surface temperatures on exposed parts of 200°C (392°F) for Groups E and F locations and 160°C (329°F) for Group G locations. An exception is made where tests show that higher temperatures on small parts will not result in ignition or charring of the appropriate test dusts.

6.4 Class III Locations
Equipment suitable for Class II, Division 2 locations is acceptable for use in Class III locations. Wiring methods are required to be rigid metal conduit, rigid non-metallic conduit, intermediate metal conduit, electrical metallic tubing, dust-tight wireways or type MI, MC or SNM cable. Boxes and fittings are required to be dust-tight where flexible connections are necessary.

Always consult the National Electrical Code Handbook and ANSI/ISA RP 12.06.01 when installing equipment in hazardous locations. Make sure your copies of these publications are current. A certified electrician must make all electrical installations. These installations must be certified “safe” by the authority having jurisdiction over the hazardous location before the installations are put into operation.
Also, the scale professional should ensure all wires are connected as they should be. For example, load cells are connected to the correct excitation, sense and signal terminals and all communication lines are correctly connected to provide RS232, BCD or 20 mA current loop data transmission.

6.5 Initial Calibration

After the certified electrician has properly installed the weighing system to your specifications and the authority having jurisdiction over the area has certified the systems safe for operation, then the scale professional may proceed with the initial calibration.

6.5.1 Explosion Proof/Dust Ignition Proof Equipment

To perform calibration on equipment in explosion proof/dust ignition proof equipment, the enclosure must be opened. Before opening the enclosure, make sure the hazardous area has been made “safe.” That is, the explosive atmosphere is not present in the area. Have the authority having jurisdiction over the area declare the area safe before opening any enclosures. After the area is declared safe, proceed with calibration as you would for a normal scale installation using equipment instruction manuals. After the calibration is completed, secure the enclosure by torquing the bolts/fasteners to the appropriate manufacturer recommended torque values. Failure to properly torque the enclosure could compromise the system’s explosion proof/dust ignition proof integrity. Before applying power to the system, contact the authority having jurisdiction so he/she can certify the system safe for use.

6.5.2 Intrinsically Safe Systems

Because intrinsically safe systems do not emit enough energy to ignite the hazardous location, they may be calibrated in a hazardous atmosphere. Some preliminary adjustments may need to be made when setting up intrinsically safe equipment. You should be electrically grounded while making these internal adjustments to prevent static discharge and damage to components. The equipment should be in contact with the same ground. Since you will be grounded, it is imperative that you do not come into contact with electrical power as you may be severely injured. A common way to ground yourself is through a conductive wrist strap connected to ground through a 1 MΩ resistor. This constitutes a “soft” ground to prevent lethal currents from passing through your body in case you contact live circuits.

Before performing any calibration, make sure the authority having jurisdiction over the area has given you the go-ahead. Also, have the authority having jurisdiction over the area inspect the system after you have set up and calibrated the system.
1. In which publications can correct hazardous area installation procedures be found?

2. What are the purposes of seals in Class I, Division 1 locations?

3. What is the minimum separation distance between conductors and cables of intrinsically safe circuits not in raceways or cable trays?

4. Explain why and how intrinsically safe circuits should be identified.

5. What is the maximum resistance for a barrier ground connection? What is the smallest wire that can be used as a barrier ground conductor?

6. What is the torque specifications for Rice Lake Weighing Systems explosion proof enclosures?

7. Explain how gas or vapors can be transmitted through cables?

8. What is the purpose of seals in Class II, Division 1 locations?

9. What must be done before opening an explosion proof enclosure in a hazardous environment?

See Appendix C for answers to Review Exercises.
7.0 Service

7.1 Explosion Proof Systems
When servicing explosion proof systems, be sure the authority having jurisdiction over the area has declared the area safe before opening any enclosures in the area. All bolts and nuts should be in place and drawn tight and torqued to manufacturer’s specifications. Many hazardous areas are corrosive areas. Check for signs of corrosion. Replace corroded enclosures if necessary. Joint surfaces are susceptible to corrosion. Check and clean these surfaces. Visually check all threaded joints for corrosion. Visually check all ground connections for tightness. All enclosures should be checked to make sure they are complete. Make sure covers and plugs are not missing.

Some explosion proof enclosures have a lens assembly that screws into place. This assembly must be handled carefully. After taking the lens assembly off of the enclosure, place it in a protected area so the threads are not damaged nor the lens scratched. The threads must be clean. Remember, threads on an explosion proof enclosure are critical as they serve to cool escaping exploded gases.

⚠️ Caution
Scratches on the lens weakens the lens’ ability to contain the amount of the explosion it is designed to contain. An explosion could shatter a scratched lens causing serious fire and potential loss of life. Inspect the lens during periodic inspections.

7.2 Dust Ignition Proof
Dust ignition proof equipment is inspected much like explosion proof equipment. If a dust ignition proof enclosure is opened at any time, all dust that enters the enclosure should be carefully cleaned out before re-closing the enclosure.

7.3 Intrinsically Safe Systems

7.3.1 Maintenance
The condition of each safety barrier should be checked at least once each year. These periodic inspections should ensure that no accumulation of dust, corrosion, film or moisture is present on barrier terminals, ground terminals and conductors or the ground sink. Connections should be checked and tightened if vibration has caused them to loosen. No stray wire strands are allowed, as they may short out terminals. A test of the ground system resistance should be made to ensure maintenance of less than the $1\,\Omega$ specification. Under no circumstances should a test instrument or lead of any kind contact intrinsically safe terminals or wiring. Check to see if all safety components of the system are intact, including both diodes in a diode barrier. Check to see that the separation between the intrinsically safe and non-intrinsically safe circuits, both in hazardous and non-hazardous areas is still being maintained and there are no changes from the original system design. Remember, barriers are by design made unrepairable. Repair of all intrinsically safe instruments can be made only at the factory or a Factory Mutual approved service center. Some barriers are equipped with keyed fuse assemblies. The fuse is replaceable but is keyed so it fits in only the size of barrier that it is intended. This eliminates the possibility of a wrong size fuse being installed into the barrier.

7.3.2 Barrier Replacement
The following are guidelines for barrier replacement. Do not use these guidelines as your only reference for replacement. Replacement should be accomplished in accordance with the manufacturer’s specifications. Maintenance on any equipment associated with hazardous locations must be accomplished per manufacturer’s directions. Be sure to have the manufacturer(s) manuals with you and use them at all times, even if you have accomplished the tasks many times.
1. Disconnect the wiring from the barrier’s non-hazardous terminals prior to disconnecting the wires from
the intrinsically safe terminals.

2. Cover bare wire ends with tape or other insulating material, especially those conductors that are towards
the hazardous location.

3. Disconnect the barrier from ground. In most cases, this step will also remove the safety barrier from the
mounting hardware.

4. Reverse this procedure to mount the new barrier.

Anytime any hazardous area system is serviced and recalibrated, have the system re-inspected and rendered
“safe” by the authority having jurisdiction over the area prior to reapplying power to and/or operating the system.
1. Name three things to check when servicing explosion proof systems.

2. Name four guidelines to use when replacing intrinsic safety barriers.

3. Who should repair intrinsically safe equipment?

See Appendix C for answers to Review Exercises.
Appendix A

**National Fire Protection Association**
1 Batterymarch Park
Quincy, MA 02269-9990
1-800-344-3555

**Factory Mutual Global**
1151 Boston-Providence Turnpike
Norwood, MA 02062
617-762-4300

**Underwriters Laboratories, Inc.**
Publications Stock
333 Pfingsten Road
Northbrook, IL 60062
708-272-8800 (Ext. 2612 or Ext. 2622)

**Instrument Society of America**
67 Alexander Drive
Research Triangle Park, NC 27709
919-549-8411
Appendix B

GLOSSARY

AIT
Auto Ignition Temperature.

ANSI
American National Standards Institute.

API
American Petroleum Institute.

Approved
Acceptable to the authority having jurisdiction.

Associated Apparatus
Apparatus in which the circuits are not necessarily intrinsically safe themselves, but may affect the energy in the intrinsically safe circuits and are relied upon to maintain intrinsic safety. An associated apparatus has identified intrinsically safe connections for intrinsically safe apparatus and also may have connections for non-intrinsically safe apparatus.

Authority Having Jurisdiction
Where public safety is primary, the “Authority having Jurisdiction” may be a federal, state, local or other regional institution, department or individual. Some examples are a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector or other having statutory authority. For insurance purposes, an insurance inspection department rating bureau or other insurance company representative may be the “Authority having Jurisdiction.”

Auto Ignition Temperature (AIT)
The minimum temperature required for a substance to initiate or cause self-sustained combustion independently of the heating or heated equipment. Also referred to as ignition temperature.

BASEEFA
British Approvals Service for Electrical Equipment in Flammable Atmospheres.

BSI
British Standards Institute.

CSA
Canadian Standards Association
Catalytic Reaction
A relatively fast, self-sustaining, energetic, sometime luminous, sometimes audible reaction that occurs as a result of the catalytic action of any substance on the sample or its decomposition products, in a mixture with oxygen.

CENELEC
European Electrotechnical Committee for Standardization

Class I Location
A location in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Control Drawing
A drawing or document provided by the manufacturer of the intrinsically safe or associated apparatus that details the allowed interconnections between the intrinsically safe and associated apparatus.

DIP
Dust ignition proof.

Dust Ignition Proof
Equipment so enclosed to exclude ignitable amounts of dust or amounts that might affect performance or rating and that where installed and protected in accordance with the NEC will not permit arcs, sparks, or heat otherwise generated or liberated inside the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

Dust-Tight
Equipment so constructed that dust will not enter the enclosing case under specified test conditions.

Entity Approval
Each piece of intrinsically safe equipment is evaluated separately and assigned a set of safety parameters. Entity approved equipment can be used with other entity approved equipment. “Entity” is an American word. In Europe they use the word “Parametric” in lieu of “Entity”.

Explosion Proof Apparatus
An apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it. It must also prevent the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within. It must operate at external temperatures so that a surrounding flammable atmosphere will not be ignited by it.

Flash Point
The flash point of a liquid is the minimum temperature at which the liquid gives off sufficient vapor to form an ignitable mixture with air near the surface of the liquid or within the test vessel used.

FM
Factory Mutual Global
Fuse-Protected Shunt Diode Barrier
A network designed to limit current and voltage that consists of a series fuse, voltage-limiting shunt diodes, and a current limiting resistor or other current-limiting resistor or other current-limiting components. The fuse is intended to protect the diodes from open-circuiting when high fault current flows.

Hazardous (Classified) Location
A location where fire or explosion hazards may exist due to the presence of flammable gases or vapors, flammable liquids, combustible dust or easily ignitable fibers or flyings.

Hot-Flame Ignition
A rapid, self-sustaining, sometimes audible gas-phase reaction of the sample or its decomposition products with an oxidant. A readily visible yellow or blue flame usually accompanies the reaction. Also called the Auto Ignition Temperature.

IEC
International Electrotechnical Commission

ISA
Instrument Society of America

Parametric Approval
Each piece of intrinsically safe equipment is evaluated separately and assigned a set of safety parameters. Parametrically approved equipment can be used with other parametrically approved equipment. “Parametric” is a European word. In North America we use the word “Entity” in lieu of “Parametric”.

Pressurization
The process of supplying an enclosure with clean air or an inert gas with or without continuous flow at sufficient pressure to prevent the entrance of combustible dust.

Protective Component
A component or assembly which is so unlikely to become defective in a manner that will lower the intrinsic safety of the circuit that it may be considered not subject to fault when analysis or tests for intrinsic safety are made.

Purging
The process of supplying an enclosure with clean air or an inert gas at sufficient flow and positive pressure to reduce to an acceptable safe level the concentration of any flammable gases or vapors initially present, and to maintain this safe level by positive pressure with or without continuous flow.

Resistivity
The electrical resistance offered by a unit cube of material to the flow of direct current between opposite faces of the cube. It is measured in ohm-centimeter.

SAMA
Scientific Apparatus Makers Association
**Simple Apparatus**
An apparatus that does not generate or store more than 1.2 Volts, 100 milliamps, 20 microjoules, 25 milliwatts. A simple apparatus does not need to be approved for use with intrinsically safe circuits. However it does need to be connected to an intrinsic safe barrier to prevent a fault from being introduced into the intrinsically safe area. Example are switches, thermocouples, light emitting diodes, and resistance temperature devices (RTD's).

**SIT**
Spontaneous Ignition Temperature

**SMRE**
Safety in Mines Research Establishment

**System Approval**
A method used by approval, certifying, or listing agencies in which intrinsically safe equipment including barriers, are approved as a system and cannot be used in combination with any other item or device for intrinsically safe applications.

**UEL (UFL)**
Upper Explosive Limit (Upper Flammable Limit). A mixture above the UEL (UFL) is too rich to burn.

**UL**
Underwriters' Laboratories, Inc.

**Vapor Density**
The ratio of the weight of a volume of pure vapor or gas (no air present) to an equal volume of dry air at the same temperature and pressure. A vapor density of less than 1 indicates that the substance is lighter than air and will tend to rise in a relatively calm atmosphere. A vapor density greater than 1 indicates that the substance is heavier than air and may travel along grade level for a considerable distance to a source of ignition and flash back, assuming the gas or vapor is flammable.
1. Place the letter from the title next to its corresponding publication.

   B  1. ANSI/UL 913

   E  2. NFPA 496

   D  3. NFPA 70

   A  4. ANSI/ISA RP 12.06.01

   C  5. NFPA 497M

A. “Installation of Intrinsically Safe Instrument Systems in Class I Hazardous Location”

B. “Standard for Intrinsically Safe Apparatus and As-associated Apparatus for use in Class I, II and III, Division 1 Hazardous Locations”

C. “Classification of Gases, Vapors and Dusts for Electrical Equipment in Hazardous (Classified) Locations”

D. “National Electrical Code Handbook”

E. “Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations”
I. Classify each environment below according to Class, Division and Group.

1. Location where fibers that produce combustible flyings are handled.
   Class III, Division 1

2. A location containing gasoline which is processed in a closed system.
   Class I, Division 2, Group D

3. A location where ethylene oxide gas may exist during maintenance operations.
   Class I, Division 1, Group D

4. A location where coal dust is sensitized to present an explosion hazard and having a resistivity of 1000 ohm-centimeter during normal conditions.
   Class II, Division 1, Group F

5. A location where combustible dusts having a resistivity of 100,000,000 ohm-centimeter are in the air as a result of infrequent malfunctioning of handling equipment.
   Class II, Division 2, Group G

6. A location where ethylene gas is released because of faulty equipment operation.
   Class I, Division 1, Group C

7. A location adjacent to a Class I, Division 1 location where manufactured gas containing 33% hydrogen by volume is present.
   Class I, Division 2, Group B
REVIEW EXERCISE

Explosion Proof Systems

(From page 16)

1. Explain how the explosion proof enclosure flange and thread design prevent hazardous area explosions.

Flanges are machined so there is a slope formed. The opening is larger at the outside of the flange than at the inside. Exploded gases gradually escape through the sloped flange opening, causing the gas to cool before it reaches the outside environment.

The threads are long as compared to their width. The gas cools as it travels through the threads to the outside environment.
REVIEW EXERCISE

Intrinsic Safety

(From page 29)

1. What is the purpose of intrinsically safe circuitry?

To limit electrical and thermal energy to a level below that required to ignite a specific hazardous atmospheric mixture.

2. For the following statements, circle “T” if the statement is true and circle “F” if the statement is false.

   T / F   Intrinsically safe circuits always operate below minimum ignition energy levels.
           TRUE
   T / F   Intrinsic safety design is applied to Class I, II, and III, Division 1 hazardous locations.
           TRUE
   T / F   The length of cable connected to intrinsically safe circuits has no bearing on its energy producing effects.
           FALSE
   T / F   If circuit power requirements are above the minimum ignition levels of the hazardous location, engineering means other than intrinsic safety need to be employed.
           TRUE
   T / F   Intrinsic safety systems designed for Class II hazardous locations are suitable for use in Class I hazardous locations of the same group.
           FALSE
REVIEW EXERCISE

Purged Systems

(From page 32)

1. What is the purpose of purged systems as they pertain to hazardous environments?

Purged enclosures are designed to keep the hazardous environment out of the instrument enclosure by maintaining a slightly positive pressure inside the enclosure.
REVIEW EXERCISE

Enclosure Ratings

(From page 36)

I. Place the letter of the description in Column B next to its corresponding enclosure “Type” in Column A.

C  1. Type 8
A  2. Type 7
D  3. Type 9
B  4. Type 4

A. Use in Class I, Groups A, B, C & D, indoor use only.

B. Use in indoor and/or outdoor applications. Excludes water under test conditions.
   Non-hazardous design.

C. Use in Class I, Groups A, B, C & D, indoor and/or outdoor applications.

D. Use in Class II, Groups E, F or G, indoor use only.

II. Describe when non-hazardous designed enclosures may be used in hazardous locations.

Enclosures rated for non-hazardous locations which have met the requirements for
the dust test described in section 6.5 of NEMA Standard No. 250 may be used
in Class III, Division 2, Group G and Class III, Division 1, and 2 locations.
REVIEW EXERCISE
Specifying Hazardous Environment Equipment
(From page 49)

1. Who is responsible for classifying hazardous environments?
   The authority having jurisdiction over the area, e.g., Plant Safety Engineer,
   Insurance Underwriter, Fire Safety Inspector.

2. Determine the system output sensitivity for the following scale:

   | Dead load  | 50 lbs   | Load Cell Size: 1000 lbs/350Ω |
   | Live Load  | 500 lbs  | F.S.O.: 3mV/V |
   | Scale Cap. | 500 lbs x .05 lbs | Excitation Voltage: 10V |
   | +Excitation Barrier Resistance: 40Ω | -Excitation Barrier Resistance: 65Ω |

   **1.15 μV/grad**

3. Determine the system output sensitivity for the following system:

   | Dead load  | 1000 lbs   | Load Cell Size: 4000 lbs/700Ω |
   | Live Load  | 6000 lbs  | F.S.O.: 3mV/V |
   | Scale Cap. | 6000 lbs x 1 lb | Excitation Voltage: 15VDC |
   | +Excitation Barrier Resistance: 50Ω | -Excitation Barrier Resistance: 75Ω |

   **2.4 μV/grad**
1. In which publications can correct hazardous area installation procedures be found?
   National Electrical Code Handbook and ANSI/ISARP 12.6

2. What are the purposes of seals in Class I, Division 1 locations?
   Seals complete the explosion proof enclosures. Seals are used to minimize the passage of gases, vapors, and/or flames from one portion of the electrical installation to another, through the conduit system.

3. What is the minimum separation distance between conductors and cables of intrinsically safe circuits not in raceways or cable trays?
   2 inches

4. Explain why and how intrinsically safe circuits should be identified.
   Intrinsically safe circuits must be identified at terminal and junction locations to prevent unintentional interference with the circuits during testing and servicing. Spacing between labels will not be more than 25 feet.

5. What is the maximum resistance for a barrier ground connection? What is the smallest wire that can be used as a barrier ground conductor?
   The maximum resistance is 1 ohm. The smallest wire size is #12 AWG.

6. What is the torque specifications for Rice Lake Weighing Systems explosion proof enclosures?
   The torque specification is 35 – 45 ft-lbs.

7. Explain how gas or vapors can be transmitted through cables?
   Gas or vapors may be transmitted through the conductor interstices or through the space between the cables called the cable core.

8. What is the purpose of seals in Class II, Division 1 locations?
   Seals in Class II, Division 1 locations must prevent dust from entering an otherwise dust tight enclosure.

9. What must be done before opening an explosion proof enclosure in a hazardous environment?
   The hazardous are has to be made “safe”. The explosive environment cannot be present in the area and the authority having jurisdiction over the area must declare the area safe prior to the enclosure being opened.
REVIEW EXERCISE

Service

(From page 61)

1. Name three things to check when servicing explosion proof systems.

   1. All bolts and nuts are in place and torqued
   2. Check for corrosion
   3. Check that all parts are in place and tight

2. Name four guidelines to use when replacing intrinsic safety barriers.

   1. Disconnect non-hazardous wiring prior to disconnecting hazardous wiring
   2. Cover bare wire ends with insulating material
   3. Disconnect the barrier from the ground
   4. Reverse this procedure step-by-step when installing the barrier

3. Who should repair intrinsically safe equipment?

   The factory or Factory Mutual Approved service center are the only agencies that should repair intrinsically safe equipment.
### WIRING IN CLASS I LOCATIONS

<table>
<thead>
<tr>
<th>WIRING SYSTEM</th>
<th>DIVISION 1</th>
<th>DIVISION 2</th>
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<tbody>
<tr>
<td>Threaded rigid metal conduit</td>
<td>IS: A  NIS: A</td>
<td>IS: A  NIS: A</td>
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<tr>
<td>Threaded steel intermediate metal conduit</td>
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<td>IS: A  NIS: A</td>
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<td>Flexible metal explosion proof fitting</td>
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<td>IS: A  NIS: A</td>
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<td>IS: A  NIS: d A</td>
<td>IS: A  NIS: A</td>
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<tr>
<td>Type PLTC, MC, SNM, and TC cable</td>
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<td>IS: A  NIS: A</td>
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<tr>
<td>Flexible metal conduit</td>
<td>IS: A  NIS: NA</td>
<td>IS: A  NIS: c,e A</td>
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<tr>
<td>Liquid-tight, flexible metal conduit</td>
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<td>IS: A  NIS: c,e A</td>
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<tr>
<td>Electrical metallic tubing (steel)</td>
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<td>IS: A  NIS: NA</td>
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<tr>
<td>Flexible cord</td>
<td>IS: A  NIS: Note 3 f</td>
<td>IS: A  NIS: A cf Note 3 or 4</td>
</tr>
<tr>
<td>Any other wiring method suitable for nonhazardous locations</td>
<td>IS: A  NIS: NA</td>
<td>IS: A  NIS: NA</td>
</tr>
</tbody>
</table>

*Table 7-1. Wiring, Class I*

**Abbreviations:** IS = Intrinsically safe, NIS = Not Intrinsically Safe, A = Acceptable, NA = Not Acceptable, NEC = National Electrical Code

**a** See the NEC for a description and use of wiring systems.

**b** Acceptable only where flexibility needed.

**c** Acceptable only with termination fittings approved for Class I Division 1 locations of the proper groups.

**d** Special bonding/grounding methods for hazardous (classified) locations are required.

**e** Extra-hard-usage type with grounded conductor only acceptable.

**NOTES:**

1. Acceptable if entire conduit system and all enclosures are purged and pressurized using type X purging. Acceptable if entire conduit system and all enclosures are purged and pressurized using type Y purging, and there are no ignition-capable parts (arching, sparking or high temperature) under normal operating conditions.
2. Acceptable if circuit, under normal operating conditions, cannot release sufficient energy to ignite hazardous atmospheric mixture when any conductor is opened, shorted to ground, or shorted to any other conductor in the same cable or raceway.
3. Acceptable on approved portable equipment where provisions made for cord replacement per NEC.
4. Acceptable on process control instruments to facilitate replacements per NEC.
### WIRING IN CLASS II LOCATIONS $^{a,b}$

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<td>A</td>
<td>$^c$A</td>
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<td>Type M1 cable</td>
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<td>$^e$A</td>
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<td>A</td>
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<td>Type MC and SNM cable</td>
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<td>A</td>
<td>A</td>
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<td>Type PLTC and TC cable</td>
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<tr>
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<td>$^{c,d,g}$A</td>
<td>A</td>
<td>$^{c,d,g}$A</td>
</tr>
<tr>
<td>Flexible cord</td>
<td>$^d$A</td>
<td>$^{c,d,h}$A</td>
<td>A</td>
<td>$^{c,d,h}$A</td>
</tr>
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<td>Any other wiring method suitable for non-hazardous locations</td>
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<td>Electrical metallic tubing</td>
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<td>A</td>
<td>A</td>
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</tbody>
</table>

$^a$ Abbreviations: IS = Intrinsically safe, NIS = Not Intrinsically Safe, A = Acceptable, NA = Not Acceptable, NEC = National Electrical Code

$^b$ See the NEC for a description and use of wiring systems.

$^c$ Acceptable only where flexibility needed.

$^d$ Acceptable only with dust-tight seals at both ends when electrically conductive dusts will be present.

$^e$ Acceptable only with termination fittings approved for Class II, Division 1 locations of the proper groups.

$^f$ Acceptable in ventilated channel-type cable trays in a single layer with a space not less than the larger cable diameter between adjacent cables.

$^g$ Special bonding/grounding methods for hazardous (classified) locations are required.

$^h$ Extra-hard-usage type with grounded conductor only acceptable.

*Table 7-2. Wiring, Class II*
Appendix E

CABLE TYPES

AC - Armored Cable
Type AC cable is a flexible metallic enclosure with circuit conductors installed at the time of manufacturing. The maker of AC cable must be marked along its total length. AC cable is used for branch circuits and feeders. It must have a bonding strip that touches the outer flexible metal covering for its full length. AC type cable is to be secured at intervals not to exceed 4-1/2 feet and within 12 inches of a box or fitting. The 12 inches may be extended to 24 inches at terminals where there is a necessity for flexibility. The bends radius is taken from the inner edge of the bend and shall be not less than five times the diameter of the cable. Approved fittings to prevent abrasion of the conductors and their insulation shall be used. An approved insulating bushing is required to be inserted at the end between the conductors and the outer metallic covering. The connection to the fitting box must be designed that the insulated bushing will be visible for inspection without removing the fitting.

ACL - Lead Covered Armored Cable
The conductors are covered with lead. Used when armored cable is exposed to weather, continuous moisture, exposed to oil, for underground raceways, embedded in masonry or concrete or in filling buildings under construction and elsewhere where conditions may cause the insulation to deteriorate. ACL is not permitted for direct burial in the earth. An insulated bushing, as required for AC cable, is not required for ACL cable.

FCC - Flat Conductor Cable
FCC contains flat conductors made only of copper. Three or more flat copper conductors which are placed edge to edge and entirely enclosed with an assembly of insulation make up FCC cable. They are permitted to be used with individual branch circuits for general purpose and appliance branch circuits. FCC can be used on floors that are of sound construction and smooth. If metal surface raceways are used on walls FCC can be used. FCC cable will NOT be installed outdoors where they will be in wet locations, wherever subject to corrosive vapors, hazardous locations, residences, hospitals or schools.

IGS - Integrated Gas Spacer Cable
IGS is to be under pressure from an inert gas. It may be used underground, as well as for service entrance conductors as well as feeder or branch circuit conductors. IGS shall not be used in direct contact with the building when exposed. The insulation is composed of dry kraft paper tapes, which shall be pressurized by sulfur hexafluoride gas. Both the paper and gas shall be approved for electrical use. The pressure of the gas between the taped conductors and the outer nonmetallic conduit shall be 20 pounds per square inch gage (psig).

MI - Mineral Insulation
The cable consists of solid copper conductors insulated from each other and enclosed in a gas-tight, seamless copper sheath by tightly packed magnesia oxide powder. The cable materials are highly inorganic and will outlast any system using usual types of insulation. MI cables are highly resistant to heat, cold, liquids, and corrosion. Because there are no voids in the cable it is suitable for use in hazardous locations Class I, II, and III without the need to seal against the passage of gases, vapors or flames. It is relatively small in diameter and readily usable in crowded areas. The copper sheath is corrosive resistant, but where corrosive condition is harmful a plastic outer jacket can be factory installed.
Because the magnesium oxide is highly absorbent it is necessary to seal the ends whenever the cable is cut so moisture in the air is not absorbed by the insulation. A sealing compound must be placed at the end of the mineral insulation and the bare conductors must be provided with insulating sleeving. Type MI seals have a compression ring and fittings similar to those used on copper tubing. In addition there is a neoprene sleeve which slips into these fittings and is sealed with an epoxy resin, after which a neoprene bushing with holes for the conductors and the sleeves is inserted. Sealing must be done immediately after stripping or heating the cable to prevent the entrance of any moisture. The cable must be supported every 6 feet and bends must have a radius of at least five times the cable, diameter. Single conductor MI cable must be used when entering metal boxes to prevent induced currents from heating the cable.

**MC - Metal Clad**

There are three forms of MC cable.

1. Spiral armor formed of steel or aluminum strip. This type appears to be the same as AC cable but there are differences. A separate insulated (green) equipment grounding conductor is required because it does not have the bonding strip that AC (armored cable) does.

2. Smooth seamless metal jacket (usually aluminum) The bending radius for cables not more than 3/4 inch in diameter shall be a minimum of 10 times the diameter of the cable. For MC cable of more than 1-1/2 inches in diameter, the bending radius shall be a minimum of 12 times the diameter of the cable. For MC cable more than 1-1/2 inches in diameter the bending radius shall be a minimum of 15 times the diameter of the cable.

3. Corrugated seamless metal jacket. The bending radius shall not be less than seven times the diameter of the cable, measured for the radius from inside the coil.

Insulating bushings are not required but connectors must be specifically listed for use with MC cable. The connector throat is intended to hold the conductors away from the cut end of the armor. MC cable cannot be fished. MC is permitted for use as service entrance, in hazardous locations and in places of assembly. MC cable can be used for wet locations if the sheath is impervious to moisture or where the contained conductors are approved for use in wet locations.

MC cable can not be used where corrosive conditions exist. Some of the corrosive conditions are; direct burial in earth, causing electrolysis of the metal sheath or cinder fills which will consume the metal sheath rapidly. Some of the corrosive chemicals that deteriorate MC cable are hydrochloric acid, chlorine vapor, strong chlorides, and caustic alkalies. If the metal sheath is made of a material that resists corrosion caused by corrosive vapors it may be used per direction of the inspection authority.

MC cable must be supported every 6 feet.

**MV - Medium Voltage**

MV cable may be multiconductor or single conductor that is a solid dielectric cable. MV cable may be used for up to 35,000 volts, nominal, for power systems. It may also be used in wet or dry locations in raceways or cable trays. It may not be used when exposed to direct sunlight unless specifically identified for that purpose. Copper, aluminum or copper-clad aluminum conductors are permitted.

**NM - Nonmetallic Sheathed Cable**

NM is an assembly of two or more conductors having an outer sheath of moisture-resistant, flame-resistant, nonmetallic material. This cable is commonly called Romex. NM may have an uninsulated conductor or green insulated conductor for equipment grounding purposes in addition to the current-carrying conductors. NM cable is used mostly in residential areas.

There must be a distinctive marking on the exterior of the cable for its entire length that specifies the cable type and the name of the manufacturing company.

NM cable must not be used as service entrance, in commercial garages, theaters and assembly halls, motion picture studios, storage battery rooms, hoistways, hazardous locations, or embedded in poured cement, concrete, aggregate, fill, or plaster, or adobe. It may not be used where exposed to corrosive vapors or fumes.
NMC - Nonmetallic Sheathed Cable
Non metallic sheathed cable has an overall covering that is not only flame-retardant and moisture resistant but also fungus retardant and corrosion-resistant.
NM cable must not be used as service entrance, in commercial garages, theaters and assembly halls, motion picture studios, storage battery rooms, hoistways, hazardous locations, or embedded in poured cement, concrete or aggregate.

SNM - Shielded Nonmetallic Sheathed
SNM is permitted where the operating temperature of the cable is maintained at or below the temperature marked on the cable, in cable trays and raceways such as conduit and in specified hazardous locations. Its bends shall have a radius from the inner surface of the bend of not less than five times the diameter of the cable. Only fittings that are identified for use with SNM cable for connecting it to enclosures are to be used. The outer jacket is water-, oil-, flame-, corrosion-, fungus-, and sunlight-resistant.

SE - Service Entrance Cable
SE cable may be a single conductor or a multi conductor assembly. It is usually supplied with an outer covering but may be supplied without the covering. The covering must be flame-retardant and moisture-resistant. The neutral may be bare or covered. It may have a grounding conductor for the purpose of grounding equipment. When SE cable consists of two or more insulated conductors they are permitted to have a bare conductor wrapped around the insulated conductors and it will serve as a neutral conductor. SE cables are permitted to be used for branch circuits and feeders on interior wiring where all of the circuit conductors are rubber-covered or thermoplastic type.

TC - Power and Control Tray Cable
TC cable is made in copper, aluminum and copper-clad aluminum. The outer sheath is flame retardant and nonmetallic. If used in wet location it must be resistant to moisture and corrosive agents. TC cable is used where lighting and power, control and signal, and communication circuits may be used in cable trays and raceways outdoors, when supported by messenger wire. In some cases it may be used in hazardous areas. TC cable cannot be mounted on cleats or brackets in an attempt to use it as open wiring. It must be listed for exposure to direct sunlight if used in such a location. Direct burial is not permitted unless it is specifically listed for that use.

UF - Underground Feeder
UF is used for underground branch circuits and feeders. It is not to be confused with USE which is direct burial cable for services. The outer covering is flame-retardant, moisture-resistant, fungus-resistant, and corrosive-resistant.
UF is NOT to be used as service entrance cable, in theaters, commercial garages, motion picture studios, storage battery rooms, nor hazardous locations. It is not to be embedded in poured concrete or aggregate. It is not to be used in sunlight, unless specifically listed for such use.

USE - Underground Service Entrance Cable
USE is a direct burial cable recognized for use underground. Its insulation shall be moisture-resistant but not flame retardant.