



A Guide to Safe Electronic Weighing in Hazardous Locations

Hazardous Locations	2
Methods of Protection	3
Approval/Listing of Equipment	6
Weighing Equipment in Hazardous Areas	6
System Configurations	8
Overview of International Requirements	9
List of Approved Products	12
References	13



A Guide to Safe Electronic Weighing in Hazardous Locations

Hazardous Locations

This Vishay BLH handbook is intended to educate the user regarding the proper selection of electronic weighing systems used in hazardous locations. This document does not cover the installation of equipment as this is typically the responsibility of the installing electrician and/or engineering design firm. Information contained herein has been compiled from a number of published sources and condensed to cover the subject as related to electronic weighing equipment only.

1.1 The National Electric Code (ANSI/NFPA 70)

The stated purpose of the (NEC) code is 'the practical safeguarding of persons and property from hazards arising from the use of electricity'. Articles 500 through 517 of the code cover the installation of electrical equipment in locations where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers.

1.2 Hazardous Area Classifications

The classification of hazardous areas is dependent upon the properties of various hazardous materials and the likelihood of their presence. The following table is an interpretation of the classifications.

Table 1 – Location Classifications	
Class	
I	Vapor
II	Dust
III	Fiber
Division	
1	Always Present
2	Present Under Fault Conditions
Group	
A	Acetylene
B	Hydrogen
C	Ethylene
D	Propane
E	Metal Dust
F	Carbon Dust
G	Grain Dust

1.3 Temperature Classifications

The auto ignition temperature (AIT) of a hazard is a consideration when specifying equipment. A system of marking the external surface temperature of equipment for hazardous areas exists to identify suitability for a particular application. The following chart lists the temperature ranges for the various ratings.

Table 2 – External Surface Temperature Identification Numbers		
Maximum Temperature		ID Number
°C	°F	
450	842	T1
300	572	T2
280	536	T2A
260	500	T2B
230	446	T2C
215	419	T2D
200	392	T3
180	356	T3A
165	329	T3B
160	350	T3C
135	275	T4
120	248	T4A
100	212	T5
85	185	T6

NFPA standard 497M provides information of the ignition temperatures for Class I and Class II materials.

1.4 NEMA Designations

The National Electrical Manufacturers Association (NEMA) classifies enclosures for electrical equipment based upon application. The association publishes a performance standard that is used in conjunction with other standards to test and certify, approve or list enclosures for use in ordinary as well as hazardous locations.

A Guide to Safe Electronic Weighing in Hazardous Locations

Table 3 – NEMA Classifications of Non-Hazardous Locations

Protects Against:	1	2	4	4X	5	6	6P	11	12	12K	13
Incidental contact with enclosed equipment	*	*	*	*	*	*	*	*	*	*	*
Falling dirt	*	*	*	*	*	*	*	*	*	*	*
Falling liquids and light splashing		*	*	*		*	*	*	*	*	*
Dust, lint, fibers, and flyings			*	*	*	*			*	*	*
Hose down and splashing water			*	*		*	*				
Oil or coolant seepage									*	*	*
Oil or coolant spraying and splashing											*
Corrosive agents				*			*	*			
Occasional temporary submersion						*	*				
Occasional prolonged submersion							*				

Table 4 – NEMA Classifications of Hazardous Locations

<p>NEMA 7 – Enclosures for indoor use in Class I, Groups A, B, C, and D hazardous locations as defined by the NEC. Designed to withstand the pressure resulting from an internal explosion and to contain the explosion from igniting the atmosphere surrounding the enclosure.</p> <p>NEMA 8 – Enclosures for indoor or outdoor use in Class I, Groups A, B, C, and D hazardous locations as defined by the NEC. All potentially arcing contacts and connections are immersed in oil to prevent ignition of an explosive atmosphere.</p> <p>NEMA 9 – Enclosures for indoor use in a Class II, Group E or G hazardous locations as defined by NEC. Enclosures prevent the entrance of dust.</p> <p>NEMA 10 – Non-ventilated enclosures meeting the requirements of the Mine Safety and Health Administration, 30 C.F.R. Part 18.</p>
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Methods of Protection

Whenever possible electrical equipment should be installed outside of the hazardous area. In situations where this is not possible, methods are available to make the equipment safe for the location. The method of choice for a specific application is often a function of cost, simplicity and expected reliability. In some cases a system that combines several different technologies is the best choice.

2.1 Simple Apparatus

International authorities recognize that ‘Simple Apparatus’ such as thermocouples, resistive sensors, LED’s and switches may be employed in a hazardous area without third party certification if they do not generate or store more than 1.2V, 0.1A, 20J, and 25W. This concept has not yet gained widespread acceptance in the U.S.

2.2 Explosion-Proof Enclosure Systems

Explosion-proof enclosures for electrical equipment are designed to control an internal explosion so that it does not ignite a combustible hazard external to the system. In many cases these enclosures are heavy aluminum castings that are designed to withstand the pressure produced by an explosion, plus a safety factor. In addition to the strength of the enclosure, all penetrations are of sufficiently close tolerance and length to quench any flames that would otherwise propagate outside the enclosure. Explosion-proof equipment designs are available to satisfy any of the classification requirements.

2.3 Purged and Pressurized Enclosure Systems

Purged and pressurized enclosures are used to reduce the classification within the enclosure by some degree. Purging is a technique of supplying a sealed enclosure with a clean supply of inert gas or air in order to

A Guide to Safe Electronic Weighing in Hazardous Locations

remove and or prevent the entrance of a combustible vapor or dust. Three types of purges are recognized by NFPA, and are designated as types X, Y, and Z. A Type Y purge reduces the classification within the enclosure from Div. 1 to ordinary and is equipped with various interlocks to prevent application of power before a sufficient purge period has elapsed. A Type Y purge enclosure reduces the classification from Div. 1 to Div. 2, and a Type Z purge reduces a Div. 2 to ordinary.

2.4 Non-Incendive System Equipment

Non-incendive equipment is incapable of releasing sufficient electrical or thermal energy to ignite flammable gases or vapors under 'normal' operating conditions. Equipment of this type is suitable for use in Class I, Division 2 locations without special enclosures or other safeguards. In order for equipment to qualify as non-incendive, thermal energy from devices such as power supplies, resistors, etc., must be below that required to ignite the anticipated hazard (ref. par. 1.3, Temperature Classifications). In addition, the energy released at make and break contacts within the circuit must be below the minimum required energy needed to ignite the hazard (ref. Figure 2 – Typical Ignition Curve).

2.5 Intrinsically Safe Systems

Intrinsic Safety is based on the principal of restricting electrical energy available in the hazardous area equipment circuits under both normal and fault operating conditions. Limiting energy below the minimum level required to ignite the material makes any sparking contacts or heat producing components incapable of being an ignition source. This type of protection is used in Division 1 locations.

Intrinsically safe equipment can be approved as a complete system (loop) or as individual components under the 'entity' concept. A loop approval will specify each component of a system and the interconnection methods, etc., needed to gain and maintain an approval. The entity approval of a component of a system will allow for the interconnection of apparatus not specifically examined as a combination. The criteria for the interconnection is that specific entity parameters such as voltage, current, capacitance, and inductance are observed.

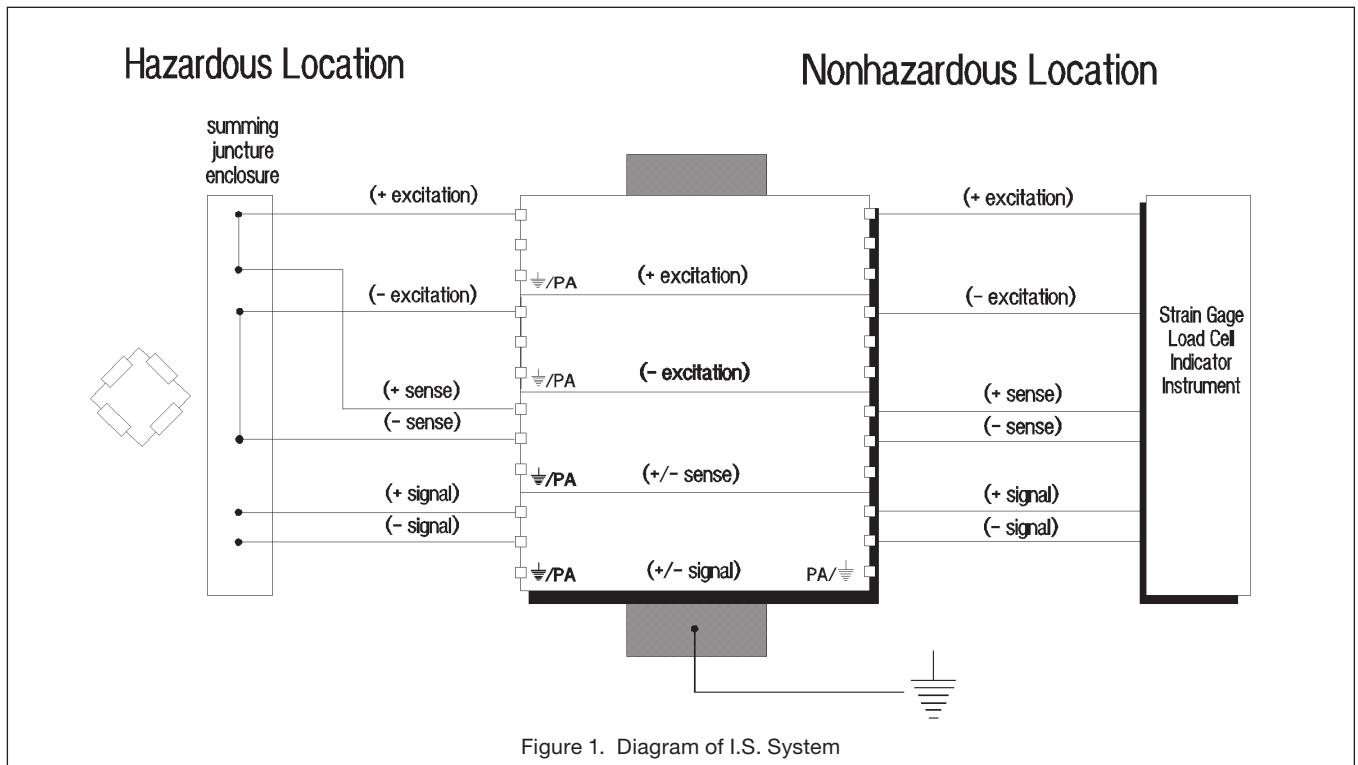


Figure 1. Diagram of I.S. System

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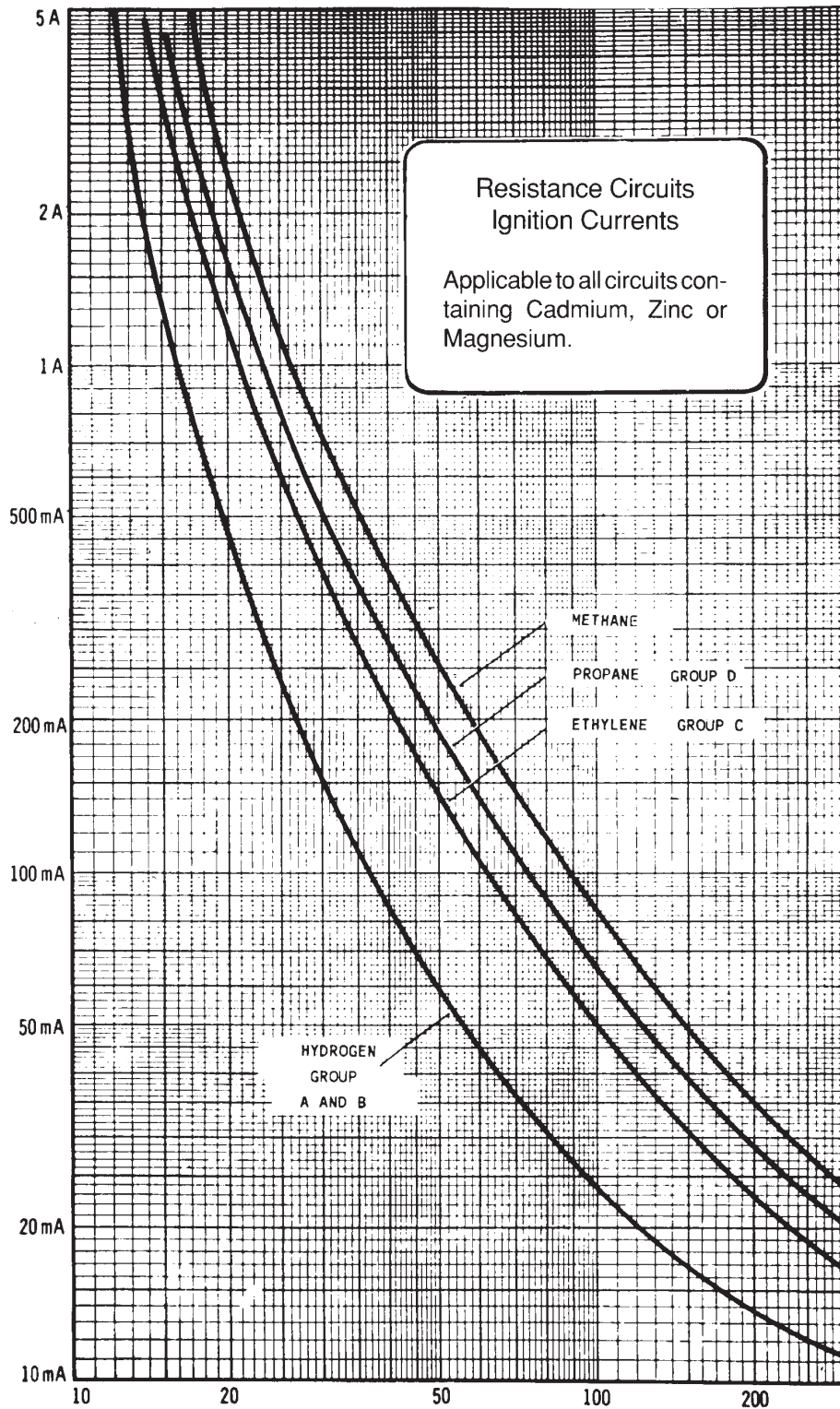


Figure 2 - Typical Ignition Curve

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Approval/Listing of Equipment

In many cases the NEC requires that the equipment used in hazardous locations be 'approved' by the authority having jurisdiction. The 'authority' can be a local building code official, fire marshal, insurance company, plant safety committee, or any combination thereof. These authorities often require that equipment be evaluated by a third party organization to ensure conformance to recognized standards. In the U.S.A., the predominant third party test/evaluation organizations are Factory Mutual Research (FM) and Underwriters Laboratories (UL). The standards applied to hazardous location equipment are developed and maintained by FM and UL and in some cases ISA and/or ANSI.

3.1 Standards

ISA 82.01, 82.02, and 82.03 - Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment

NFPA 496 - Purged and Pressurized Enclosures for Electrical Equipment

FM 3600 - Electrical Equipment for Use in Hazardous Location, General Requirements

FM 3610 - Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1 Hazardous Locations

FM 3611 - Electrical Equipment for Use in Class I, Division 2, Class II Division 2 and Class III, Division 1 and 2 Hazardous Locations

FM 3615 - Explosion-proof Electrical Equipment, General Requirements

FM 3810 - Electrical and Electronic Test, Measurement and Process Control Equipment

3.2 FM Labels

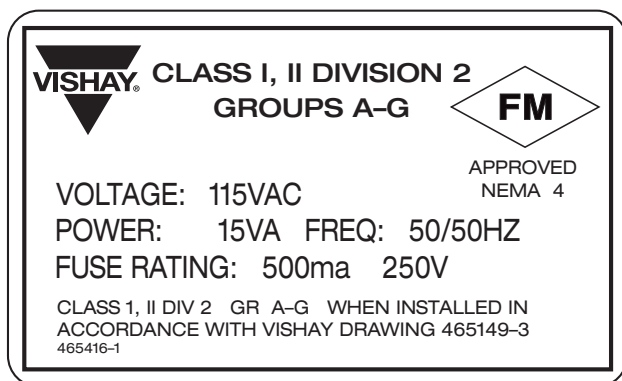


Figure 3 - Typical FM Label

Weighing Equipment in Hazardous Areas

Different elements of a process weighing system can be installed in locations with varying degrees of protection requirements. For example, it is common for the sensors to be installed in a Division 1 location while the display device is located in a non-hazardous area. Consequently, the design of the system will require differing levels of protection depending upon the location of specific components. In addition, the functional requirements of a device may preclude the use of a particular protection method. For example, load cells are required to deflect under load in order to operate, consequently, an explosion-proof enclosure/construction would not be a suitable method of protection.

4.1 Transducers

Electronic load cell transducers consist of a metal element with a series of strain gage sensors bonded to it. Strain gages operate like variable resistors and individually are considered 'Simple Apparatus' because they do not produce or emit heat or electrical energy. To produce an output signal, a load cell requires excitation. Therefore, when installed in a hazardous area, some consideration must be given to the level of energy at the load cell under normal and fault conditions.

Load cells typically have an impedance of 350 or 700 ohms and are excited using 10 or 15 Vdc. A single 350 ohm load cell will draw no more than 42.8 mA at 15 Vdc. These voltage and current levels are well below the minimum ignition energies of commonly encountered vapors, liquids, dusts or fibers and therefore are not a potential ignition source under normal operating conditions. Due to the lack of arcing or heat producing components, 350 and 700 ohm load cell transducers meet the requirements of non-incendive apparatus and are thus suitable for use in a Division 2 hazardous location.

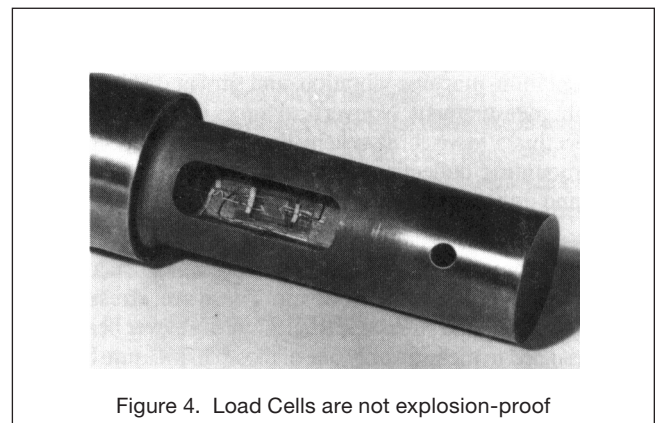


Figure 4. Load Cells are not explosion-proof

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While load cells are safe under normal operating conditions they do not possess any internal protection from voltage or current surges that may occur (during abnormal conditions) in equipment connected to them. This lack of fault protection requires that another device(s) be installed between the transducer and the device it is connected to for power and signal. Commercially available intrinsic safety barriers are available to perform this function. Since the transducer is safe under normal conditions and the barriers provide protection for fault conditions, the transducer with barrier protection is therefore suitable for use in a Division 1 location.

4.2 Summing Units

Multi-transducer weighing systems often use a summing unit to average the load cell outputs in a single scale system. The summing circuit distributes excitation power to each cell and averages the cell outputs by connecting excitation and signal leads in parallel. In addition, isolation resistors and a guard circuit are employed to increase performance. The summing unit, much like a load cell, contains only resistive type elements. However, because up to eight 350 ohm cells can be powered in parallel, the energy in the circuit can be up to 350 mA at 15 Vdc. Vishay BLH summing units do not use make or break contacts and heat dissipated through the isolation resistors is very low, making these units non-incendive and suitable for a Division 2 location. For Division 1 locations intrinsic safety barrier protection is required.

Note: Explosion-proof or purged enclosures can be used to make the summing unit safe but intrinsic safety barriers are still required to make the load cells safe.

4.3 Indicator/Transmitters

Contemporary microprocessor based transmitters and

indicating transmitters operate at power levels much below that anticipated by their 120/220 Vac supply voltage. Voltage and current levels at various push buttons and switches are nominally only 5 V at less than 1 mA which is well below the minimum ignition energy of common hazards. Heat produced in power supply transformers, while significantly higher than that produced in the transducer or summing unit, is low enough to not require a temperature rating. These operating characteristics, coupled with proper wiring, make these units suitable for Class I, Division 2 locations without special enclosures, and Class II, Division 2 with dust-tight enclosures. Installing indicators and transmitters in an explosion-proof housing satisfies Division 1 location requirements. Use of the proper purge type enclosure is also acceptable for making a unit suitable for a Division 1 location and, in many cases, is less expensive than explosion-proof construction.

4.4 Intrinsic Safety Barriers

Application of transducers and summing units in Division 1 locations requires the use of intrinsic safety barriers. Under normal operating conditions, I.S. barriers have no arcing or heat producing contacts and can be installed in a Division 2 location in a general purpose enclosure. When installed in Division 1 locations, an explosion-proof or purged enclosure is required.

Safety Barrier Circuit Diagram

Electrical energy is limited in hazardous areas through the use of safety barriers which are mounted as interfaces between non-hazardous and hazardous locations. Essentially, safety barriers pass measurement and control signals without loss, but in the event of an electrical fault, limit the voltage and current entering the hazardous area. Barriers consist of three components:

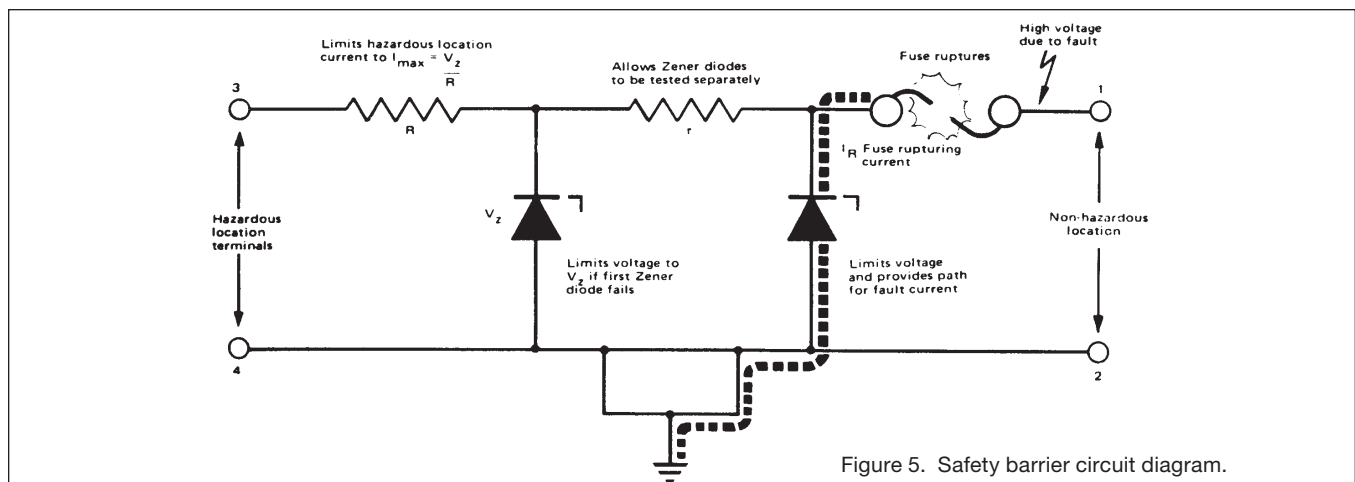


Figure 5. Safety barrier circuit diagram.

A Guide to Safe Electronic Weighing in Hazardous Locations

1. Fuse: to limit the maximum current that can flow through the diodes.
2. Resistance: to limit the maximum current entering the hazardous area.
3. Shunt clamping device: to limit the voltage between ground and signal line. Zener diodes are used for this purpose.

System Configurations

Given the variety of potential applications and product configurations available, there is an infinite range of hybrid system configurations possible. The following diagrams outline some typical configurations.

Class I and II Division 2 Groups A-D, F & G Locations

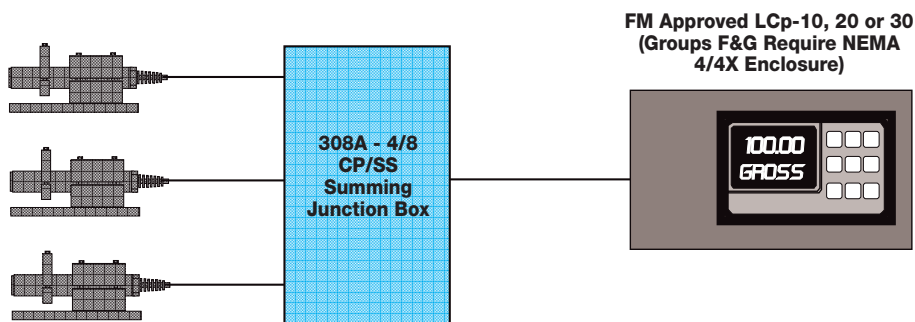


Figure 6. Division 2 application: non-incendive; intrinsic safety barriers not required.

Class I and II Division 1 Groups A-G Location

Ordinary Location

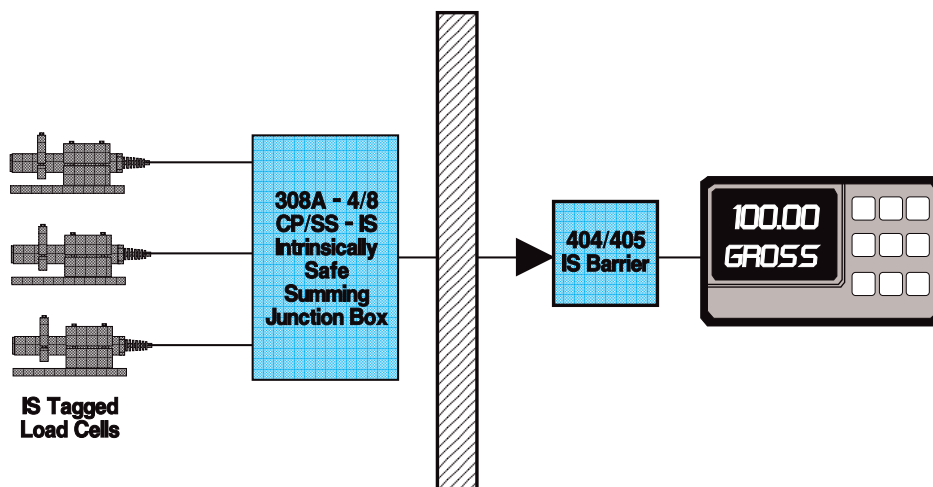
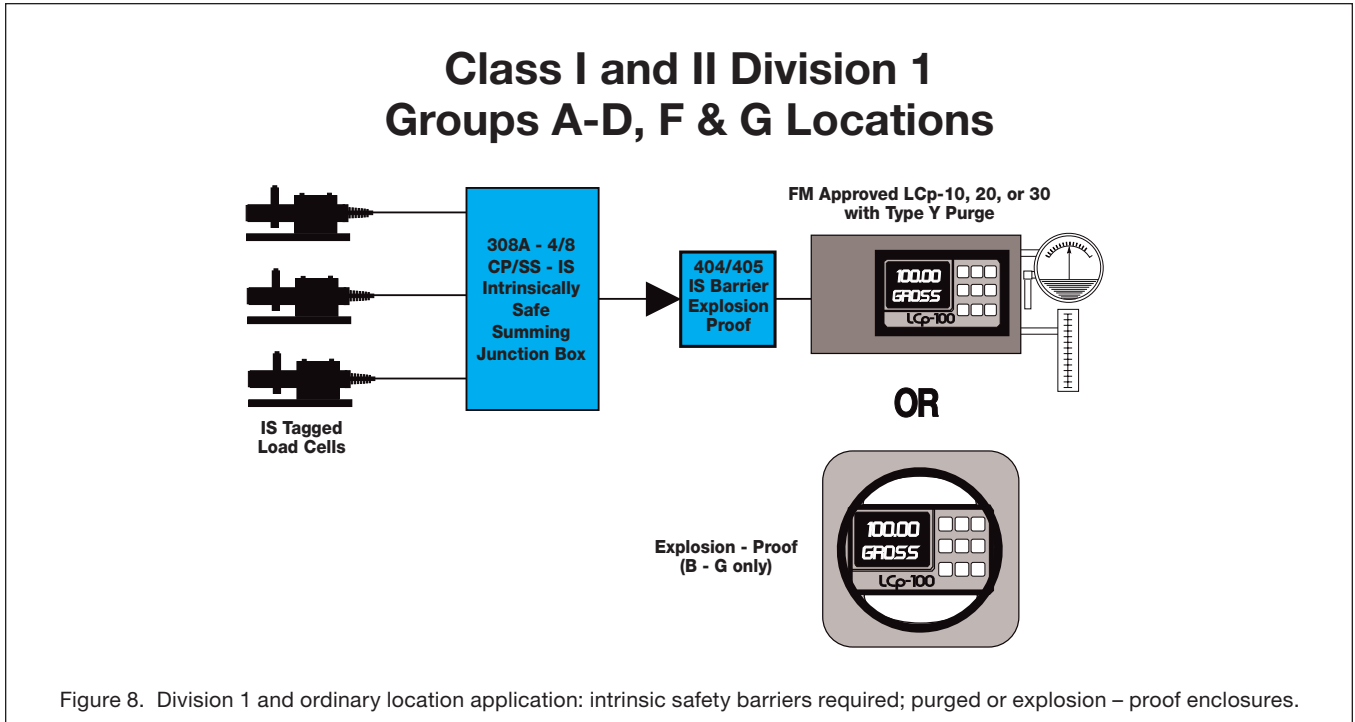


Figure 7. Division 1 and ordinary location application: intrinsic safety barriers required; instrument located in safe area.

A Guide to Safe Electronic Weighing in Hazardous Locations



Overview of International and European Requirements

Outside North America there are organizations that perform functions similar to the NFPA (National Fire Protection Association), FM (Factory Mutual) and NEMA (National Electrical Manufacturers Association). In general terms, the approach to safety and standardization of these organizations is in agreement with the North American authorities.

6.1 IEC – International Electrotechnical Committee

The purpose of the IEC is to establish uniform standards for a wide variety of electrical devices with the intent of encouraging international trade. There are currently 40 countries on the committee including the U.S. The IEC technical committee, TC 31, prepared the requirements for explosion and ignition protection principles based on Articles 500-503 of the National Electric Code (NEC). The summary of these requirements are published in IEC Publication 79 - *Electrical Apparatus for Explosive Gas Mixtures*.

Table 5. Publication 79 Summary	
Publication	Content
79-0	General Introduction
79-1	Construction and Test of Flame-Proof Enclosures of Electrical Apparatus
79-2	Pressurized Enclosures
79-3	Spark Test Apparatus for Intrinsically Safe Circuits
79-4	Method of Test for Ignition Temperature
79-5	Sand Filled Apparatus
79-6	Oil Immersed Apparatus
79-7	Construction and Test of Electrical Apparatus "Increased Safety"
79-8	Classification of Maximum Surface Temp.
79-9	Product Marking
79-10	Classification of Hazardous Areas



A Guide to Safe Electronic Weighing in Hazardous Locations

Table 6. Classification Comparison

Hazardous Material	NEC U.S. Standards	IEC Euronorm Standards
Gas or Vapor	Class I Division 1	Zone 0 and Zone 1
	Class I Division 2	Zone 2
Dust	Class II Division 1	Zone 10
	Class II Division 2	Zone 11
Fibers or Flyings	Class III Division 1	Zone 10
	Class III Division 2	Zone 11

Classification of Hazardous Areas

IEC publication 79-10 defines the guidelines for classifying hazardous areas. Instead of using Classes and Divisions, the term Zones is used as defined below:

- **Zone 0** - Zone 0 is an area in which an explosive gas-air mixture is continuously present or present for long periods. (This is comparable to Class I, Division 1 areas as defined by the National Electrical Code.) Generally, most industrial users try to keep all electrical equipment out of Zone areas. The only equipment approved for use in Zone 0 applications is intrinsically safe equipment.
- **Zone 1** - Zone 1 is an area in which an explosive gas-air mixture is likely to occur in normal operations. Zone 1 also is comparable to Class I, Division 1 applications.
- **Zone 2** - Zone 2 is an area in which an explosive gas-air mixture is not likely to occur and if it does, it is only for a short period of time. (This is comparable to a Class I, Division 2 location area as defined by the NEC.)
- **Zone 10** - Zone 10 is an explosive atmosphere resulting from dust which is present continuously or for long periods of time. (This is comparable to a Class II, Division 1 application.)
- **Zone 11** - Zone 11 is a short lived explosive dust atmosphere from unsettling dust deposits. (This is comparable to a Class II, Division 2 location.)

Note: Class III locations (fibers and flyings) are covered in Zone 10 and Zone 11 areas.

6.2 CENELEC — The European Committee for Electrotechnical Standardization

Members of the European Community have established uniform standards for hazardous location electrical equipment with the goal of reducing trade barriers among the European nations. The standards are based on IEC recommendations and are designated as EN (Euronorm) standards.

Table 7. EURONORM Standards

Methods	EURONORM
General Requirements	EN50014
Oil Immersion "o"	EN50015
Pressurization "p"	EN50016
Sand Filled "q"	EN50017
Flameproof "d"	EN50018
Increased Safety "e"	EN50019
Intrinsic Safety "i"	EN50020

A Guide to Safe Electronic Weighing in Hazardous Locations

6.3 I.P. – Ingress Protection

The degree of protection the enclosure provides is the ingress protection (similar to the U.S. NEMA designations).

Marking for the degrees of protection include "IP" (Ingress Protection) followed by two numerals. The first numeral indicates the protection provided for personnel against contact with live or moving parts inside the enclosure and protection of equipment against ingress of solid foreign bodies, i.e., dust. The second numeral designates the protection of the equipment against liquids.

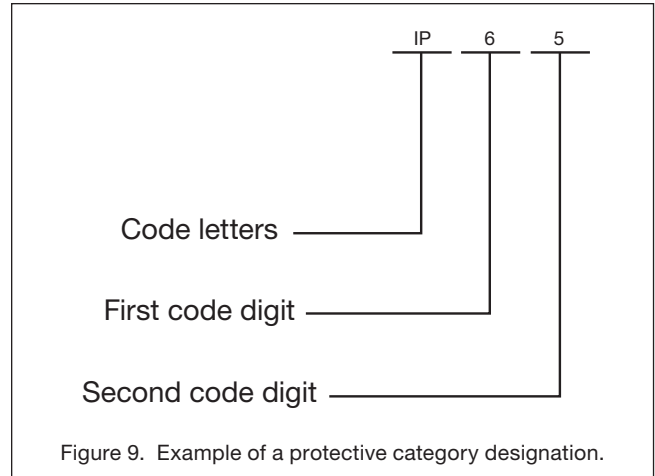


Figure 9. Example of a protective category designation.

Table 8. Protection Against Solid Objects

First IP Digit	Degree of Protection (contact hazard and foreign object protection)
0	No special protection
1	Protection against penetration of solid objects larger than 50mm (1.92") in diameter (large objects) ¹ No protection against intentional access, e.g., by hand, but keeping larger parts of the body at a distance
2	Protection against entry of solid objects larger than 12mm (0.47") in diameter (medium objects) ¹ Keeping out fingers and other small objects
3	Protection against entry of solid objects larger than 2.5mm (0.10") in diameter (small objects) ^{1, 2} Keeping out tools, wires, and other objects, larger than 2.5mm (0.10") in diameter
4	Protection against entry of solid objects larger than 1.0mm (0.04") in diameter (granular objects) ^{1, 2} keeping out tools, wires, and similar objects, of a thickness exceeding 1mm (0.04")
5	Protection against harmful dust deposits. Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with operation of the equipment (dust protected) ³ Full contact protection
6	Protection against ingress of dust (dust-light) Full contact protection

1. With equipment of protection grades 1 to 4, solid objects of regular or irregular shape with three dimensions square to each other larger than the corresponding diameter values, will be prevented from entering.
2. For protection grades 3 and 4, the application of this table to operating equipment with drain-age holes or cooling air vents is the responsibility of the competent specialist.
3. For protection grade 5, the application of this table to operating equipment with drainage holes is the responsibility of the competent specialist.

A Guide to Safe Electronic Weighing in Hazardous Locations

Table 9. Protection Against Liquids

Second IP Digit	Degree of Protection (water protection)
0	No special protection
1	Protection against dripping water It must not have any harmful effect (dripping water)
2	Protected against dripping water Dripping water shall have no harmful effect when the enclosure is lifted at any angle 15° from its normal position (indirect dripping water)
3	Spraying water falling at any angle up to 60° from the vertical shall have no harmful effect (spraying water)
4	Water splashed against the enclosure from any direction shall have no harmful effect (spraying water)
5	Water projected by a nozzle against the enclosure from any direction shall have no harmful effect (water jets)
6	Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities (flooding)
7	Ingress of water in a harmful quantity Shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (temporary submersion) Test is 30 minutes in H ₂ O at 1 meter
8	The equipment is suitable for continuous submersion in water under conditions which shall be specified by the manufacturer (submersion) ¹
1. This protection grade signifies an airtight enclosure. However, water may enter in certain equipment provided that it has no harmful effect.	

List of Approved Products

Approved or certified products fall into three general categories of approval. Ordinary location approval indicates that the device has been examined and found to satisfy the minimum requirements for electrical safety. Equipment approved for Division 2 hazardous locations meets not only the minimum requirements but also the additional requirements for use in the hazardous location.

Division 1 approval indicates that the device satisfies ordinary and Division 2 as well as Division 1 — the most stringent hazardous location — requirements.

For the U.S. and Canadian markets Vishay BLH maintains approvals and certifications with both FM (Factory Mutual) and CSA (Canadian Standards). These approvals are, in many cases, acceptable in other parts of the world.



A Guide to Safe Electronic Weighing in Hazardous Locations

Table 10. List of Vishay BLH Approved Products

Transducers		
FM Class I & II, FM Class I & II, CSA Class I & II,	Div. 2 Groups A-G Div. 1 Groups A-G w/I.S. Barriers Div. 1 Groups A-G w/I.S. Barriers	KIS, Z-Blok, KDH, C2P1 C3P1, T2P1, T3P1, U3SB U3G1, Alpha, PHL, PLB, SBP1
Summing Units		
FM Class I & II, FM Class I & II, UL Class I & II, CSA Class I & II, Class I & II, CSA Class I & II,	Div. 2 Groups A-G Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups A-G w/I.S. Barriers Div. 1 Groups A-G w/I.S. Barriers	304, 308 308AFM
Transmitters		
FM Class I & II, CSA Class I & II, FM Class I & II, UL Class I & II, CSA Class I & II,	Div. 2 Groups A-G Div. 2 Groups A-G Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl.	DXp-10, DXp-15 DXt-10, DXt-15 DXp-40, DXt-40
Indicators		
FM Class I & II, CSA Class I & II, FM Class I & II, UL Class I & II, CSA Class I & II,	Div. 2 Groups A-G Div. 2 Groups A-G Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl.	LCp-100, LCp-200, LCp-104
Network Controllers		
FM Class I & II, CSA Class I & II, FM Class I & II, UL Class I & II, CSA Class I & II,	Div. 2 Groups A-G Div. 2 Groups A-G Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl.	LCp-400
Miscellaneous		
FM Class I & II, CSA Class I & II, FM Class I & II, UL Class I & II, CSA Class I & II,	Div. 2 Groups A-G Div. 2 Groups A-G Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl. Div. 1 Groups B-G w/Ex. Encl.	I.S. Barriers 401, 401A, 404, 404A, 405, 405A, 406A, 408A 504A, 506A, 508A

References

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

Factory Mutual Research Corporation
1151 Boston-Providence Turnpike
Norwood, MA 02062
617-762-4300

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

Instrument Society of America
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, NC 27709
919-549-8411



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National Electrical Equipment Manufacturers Assoc.
2101 L Street N.W.
Washington, DC 20037

Canadian Standards Association
178 Rexdale Blvd.
Rexdale, (Toronto) Ontario M9W 1R3
(416) 747-4000

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VISHAY SYSTEMS AMERICAS

3 EDGEWATER DRIVE
NORWOOD, MA 02062
USA
PH: +1-781-298-2200
FAX: +1-781-762-3988
E-MAIL: VTS.US@VISHAYMG.COM

VISHAY SYSTEMS CANADA

12 STEINWAY BLVD, UNIT 1
TORONTO, ONTARIO M9W 6M5
CANADA
PH: +1-800-567-6098 (TOLL FREE)
+1-416-251-2554
FAX: +1-416-251-2690
E-MAIL: VT.CAN@VISHAYMG.COM

ASIA

VISHAY SYSTEMS TAIWAN*

15 FL, NO. 86, SEC.1 SHINTAI 5TH RD.
SHIJR CITY, TAIPEI, 221
TAIWAN, R. O. C.
PH: +886-2-2696-0168
FAX: +886-2-2696-4965
E-MAIL: VT.ROC@VISHAYMG.COM
*ASIA EXCEPT CHINA

VISHAY SYSTEMS CHINA

NO. 5 BINGUAN NAN DAO YOUYI RD.
HEXI DISTRICT, TIANJIN CHINA
CODE 300061
PH: +86-22-2835-3503
FAX: +86-22-2835-7261
E-MAIL: VT.PRC@VISHAYMG.COM

EUROPE

VISHAY MEASUREMENTS GROUP UK

STROUDLEY ROAD
BASINGSTOKE
HAMPSHIRE RG24 8FW
UNITED KINGDOM
PH: +44-125-685-7490
FAX: +44-125-634-6844E-MAIL:
VT.UK@VISHAYMG.COM

VISHAY MEASUREMENTS GROUP GERMANY

TATSCHENWEG 1
74078 HEILBRONN
GERMANY
PH: +49-7131-3901-260
FAX: +49-7131-3901-2666
E-MAIL: VT.DE@VISHAYMG.COM

VISHAY MEASUREMENTS GROUP FRANCE

16 RUE FRANCIS VOVELLE
28000 CHARTRES
FRANCE
PH: +33-2-37-33-31-25
FAX: +33-2-37-33-31-29
E-MAIL: VT.FR@VISHAYMG.COM

VISHAY SYSTEMS SWEDEN

P.O. BOX 423
SE-691 27 KARLSKOGA
SWEDEN
PH: +46-586-63000
FAX: +46-586-63099
E-MAIL: VT.SE@VISHAYMG.COM

VISHAY SYSTEMS NORWAY

BROBEKKVEIEN 80
0582 OSLO
NORWAY
PH: +47-22-88-40-90
FAX: +47-22-88-40-99
E-MAIL: VT.SE@VISHAYMG.COM

VISHAY MEASUREMENTS GROUP ISRAEL

8A HAZORAN STREET
P.O. BOX 8381, NEW INDUSTRIAL ZONE
NETANYA 42506
ISRAEL
PH: +972-9-863-8888
FAX: +972-9-863-8800
E-MAIL: VT.IL@VISHAYMG.COM

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