Installation guide for hazardous areas

This installation guide should not be used as the controlling document for the installation of devices in a hazardous area.

This guide is NOT A CONTROL DRAWING.

Any installation of devices within a hazardous area as defined in the NEC® or ATEX Directive MUST BE in accordance with that device's CONTROL DRAWING and local ordinances.

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Acronyms

ATEX	Appareils destinés à être utilisés en ATmosphères EXplosibles
CENELEC	European Committee for Electrotechnical Standardization
IEC	International Electrotechnical Commission
NEC®	National Electric Code® is a registered trademark of the National Fire Protection Association
NFPA	National Fire Protection Association
CSA	Canadian Standards Association
IEPE	Integrated Electronic PiezoElectric (transducer)

Terms and definitions

Sensor	Accelerometer or PiezoVelocity transducer (PVT)
Power/signal	The connection to an IEPE sensor carrying the power and the superimposed signal
Common	The return side of the IEPE circuit
Ω, MΩ	Ohm, Meg-Ohm (million Ohms)
Ignitable	Any substance that can be burned
Flammable	Capable of being easily ignited and of burning quickly
Combustion	A usually rapid chemical process that produces heat and, often, light
Combustible	A mixture or substance that can be ignited to produce combustion
Dust	Small particles of solid material that can be suspended in the air easily
Fiber	Thread-like material
Flyings	Small metal particles produced during machining, turning or grinding in metalworking

1.0 Introduction

The concept of intrinsic safety in wiring recognizes that a sufficient concentration of ignitable, flammable or combustible materials will be present, with air or another oxidizer, to represent a fire or explosion hazard. These mixtures could easily be ignited by a match or other open flame, or by a high-energy spark. The wiring used in areas where these mixtures are present can be implemented in a manner which absolutely precludes any possibility of igniting these mixtures. That is the essence of intrinsic safety. Intrinsically safe wiring will never have enough energy available within the defined hazardous area to ignite any explosive or combustible mixture of gasses, dusts, or metals.

Where it is impossible to reduce the electrical circuit energy (as with electric motor power) the circuits must be physically isolated from the hazardous atmosphere, dust or metals. This is the principle behind explosion-proof wiring. Even if the circuit did ignite a quantity of hazardous mixture, the wiring container, can "contain" the resulting explosion and cool any escaping hot gasses so that they would be incapable of igniting the hazardous mixture outside of the explosion-proof container.

1.1 The fire triangle

The fire triangle is a tool to illustrate the three elements which must be present to have a fire or explosion: fuel, oxidizer, and energy. Fuel and oxidizer must be present in a concentration appropriate to form a combustible mixture. The ignition source must supply enough energy to initiate combustion. If any one of the elements of the triangle is not present in sufficient amount, then combustion cannot occur.

The availability of **energy**, by either thermal or electrical means, can cause the ignition of a combustible mixture. It need not be a spark or a flame; temperature alone can supply the energy of initiation. The energy required to ignite various groups of combustible substances have been proven by experimentation. Graphs of this data have been produced, and can be used to indicate safe levels of energy. Only a very small amount of energy may be required to cause ignition, such as the mixture of hydrogen and air, which requires only 2O µJoule of energy to ignite. In electrical circuits the mechanism for the release of this ignition energy is often a spark from a circuit wiring fault that creates a gap in the wire allowing a spark to form. Electrical components and equipment with hot surfaces also can cause ignition.

Fire is simply an oxidation process. Some oxidation processes proceed at a slow pace while fire is a rapid oxidation process. While the **oxidizer** in most fires is oxygen, other chemicals may be oxidizers. For example, elemental magnesium will react violently with water to release heat. The magnesium is the fuel and water provides the oxidizer.

The **fuel** component can be almost any substance. Most materials will burn under the right temperature and pressure conditions. If steel is finely granulated, placed in a pure oxygen environment, and then exposed to high temperatures, it will burn rapidly; almost like it was coal. Flour in a bakery can do the same thing as can the dust produced from grain stored in a grain elevator.

Certain fuels, when combined with air, can form an explosive mixture. *The main difference between a rapid fire and an explosion is that an explosion creates a pressure wave due to the rapid production of hot gas volume.* That pressure wave is what is responsible for the "bang" associated with an explosion. The explosive pressure wave can cause serious damage to facilities and humans.

1.2 Fire loss control

The concepts embodied in the fire triangle have been codified by various organizations. In the United States, one of the earliest organizations established was the predecessor of FM Global. In 1835 Zachariah Allen, a Rhode Island native and prominent textile mill owner, set out to reduce the insurance premium on his Rhode Island mill by making property improvements that would minimize the chance of fire loss.[1] Although widely accepted today, the concept of loss control was virtually unheard of at the time; but to Allen, a proactive approach to preventing losses before they occurred made good economic sense. As Allen predicted, proper fire prevention methods, monitored by regular fire inspections for mill policyholders, resulted in fewer losses.

As time went on, more and more companies and businesses realized financial benefits and insurance companies worked with their policyholders to help them reduce their fire risks. Insurers, today, regularly require facilities to use equipment that has been certified to comply with generally accepted standards for risk reduction. Carrying one or another of many such marks identifies equipment meeting such standards. Examples are Underwriters Laboratories, Inc. (UL), Factory Mutual (FM), and Canadian Standards Organization (CSA).

1.3 The National Electrical Code®

By the end of 1895, there were five different recognized standards in the United States that addressed the safe use of electrical equipment, as well as British and German codes. Each different code meant a different set of standards for making an electrical installation, resulting in confusion and controversy. On a quest for solidarity, several US and international organizations held an 1896 meeting in New York and named itself the "Joint Conference of Electrical and Allied Interests." The committee selected the most suitable criteria from all the various codes to establish the "National Code." Because it was so fair and broad in its application, it was adopted without delay by the National Board of Fire Underwriters and then issued by them as the "National Electrical Code of 1897." Thus, the "NEC®" was born.[2]

In the United States today, the National Fire Protection Association (NFPA) publishes the NFPA 70 National Electrical Code®, also known as the NEC®. The NFPA does not police or enforce compliance with the NEC®, and they do not certify, test or inspect products, designs, or installations for compliance. However, most states and localities within the U.S. cite the NEC® as the authority controlling electrical installations.

The European market is served by the ATEX directive and the IEC. The IEC also has worldwide influence. The IEC publishes the IECEx scheme, a set of standards that specifies requirements for both hazardous area electrical equipment and requirements for the quality system of manufacturers of hazardous area electrical equipment. Certification organizations perform the testing and qualifications required by the IECEx scheme. Some Wilcoxon Research sensors were evaluated to the IEC requirements and have been certified by KEMA to meet the requirements of the IECEx scheme.

2.0 Hazardous areas and classifications

2.1 Class, Division and Zone

NEC® Article 500 is entitled "Hazardous (Classified) Locations, Classes I, II, and III, Divisions 1 and 2." Articles 500 through 516 enumerate the various classifications and standards applicable to hazardous locations in the United States. Article 505 allows the use of the "Zone" system for flammable gasses, vapors, or liquids. Consequently, the Zone system does not apply to dust, fiber, or flyings.

Location	Flammable or combustible materials
Class I	gases or vapors
Class II	dust
Class III	fibers or flyings

Table 2.1.1: Class location definitions

Flammables present:	Continuously	Intermittently	Abnormally
NEC® 505	Zone 0	Zone 1	Zone 2
NEC® 500	Division 1	Division 1	Division 2

Table 2.1.2: Area location comparisons, Class I NEC® Zone versus Division locations

Hazardous area locations are classified by the type of combustible material present, the extent of time it is present, and the physical construction of the area where such material is present.

The presence of flammable gasses or vapors in quantities sufficient to produce an explosive or ignitable mixture constitutes a Class I location. A Class II location is characterized by combustible dust. Class III locations have easily ignitable fibers or flyings, but not suspended in the air in quantities sufficient to produce an ignitable airborne mixture.

Division 1 locations, in general, are those areas where ignitable or flammable concentrations of combustible materials exist continuously or repeatedly during normal operations. Division 2 locations, in general, are those areas where such materials exist in ignitable or flammable concentrations only during periods of abnormal operating conditions.

Zone 0 locations, in general, are those areas where ignitable or flammable concentrations of combustible materials exist continuously or for long periods of time. Zone 1 locations, in general, are those areas where ignitable or flammable concentrations of combustible materials are likely to or frequently exist during normal operations. Zone 2 locations, in general, are those areas where ignitable or flammable concentrations of combustible materials are not likely to occur during normal operations or will exist for only a brief period of time.

For all of these locations there are also various groups of gasses, vapors, dusts or fibers. The groups have been established based on the ignition energy required for each of

Typical gas, fiber, or dust	NEC material category
Acetylene	Class I, Group A
Hydrogen	Class I, Group B
Ethylene	Class I, Group C
Propane	Class I, Group D
Methane	not covered within NEC®
Metallic dust	Class II, Group E
Coal dust	Class II, Group F
Grain Dust	Class II, Group G
Fibers	Class III

Table 2.1.3: Apparatus grouping

the constituents within that group. Table 2.1.3 identifies typical materials within each group and the group identification.

Max surface temperature (°C)	NEC®
450	T1
300	T2
280	T2A
260	T2B
230	T2C
215	T2D
200	T3
180	T3A
165	T3B
160	T3C
135	T4
120	T4A
100	T5
85	-

Table 2.1.4: Temperature code/class for apparatus

All flammable materials have an ignition temperature. Even if the material is not exposed to an open flame or spark, they will ignite if they are exposed to an object whose temperature exceeds the ignition temperature for that material. All apparatus designed for installation in hazardous areas are rated for their maximum surface temperature. Consequently, all apparatus have a temperature code associated with their hazardous area classification. Table 2.1.4 show the temperature code/class for apparatus.

2.2 Methods of protection

There are four basic principles to provide protection for hazardous area electrical circuit wiring: (1) prevent arcs, sparks and hot surfaces; (2) prevent the combustible material from entering the space; (3) contain any explosion of combustible material within the electric enclosure; or (4) limit the energy available for sparks and hot surfaces. Methods of protection and their permitted use areas are summarized in table 2.2.1.

Protection method (Aex identification)	NEC® Class I Zone	NEC® Class I Division	NEC® Class II Division	NEC® Class III Division
Intrinsic Safety (ia)	0, 1, or 2	1 or 2	1 or 2	1 or 2
Intrinsic Safety (ib)	1 or 2	2		
Flameproof (d)	1 or 2	2		
Explosion Proof		1 or 2		
Pressurization (p)	1 or 2	1 or 2	1 or 2	
Increased Safety	1 or 2	2		
Encapsulation (m)	1 or 2	2		
Oil immersion (o)	1 or 2	2		
Dust Ignitionproof			1 or 2	
Hermetically		2	2	1 or 2
Dusttight			2	1 or 2
Powder Filled (q)	1 or 2	2		
Non-Sparking (n)	2	2		
Non-Incendive	2	2	2	1 or 2

Table 2.2.1: Protection methods and permitted use for NEC®

These protection methods are the methods permitted. NEC® Article 500.8 (A) (1) (1) states that the suitability of identified equipment shall be determined from (1) the equipment listing or labeling, (2) evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation, or (3) evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment. Subparagraph (2) states that equipment that has been identified for a Division 1 location shall be permitted in a Division 2 location of the same class and group.

2.2.1 Intrinsic safety

The National Electric Code® defines an intrinsically safe circuit as a circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under prescribed test conditions. It also defines an intrinsically safe system as one that is an assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables in that those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits.3 Intrinsically safe apparatus have been tested to meet these requirements. The testing of the apparatus is designed to verify the operating parameters of the device and set the limits for its use in hazardous areas.

In a typical intrinsically safe system for vibration transducers, the transducer is an approved device with an intrinsically safe circuit and is wired through an approved zener barrier device to the non-hazardous area. All wiring between the transducer and the barrier must also meet the requirements for hazardous (classified) area installation.

Zener barrier devices limit the availability of energy to the wiring in the hazardous area. Figure 2.2.1 illustrates the internal schematic of a basic zener barrier. The zener diode in the center of the circuit acts to clamp the voltage available to the circuit in the hazardous area. Zener diodes are used because they have a very high resistance until the voltage rises to their conduction voltage. Once in conduction, the diode "clamps" the voltage to a maximum value. It is this property of the zener diode that is exploited for use in instrumentation circuits in hazardous areas. The resistor, R, limits the maximum current available to the hazardous area circuit wiring. Since the voltage and the current are limited, the power is also limited.

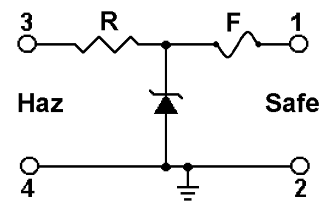


Figure 2.2.1 - Basic zener barrier schematic

As an additional safety method, the barrier device also contains a fuse. The fuse will act to limit the current through the barrier circuit in the event that either the resistor or the zener should fault.

WARNING: Wilcoxon transducers that carry approvals for intrinsically safe circuits must always be installed with safety barriers in the circuits for Class I Division 1, Zone 0 or Zone 1 areas. Simply buying a transducer that carries an intrinsically safe rating is not sufficient for permanently installed vibration transducers. Portable vibration analyzers or data collectors used within hazardous (classified) areas must also be rated for use within those areas.

2.2.1.1 Intrinsically safe apparatus entity parameters

An intrinsically safe system is an assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables. In the case of vibration sensors, the intrinsically safe apparatus is the sensor itself. The associated apparatus is the safety barrier.

The sensor must be installed in a specific manner as outlined in an installation drawing which is part of the certification. The certification process establishes the mechanical mounting and electrical connection requirements. In many instances, the sensor must be connected to an intermediate device, a safety barrier, which protects harmful voltages and currents from reaching the sensor in the event of a failure either in the sensor or the associated readout equipment. Apparatus have four rating parameters: voltage, current, capacitance, and inductance.

The open-circuit voltage available at the terminals of the barrier is V_{oc}. The short-circuit current available at the terminals of the barrier is I_{sc}. The maximum capacitance that can be connected to the barrier apparatus is C_a while the maximum inductance that can be connected is L_a. The vibration sensor voltage rating, V_{max}, is the maximum voltage that can be applied to the terminals of the sensor. The current rating, I_{max}, is the maximum current that can be applied through the terminals of the sensor. The maximum value of acceptable internal capacitance, C_i, and inductance, L_i, are also stated. When the sensor and barrier are connected together in a system, the cable capacitance, C_{cable}, and inductance, L_{cable}, must also be considered in the system.

By comparing the ratings of the vibration sensors with those of the barrier and taking the cable values into account, an appropriate safety barrier can be selected. As long as the ratings satisfy the following equations, the system will meet the requirement for an intrinsically safe system.

V_{oc} must be equal to or less than V_{max}	$V_{oc} \leq V_{max}$
I_{sc} must be equal to or less than I_{max}	$I_{sc} \leq I_{max}$
C_a must be greater than or equal to $C_i + C_{cable}$	$C_a \geq C_i + C_{cable}$
L_a must be greater than or equal to $L_i + L_{cable}$	$L_a \geq L_i + L_{cable}$

Example

The ratings for the Wilcoxon 793E intrinsically safe rated accelerometer are: V_{max} = 30 V dc, I_{max} = 180 mA ,
C_i = 0.03 μF. There are no inductive elements in the sensor therefore L_i = 0.00 mH.

A barrier such as Wilcoxon ISBS-STD-08 has the following parameters:
V_{oc} = 28 V dc, I_{sc} = 93 mA, plus the additional requirements C_a = 0.083 μF, and L_a = 4.2 mH (higher values of L_a are permissible because there are no inductive elements in the sensor).

In a typical application these devices are connected using 200 feet of the Wilcoxon J9T2A cable, which has a capacitance of 30 pF per foot. The cable capacitance is then 200 times 30 pF, equaling 0.006μF.

Now, let's put the numbers into the equations to see if these two devices are compatible for use as an intrinsically safe system. The equations, again, are stated here and the numbers substituted into the equation. If all the equations are satisfied as "True" the two devices can be used as an intrinsically safe system.

$V_{oc} \leq V_{max}$	28 V $\leq$ 30 V	**True**
$I_{sc} \leq I_{max}$	93 mA $\leq$ 180 mA	**True**
$C_a \geq C_i + C_{cable}$	0.083 μF $\geq$ 0.03 μF + 0.006 μF	**True**
$L_a \geq L_i + L_{cable}$	4.2 mH $\geq$ 0.00 mH + 0.00 mH	**True**

2.2.2 Explosion proof

The principle behind explosion-proof transducers and wiring is that if the ignition of flammable material that occurs within the transducer or wiring it will be contained. The hot gasses and flames will not be allowed to escape into the hazardous area and further propagate the fire or explosion. All circuit wiring is run in conduit and junction boxes approved for explosion-proof installation.

Explosion proof transducers and wiring must be installed according to ANSI/UL 1203-1994, Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations.

2.2.3 Air purge

When installations are not explosion proof or intrinsically safe, pressurization is often used to maintain the classified area safety. Wiring and enclosures are protected using a positive air pressure maintained within the enclosure, junction boxes and conduit.

The concept of pressurization protection is covered under ANSI/NFPA 496-1998, Purged and Pressurized Enclosures for Electrical Equipment.

2.2.4 Other methods

Flameproof (d), increased safety (e), encapsulation (m), oil immersion (o), dust ignition proof, dust tight, powder filled (q), non-sparking (n), non-incendive, and hermetically sealed are other levels of protection. Each is used where appropriate for electrical circuit wiring. Many of them apply to AC powered circuits, but few are used for instrumentation circuit wiring.

2.3 Class I, Division 2 locations

In the United States, section 500 of the NEC® specifically cites hermetic sealing as a protective method allowed for Class I, Division 2 areas. Hermetically sealed accelerometers can be installed in Class I, Division 2 locations.

Accelerometers do not have to be specifically marked as suitable for Division 2 locations. General purpose equipment that is operated in Class I areas must be marked with a temperature code if they have surfaces that rise above 100°C when operating in an ambient temperature of 40°C. Since Wilcoxon accelerometers do not rise above 100°C in an ambient temperature of 40°C, they do not require marking.

The governing judgment as to the acceptability of accelerometers for installation is in section 500.8. It cites the following as an item of guidance for determining the suitability of equipment for installation: "Evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment."

ANSI/ISA–12.12.01–2000, Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations states in the Scope, paragraph 2.5, "This standard is not intended to cover equipment for use in Class I and Class II, Division 1 locations, such as equipment constructed to be intrinsically safe, dust ignition-proof, or explosion-proof. Such equipment is, however, suitable for use in Class I and Class II, Division 2 locations in the same group for which it is suitable in Division 1."

2.4 Wiring methods

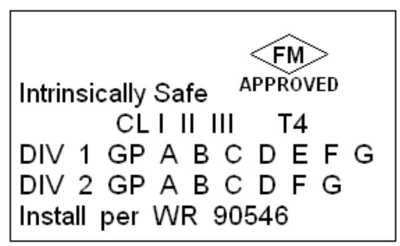
2.4.1 Intrinsically safe circuits

The NEC® Article 504 controls the wiring of intrinsically safe circuits. It generally requires that intrinsically safe circuits be physically separated from nonintrinsically safe circuits. Conductors and cables of intrinsically safe circuits not in raceways or cable trays shall be separated at least 50 mm (2 inches) and secured from conductors and cables of any non-intrinsically safe circuits. Conductors of intrinsically safe circuits can only be placed in the same raceway or cable tray with non-intrinsically safe circuits when the intrinsically safe circuits are separated by a distance of 50 mm (2 inches) or by a grounded metal partition or approved insulating partition. The 50 mm separation of circuits also applies to the wiring within enclosures.

Intrinsic safety barriers have their input and output terminals separated by 50 mm because of the spacing requirement. The input wiring of the enclosure where the barriers are installed must maintain the required 50 mm physical separation between the intrinsically safe circuits and the non-intrinsically safe circuits. Most barrier manufacturers offer special mounting hardware to label the circuits and keep the isolation required between the input and output wiring.

2.5 Marking examples

Intrinsically safe rated transducers will have the information regarding the Class, Division or Zone, Group, and Temperature ratings engraved directly on the sensor case. Illustrated here is the engraving from a Wilcoxon Research 793E accelerometer. The engraving also indicates the installation control document number (WR 90546) shipped with all intrinsically safe sensors.



3.0 Wiring Wilcoxon Research intrinsically safe sensors

3.1 Dynamic vibration sensor wiring

More than twenty Wilcoxon Research accelerometers are certified to be Intrinsically Safe. Acceleration output, velocity output, and low frequency capability Integrated Electronic Piezoelectric (IEPE) sensors are available with Intrinsically Safe certification. They are powered using a constant-current diode or similar Field Effect Transistor (FET) based powering system. In addition, there is a family of Wilcoxon loop powered sensors for use in 4-20 mA applications.

3.1.1 Effects of barrier on bias output voltage

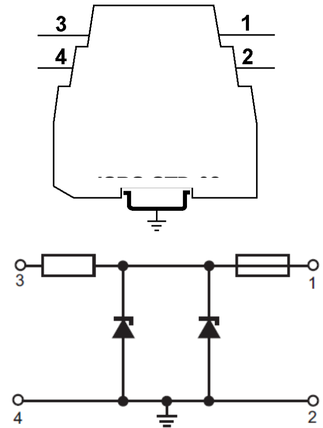


Figure 3.1.1.1 - Barrier schematic ISBS-STD-08

IEPE sensors have an output that is a combination of the DC bias output voltage (BOV) and the superimposed vibration signal. The BOV is controlled by the sensor design and exists as long as the current source provides adequate current. The sensor generally needs at least 1 mA of current. It is common to use current values of 2 to 4 mA for the constant-current source. When IEPE sensors are used in intrinsically safe circuits, the effects of the zener safety barrier must be considered in the sensor operating circuit. It is possible to use a barrier that provides a safe circuit, but precludes the proper operation of the sensor.

Illustrated in figure 3.1.1.1 is the package outline for the ISBS-STD-08 barrier. It has four wiring connections. Terminals 1 and 2 are the safe area connections and terminals 3 and 4 are the hazardous area terminal connections. An intrinsically safe rated accelerometer, such as the Wilcoxon 793E, would be connected to terminals 3 and 4.

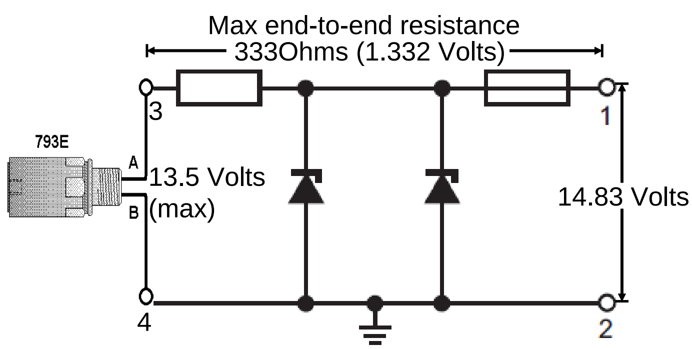


Figure 3.1.1.2 - Circuit voltages

As illustrated in figure 3.1.1.2, the 793E will be connected across terminals 3 and 4 in the circuit. The manufacturing specification of the 793E calls for its BOV not to exceed 13.5 volts. If the 793E is powered using a constant-current diode value of 4 mA, then the resistance of the barrier will cause a voltage drop of 1.332 volts (333 x .004). The total voltage drop across the barrier and the 793E could then be as high as 14.83 volts (13.5+1.33) and will appear to be the BOV of the accelerometer as viewed across terminals 1 and 2 of the barrier. This is the effective maximum BOV that would be seen by an analyzer connected to this circuit and using a powering current of 4 mA.

Since the accelerometer should allow for a maximum voltage to be 2 volts less than the open-circuit supply voltage, a BOV of 14.83 volts means that the dynamic range of the sensor will be limited. Assuming a typical supply voltage of 24 volts, the signal can only go 7.17 volts from the zero reference before entering this "forbidden" 2 Volt zone of operation. That means the effective dynamic signal is limited to 71.7 g's (7.17 Volts at 100 mV/g). If the 793E had its nominal BOV of 12 Volts across its terminals, then the BOV seen at the output of the ISBS-STD-08 would be about 13.33 Volts and the entire dynamic range would be available.

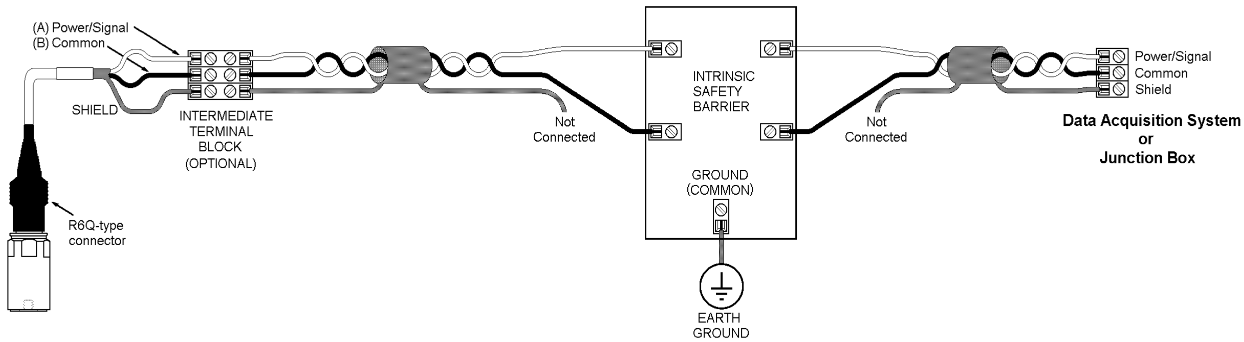


Figure 3.1.1.3 - 793E wiring example

Figure 3.1.1.3 shows the wiring for the 793E accelerometer. Shielded, twisted pair wire is used throughout. The connector at the accelerometer must connect the shield of the wire to the case of the 793E. However, the shield should not be connected to ground at the barrier or an electrical ground loop will be created in the shield circuit. The shield on the output of the barrier should also not be connected at the barrier for the same reason. The barrier itself will be connected to an earth ground as required by the NEC®.

3.1.2 Troubleshooting

Improper wiring of Wilcoxon sensors will result in a loss of signal or excessive noise in the signal. There are some simple steps that can verify proper installation. All troubleshooting described here using an ohmmeter is conducted with the circuit "de-energized" so as not to confuse the readings. If the proper reading is not indicated, the user must take action to determine why that connection is not correct.

The most common wiring faults are reversed wires and ground loops. Reversed wires occur where the power/signal and the common wire get reversed. Ground loops are formed when there is more than one circuit path to ground. The shields should connect to ground at only one point and that must be verified.

The Wilcoxon R6Q and the R6SL connectors will connect the shield to the case of a 2-pin sensor. These connectors are designed with a conductive spring inside the shell which makes contact with the neck of the connector to provide an electrical connection between the shield and the case of the sensor. Some intrinsically safe sensors require a third pin on their connector (pin "C") that internally connects to the case of the sensor.

Wilcoxon uses several cables for its sensors. The black wire is the ‘common’ in the circuit and connects to pin "B" of the connector of the sensor. The wire for the "power/signal" connection will either be red or white and connects to pin "A" of the sensor. Both the "A" and "B" pins of the sensor are isolated from ground. Ohmmeter readings between either pin "A" and the case or pin "B" and the case should give a high reading, over 10 MΩ. With three-pin sensors, the reading between pin "C" and the case should be less than 1Ω.

With the sensor installed on the machine, the cable connected, and the output terminated in the junction box or data acquisition system, the integrity of the shield/ground connection can be tested. The safety barrier will be grounded to a good earth ground (as required by the NEC®) and the shields can be tested separately to verify they connect to ground.

The resistance between each wire's shield and the ground at the barrier should be less than 10Ω. Verify that the shields are not connected to any circuit or ground at the barrier. Then, go to the sensor and remove the connector. The resistance between the shield and the machine case should be over 10 MΩ. Re-connect the cable to the sensor.

At the junction box or data acquisition equipment, disconnect the wire (plug) from the input panel. The resistance between the shield and the ground connection should be over 10 MΩ. Re-connect the cable to the input.

3.2 4-20 mA loop powered sensor wiring

Wire intrinsically safe loop powered sensors (LPS™), such as Wilcoxon models PC420-IS and PC421-IS, with an isolated type of connector on which the shield does not connect to the case. Wilcoxon Research connectors R6W, R6QI, and R6SLI all isolate the shield from the transducer case.

Where LPS™ intrinsically safe units are installed, it is important to avoid ground loops in the shield circuit wiring. Figure 3.2 shows how the shields should be connected to avoid the possibility of ground loops. The shield at the LPS™ should be isolated from connecting to the case. The shield of the cable from the sensor should connect to ground at the barrier. The signal output cable from the barrier should not connect to ground at the barrier, but must be connected to ground at the PLC or DCS.

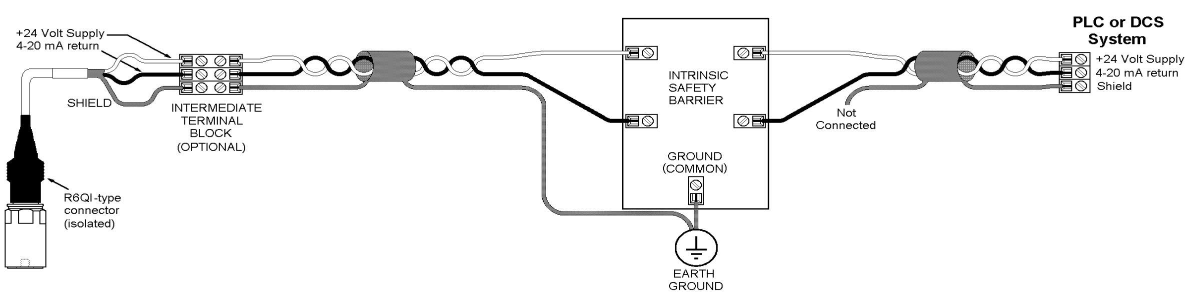


Figure 3.2 – LPS Series wiring

Wilcoxon recommends safety barrier models ISBS-420-03 (panel mount) or ISBS-420-06 (DIN rail mount), or equivalent. The ISBS-420-06 barrier has the following parameters: V_{oc} = 28 Volts, I_{sc} = 93 mA. The LPS™ Series transducers have the following parameters: V_{max} = 30 Vdc, I_{max} = 106 mA; C_i = 0.03 F. The LPS™ Series transducer and the associated safety barrier must satisfy the following equations to be used together.

Example

$V_{oc} \le V_{max}$	28 V ≤ 30 V	**True**
$I_{sc} \le I_{max}$	93 mA ≤ 106 mA	**True**
$C_a \ge C_i + C_{cable}$	0.083 μF ≥ 0.03 μF + 0.006 μF (200 ft of cable @ 30 pF/ft)	**True**

Since the relationship between the parameters satisfy the equations, ISBS-420-06 can be used with the LPS™ Series transducers in a Class 1, Division 1 (or Zone 0), Group A gas hazardous area installation. However, the user must also follow the guidelines for the ISBS-420-06 as to the maximum allowable capacitance in the cable. The ISBS-420-06 lists the maximum capacitance as 0.083 μF. The Wilcoxon J9T2A cable has 0.00003 μF per foot of cable. Therefore it would take more than 4,000 feet of J9T2A cable to exceed the capacitance limits imposed by the ISBS-420-06.

3.2.1 Troubleshooting the 4-20 mA LPS Wiring

An example of the loop wiring using an ISBS-STD-06 is shown above in figure 3.2. The shield of the hazardous area wiring connects to the ISBS-420-06 intrinsically safe ground. Check the shielding in a manner similar to that in the dynamic sensor section of this document.

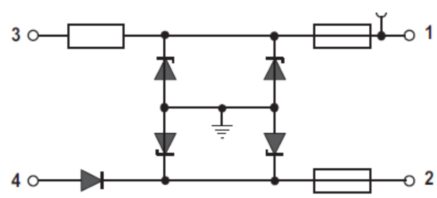


Figure 3.2.1.1 – ISBS-STD-06 schematic

Figure 3.2.1.1 illustrates a properly connected sensor. The +24 Volt DC power for the LPS transducer connects to terminal "1" and the power connection to the transducer to terminal "2". The return signal from the LPS transducer connects to terminal "4". Between terminal "4" and "3" is a diode that restricts the signal to allow current flow only from the hazardous area, but not to flow into the hazardous area.

If the power and return were accidentally switched at the input to the barrier (power to "2" and return to "1", there would be no current flowing in the circuit. The loop current would be zero. Likewise, if the wiring to the LPS is reversed (power to pin "B" and return to pin "A") there will be no current allowed to flow in the circuit due to the protective diodes installed in the LPS Series intrinsically safe transducers.

WARNING: All troubleshooting work performed on an intrinsically safe wiring installation in a hazardous area should be conducted under a "Hot Work" permit under the guidelines for permits in your plant. If diagnostics are performed using a "Cold Work" permit, the multimeter used for circuit measurements MUST BE rated for use in a hazardous area.

4.0 Technical assistance

4.1 Technical and application assistance

For technical or application assistance, please contact Wilcoxon's Application Engineering at 301-330-8811, fax to 301-330-8873, or email info@wilcoxon.com.

4.2 Customer service

To obtain additional technical reports or sales support, please contact customer service at 301-330-8811, or fax to 301-330-8873.

References:

[1] Source: http://www.fmglobal.com/corporate_info/history.html, April 2003

[2] http://www.nfpa.org/itemDetail.asp?categoryID=524&itemID=18295&URL=Publications/necdigest/About%20the%20NEC®/History, April 2006

[3] NEC® Article 504.2, NFPA, 2002