shall be of the grounding type, shall be designed to minimize the accumulation or the entry of fibers/flyings, and shall prevent the escape of sparks or molten particles.

*Exception: In locations where, in the judgment of the authority having jurisdiction, only moderate accumulations of ignitible fibers/flyings are likely to collect in the vicinity of a receptacle, and where such receptacle is readily accessible for routine cleaning and mounted to minimize the entry of fibers/flyings, general-purpose grounding-type receptacles shall be permitted.*

**503.150 Signaling, Alarm, Remote-Control, and Local Loudspeaker Intercommunications Systems — Class III, Division 1 and Division 2.** Signaling, alarm, remote-control, and local loudspeaker intercommunications systems shall comply with the requirements of this article regarding wiring methods, switches, transformers, resistors, motors, luminaires, and related components.

**503.155 Electric Cranes, Hoists, and Similar Equipment — Class III, Divisions 1 and 2.** Where installed for operation over combustible fibers or accumulations of flyings, traveling cranes and hoists for material handling, traveling cleaners for textile machinery, and similar equipment shall comply with 503.155(A) through (D).

In Class III locations, two hazards can be introduced by cranes, equipped with rolling or sliding collectors that contact with bare conductors, that are installed over accumulations of fibers/flyings.

The first hazard results from arcing between a conductor and a collector rail igniting combustible fibers or lint that has accumulated on or near the bare conductor. This hazard can be prevented by maintaining the proper alignment of the bare conductor, by using a collector designed so that proper contact is always maintained, and by using guards or shields to confine hot metal particles that result from arcing.

The second hazard occurs if enough moisture is present and fibers/flyings accumulating on the insulating supports of the bare conductors form a conductive path between the conductors or from one conductor to ground, permitting enough current to flow to ignite the fibers. If the system is ungrounded, a current flow to ground is unlikely to start a fire.

A suitable recording ground detector sounds an alarm and automatically de-energizes contact conductors when the insulation resistance is lowered by an accumulation of fibers on the insulators or in case of a fault to ground. A ground-fault indicator that maintains an alarm until the system is de-energized or the ground fault is cleared is permitted.

**(A) Power Supply.** The power supply to contact conductors shall be electrically isolated from all other systems, ungrounded, and shall be equipped with an acceptable ground detector that gives an alarm and automatically de-energizes the contact conductors in case of a fault to ground or gives a visual and audible alarm as long as power is supplied to the contact conductors and the ground fault remains.

**(B) Contact Conductors.** Contact conductors shall be located or guarded so as to be inaccessible to other than authorized persons and shall be protected against accidental contact with foreign objects.

**(C) Current Collectors.** Current collectors shall be arranged or guarded so as to confine normal sparking and prevent escape of sparks or hot particles. To reduce sparking, two or more separate surfaces of contact shall be provided for each contact conductor. Reliable means shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings.

**(D) Control Equipment.** Control equipment shall comply with 503.115 and 503.120.

**503.160 Storage Battery Charging Equipment — Class III, Divisions 1 and 2.** Storage battery charging equipment shall be located in separate rooms built or lined with substantial noncombustible materials. The rooms shall be constructed to prevent the entrance of ignitible amounts of flyings or lint and shall be well ventilated.

# ARTICLE 504 Intrinsically Safe Systems

Δ **504.1 Scope.** This article covers the installation of intrinsically safe (I.S.) apparatus, wiring, and systems for hazardous (classified) locations.

Informational Note: See ANSI/ISA RP 12.06.01, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation — Part 1: Intrinsic Safety*, for additional information.

There are two standards used in the United States for construction and performance requirements for intrinsically safe (IS) systems: ANSI/UL 913, *Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations*, and ANSI/UL 60079-11, *Electrical Apparatus for Explosive Gas Atmospheres — Part 11: Intrinsic Safety "I,"* which is based on the IEC 60079-11 standard. The *NEC*® offers the choice of designating hazardous locations as two divisions (1 and 2) or three zones (0, 1, and 2). Equipment certified by a testing laboratory for Zone 1 would not necessarily meet UL 913 requirements for Division 1.

Due to its physical and electrical characteristics, an IS circuit does not develop sufficient electrical energy (millijoules) in an arc or spark to cause ignition or sufficient thermal energy resulting from an overload condition to cause the temperature of the installed circuit to exceed the ignition temperature of a specified gas or vapor under normal or abnormal operating conditions.

An abnormal condition may occur due to damage, failure of electrical components, excessive voltage, or improper adjustment or maintenance of the equipment. Abnormal conditions are mitigated by associated apparatus such as the IS barrier shown in Exhibit 504.1.

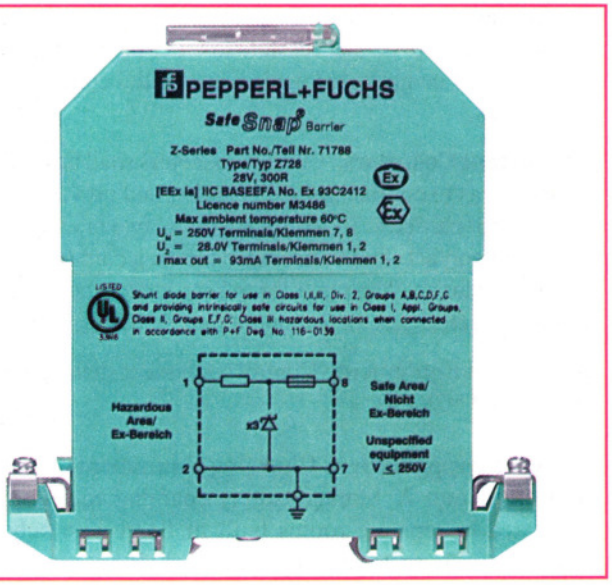


EXHIBIT 504.1 A typical IS barrier that limits the energy available to the hazardous location. *(Courtesy of Pepperl+Fuchs, Inc.)*

**504.3 Application of Other Articles.** Except as modified by this article, all applicable articles of this *Code* shall apply.

Because IS wiring must be low energy, the wiring itself is most likely to be a Class 2 or a power-limited fire-protective signaling circuit. See Article 725 or 760, as appropriate, for the requirements for such wiring. The installation may also fall under the scope of Article 800. The associated apparatus, on the other hand, may be supplied by ordinary power circuits, in which case other *NEC* requirements may apply.

The associated apparatus is not normally suitable for a hazardous location. Therefore, another protection technique, such as installing the associated apparatus in an explosionproof enclosure, is commonly used if it must be installed in a hazardous location. IS systems are not exempt from the grounding and bonding requirements of 501.30, 502.30, 503.30, and 505.30.

**504.4 Equipment.** All intrinsically safe apparatus and associated apparatus shall be listed.

*Exception: Simple apparatus, as described on the control drawing, shall not be required to be listed.*

**504.10 Equipment Installation.**

**(A) Control Drawing.** Intrinsically safe apparatus, associated apparatus, and other equipment shall be installed in accordance with the control drawing(s).

A simple apparatus, whether or not shown on the control drawing(s), shall be permitted to be installed provided the simple apparatus does not interconnect intrinsically safe circuits.

An example of the control drawing required to be followed to correctly install an IS system is shown in Exhibit 504.2. This drawing is normally provided by the associated equipment manufacturer. A similar drawing is provided by the IS equipment manufacturer. Compliance with the requirements of both drawings is required to properly install an IS system.

Informational Note No. 1: The control drawing identification is marked on the apparatus.

Informational Note No. 2: Associated apparatus with a marked Um of less than 250 V may require additional overvoltage

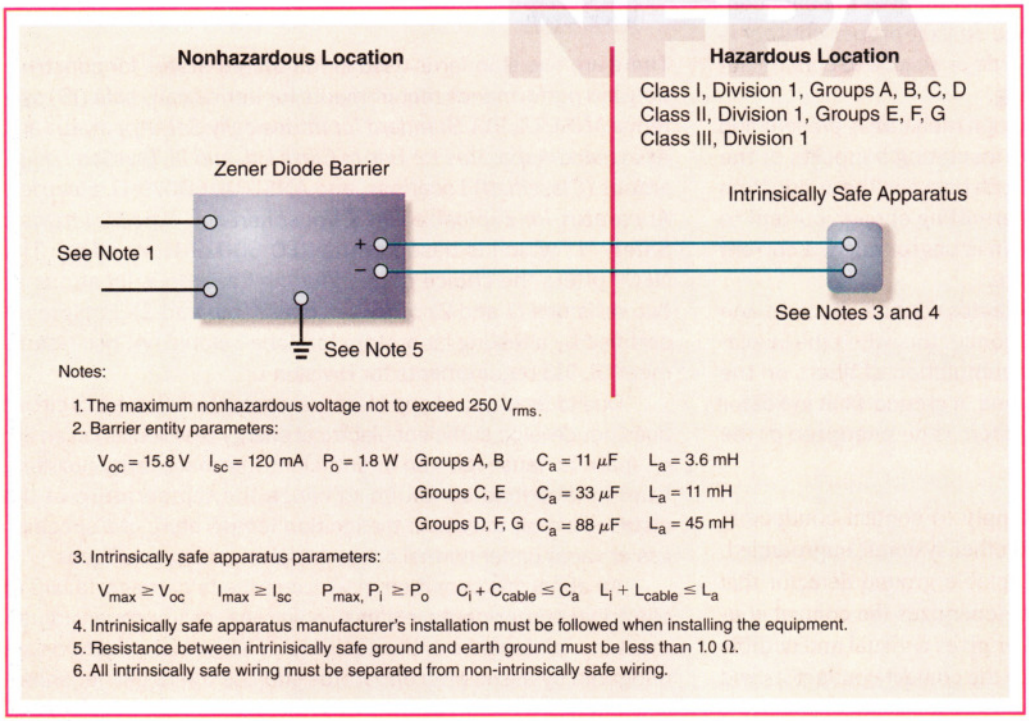


EXHIBIT 504.2 A sample zener carrier control drawing.

protection at the inputs to limit any possible fault voltages to less than the Um marked on the product.

An IS system is required to be installed according to the control drawings, which may put limitations on cables and on the separation of circuits in the system. Control drawings also illustrate what is permitted to be connected in the system. Compliance with all the conditions in the control drawings is essential if intrinsic safety is to be maintained. The investigation of the equipment by third-party testing laboratories is based on installation in accordance with the control drawing. See Exhibit 504.2 for an example of a control drawing.

**(B) Location.** Intrinsically safe apparatus shall be permitted to be installed in any hazardous (classified) location for which it has been identified.

Associated apparatus shall be permitted to be installed in any hazardous (classified) location for which it has been identified.

Simple apparatus shall be permitted to be installed in any hazardous (classified) location in accordance with 504.10(D).

**(C) Enclosures.** General-purpose enclosures shall be permitted for intrinsically safe apparatus and associated apparatus unless otherwise specified in the manufacturer's documentation.

**(D) Simple Apparatus.** Simple apparatus shall be permitted to be installed in any hazardous (classified) location in which the maximum surface temperature of the simple apparatus does not exceed the ignition temperature of the flammable gases or vapors, flammable liquids, combustible dusts, or ignitible fibers/flyings present. The maximum surface temperature can be determined from the values of the output power from the associated apparatus or apparatus to which it is connected to obtain the temperature class. The temperature class can be determined by:

(1) Reference to Table 504.10(D)
(2) Calculation using the following equation:

$$T = P_O R_{th} \times T_{amb} \qquad \textbf{[504.10(D)]}$$

where:

$T$ = surface temperature
$P_O$ = output power marked on the associated apparatus or intrinsically safe apparatus
$R_{th}$ = thermal resistance of the simple apparatus
$T_{amb}$ = ambient temperature (normally 40°C) and reference Table 500.8(C)(4)

***TABLE 504.10(D)*** *Assessment for T4 Classification According to Component Size and Temperature*

| Total Surface Area Excluding Lead Wires | Requirement for T4 Classification |
|---|---|
| <20 mm² | Surface temperature ≤275°C |
| ≥20 mm² ≤10 cm² | Surface temperature ≤200°C |
| ≥20 mm² | Power not exceeding 1.3 W* |

*Based on 40°C ambient temperature. Reduce to 1.2 W with an ambient of 60°C or 1.0 W with 80°C ambient temperature.

In addition, components with a surface area smaller than 10 cm² (excluding lead wires) may be classified as T5 if their surface temperature does not exceed 150°C.

Simple apparatus stores little or no energy. Simple apparatus is permitted to be used without requiring the apparatus to be listed or to be specifically mentioned on the control drawing. See the first informational note following the definition of *simple apparatus* in Article 100 for examples of simple apparatus.

**504.20 Wiring Methods.** Any of the wiring methods suitable for unclassified locations, including those covered by Chapter 7 and Chapter 8, shall be permitted for installing intrinsically safe apparatus. Sealing shall be as provided in 504.70, and separation shall be as provided in 504.30.

An IS system evaluation also includes wiring faults and cable parameters (e.g., short circuits and cable capacitance). Any of the wiring methods for unclassified locations may be used for IS systems, as long as the conditions specified in the control drawings are followed.

**See also**

**504.3** and its commentary for more information on the types of circuits typically used in an IS system

**504.30 Separation of Intrinsically Safe Conductors.**

It is essential that non-IS circuits and IS circuits be physically and electrically separated to prevent unsafe energy from being introduced into the IS system by a wiring fault. Other low-voltage, low-energy circuits, such as Class 2 and communications circuits, are not IS circuits and must not be installed in the same raceways or cables as IS circuits in either a hazardous or a nonhazardous location.

**(A) From Nonintrinsically Safe Circuit Conductors.**

Δ **(1) In Raceways, Cable Trays, and Cables.** Conductors of intrinsically safe circuits shall not be placed in any raceway, cable tray, or cable with conductors of any nonintrinsically safe circuit, unless they meet the requirements of one of the following methods:

(1) Separated from conductors of nonintrinsically safe circuits in accordance with one of the following:
   a. By a distance of at least 50 mm (2 in.) and secured
   b. By a grounded metal partition that is 0.91 mm (0.0359 in.) or thicker
   c. An approved insulating partition
(2) All of the intrinsically safe circuit conductors or nonintrinsically safe circuit conductors are in Type MC cable, Type MI cable, or other approved grounded metal-sheathed or metal-clad cables where the sheathing or cladding is capable of carrying fault current to ground
(3) In a Division 2 or Zone 2 location, installed in a raceway, cable tray, or cable along with nonincendive field wiring circuits when installed in accordance with 504.30(B)

(4) Where passing through a Division 2 or Zone 2 location to supply apparatus that is located in a Division 1, Zone 0 or Zone 1 location, installed in a raceway, cable tray, or cable along with nonincendive field wiring circuits when installed in accordance with 504.30(B)

Items No. 3 and No. 4 permit IS circuits in a Division 2 or Zone 2 location to be installed with nonincendive field wiring circuits if the circuits are installed as required for two separate IS circuits.

Δ **(2) Within Enclosures.** Conductors of intrinsically safe circuits shall be secured so that any conductor that might come loose from a terminal is unlikely to come into contact with another terminal. The conductors shall be separated from conductors of nonintrinsically safe circuits by one of the following methods:

(1) Separation by at least 50 mm (2 in.) from conductors of any nonintrinsically safe circuits, and secured
(2) Separation from conductors of nonintrinsically safe circuits by use of a grounded metal partition 0.91 mm (0.0359 in.) or thicker or approved restricted access wiring ducts separated from other wiring ducts by a minimum of 19 mm (¾ in.)
(3) Separation from conductors of nonintrinsically safe circuits by use of rigid insulating partition 0.91 mm (0.0359 in,) or thicker that extends to within 1.5 mm (0.0625 in.) of the enclosure walls
(4) Use of separate wiring compartments for intrinsically safe and nonintrinsically safe terminals
(5) Either all intrinsically safe circuit conductors or all nonintrinsically safe circuit conductors are installed in grounded metal-sheathed or metal-clad cables, where the sheathing or cladding is capable of carrying fault current to ground

Δ **(3) Other (Not in Raceway or Cable Tray Systems).** Conductors and cables of intrinsically safe circuits run in other than raceway or cable tray systems shall be separated by at least 50 mm (2 in.) and secured from conductors and cables of any nonintrinsically safe circuits unless one of the following applies:

(1) All of the intrinsically safe circuit conductors are in Type MI or MC cables.
(2) All of the nonintrinsically safe circuit conductors are in raceways or Type MI or Type MC cables where the sheathing or cladding is capable of carrying fault current to ground.

Even where not installed in an enclosure, raceway, or cable tray, IS circuit conductors are required to be securely separated from other conductors.

**(B) From Different Intrinsically Safe Circuit Conductors.** The clearance between two terminals for connection of field wiring of different intrinsically safe circuits shall be at least 6 mm (0.25 in.), unless this clearance is permitted to be reduced by the control drawing. Different intrinsically safe circuits shall be separated from each other by one of the following means:

(1) The conductors of each circuit are within a grounded metal shield.
(2) The conductors of each circuit have insulation with a minimum thickness of 0.25 mm (0.01 in.).

*Exception: Unless otherwise identified.*

The minimum required clearance provides a safeguard against an inadvertent connection between adjacent terminals (with different IS circuits) that could occur during maintenance or connection of a new circuit to an existing terminal block for IS circuits.

**(C) From Grounded Metal.** The clearance between the uninsulated parts of field wiring conductors connected to terminals and grounded metal or other conducting parts shall be at least 3 mm (0.125 in.).

### 504.50 Grounding.

Δ **(A) Intrinsically Safe Apparatus, Enclosures, and Raceways.** Intrinsically safe apparatus, enclosures, and raceways, if of metal, shall be connected to the equipment grounding conductor.

Informational Note: See ANSI/ISA RP 12.06.01, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation — Part 1: Intrinsic Safety*. In addition to an equipment grounding conductor connection, a connection to a grounding electrode might be needed for some associated apparatus, such as zener diode barriers, if specified in the control drawing.

Δ **(B) Associated Apparatus and Cable Shields.** Associated apparatus and cable shields shall be grounded in accordance with the required control drawing. See 504.10(A).

Informational Note: See ANSI/ISA RP 12.06.01, *Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation — Part 1: Intrinsic Safety*. In addition to an equipment grounding conductor connection, a connection to a grounding electrode might be needed for some associated apparatus, such as zener diode barriers, if specified in the control drawing.

Exhibit 504.3 illustrates a common type of zener diode barrier, which is also called a shunt diode barrier. (See Exhibit 504.1.) Maintaining a low-impedance path to ground for zener diode barrier systems is important because such systems shunt fault currents to ground.

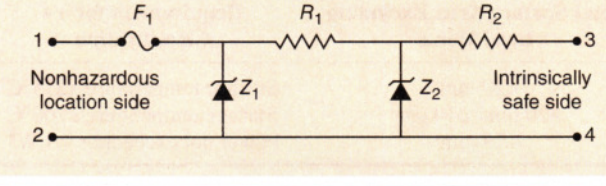


EXHIBIT 504.3 Zener, or shunt, diode barrier.

**(C) Connection to Grounding Electrodes.** Where connection to a grounding electrode is required, the grounding electrode shall be as specified in 250.52(A)(1), (A)(2), (A)(3), and (A)(4) and shall comply with 250.30(A)(4). Sections 250.52(A)(5), (A)(7), and (A)(8) shall not be used if any of the electrodes specified in 250.52(A)(1), (A)(2), (A)(3), or (A)(4) are present.

Where a grounding electrode is necessary for associated apparatus, the electrodes specified in 250.52(A)(1) through (A)(4) (metal underground water pipes, metal in-ground support structures, concrete-encased electrodes, and ground rings) are required to be used if present. These electrodes usually provide lower resistance grounds than ground rods and plate electrodes, which are covered in 250.52(A)(5) and (A)(7).

**See also**

**504.50(B),** Informational Note, for where this connection might be required

**504.60 Bonding.**

**(A) Intrinsically Safe Apparatus.** Intrinsically safe apparatus, if of metal, shall be bonded in the hazardous (classified) location in accordance with 501.30(B), 502.30(B), 503.30(B), 505.30(B), or 506.30(B), as applicable.

**(B) Metal Raceways.** Where metal raceways are used for intrinsically safe system wiring, bonding at all ends of the raceway, regardless of the location, shall be in accordance with 501.30(B), 502.30(B), 503.30(B), 505.30(B), or 506.30(B), as applicable.

**504.70 Sealing.** Conduits and cables that are required to be sealed by 501.15, 502.15, 505.16, and 506.16 shall be sealed to minimize the passage of gases, vapors, or dusts. Such seals shall not be required to be explosionproof or flameproof but shall be identified for the purpose of minimizing passage of gases, vapors, or dusts under normal operating conditions and shall be accessible.

*Exception: Seals shall not be required for enclosures that contain only intrinsically safe apparatus, except as required by 501.17.*

The use of an IS system does not remove the need to seal interconnecting cables. Any cable capable of transmitting material to another location must be sealed. These seals are not required to be explosionproof or flameproof, but they must be identified to minimize the passage of gases or dust and must be accessible.

**504.80 Identification.** Labels required by this section shall be suitable for the environment where they are installed, with consideration given to exposure to chemicals and sunlight.

**(A) Terminals.** Intrinsically safe circuits shall be identified at terminal and junction locations in a manner that is intended to prevent unintentional interference with the circuits during testing and servicing.

**(B) Wiring.** Raceways, cable trays, and other wiring methods for intrinsically safe system wiring shall be identified with permanently affixed labels with the wording "Intrinsic Safety Wiring" or equivalent. The labels shall be located so as to be visible after installation and placed so that they may be readily traced through the entire length of the installation. Intrinsic safety circuit labels shall appear in every section of the wiring system that is separated by enclosures, walls, partitions, or floors. Spacing between labels shall not be more than 7.5 m (25 ft).

*Exception: Circuits run underground shall be permitted to be identified where they become accessible after emergence from the ground.*

Informational Note No. 1: Wiring methods permitted in unclassified locations may be used for intrinsically safe systems in hazardous (classified) locations. Without labels to identify the application of the wiring, enforcement authorities cannot determine that an installation is in compliance with this *Code*.

Informational Note No. 2: In unclassified locations, identification is necessary to ensure that nonintrinsically safe wire will not be inadvertently added to existing raceways at a later date.

**(C) Color Coding.** Color coding shall be permitted to identify intrinsically safe conductors where they are colored light blue and where no other conductors colored light blue are used. Likewise, color coding shall be permitted to identify raceways, cable trays, and junction boxes where they are colored light blue and contain only intrinsically safe wiring.

ARTICLE
# 505 Zone 0, 1, and 2 Locations

Δ **505.1 Scope.**

*N* **(A) Covered.** This article covers the requirements for the zone classification system as an alternative to the division classification system covered in 500.1 for electrical and electronic equipment and wiring for all voltages where fire or explosion hazards might exist due to flammable gases, vapors, or liquids for the following:

(1) Zone 0 hazardous (classified) locations
(2) Zone 1 hazardous (classified) locations
(3) Zone 2 hazardous (classified) locations

Informational Note No. 1: The term "Class I" was originally included as a prefix to Zone 0, Zone 1, and Zone 2 locations and references as an identifier for flammable gases, vapors, or liquids to differentiate from Class II and Class III locations. Zone 0, Zone 1, and Zone 2 only apply to flammable gases, vapors, or liquids, so the "Class I" prefix is redundant and has been deleted. However, the marking of "Class I" is left as an optional marking within this Article.

Informational Note No. 2: See NFPA 497-2021, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, for extracted text that is