MINCO

APPLICATION AID #19

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Specifying Temperature Sensors for Hazardous Areas

The manufacture of petroleum products, paint, and many chemicals can lead to the release of flammable gases. When these gases accumulate in enclosed areas, a single electrical spark can ignite a disastrous explosion.

Proper selection, installation, and maintenance of electrical devices will prevent such occurrences; but many specifiers experience confusion when designing for hazardous atmospheres. For example, what is the difference between explosionproof, intrinsically safe, and nonincendive equipment? How do you distinguish between the various types of hazardous (or classified) areas? Who decides whether an instrument can be safely installed in a particular area, and what is the basis of that decision?

This application aid will attempt to clarify these issues with respect to temperature sensors and transmitters.

Classification of hazardous areas

Hazardous areas are classified using two basic parameters: first, the type of flammable material; second, the probability that a hazardous material is present. Different countries use different schemes to define hazardous areas.

North America

In North America, under the auspices of the National Electrical Code (NEC) and Canadian Electrical Code (CEC), flammable materials are divided into three classes: gases, dusts, and fibers. Gases and dusts are subdivided into groups with similar explosive potential. Table 1 lists some typical materials found in each category, in descending order of flammability.

Class I: Flammable gases and vapors	**Group A:** Acetylene
	Group B: Hydrogen, butadiene, ethylene oxide, propylene oxide
	Group C: Ethylene, coke oven gas, diethyl ether, dimethyl ether
	Group D: Propane, acetone, alcohols, ammonia, benzene, butane, ethane, ethyl acetate, gasoline, heptanes, hexanes, methane, octanes, pentanes, toluene
Class II: Combustible dusts	**Group E:** Metal dust
	Group F: Coal, coke dust
	Group G: Grain, plastic dust
Class III: Combustible flyings and fibers	Wood flyings, paper fibers, cotton fibers

Table 1.

In addition to classifying types of hazardous materials, the area is defined by the probability that those materials are present.

Division 1:	Areas where hazardous materials may be present under normal operating conditions.
Division 2:	Areas where hazards arise only as the result of leaks, ventilation failure, or other unexpected breakdowns.

Division 2 areas have a low probability of danger. Only an abnormal mishap such as a spill or equipment failure can create a hazard. As a rule of thumb, the probability of the presence of explosive materials must be less than 1% for an area to be assigned to Division 2. Even so, equipment that poses a constant threat of sparks still requires enclosures similar to those used in Division 1, and many installers use Division 1 equipment throughout Division 2 areas to be on the safe side.

Europe

The European classifying agency is the International Electrotechnical Commission (IEC). It groups aboveground gases into three groups, and adds a fourth group for underground methane. (In the U.S., undergound methane is addressed by MSHA.) Table 2 lists some typical materials found in each category, in descending order of flammability.

Group IIC	Acetylene, hydrogen
Group IIB	Ethylene, coke oven gas, diethyl ether, dimethyl ether, ethylene oxide
Group IIA	Propane, acetone, alcohols, ammonia, benzene, butane, ethane, ethyl acetate, gasoline, heptanes, hexanes, methane, octanes, pentanes, toluene
Group I	Methane (underground)

Table 2.

IEC also classifies hazardous areas by zone, based on the probability that hazardous materials are present.

Zone 0:	Areas where flammable gas is continuously present, or present for long periods (typically over 1000 hours/year). (Zone 20 for combustible dusts.)
Zone 1:	Areas where flammable gas may exist under normal operating conditions (typically 10-1000 hours/year). (Zone 21 for combustible dusts.)
Zone 2:	Areas where flammable gas is not likely to occur, and if it does, exists for a short time (typically 1-10 hours/year). (Zone 22 for combustible dusts.)

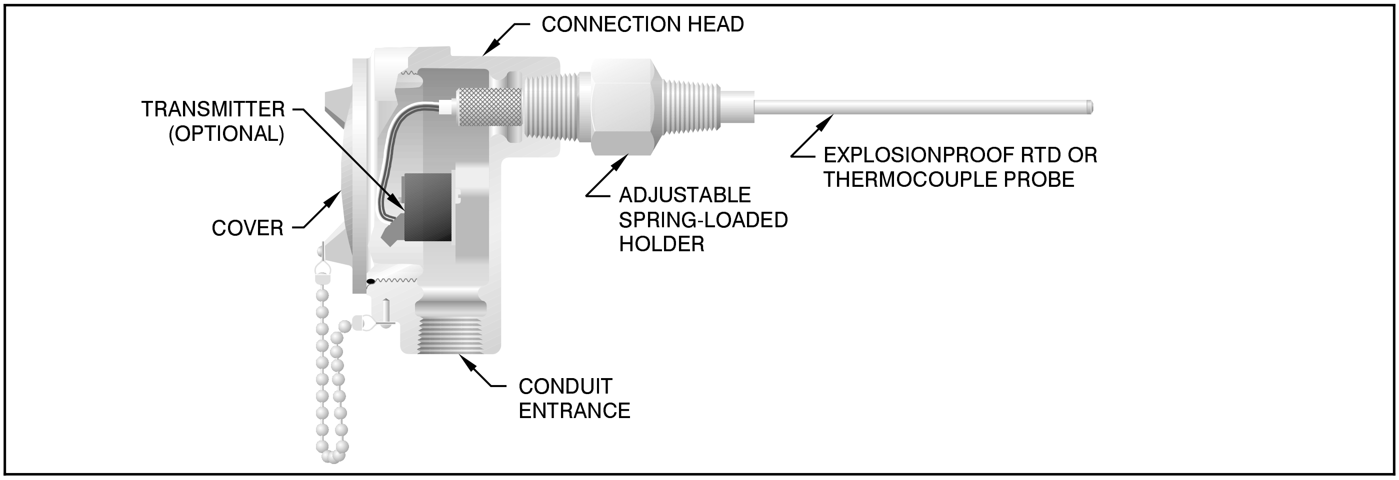


Figure 1: Explosionproof temperature sensor assembly

Methods of protection

Prevention of explosions may incorporate any of three methods: containment (e.g. explosionproof, flameproof), energy limitation (e.g. intrinsically safe, nonincendive), and isolation (e.g. purged, sealed). Some installations utilize a combination of these methods for added safety.

Acceptable protection methods for specific risk areas are listed in Table 3.

Containment

The principle of containment is not to prevent explosions, but to contain them inside enclosures from which they cannot propagate to surrounding atmospheres. In North America, these enclosures are called explosionproof; and in Europe, they are known as flameproof.

Figure 1 shows an explosionproof assembly consisting of an RTD or thermocouple probe, spring-loaded fitting, connection head, and transmitter. If the electrical circuits should produce a spark sufficiently powerful to ignite gases inside the head, the resulting flame has three possible escape paths: around the cover, between the probe and holder, or down the external conduit.

The cover threads are designed to block the first path. The spring-loaded holder has tight tolerances and an extended length to form a long and narrow spark gap between the probe and fitting. This prevents flame propagation down the second path. (The probe/holder assembly meets requirements similar to rotating shafts in explosion-proof motors).

The third potential escape route, external conduit, is the responsibility of the installer. NEC requires rigid conduit and placement of seals at regular intervals to act as flame stops.

Isolation

Isolation is a technique that prevents potentially explosive atmospheres from coming in contact with potential ignition sources. An approach used for instrument cabinets or, in some cases, entire control rooms is to continually purge the enclosure with pressurized “safe” air and thus prevent the entry of flammable gases. Other methods of isolation include oil immersion, powder filling, and hermetic sealing.

NEC (North America)		CENELEC (Europe)	
Hazardous area classification (Class I)	**Protection method**	**Hazardous area classification**	**Protection method**
Division 1	Explosionproof Intrinsically safe (2 fault) Purged/pressurized (Type X or Y)	Zone 0	Intrinsically safe (2 fault): “ia”
		Zone 1	Encapsulation: “m” Flameproof: “d” Increased safety: “e” Intrinsically safe (1 fault): “ib” Oil immersion: “o” Powder filling: “q” Purged/pressurized: “p”
Division 2	Hermetically sealed Nonincendive Non-sparking Oil immersion Purged/pressurized (Type Z) Sealed device	Zone 2	Hermetically sealed: “nC" Nonincendive: ”nC" Non-sparking: “nA” Restricted breathing: “nR” Sealed device: “nC”

Table 3.

Energy limitation

For a spark to start an explosion it must have sufficient energy to ignite the gas. Many instruments such as RTD's, thermocouples, and transmitters function at power levels below the threshold of danger. A signal loop terminating at these devices may be deemed "intrinsically safe" if it is incapable of ignition under four conditions: normal power levels, faults in the control room, faults in the signal line, and faults in the sensor or transmitter. Intrinsically safe circuits meeting these conditions require no special housings. They offer an increasingly popular and often less costly alternative to explosionproof instrument enclosures.

Because most controlling and recording instruments operate on line power, shorts or opens in their circuitry might release hazardous voltages down signal lines to sensors. An intrinsically safe circuit therefore requires a Zener diode barrier in the signal line to limit the amount of energy entering the hazardous area. Several manufacturers offer barriers for use in thermocouple, RTD, or 4 to 20 mA lines. In the intrinsically safe installation shown in Figure 2, note that the barrier must be located in a safe area and not at the sensing site. There must be no entrance of flammable gases into the safe area.

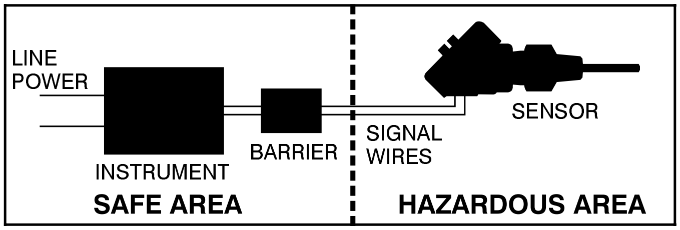


Figure 2: Intrinsically safe installation

One must also consider the possibility of the transmitter storing energy and releasing it as a spark. The capacitance and inductance of the circuits are calculated assuming various line and instrument faults; if the potential stored energy is sufficiently low the transmitter is considered safe.

Finally, under both normal or abnormal operating conditions the sensor or transmitter must not produce surface temperatures capable of ignition.

Intrinsic safety certification might cover a matched set consisting of a transmitter and barrier (loop approval), or might cover the transmitter alone (entity approval). The installer must ensure that the entity parameters of the transmitter fall within the specified limits of the chosen barrier.

Nonincendive devices

Devices classified as "nonincendive" are similar to intrinsically safe devices but do not require barriers to guard against fault conditions. The regulators reason that, in Division 2 (or Zone 2) areas, the probability of two simultaneous faults—a materials spill and an electric overload—is essentially zero.

Any purely passive device, such as an RTD or thermocouple, should be safe for Division 2 areas in normal operation. Most, but not all, transmitters are suitable.

Europeans also recognize "increased safety" equipment as an intermediate between intrinsically safe and nonincendive apparatus. This approach uses various constructional safeguards to avoid arcing or sparking components.

Electrical apparatus classification

The classification of an electrical apparatus follows the same scheme as the hazardous area classification in which the apparatus can be used, with the addition of a temperature class/code. The temperature class/code (Table 4) indicates the maximum surface temperature of the apparatus, under normal or fault conditions, at an ambient temperature of 104°F (40°C). It ensures that the apparatus will never exceed the ignition temperature of the hazardous material involved.

Temperature class/code	Maximum surface temperature
T1	842°F (450°C)
T2	572°F (300°C)
T3	392°F (200°C)
T4	275°F (135°C)
T5	212°F (100°C)
T6	185°F (85°C)

Table 4.

Standards and certification

In theory, there are two types of entities to consider: Standards Agencies and Testing Laboratories.

Standards Agencies

Standards Agencies set the standards for safety equipment. Examples are NFPA (USA), ISA (USA), CSA (Canada), CENELEC (Europe), and IEC (international).

Testing Laboratories

Testing Laboratories determine conformance to standards. In this category are UL (USA), FM (USA), CSA (Canada), BASEEFA (UK), SIRA (UK), PTB (Germany), LCIE (France), TÜV (Germany), and KEMA (Netherlands). Reciprocity between different authorities is rare.

In practice, testing labs may publish their own standards for equipment design, especially in the U.S. where labs compete with each other as private-sector enterprises. European labs are required to apply CENELEC standards. CENELEC approval by any European Community lab implies approval by others, although customers may not always accept that approval. A new procedure, ATEX Directive 94/9/EC, promises to improve reciprocity throughout the European Union. As of 1 July 2003, manufacturers must comply with the new directive to market in the EU.

Factory Mutual (FM) certification carries the most weight in the U.S. but has low recognition elsewhere. FM standards differ from CENELEC on some points, and there is no reciprocity of approval.

Suitability of Minco products for hazardous areas (North American classification)

Minco offers a number of temperature sensors, transmitters, and accessories for use in hazardous areas. Table 5 lists the products certified to the North American standard. Keep in mind that any apparatus suitable for Division 1 is also suitable for the equivalent Class and Group in Division 2.

Apparatus	Division 1			Division 2
	Explosionproof (Class I) Dust-ignition-proof (Class II, III)	Explosionproof (Class I) Dust-ignition-proof (Class II, III)	Intrinsically safe (requires barrier)	Nonincendive
	Class I, Groups ABCD Class II, Groups EFG Class III	Class I, Groups BCD Class II, Groups EFG Class III	Class I, Groups ABCD	Class I, Groups ABCD
Temperature sensors				
Explosionproof assemblies with an approved probe*, transmitter (optional), FG118, and CH405 or CH407	FM APPROVED	FM APPROVED	✓	✓
Explosionproof assemblies with an approved probe*, transmitter (optional), FG118, and CH105, CH107, CH342, or CH343	✗	FM APPROVED, CSA	✓	✓
AS5180, AS5181, AS5185, AS5186, AS5190	✗	FM APPROVED, CSA	✓	✓
AS5301-AS5396 (transmitter optional)	✗	FM APPROVED, CSA	✓	✓
Temperature transmitters				
TT176 TT190 TT210 TT211 TT216 TT220 TT221 TT230 TT676 TT710 TT711 TT720	Suitable if used with an appropriate enclosure	Suitable if used with an appropriate enclosure	FM APPROVED	FM APPROVED
Connection heads				
CH405, CH407	FM APPROVED	FM APPROVED	✓	✓
CH105, CH107, CH342, CH343 TI196 (houses temperature indicator and optional transmitter**)	✗	FM APPROVED, CSA	✓	✓

*Approved probes are models S334, S347, S834, S847, S864, S877, TC2160, TC2192

**Minco Temptran™ models TT110, TT210, TT150, TT710

FM APPROVED = FM approved

✓ = Suitable, but not FM approved or CSA certified

CSA = CSA certified

✗ = Not suitable

Table 5.

For specifications and ordering information regarding any of the Minco products listed in Table 5, call Minco and request Bulletin TS–102.

To learn more about Minco—who we are, and what we do—call Minco and request Bulletin PS–4.

Suitability of Minco products for hazardous areas (European classification)

Table 6 lists available Minco products that are certified to the European standard. Any apparatus suitable for Zone 0 is also suitable for the equivalent Group in Zone 1 or Zone 2, and a Zone 1 approved apparatus is suitable for the equivalent Group in Zone 2.

Apparatus	Zone 0	Zone 1		Zone 2
		Flameproof - "d"	Increased Safety - "e"	
		Group IIC	Groups IIA, IIB, IIC	
Temperature sensors				
Assemblies including connection head, spring-loaded holder, probe, and transmitter (optional) MAS6000–MAS6499	✘	Ex EEx d IIC T6		★
Stator embedment temperature sensors MS102005–MS104558, MS212005–MS214558	✘		Ex EEx e II	★
Connection heads				
TI196 (houses temperature indicator and optional transmitter**)	✘	Ex EEx d IIC		★

**Minco Temptran™ models TT110, TT210, TT150, TT710

Ex = CENELEC approved

✘ = Not suitable

★ = By definition, any apparatus suitable for Zone 1 is also suitable for Zone 2

Table 6.

Acronyms

ANSI	American National Standards Institute
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmospheres
CEC	Canadian Electric Code
CENELEC	European Electrotechnical Committee for Standardization
CSA	Canadian Standards Association
FM	Factory Mutual Research Corporation
IEC	International Electrotechnical Commission
I.S.	Intrinsically Safe
ISA	Instrument Society of America
KEMA	Keuring van Elektrotechnische Materialen
LCIE	Laboratoire Central des Industries Electriques
MSHA	Mine Safety and Health Administration
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
PTB	Physikalisch-Technische Bundesanstalt
TÜV	Technischer Überwachungs Verein
TÜV/PS	Technische Überwachung Verein Product Services
UL	Underwriters Laboratories, Inc.

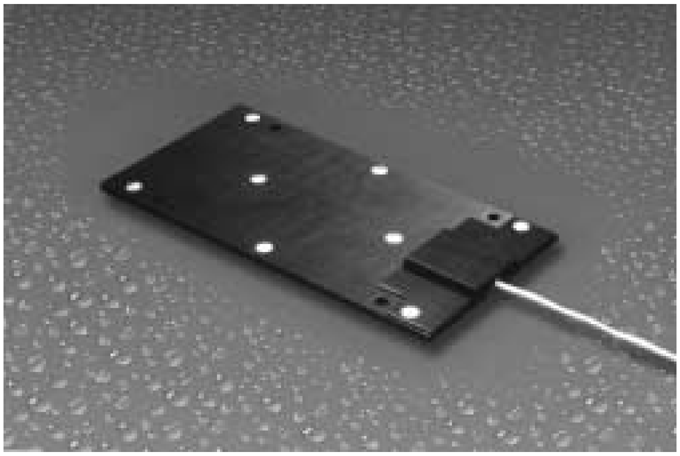
For further information

Installers should read NEC Articles 500-505 for U.S. installations, CEC Section 18 and 20 for Canadian installations, and CENELEC Standards EN50014-50039, and EN60079 for European installations.

A good general reference is *Electrical Instruments in Hazardous Locations*, Ernest C. Magison, Instrument Society of America, Pittsburgh, 1978.

Other Minco products

Heaters for hazardous areas



This anti-condensation heater is certified to EEx e II T3.

Minco offers two heater models with increased safety certification. These heaters were specifically designed as anti-condensation heaters for motors and generators in hazardous areas. Both heaters are suitable for Zone 1 or Zone 2, Groups IIA, IIB, or IIC. A multi-conductor cable allows a variety of input voltages, ranging from 110 VAC to 525 VAC.

The model pictured is 12.5" long and 6.5" wide. A larger model is available (not pictured), with a 26.5" length and a 6.5" width.

For more information (including specifications), contact Minco, and speak with one of our Sales Engineers.

Room air temperature sensors for hazardous areas

This explosionproof sensor is perfect for wall mounting in hazardous areas—paint booths, chemical storage rooms, petroleum facilities—just to name a few. It's UL listed and CSA approved for Class I, Groups C and D; Class II, Groups E, F, and G; and Class III. There are four element options: 100 Ω or 1000 Ω Platinum, and 2252 Ω or 10,000 Ω thermistor. You also have a choice of two or three leads.

For more information, contact Minco, and speak with one of our Sales Engineers, or request Bulletin RT-11.

Other Minco products

Temperature Sensors

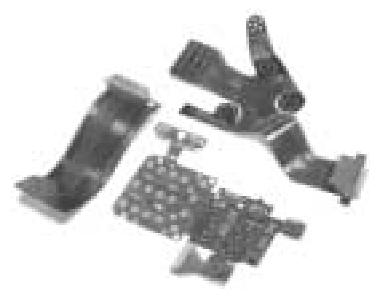
Minco RTD's, thermocouples, and thermistors come in a wide variety of packages.

Request Bulletin TS-102.

Thermofoil™ Heaters

Etched foil heaters for fast warmup and precise, contoured heating in a thin, lightweight package.

Request Bulletin HS-201.



Flexible Circuits

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Request Bulletin FC-301.

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