PR electronics

Introduction to Intrinsic Safety

PERFORMANCE
MADE
SMARTER

Hazardous Area Safety Concerns

Measurement and Control Signals

General Ex Terms

- Industry types, zone, module category
- Gas classification
- Temperature classification
- nA and Ex d approvals

Intrinsic Safety

FM / ATEX Labelling

Dust Explosion (before)

Dust Explosion (After)

Explosions

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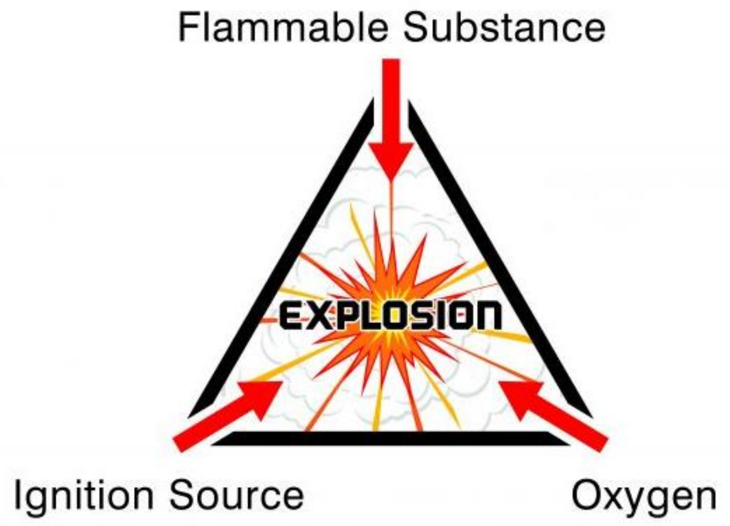
Definition:

*“An **explosion** is a rapid increase in volume and release of energy in an extreme manner, usually with the generation of high temperatures and the release of gases”*

For an explosion to occur, three conditions must be fulfilled; see the explosion triangle diagram.

1. Flammable gas or dust
2. Oxygen
3. Source of ignition

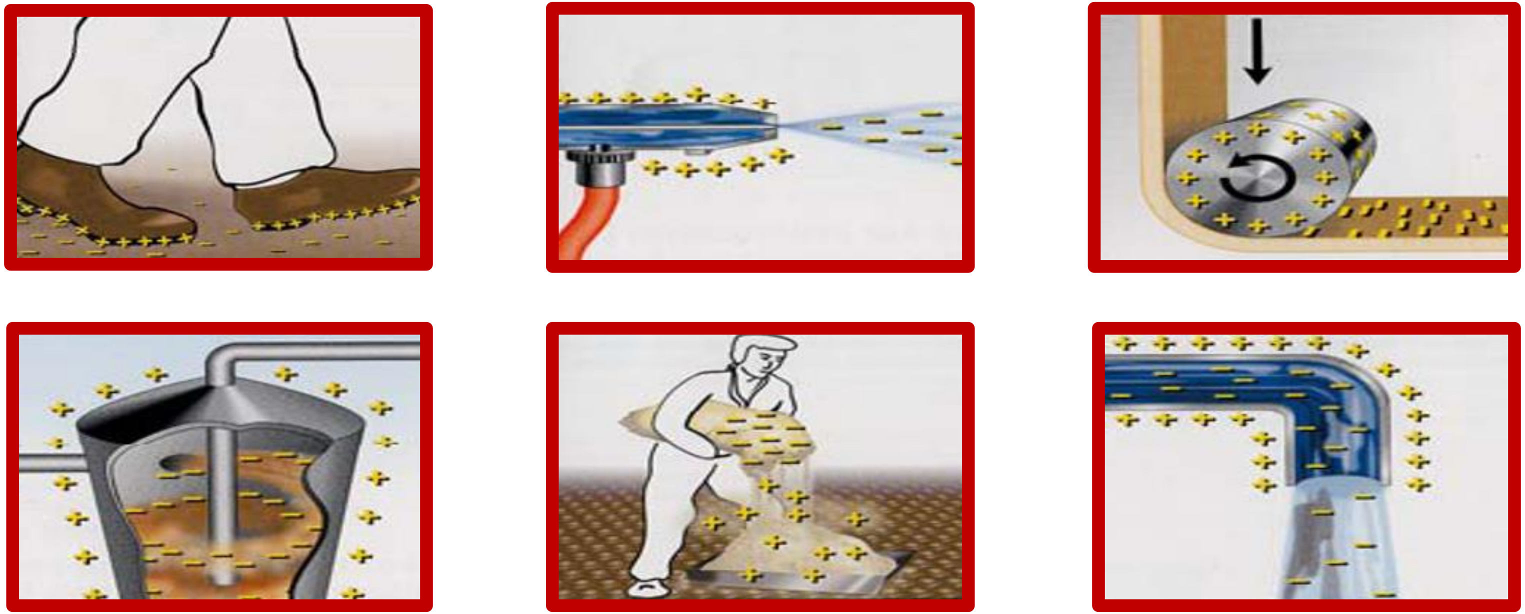
If one of these three conditions are removed, an explosion cannot occur.



Sources of ignition

- Flames
- Direct fired process heating
- Use of cigarettes/matches etc
- Cutting and welding flames
- Hot surfaces
- Heated process vessels
- Electrical equipment and lights
- Spontaneous heating
- Friction heating
- Impact sparks
- Sparks from electrical equipment
- Electrostatic discharge sparks
- Lightning strikes

Formation of Static Electricity



Directives

To increase the awareness and protection against explosions, directives and standards exist which ensure manufacturers and operators follow guidelines to achieve the highest level of safety.

As in most fields of electrical installation, different countries have approached the standardization and testing of equipment for hazardous areas in different ways, although these are beginning to converge to make compliance more standard.

The IEC Ex standard is an attempt to create a single Ex standard that is acceptable to all.

Country/Region	Standard & Marking	Description
North America	UL LISTED	For North America hazardous locations, equipment certification are performed by nationally recognized laboratories UL, MET, FM and CSA. In addition, the American National Standard Institute coordinates US standard to be used internationally and allow equipment to be used globally.
Europe	ATEX	This standard is in accordance with EU directives; EN 60079 and 61241 specifically cover explosion protection. The CE along with Ex mark follows indications of the group and category. Also, if Group II equipment relates to the gases (G) or dust (D)
International	IEC Ex	This standard addresses "Hazardous Locations", "Hazardous Area", and "Explosive Atmosphere". Places where flammable liquids, vapors, gases or combustible dusts along with sufficient quantities to cause fire or explosion.

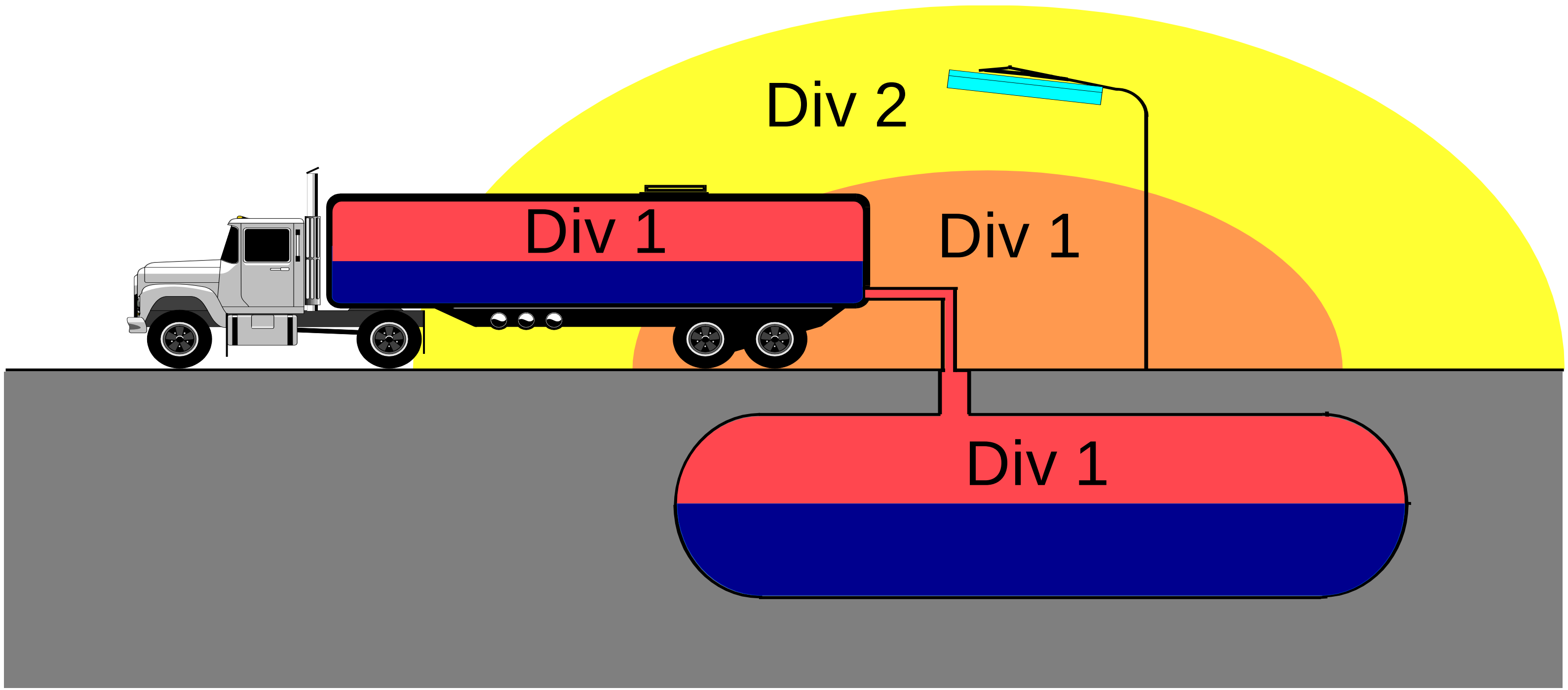
Class & Divisions

North America defines hazardous areas based on Class and Division as below:

Classification of Zones vs Divisions

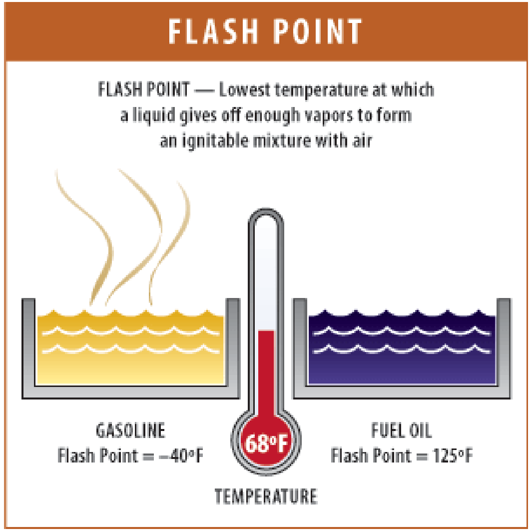
	EU (ATEX and IEC)		North America (FM and UL)	
Definition	Gas	Dust	Gas	Dust
An area in which and explosive atmosphere is continually present	Zone 0	Zone 20	Class I, Division 1	Class II, Division 1
An area where an explosive atmosphere is likely to occur in normal operation	Zone 1	Zone 21	Class I, Division 1	Class II, Division 1
An area where an explosive atmosphere is not likely to occur in normal operation, but may occur for short periods	Zone 2	Zone 22	Class I, Division 2	Class II, Division 2

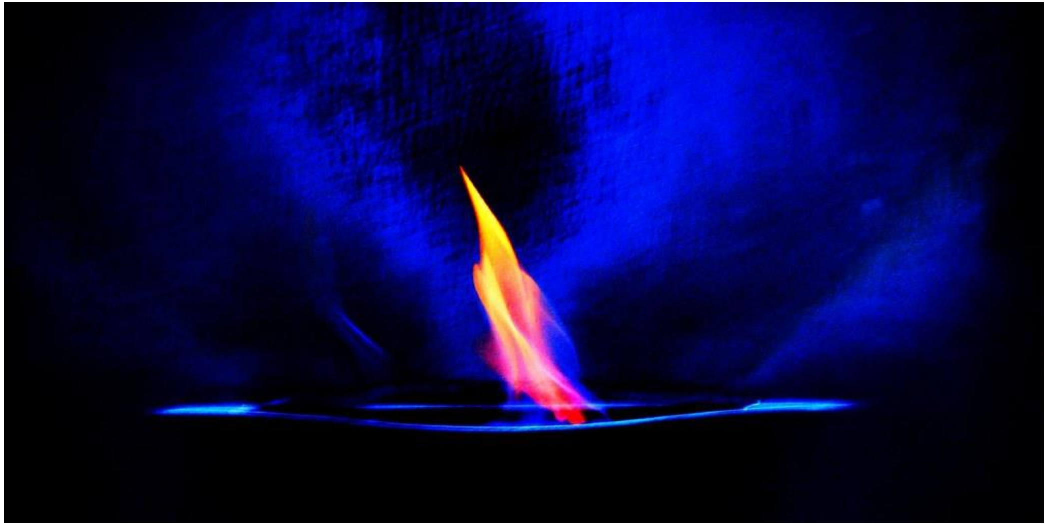
FM Division example



Liquid Flash Point

Flammability of combustible liquids are defined by their flash-point. The flash-point is the temperature at which the material will generate sufficient quantity of vapor to form an ignitable mixture.





LEL versus UEL

Explosive Limits (LEL & UEL)

Lower Explosive Limit (LEL):
The lowest concentration of flammable gas in the air at which ignition can occur.

Upper Explosive Limit (UEL):
The highest concentration of flammable gas in the air at which ignition can occur.

Flammable Range

Examples:

Hydrogen	LEL = 4.0%	UEL = 75%
Gasoline	LEL = 1.4%	UEL = 7.6%
Propane	LEL = 2.1%	UEL = 9.5%

Too Lean to Burn	Flammable Range	Too Rich to Burn
LEL		UEL

Minimum Ignition Energy

The Minimum ignition energy (MIE) is the minimum amount of energy required to ignite a combustible gas or dust cloud, from a spark for example.

Gas/Dust	MIE
Butane	250µJ
Ethylene	70µJ
Hydrogen	17µJ
Flour	50mJ
Sugar	30mJ
Aluminium	10mJ

Gas and Dust Classification

Gas and dust can be classified into different groups based on how hazardous they are. To simplify the process of classification a number of gas and dust groups have been created based on the hazardous nature of each. Related electrical equipment can be classified into different groups.

Gases are grouped into IIA,IIB and IIC, while Dusts are grouped IIIA, IIIB and IIIC

MESG = Maximum Experimental Safety Gap

MIE = Minimum Ignition Energy

Gas	MESG	MIE	EU Group	US Group
Propane	0.91mm	140µJ	IIA	D
Ethylene	0.65mm	70µJ	IIB	C
Hydrogen	0.29mm	17µJ	IIC	B
Acetylene	0.37mm	17µJ	IIC	A

More Dangerous

Dust Type	EU Group	US Group
Filings (particle>0.5mm)	IIIA	Class III
Carbonaceus Dusts	IIIB	F
Non-Conductive (particle<0.5mm)	IIIB	G
Electrically Conductive	IIIC	E

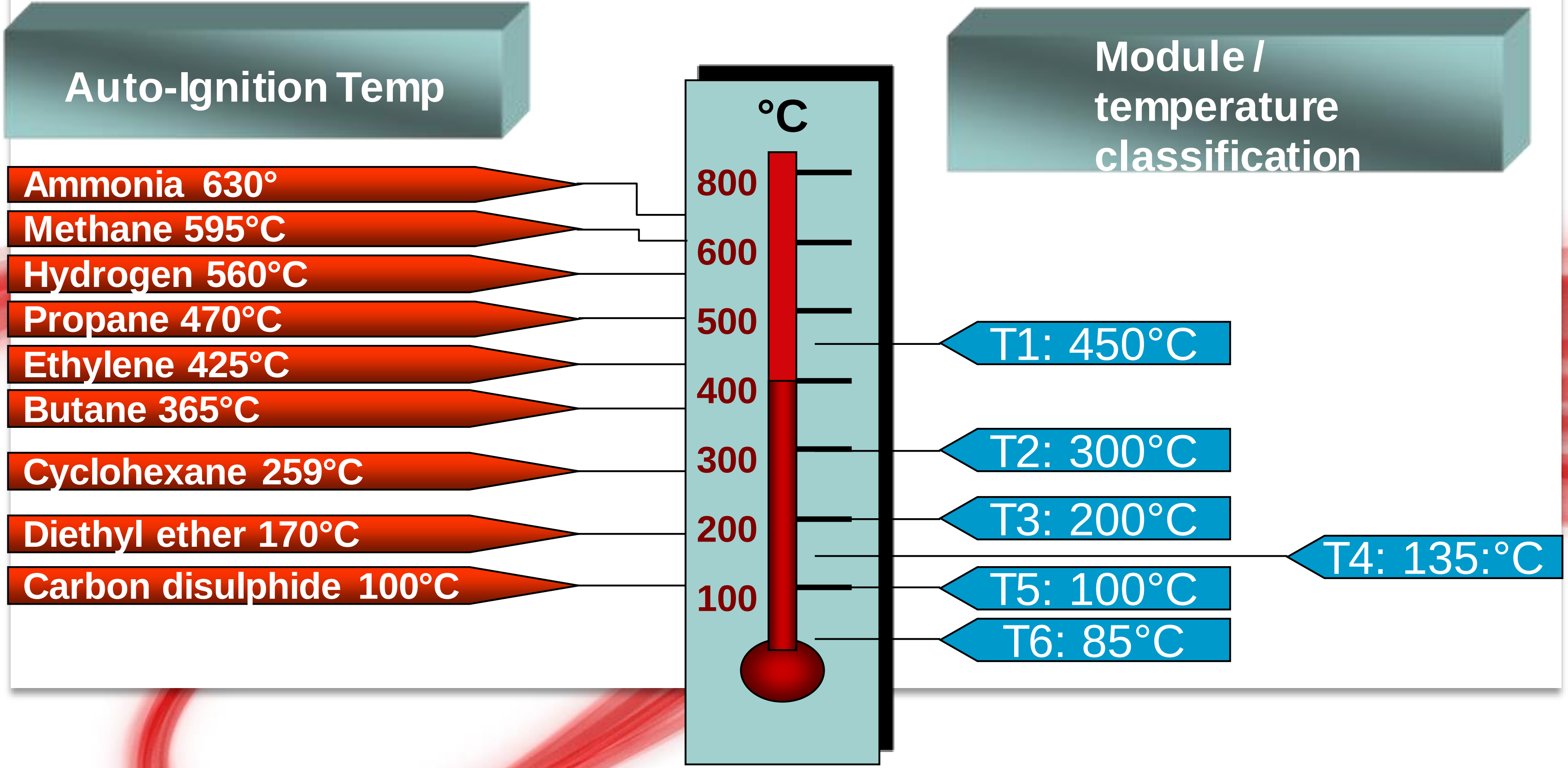
Temperature classification

The maximum safe surface temperature of anything that comes into contact with flammable gas

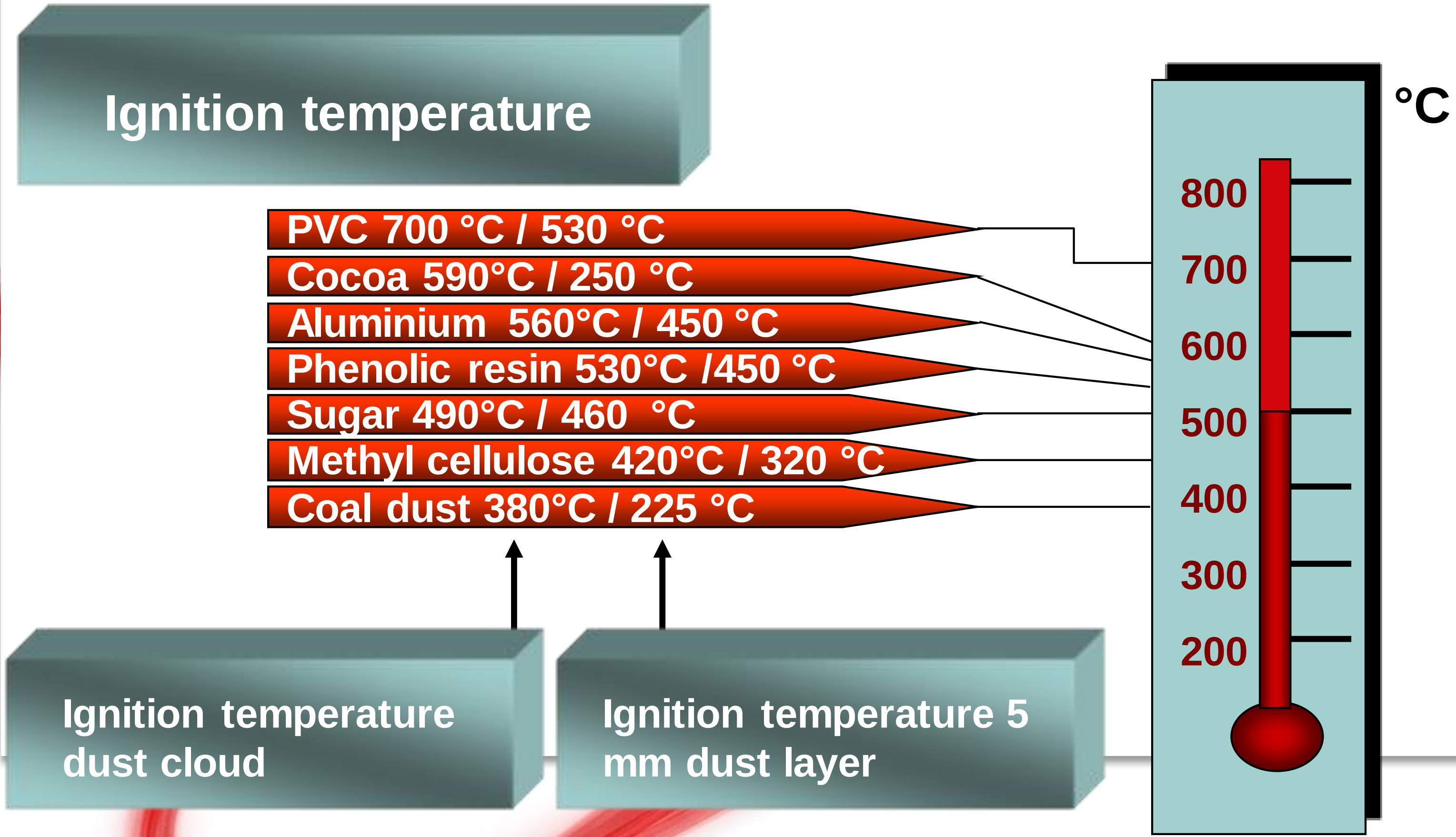
Temperature classes	Max. surface temperature T amb. = 40°C
T1	450 °C
T2	300 °C
T3	200 °C
T4	135 °C
T5	100 °C
T6	85 °C

Strictest demand

Gas / temperature compatibility



Dust and Ignition Temperature



Ex Area

The Ex specification determines the protection methods to be used.

Which type of industry?

Module group
Class I : Hazardous Gasses
Class II: Hazardous Dusts

Ex atmosphere - how often?

Module category:
Div 1: Continuous or occasional presence
Div 2: Normally not, only for short periods

Which gasses?

Gas group:
IIA - IIB - IIC

How hot?

Temperature classes
T1 - T6

Ex nA – non sparking

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Equipment that under normal operation will not produce arcs, sparks or surface temperature high enough to cause ignition of the surrounding gas vapor mixture, applicable for Zone 2 use only.

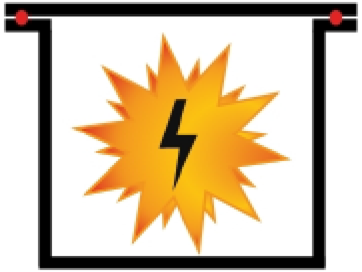
Typical products include Zone 2 lighting fixtures, instrumentation, and certain enclosures.

Zone 2 Suitable Ex nA – Non-Sparking EN/IEC 60079-15

PR products that carry an Ex nA approval include 3000 series, 9000 series, and most 4000 series

Ex d- flameproof enclosure

An Ex d flameproof enclosure or device is designed so that hot gases / flames generated during an internal explosion are cooled / quenched below the ignition temperature of the surrounding flammable atmosphere as they escape through the joints of the unit.



In addition, the external surfaces of the enclosure must not become hot enough to ignite the surrounding atmosphere due to heat energy within the unit. This heat energy may be the result of normal operation, or extra heat produced in the case of equipment fault within the unit.

Maximum surface temperature < Ignition Temperature

PR products that carry an Ex d approval include the 7501 Field Mounted Temperature Transmitter

General Ex Terms

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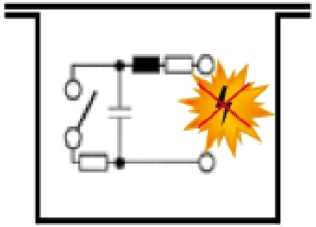
Intrinsic Safety

FM / ATEX Labelling

EX ia, ib, ic– intrinsic safety concept



Safety category "Intrinsic safety" Ex i is based on the principle of limiting the current, voltage and energy stored capacitively and inductively within an electric circuit.

An intrinsically safe circuit consists of at least one piece electrical equipment in the hazardous area and one piece of an associated apparatus located outside the hazardous area. The intrinsically safe equipment and the associated apparatus must fulfill specific intrinsic safety requirements.

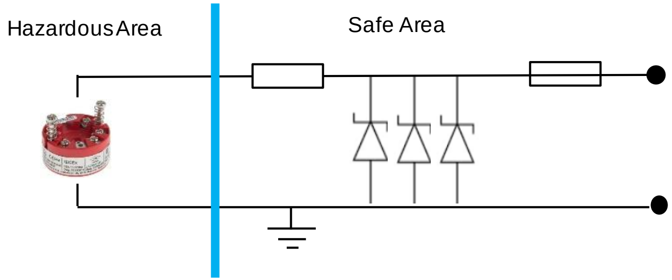
Electrical equipment in the non-hazardous area does not require intrinsic safe approval when connected downstream of the associated apparatus.

Galvanic isolators or zener barriers are commonly used to separate intrinsically safe equipment from non intrinsically safe equipment in the non-hazardous area.

PR products that carry an Ex ia approval include 5300 series, 5000 series, 6000 series and 9000 series

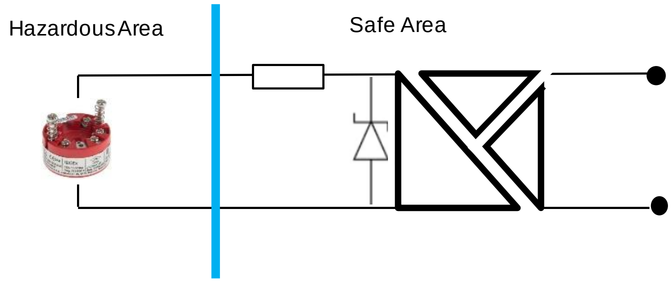
Barrier Comparison

Zener barrier



Disadvantages:
- Maintaining an I.S ground
- No protection against ground loops
- Fuse replacement requirement
- No protection against EMI noise
- No signal conversion / scaling
- No diagnostics

Galvanic Isolated barrier



Advantages:
- No I.S ground requirement
- Elimination of ground loops
- Lower install/maintenance costs
- Better noise rejection
- Signal conversion capability
- Improved diagnostic capability

IS Loop Calculations

Intrinsic safety applies not only to individual items of equipment, but to the entire signal loop.
To ensure the integrity of an intrinsic safety instrument loop, a calculation has to be done based on the IS entity data issued with each piece of equipment.

Hazardous Area
- Ui
- Ii
- Pi
- Ci
- Li

Maximum input capacity

Cable L C

Cable characteristics

Safe Area
- Uo
- Io
- Po
- Co
- Lo

Maximum output capacity

Requirements
- Uo < Ui
- Io < Ii
- Po < Pi
- Lo > Lcable + Li
- Co > Ccable + Ci

Electrical data

Type of protection Ex ia:
Supply and output circuit (terminals 1 and 2):
in type of protection intrinsic safety Ex ia IIC, Ex ia IIIC or Ex ia I I
safe circuit, with the following maximum values:
U_i = 30 V; I_i = 120 mA; P_i = 0.84 W; C_i = 1 nF; L_i = 10 µH.

Sensor circuit (terminals 3 ... 6):
in type of protection intrinsic safety Ex ia IIC, Ex ia IIIC or Ex ia I I
U_o = 9.6 V; I_o = 28 mA; P_o = 67 mW; C_o = 3.5 µF; L_o = 35 mH.

The sensor circuit is not infallibly galvanic isolated from the supply
between the circuits is capable of withstanding a test voltage of 500

Types of protection Ex ic and Ex nA
Supply and output circuit, 4 ... 20 mA (terminals 1 and 2), in type of
U ≤ 35 Vdc; or
in type of protection intrinsic safety Ex ic IIC or Ex ic IIIC, only fo
cuit, with the following maximum values: U_i = 35 V; C_i = 1 nF; L_i =

Sensor circuit (terminals 3, 4, 5 and 6) intended for connection to a
type of protection intrinsic safety Ex ic IIC or Ex ic IIIC, with the fo
U_o = 9,6 V; I_o = 28 mA; P_o = 67 mW; C_o = 28 µF; L_o = 45 mH.

Example IS Calculation

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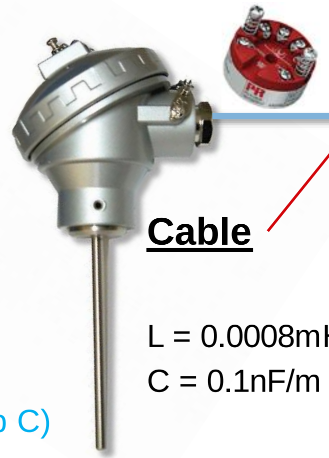
5437D

Ui = 30V
Ii = 120mA
Pi = 0.90W
Ci = 1nF
Li = 0.µH
(Gas Group C)



Cable

L = 0.0008mH/m
C = 0.1nF/m

9106B1A

Uo = 28V
Io = 93mA
Po = 0.65W
Co = 80nF
Lo = 3mH

Requirements

Uo < Ui ✓
Io < Ii ✓
Po < Pi ✓
Lo > Lcable + Li ?
Co > Ccable + Ci

Cable length

Max Lcable < Lo – Li = 2.999mH @ 0.0008mH/m = 3748m

Max Ccable < Co – Ci = 79nF @ 0.1nF/m = 790m

Max cable length possible is 790m

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Most explo… gasses

- Module / gas… …ergy content in potential spark

Highest temperatu…

- T6: lowest surface temperature

Highest degree of protection of electronics

Module category 1 G/D: Zone 0 & 20

(ia): 2 component errors will not influence the safety

PR meets the strictest requirements

General Ex Terms

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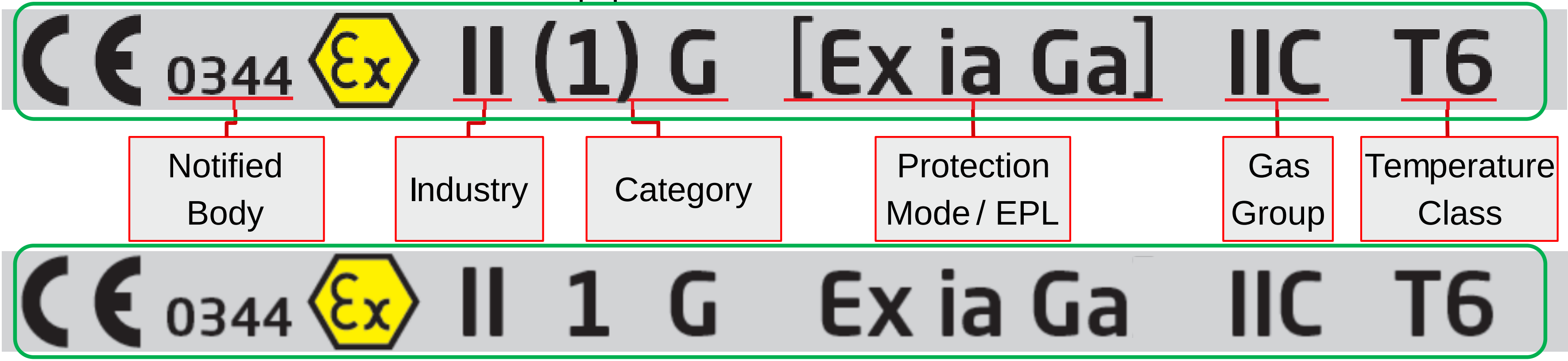
Intrinsic Safety

FM / ATEX Labelling

Ex device label examples

Equipment outside hazardous area



Equipment inside hazardous area

- Equipment marking <u>**shall**</u> comply with the hazardous area classification it is intended to be installed.

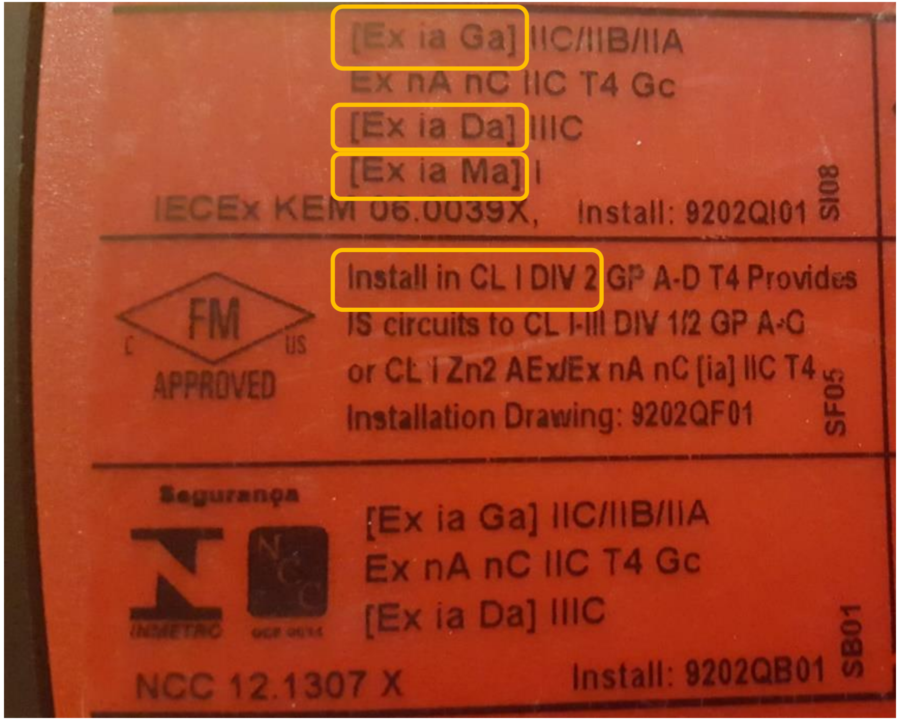
- <u>**Each equipment, depending its marking (protection mode), will have different requirements in regards to installations, maintenance or inspection ….**</u>

ATEX / FM labelling

ATEX Certificate KEMA 07 ATEX 0146 X

Marking

II 3 G Ex nA nC IIC T4
II (1) G [Ex ia] IIC/IIB/IIA
II (1) D [Ex iaD]



Example of ATEX / FM labelling

Field-mounted transmitter

Ex / I.S. approvals – 5437D:

ATEX DEKRA 16ATEX0047 X
II 1 G   Ex ia IIC T6…T4 Ga
II 2(1) G Ex ib [ia Ga] IIC T6…T4 Gb
II 1 D   Ex ia IIIC Da
I M1   Ex ia I Ma

FM16US0287X
Class I, Division 1, Groups A, B, C, D; T6…T4
Class I, Zone 0, AEx ia IIC T6…T4 Ga
Class I, Zone 0, AEx ib [ia Ga] IIC T6 … T4 Gb
Class I, Division 2, Groups A, B, C, D; T6…T4
Class I, Zone 2, AEx nA IIC T6…T4 Gc

PR 9000

PR electronics

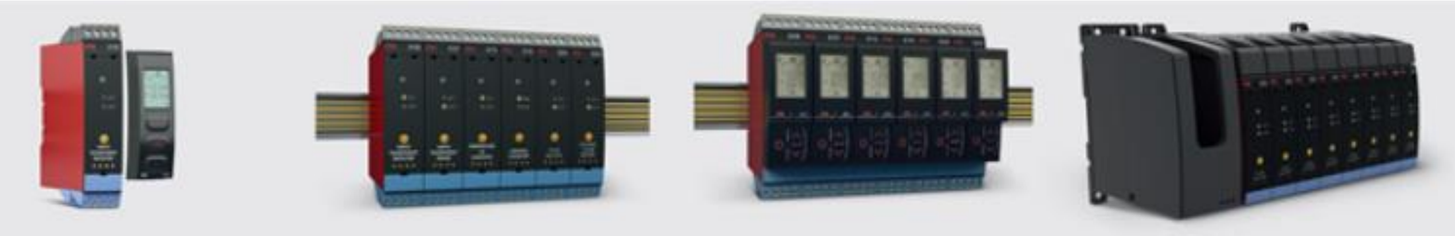
- Full Functional Safety Assessment to SIL2 /3*
- Flexible Mounting (DIN, Power Rail, Backplane)
- 4501 Display Front, 4511 Modbus option
- 2.6kV Galvanic Isolation
- Zone 2 installation option
- Active/Passive Input / Output Flexibility
- 6 devices = cover the majority of applications

9106B	HART Transparent Repeater 4-20mA
9107B	HART Transparent Driver 4-20mA
9202B	Pulse Isolator
9203B	Solenoid Driver
9116B	Universal Trip Amplifier
9113B	Temperature to mA Converter

II (1) G [Ex ia Ga] IIC/IIB/IIA
II (1) D [Ex ia Da] IIIC
I (M1) [Ex ia Ma] I
Ex nA nC IIC T4 Gc

CERTIFIED exida IEC 61508 SIL 2 CAPABLE

CERTIFIED exida IEC 61508 SIL 3 CAPABLE



* SIL3 based on redundant configurations

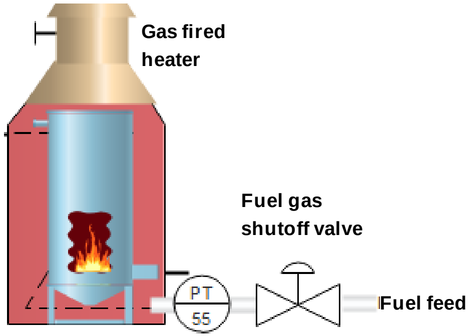
PR Ex Temperature Ranges – DIN mount

- 1 or 2 channel versions
- High Accuracy
- Flexible Inputs
- Excellent Long term stability
- Wide linearization options
- HART 5 and HART 7

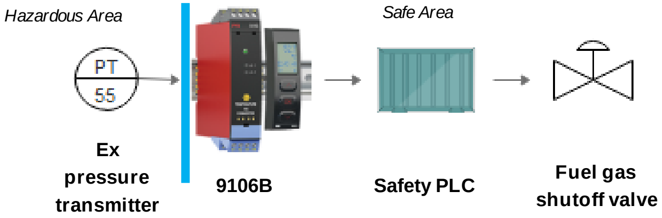
6333B	RTD Transmitter
6334B	TC Transmitter
6331B	Universal Temperature Transmitter
6335D	HART 5 Temperature Transmitter
6337D	HART 7 Temperature Transmitter
6350B	Profibus PA/Foundation Fieldbus Transmitter
3331	Universal Temperature Converter
3333	RTD Converter
3337	HART 7 Temperature Converter

IS Barrier Installation Examples

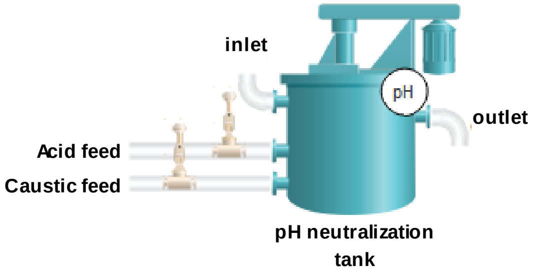
Fuel Gas Pressure Application



Gas feed to a heater must be carefully monitored to ensure that any reduction in pressure, which could cause a loss of flame, is detected. A 9106 4-20mA repeater IS barrier is used between the pressure transmitter and a safety PLC. When a low pressure event takes place, the safety PLC will send a signal to close the gas shutoff valve, thus preventing a build-up of non combusted fuel in the heater.



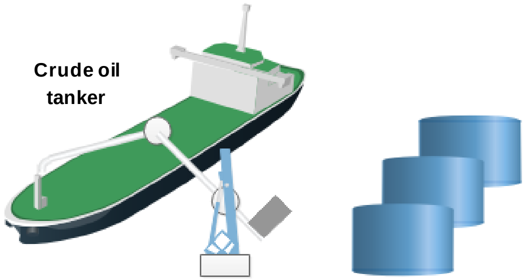
pH Neutralization Application



pH control is a process requirement in a wide range of industries, from chemical manufacturing, waste water treatment, life sciences etc. pH is neutralized by the addition of acid or caustic solutions. pH is measured and solution feed rates are calculated to reach the target pH. A 9107B IS barrier driver is used to supply 4…20 mA from a PLC/controller to an I/P converter which in turn controls the feed valve position.

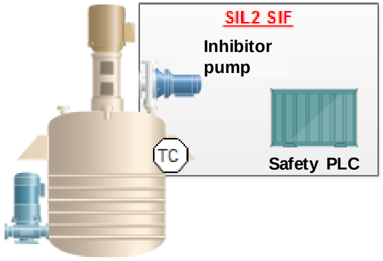
IS Barrier Installation Examples

Loading Arm Application



Loading arms are used for the transfer of liquids or compressed gases from tankers and carriers. For safety reasons the loading arm position must be known at all times and must adjust to draft, tide, and positional variations. Numerous limit switches are used to indicate such things as slew angle, apex angle, pulley angle etc. The 9202B switch/pulse IS barrier is used to interface the limit switches with the control system.

Bioreactor Temperature Application



Many chemical reactions are exothermic. Batch reactors often utilize cooling jackets through which cooling water is pumped. If the pump fails, internal temperature rises causing a runaway reaction and possible explosion.
To prevent this, a 9113 temperature IS barrier can be used as part of an over-temperature SIL2 safety function. The safety system will inject a reaction inhibitor when over-temperature is detected.

Any Questions?

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