MARECHAL electric

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Technical Training Manual

2009 - Part 4

English Version

EXPLOSION-PROOF PRODUCTS

Introduction

Particular standards and directives apply when flammable gases, vapours or dust are likely to be present in the environment and cause an explosion.

Plugs and socket-outlets intended to operate in such environments must have obtained a certificate of conformity to these standards from an official test house, assuring that they will not cause a fire or an explosion in the surrounding atmosphere.

Standards

- IEC 60079-0: Products for use in explosive gas atmospheres - General rules
- IEC 60079-1: Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures 'd'
- IEC 60079-7: Explosive atmospheres - Part 7: Equipment protection by increased safety 'e'
- IEC 61241-0: Electrical apparatus for use in the presence of combustible dust - Part 0: General requirements
- IEC 61241-0: Electrical apparatus for use in the presence of combustible dust - Part 1: Protection by enclosures 'tD'

Products complying with these requirements bear the symbol Ex and the marking 'Ex'.

Directives

In Europe, two directives apply to explosion-proof products:

ATEX 94/9/CE Directive (ATmospheres EXplosive)

Since July 1st 2003, manufacturers may only sell products that comply with the ATEX 94/9/CE Directive. This directive sets the essential safety requirements and imposes a classification of the products in categories, depending on their level of protection. A distinction is now made according to the nature of the explosive atmosphere: gas or dust.

This directive requires:

- For products: a type certification, a declaration of conformity and an instruction manual, allowing to affix the CE marking,
- For the manufacturers: a quality assurance system audited annually by a notified body, and the designation of an authorised person called the ATEX Manager.

1999/9/CE Directive

Since July 1st 2003, this directive imposes to users of explosion-proof products:

- To evaluate the risk of explosion on their site, to define zones and to implement minimum prescriptions to ensure workers' safety.
- To only purchase products according to ATEX 94/9/CE directive for new installations as well as for the extensions of existing installations.

Products designed according to the harmonised standards are deemed to comply with the essential safety and health requirements set in the ATEX Directive.

Protection mode(s)

Depending on the type of product, there are several modes of protection intended to eliminate the risk of explosion: increased safety 'e', internal overpressure 'p', oil immersion 'o', explosion-proof chamber 'd', powder filling 'q', encapsulation 'm', etc.

Whatever the protection mode(s), products intended to operate in potentially explosive atmospheres must:

- Prevent the formation of an arc likely to cause an explosion,
- Resist to shocks, at a higher degree than what is required for normal industrial products,
- Not be likely to accumulate electrostatic charges that may generate a spark,
- Have, within an ambient temperature range of at least -20 °C / +40 °C, a surface temperature below the self ignition temperature of the surrounding atmosphere or of the layer of dust that may have accumulated on the product.

Protection mode for plugs and socket-outlets

Plugs and socket-outlets with integral switching comprise two distinct areas, that require the implementation of two different modes of protection:

- An area which contains the contacts used to establish and break the current and where arcs or sparks occur in normal operation, when a plug is inserted or withdrawn. This area requires a 'd' explosion-proof chamber in order to contain the arc, to resist to the overpressure of an internal explosion and to laminate the flame of this explosion so that it does not propagated to the surrounding atmosphere.
- Areas where there are no arcs or sparks, where conductors are connected to the plug and socket-outlet terminals. These areas use the mode of protection by increased safety 'e', to prevent any failure.

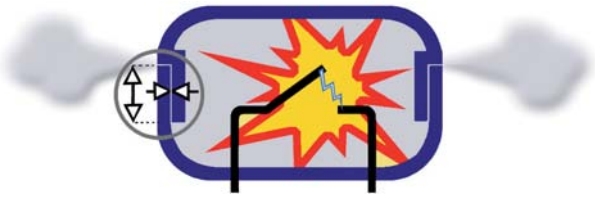
Plugs and socket-outlets without integral switching use the sole mode of protection by increased safety 'e'. They are

fitted with a locking device and warning labels to prevent any accidental disconnection under load.

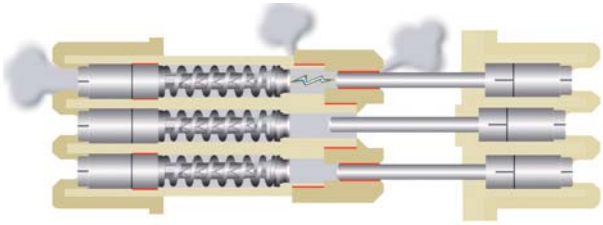
'd' explosion-proof enclosure

The arc chamber that contains the contacts used to make and break the circuit must constitute an explosion-proof enclosure, resisting to the effects of a possible internal explosion. IEC 60079-1 standard defines the characteristics of such a 'd' explosion-proof chamber that must:

- Resist to the pressure of an explosion,
- Allow this pressure to escape through interstices precisely rated in length and thickness, in order to laminate the flame so that it does not reach the outside of the enclosure.



These safety experimental maximum interstices, also called flame path, are defined according to the explosive substance and the internal volume of the envelope.



DXN1 plug and socket-outlet interior mouldings and contacts: the various flame paths (in red) perform the lamination of the flame and allow expulsion of burnt gases in case of an explosion when an arc strikes.

Eg: in an environment that may contain Acetylene and with an inner volume inferior to 100 cm³, the minimum length of the flame path is 6 mm and the maximum interstice is 0.1 mm.

'e' increased safety.

The expensive requirements of the 'd' mode of protection are not necessary for the parts of the product where conductors are terminated plug side and socket-outlet side as well as for plugs and socket-outlets that are not likely to create a spark. Particular precautions, called 'increased safety "e", are anyhow required in order to:

- Perform a perfect clamping of the cables on the enclosures,
- Not to damage conductors on tightening and to prevent the loosening of terminals in case of shock, vibration, thermal cycling or conductor yielding,
- Prevent short-circuit by defining air and creepage distances larger than those required from industrial products.

Plugs and socket-outlets, which combine explosion proof "d" chambers for the switching contacts and increased safety for cables and conductors termination, are identified by the symbol Ex **Ex de**.

DXN: a non-loosable pad penetrates into the tunnel terminal and protects the strands of the conductors from contact with the tightening screw.

Plugs and socket-outlets which use the sole mode of protection by increased safety are identified by the symbol Ex **Ex e**.

Protection mode tD against dust

Plugs and socket-outlets intended to be used in presence of flammable dust, either in suspension or accumulated, must be protected against dust ingress.

They must bear the mention of their maximum surface temperature, in a given range of ambient temperatures (Ta), taking into account the layer of dust that may accumulate.

This mode of protection by dust-proof envelope is identified by the symbol tD A21 (formerly DIP: Dust Ignition Proof) completed by the IP rating.

Example of marking:	Ex tD A21 IP6X T66 °C -40 °C<Ta<+60 °C

Product Groups

Electrical products are classified, according to the inner volume of their explosion-proof chamber, if any, and the dimensions of their flame path, in group I, IIA, IIB and IIC, to chemical products having similar explosive characteristics.

- Plugs and socket-outlets of Group I are suitable for firedamp mines (natural methane).
- Plugs and socket-outlets of Group II are intended for surface applications.
- Group II is divided in IIA, IIB and IIC, corresponding to a decreasing tolerance of the flame path in such a way that a IIC product is automatically suitable for groups IIA and IIB.
  - Group IIA: Accessories intended to operate in presence of the less explosive substances: industrial methane, propane, butane, benzene, kerosene, gasoline, ethanol, acetone, ...

- Group IIB: ethylene, methacrylate, cyclopropane ...
- Group IIC: Accessories intended to operate in presence of the most explosive substances: hydrogen, acetylene, ethyl nitrate ...

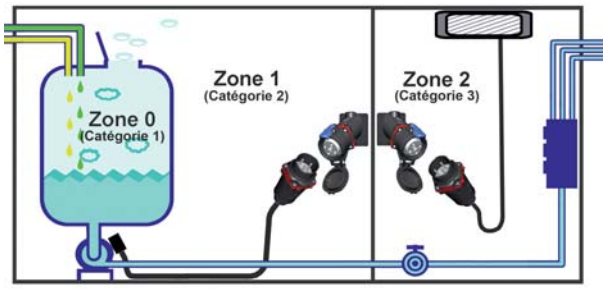
The marking of "de" products (DXN, DX, PX) is completed by the indication of their group, according to their flame path and inner volume, e.g. **EX de IIC.**

The marking of "e" products (PXN12C, DXN37C, SPeX) is completed by the sole indication of group II as they have no flame path and inner volume which determine the sub-group, e.g. **Ex e II**. They can be used in presence of all gases (except natural methane in mines that requires group I products).

Product categories and explosive zones

There are three categories of products, corresponding to six explosive zones, gas or dust:

- **Products in category 1** are intended for Zone 0 (gas) and/or Zone 20 (dust): zones with a permanent explosive atmosphere. These zones cannot be equipped with socket-outlets.
- **Products in category 2** are intended for Zone 1 (gas) and/or Zone 21 (dust): zones where an explosive atmosphere is likely to appear in normal operation. These zones can be equipped with socket-outlets.
- **Products in category 3** are intended for Zone 2 (gas) and/or Zone 22 (dust): zones where an explosive atmosphere may only appear accidentally, in case of malfunction of the installation. These zones can be equipped with Ex socket-outlets.



Considering the increasing risk, products of category 2 can be used where products of category 3 are required.

The marking on the product is completed by the indication of their permitted zones.

Eg:	2G = zones 1 & 2
	3D = zone 22
	2G/D = zones 1, 2, 21 & 22

PRODUCT CATEGORY According to 99/9/CE Directive	ZONES	
	Flammable gas, vapour or mist	Cloud of flammable dust
Category 1: Permanent or frequent presence	Zone 0 No socket-outlet	Zone 20 No socket-outlet
Category 2: Occasional (normal) presence	Zone 1 2G or 2G/D socket-outlet	Zone 21 2D or 2G/D socket-outlet
Category 3: Irregular / short term presence (abnormal)	Zone 2 3G or 3G/D socket-outlet	Zone 22 3D or 3G/D socket-outlet

Ex II2 G/D means that the accessory can be used in zones 1, 2, 21 & 22

Gas Temperature classes

All chemicals listed in the various groups have a specific self-ignition temperature.

Electrical products must bear the indication of their maximum surface temperature, in a specified maximum ambient temperature (Ta).

Indication is given by a capital "T" followed by a number from 1 to 6, in decreasing order of temperature:

- T6 corresponds to a maximum surface temperature ≤ 85 °C (e.g. 40 K temperature rise +5K safety margin in an ambient temperature of 40 °C).
- T5 corresponds to a maximum surface temperature ≤ 100 °C.
- T4 corresponds to a maximum surface temperature ≤ 135 °C.
- T3 corresponds to a maximum surface temperature ≤ 200 °C
- T2 corresponds to a maximum surface temperature ≤ 300 °C
- T1 corresponds to a maximum surface temperature < 450 °C

Dust surface temperature marking

Flammable dust has a specific self-ignition temperature.

Electrical products must bear the indication of their maximum surface temperature, in a specified maximum ambient temperature (Ta). This temperature takes into account the layer of dust likely to accumulate on the accessory.

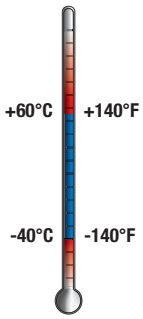
Indication is given by a capital "T" followed by the surface temperature in °C, to distinguish it from the gas temperature class, e.g. T107 °C.

Example of markings

Listed manufacturer and production site

MARECHAL ELECTRIC MAROMME
Ex II2 G/D Ex de IIC tD A21

-40 °C < Ta < +40 °C T6 T46 °C
-40 °C < Ta < +60 °C T5 T66 °C
LCIE 07 ATEX 6027 X / LCIE Ex 99.007 X



Ex	Accessory intended for explosive atmospheres
II	Accessory of group II = surface applications
2	Accessory of category 2 = for zones 1 and/or 21
G/D	Nature of atmosphere: G: Gas and D: dust
Ex	Protection against explosions 'Gas' standards: IEC/EN 60079-0, -1 & -7 'Dust' standards: EN 61241-0 & -1
de	Combined protection mode d & e d: explosion-proof enclosure (IEC/EN 60079-0 & -1) e: increased safety (IEC/EN 60079-0 & -7)
IIC	Accessory of group IIC: (Hydrogen, acetylene, ethyl nitrate)
tD	Mode of protection against dust: tD = protection by enveloppe
A21	IP test for zone 21: IP6X

T5/T6	Gas surface temperature T6: < 85 °C with Ta between -40 °C and +40 °C T5: < 100 °C with Ta between -40 and +60 °C
T °C	Dust surface temperature Surface T° < 46 °C with Ta between -40 °C & +40 °C Surface T°< 66 °C with Ta between -40 °C & +60 °C
6027	ATEX certificate number delivered by notified body (LCIE-Veritas)
99.007	Certificate of conformity to IEC standards delivered by notified body (LCIE-Veritas)
X	Indication of particular condition(s) of use, if any

These markings are completed with the following indications:

Week / year of manufacture - Type

Contact configuration – main circuit
Assigned voltage
Nominal current

CE marking = compliance with European directives
Identification of the notified body
(0081 = LCIE-Veritas)

24/08 TYPE DXN37C
36C+T
Ue = 220 V 50 Hz
Ie = 5 A
CE 0081 Pos. 01 IP65

Contact configuration
secondary circuit (if any)

Keying position
IP rating

Classifications

PX	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP65
	-40 °C < Ta < +50 °C	T6	T85 °C	
DXN1	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP66/IP67
	-40 °C < Ta < +60 °C	T5	T90 °C	
	-40 °C < Ta < +40 °C	T6	T70 °C	
DXN3	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP66/IP67
	-40 °C < Ta < +60 °C	T4	T98 °C	
	-40 °C < Ta < +40 °C	T6	T78 °C	
DXN6	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP66/IP67
	-40 °C < Ta < +60 °C	T4	T107 °C	
	-40 °C < Ta < +40 °C	T5	T87 °C	
DX 1 & 3	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP65
	-25 °C < Ta < +60 °C	T5	T84 °C	
	-25 °C < Ta < +50 °C	T6	T74 °C	
DX 6 & 9	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP65
	-40 °C < Ta < +60 °C	T4	T110 °C	
	-40 °C < Ta < +40°C	T5	T90 °C	
DX 2	Ⓔx II2 G/D	Ex de IIC	Ex tD A21	IP65
	-40 °C < Ta < +60 °C	T3	T91 °C	
PXN 12C	Ⓔx II2 G/D	Ex e II	Ex tD A21	IP65
	5 A: -40 °C < Ta < +60 °C	T6	T65 °C	
	10 A: -40 °C < Ta < +55 °C	T5	T69 °C	
	WARNING: DO NOT OPEN / DO NOT SEPARATE WHEN ENRGIZED			
DXN 37C	Ⓔx II2 G/D	Ex e II	Ex tD A21	IP65
	-40 °C < Ta < +40 °C	T6	T66 °C	
	-40 °C < Ta < +60 °C	T5	T86 °C	
	WARNING: DO NOT OPEN / DO NOT SEPARATE WHEN ENRGIZED			
SPeX	Ⓔx II2 G/D	Ex e II	Ex tD A21	IP66/IP67
	-20 °C < Ta < +40 °C	T*	T °C*	
	-20 °C < Ta < +60 °C	T*	T °C*	
	WARNING: DO NOT OPEN / DO NOT SEPARATE WHEN ENRGIZED			

T* / T °C*:

		GAS		DUST	
Section (mm²)	Current (A)	Temperature class for:		surface temperature for:	
		Ta_{max} = +40 °C	Ta_{max} = +60 °C	Ta_{max} = +40 °C	Ta_{max} = +60 °C
70	290	T5		T56 °C	
	235	T6	T5	T56 °C	T76 °C
95	415	T5		T56 °C	
	335	T6	T5	T56 °C	T76 °C
120	456	T5		T56 °C	
	376	T6	T5	T56 °C	T76 °C
150	493	T5		T56 °C	
	415	T6	T5	T56 °C	T76 °C
185	530	T5		T56 °C	
	450	T6	T5	T56 °C	T76 °C
240	570	T5		T56 °C	
	497	T6	T5	T56 °C	T76 °C
300	620	T5		T56 °C	
	540	T6	T5	T56 °C	T76 °C
400	680	T5		T56 °C	
	600	T6	T5	T56 °C	T76 °C

Principles of operation

SPeX Single-pole connector (up to 680 A)

By design, the SPeX connector cannot be separated when live, thanks to a fail-safe explosion-proof control microswitch.

With regards to the principle of operation of the single pole contact, see:

Technical Training Manual – Part 3
Advantages of Butt Contacts

PX explosion-proof plugs and socket-outlets (10 - 20 A)

PX plugs and socket-outlets use silver-nickel butt contacts similar to those of decontactors. In absence of plug, socket-outlet live contacts are totally protected by a locked safety shutter.

As soon as the plug is inserted in the socket-outlet as a bayonet light bulb, it is in the rest position and constitutes an explosion-proof chamber with the socket-outlet. The flame path is established between the inner diameter of the plug and the outer diameter of the socket-outlet interior moulding.

The circuit is closed by inserting the plug fully home, until it is retained by the latch.

Depressing the latch allows the plug to return to its rest position, circuit open. In this position, the (dead) plug can either be reconnected or withdrawn by rotation. This rotation closes the safety shutter that shields the live contacts of the socket-outlet. The cover must then be shut and can be locked by means of a triangular screw fitted on the latch.

DX metal decontactors (up to 200 A)

To avoid costly machining due to the large diameter of the products involved and the tight tolerances required, the flame path (in red) is achieved between the outer diameter of the plug and socket-outlet butt contacts and the metal sleeves of the socket-outlet interior moulding. The fitting of these two cylinders achieves a flame path.

These products combine in a single unit a plug and socket-outlet and a switch with utilisation category AC-22 A according to IEC/EN 60947-3 standard. Switches, one per phase, are activated in an explosion-proof enclosure by the rotation of the plug.

For more details on the principle of operation of the DX contacts, see:

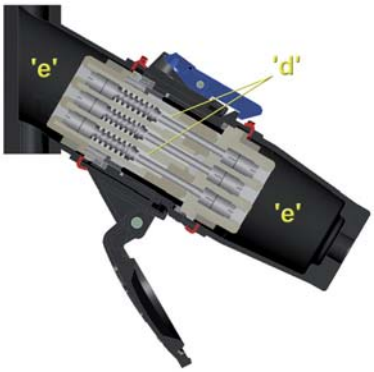
Technical Training Manual – Part 3
Advantages of Butt Contacts

In absence of a plug, live switching contacts of the socket-outlet are totally inaccessible (IP4X according to IEC/EN 60529 standard).

The keying between different voltages in a given rating is achieved by the machining of pre-cut areas in socket-outlet moulding and the assembly of matching pegs in the plug moulding.

DXN poly decontactors (from 20 to 63 A)

Made of self-extinguishing non-static material, DXN decontactors have an outstanding resistance to mechanical abuse and chemicals.



DXN decontactors combine explosion-proof arc chambers and increased safety wiring compartments.

As soon as the plug is inserted in the socket-outlet as a bayonet light bulb, it is in the rest position and constitutes an explosion-proof chamber with the socket-outlet. The plug can then be connected under load.

It is only from the rest position that the dead plug can be withdrawn by rotation. Like the DSN industrial range, the IP66/IP67 rating of the DXN explosion-proof range is achieved as soon as the contacts close.

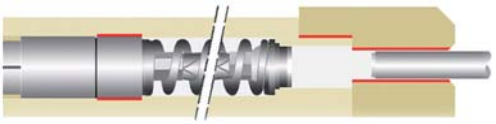
The flame path is established between the inner diameter of the plug and the outer diameter of the socket-outlet interior moulding.

Socket-outlet alone: the locked safety shutter denies access to live parts.

Socket-outlet with plug in the rest position: after positioning the plug in the socket-outlet and its rotation, the fitting of plug contacts into the safety shutter apertures achieve flame paths.

Socket-outlet with plug fully mated: contacts close in an explosion-proof chamber. The IP66/IP67 seal is achieved automatically.

Very close, in their design, to the DSN industrial range, the flame path between the plug and the socket-outlet is achieved between the outer diameter of plug contacts and the inner diameter of the holes in the safety shutter.
Socket-outlet side, flame paths are present between the safety shutter and the main moulding, and between the contacts and their moulding.



The same contacts are used for both the carrying as well as the making and the breaking of the current. This allows an **extremely compact** design and makes the product particularly suitable for "in-line" **connections**.