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A GAMBICA / REMA TECHNICAL GUIDE

VARIABLE SPEED DRIVES AND MOTORS

Application of the ATEX Directives to Power Drive Systems

GAMBICA
AUTOMATION INSTRUMENTATION & CONTROL LABORATORY TECHNOLOGY

REMA
ROTATING ELECTRICAL MACHINES ASSOCIATION

Developed by the joint GAMBICA/REMA Working Group

CEMEP

Comité Européen de Constructeurs
de Machines Electriques
et d'Electronique de Puissance

European Committee
of Manufacturers of Electrical
Machines and Power Electronics

CEMEP is the representative of the manufacturers of variable speed drives to the European Commission.

Le CEMEP est l'interlocuteur des constructeurs d'entraînements à vitesse variable auprès de la Commission Européenne.

General Secretariat
GAMBICA
St George's House,
195-203 Waterloo Road
LONDON SE1 8WB, UK
Tel.: +44 (0) 20.76.42.80.80
Fax: +44 (0) 20.76.42.80.96

A N I E	**Italy**
G A M B I C A	**United Kingdom**
G I M E L E C	**France**
TEKNOLOGIATEOLLISUUS	**Finland**
Z V E I	**Germany**
Manufacturer	**Denmark**

European Directives – Application of the ATEX Directives to Power Drive Systems (PDS)

See the Glossary at the end for explanations of abbreviation.

Introduction

Until the advent of the new ATEX Directives from the EU, the installation of electrical equipment in a potentially explosive atmosphere area (sometimes known as a hazardous area) was a relatively simple procedure, requiring only the selection of equipment certified for the appropriate area.

The implementation of the new Directives will change the perception of the system designer (specifier), and rotating machine manufacturer, who now become directly concerned. The driven equipment is now specifically covered by the requirements of the Directives, as is the compatibility of all the equipment installed on a site.

This guide does not apply to electrical equipment intended for use underground in mines, although the ATEX Directives also apply to this industry.

The CEMEP Technical Board has developed this guide. It applies to Power Drive Systems (PDS) where the electric motor is located in a hazardous area.

The CEMEP publication "Explosion Guide Electrical machines" gives guidelines for Direct-On-Line (DOL) connected medium/high voltage explosion class EEx e motors.

Contents

1 Introduction and Terminology

1.1 Introduction to ATEX

ATEX is the French acronym for “Atmosphères Explosibles” which translates to Explosive Atmospheres in English. ATEX is a set of two European Directives.

The objective of Equipment Directive ATEX 95 (officially known as Directive 94/9/EC) is to ensure that equipment and protective systems function safely when used in potentially explosive atmospheres. It applies to both mechanical and electrical equipment capable of causing an explosion through their own potential sources of ignition, and protective systems intended to halt/limit incipient explosions.

Worker Protection Directive ATEX 137 (officially known as Directive 1999/92/EC) on minimum requirements for improving the safety and health protection of workers operating in potentially explosive atmospheres defines the various zones for gases, vapours and dusts.

The purpose of this document is to:

- outline the Equipment Directive (known as ATEX 95 or 94/9/EC) that covers the design of motors, selection of the equipment category, certification of equipment, and the qualification of the manufacturing process;
- present the main principles of the Worker Protection Directive (known as ATEX 137 or 1999/92/EC), especially the risk analysis, new zone designations, and minimum safety requirements;
- clarify the role of third parties such as repair shops and address documentation / manufacturers instructions for installation, maintenance and repair;
- define fields of responsibility;
- identify appropriate standards and solutions relating to motors fed from a converter supply.

1.2 The Power Drive System

The concept of a power drive system (PDS) is used to describe an electric motor drive system within an overall installation. The terminology is used throughout IEC and EN standards relating to electrical variable speed drives to describe a combination of components, including a power converter and motor. The concept applies equally to a fixed speed drive, although this is not considered in this guide. The conventional illustration of a PDS and its component parts is shown in figure 1.

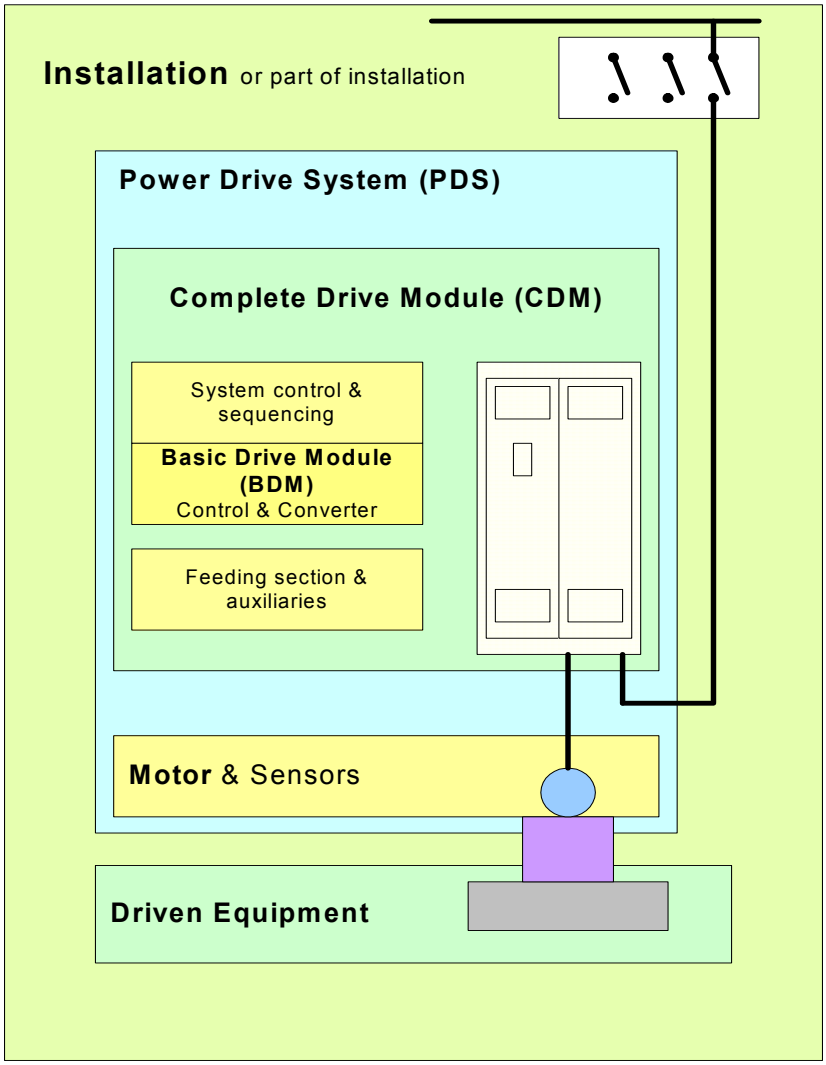

Figure 1 - The Power Drive System

- BDM Basic drive module consisting of power input, control and power output sections.
- CDM Complete drive module consisting of BDM and auxiliary sections, but excluding the motor and motor-coupled sensors.
- PDS Power Drive System, comprising CDM, motor and sensors, but excluding the driven equipment and sensors.

1.3 Definitions used in this guide [1]

Blanket certificate — a document confirming that a generic combination of equipments meets the requirements of a specific standard or standards.

Note – The document includes the restrictive conditions for use of the motor as well as information related to means of protection (e.g. loading curves).

Certificate — a document confirming that the electrical apparatus is in conformity with the requirements of a specific standard or standards.

Component — any item essential to the safe functioning of equipment but with no autonomous function.

Degree of protection of enclosure (IP) — an alpha-numerical classification according to EN 60529:1991/A1:2000 (for motors EN 60034-5:2001) to provide for:

- protection of persons against access to hazardous parts inside the enclosure;
- protection of the equipment inside the enclosure against ingress of solid foreign objects;
- protection of the equipment inside the enclosure against harmful effects due to ingress of water.

Dust Ignition Protection — all relevant measures (e.g. dust ingress protection and surface temperature limitation) to avoid ignition of a dust layer or cloud.

Electrical apparatus — items applied as a whole or in part for the utilization of electrical energy.

Enclosure — all the walls, doors, covers, cable entries, rods, spindles, shafts, etc., which contribute to the type of protection and/or the degree of protection (IP) of the electrical apparatus.

Ex apparatus — an electrical apparatus intended to be used in a potentially explosive atmosphere, which may be a single discrete unit or comprised of a number of components.

Ex component — a part of electrical apparatus for potentially explosive atmospheres, which is not intended to be used alone in such atmospheres and requires additional certification when incorporated into electrical apparatus or systems for use in potentially explosive atmospheres.

[1] A number of terms and definitions are based on the International Electrotechnical Vocabulary Published as IEC 60050 Part 426 (October 1990).

Ex and EEx — the prefix Ex before a further letter is used to denote an Ex apparatus or component, which complies with the appropriate IEC standards.

EEx is used when the Ex apparatus or component complies with the appropriate harmonized (EN) standard. However, some current EN Standards are using Ex instead of EEx, and future EN standards may also use Ex.

Ex Notified Body — an independent body that has been notified by national authorities to the European Commission based on criteria stated in ATEX 95 Directive.

Explosive dust atmosphere — A mixture with air, under atmospheric conditions, of a dust layer or cloud, which may ignite in certain circumstances. (It has to be noted that in the presence of dust not always the whole quantity of dust is consumed by the combustion).

Explosive gas atmosphere — A mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture.

Ingress protection — see degree of protection of enclosure (IP).

Layer ignition temperature — the lowest temperature of a hot surface at which ignition occurs in a dust layer of specified thickness on this hot surface.

Maximum surface temperature — the highest temperature which is attained in service under the most adverse conditions (but within the tolerances prescribed by standards) by any part or surface of an electrical apparatus, which would be able to produce an ignition of the surrounding explosive atmosphere.

Note 1 – The manufacturer will identify the product standard and also in his particular design he should take into account the following other conditions:

- fault conditions specified in the standard for the type of protection concerned;
- all operating conditions specified in any other standard specified by him, including recognized overloads;
- any other operating condition specified by him.

Note 2 – The relevant surface temperature may be internal or external depending upon the type of protection concerned.

Minimum ignition energy — the lowest energy in Joules at which ignition of combustible dust or flammable substance in the form of a gas or vapour mixture with air can occur.

Minimum ignition temperature — the lowest temperature at which ignition of combustible dust or flammable substance in the form of a gas or vapour mixture with air can occur.

Potentially explosive atmosphere

an atmosphere that could become explosive (the danger is a potential one) due to local and/or operational conditions.

The potentially explosive atmosphere is either present from the beginning or develops during the working process (e.g. in relation with the conversion of energy or the processing of materials).

Surface temperature

the temperature of any surface in contact with a potentially flammable gas, vapour or dust.

Temperature Class

a classification indicating the maximum permitted surface temperature for an equipment, selected on the basis of the minimum ignition temperature for the prospective gas/vapour (see EN 60079-14:2003).

IEC 60079-20:2000 gives data for flammable gases and vapours.

Temperature Class	Minimum Ignition temperature for gas or vapour (^{0}C)	Maximum permitted surface temperature of equipment (^{0}C)
T1	>450	450
T2	>300	300
T3	>200	200
T4	>135	135
T5	>100	100
T6	> 85	85

Type of protection

the specific measures applied to electrical apparatus to avoid ignition of a surrounding explosive atmosphere.

2 The ATEX Directives [2]

2.1 Legal position

Article 95 [3] of the EC Treaty addresses the harmonisation of the internal market and is the legal basis for Directive 94/9/EC (the ATEX Product Directive).

In contrast, Article 137 [3] of the EC Treaty addresses (amongst other things) the minimum requirements for the working environment to protect workers' health and safety and is the legal basis for Directive 1999/92/EC (the ATEX Worker Protection Directive).

Together, Directives 94/9/EC and 1999/92/EC are known as the ATEX Directives.

Harmonisation of regulations allows equipment to be sold across the European Union, without manufacturers having to satisfy different requirements for each national market.

The ATEX Directives affect all the countries of the EEA (European Economic Area), which, in addition to the European Union, also includes Iceland, Liechtenstein, and Norway. Switzerland also follows the ATEX Directives.

2.2 Classification of environment and equipment according to the ATEX Directives

The European Union has adopted two major Directives covering all equipment used in a potentially explosive atmosphere:

- the Product Directive ATEX 95 [3] (officially known as the product Directive 94/9/EC, also known as ATEX 100a [3]) concentrates on the ***responsibilities of the equipment manufacturer;***
  - It defines the Essential Health and Safety Requirements (EHSRs) of equipment;
- the Worker Protection Directive ATEX 137 [3] (officially known as the Worker Protection Directive 1999/92/EC, also known as ATEX 118 [3]). This Directive is concerned specifically with Worker Protection, and concentrates on the ***responsibilities of the end user;***
  - It classifies the environment into Zones and states, which Category of equipment must be used in each Zone.

[2] Copies of the Directives may be downloaded from the EU website http://europa.eu.int/comm/enterprise/atex/infor.htm

[3] Refers to various Articles in European treaties.

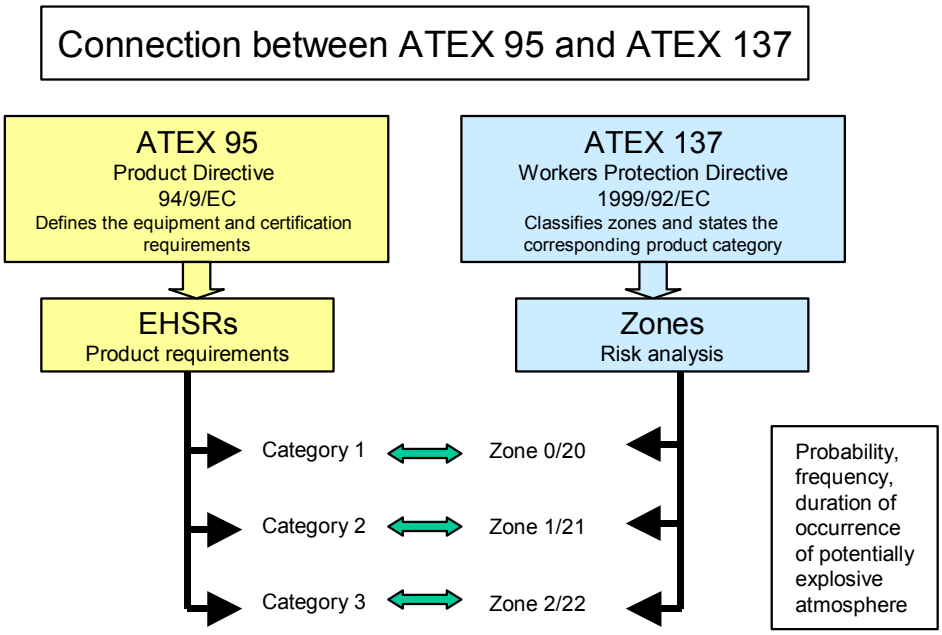

Figure 2 - Application Fields

2.3 The Product Directive (ATEX 95)

The European Parliament and the Council of 23rd March 1994 adopted a Directive for all equipment and protective systems used in potentially explosive areas under the reference: ***94/9/EC (also known as the ATEX 95)***.

This "**Product Directive**" is required to be implemented by the product manufacturer before a product may be placed on the European market for use in a potentially explosive atmosphere. This Directive constitutes a real "***new approach"*** compared to previous directives.

According to this "new approach" the ATEX Directive introduces the ***EHSRs*** needed for all equipment installed in potentially explosive atmospheres instead of prescriptive solutions given in previous directives. Directive ATEX 95 applies consistently throughout the EU and the EEA.

All equipment shall be delivered with instructions for safe:

- assembling, installation and taking into service;
- operation, adjustment and maintenance;
- dismantling.

The manufacturer shall, in most cases, use a quality management system for production quality or product quality assurance that has been assessed and approved by a Notified Body (see clause 5.4) chosen by the manufacturer.

2.4 The Worker Protection Directive (ATEX 137)

The European Parliament and the Council of 16th December 1999 adopted the ***ATEX 137 Directive (officially known as The Explosive Atmospheres Directive 1999/92/EC)*** on minimum requirements for improving the *health and safety protection of workers* potentially at risk from explosive atmospheres.

Among different articles, this Directive specifies:

- places where explosive atmospheres may occur (Zones);
- category of equipment according to the Zone.

The **users** of all equipment used in potentially explosive atmospheres (Ex – equipment) are responsible for the application of this Directive.

For the first time, the Directives contain requirements for equipment and for worker protection in locations having atmospheres with potentially combustible dust. Examples of industrial application in the case of combustible dust can be found on the Table 1.

Table 1 – Examples of existence of combustible dust

Energy production (power plant)	Coal dust may be produced when coal is crushed and dried. This dust may combine with air creating an explosive mix.
Mechanical woodworking industry	Dust is produced when wood is treated and may combine with air, to create an explosive mix in a filter or silo, for example.
Machine tooling of metals	Metal dust may be produced when the surfaces of cast pieces are dressed. The dust may then mix with air to form an explosive atmosphere. This risk relates especially to light metals.
Food and feed industry	Dust may be produced when grain, sugar, etc. are transported and stored. If the dust is removed and filtered using a vacuum cleaner, the filter may contain an explosive dust/air mix.

The safety of an installation in a potentially explosive atmosphere is the result of a co-operation between the equipment manufacturer, the installer and the end user. This directive concentrates on the duties of the end user, which are:

- the employer should train workers on potentially explosive atmosphere issues;
- authorisation should be delivered to each employee who is working in a potentially explosive atmosphere;
- explosion protection measures should be taken and an Explosion Protection Document (EPD) must be established;
- the employer should initiate a co-ordination procedure in the case of maintenance of equipment from different 'origins' in potentially explosive atmospheres. When equipment has to be repaired, the end user has the responsibility to select a competent repair shop and, where spare parts are used, to ensure they comply with the legislation where relevant;
- zone 0 or zone 20 requires category 1 equipment;
- zone 1 or zone 21 requires category 1 or category 2 equipment;
- zone 2 or zone 22 requires category 1 or category 2 or category 3 equipment;

2.5 July 1st, 2003

Any equipment put on the market after the 1st July 2003, for use in a potentially explosive atmosphere within the EU and the EEA must be in accordance with the new ATEX requirements. Restrictions are also placed on the supply of spare parts intend to be used on the equipment mentioned above.

Previous Directives 76/117/EEC, 79/196/EEC (as amended by 90/487/EEC) and 82/130/EEC were repealed as of the 1st July 2003.

The requirements for putting equipment in a potentially explosive atmosphere are defined by the following key elements:

- application of the EHSRs of the ATEX Directives;
  - o where appropriate, audit of the manufacturing factory which delivers the Ex-equipment, conducted by an expert on Ex-system quality;
  - o where appropriate, recognised bodies and test laboratories called the 'Ex Notified Body' (Ex NB) will provide these experts.
- consequences of the directives for the manufacturer or for the End-user include;
  - o design guidelines;
    - design and maintenance practice;
    - installation and selection concept for the equipment.
  - o manufacturing;
    - sustaining required quality levels.
  - o maintenance;
    - assurance of safety over the life cycle;
    - maintenance practice and schedule.

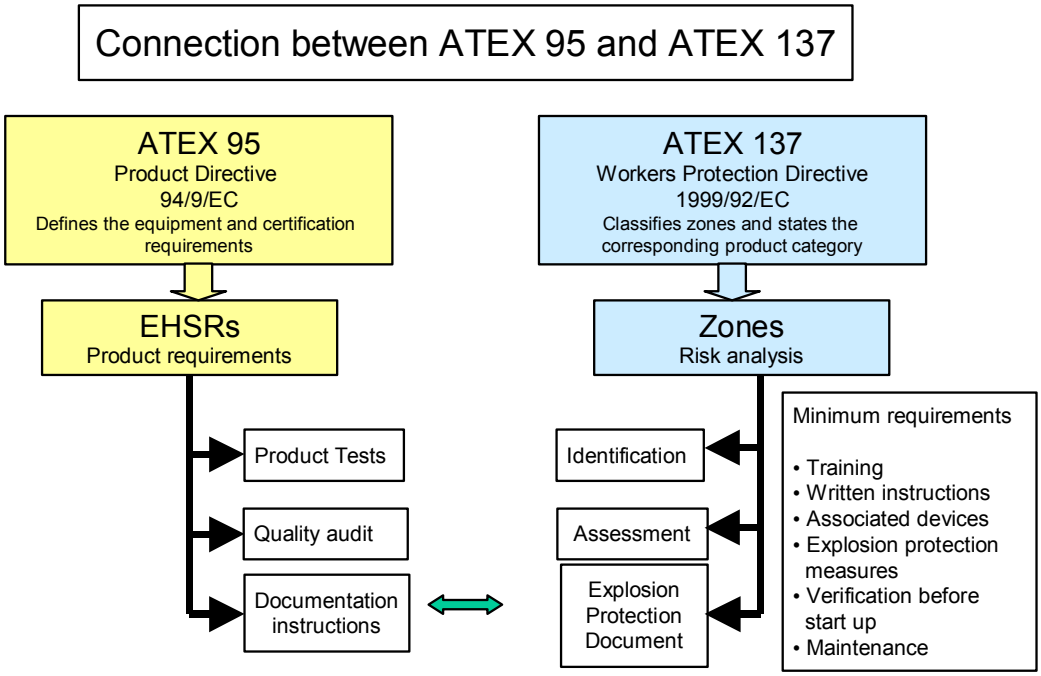

Figure 3 - Comparison of responsibilities under ATEX

3 Potentially explosive atmospheres

The parameters below characterise the potentially explosive atmosphere:

- the frequency with which a potentially explosive atmosphere may exist;
- the capability of a gas or dust laden atmosphere to ignite.

Explosive gases and dust are classified according to the likelihood of their being ignited, and other characteristics including:

- minimum ignition energy;
- minimum ignition temperature;
- layer ignition temperature.

The following standards define the classification:

- EN 1127-1:1997; Explosive atmosphere - Explosion prevention and protection Part 1: Basic concepts and methodology;
- EN 60079-10:2003; Electrical apparatus for explosive gas atmospheres. Part 10: Classification of potentially explosive atmospheres;
- EN 50281-3, 2002; Electrical apparatus for use in the presence of combustible dust. Part 3: Classification of areas where dusts are or may be present.
- EN 61241-10:2004; Electrical apparatus for use in the presence of combustible dust - Part 10: Classification of areas where combustible dusts are or may be present, is replacing EN 50282-3, and shall be used 1st July 2007 at the latest.

The following standards define the grouping and categorisation of electrical equipment:

- EN 50014:1997 as amended, Electrical apparatus for potentially explosive atmospheres – General requirements.
- EN 60079-0:2004, Electrical apparatus for explosive gas atmospheres - Part 0: General requirements, is replacing EN 50014, and shall be used 1st July 2007 at the latest.
- EN 60079-10:2003 Classification of hazardous areas;
- EN 60079-14:2003 Electrical installations in hazardous areas.

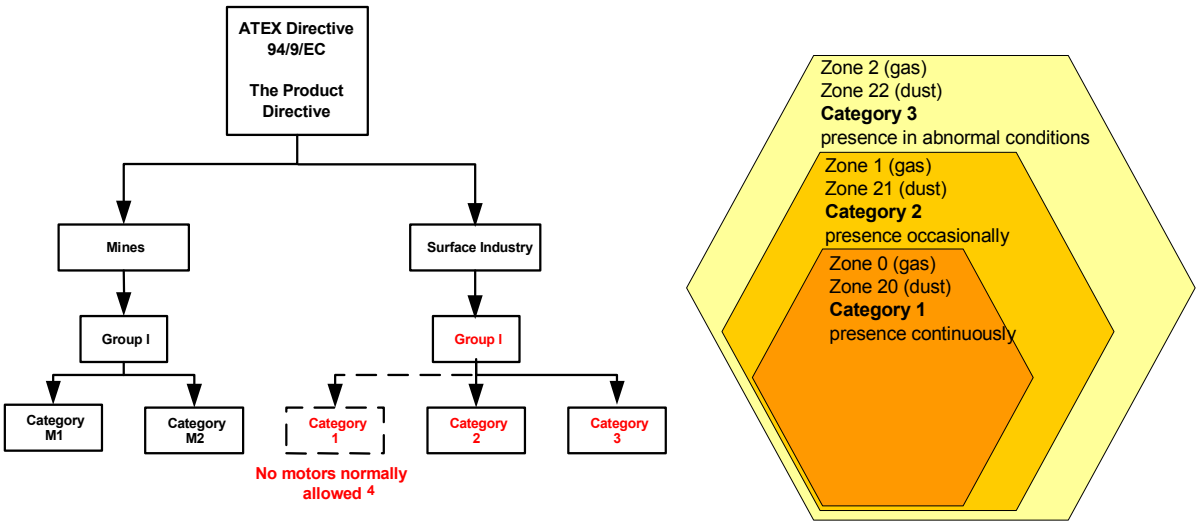

Figure 4 - Categories of Equipment [4]

4 Electric motors in potentially explosive atmospheres

4.1 General requirements

EN 50014:1997 (or EN 60079-0:2004) [5] details general requirements. It provides additional requirements for external ventilation systems.

This standard is supplemented by further standards concerning specific types of protection. These standards are introduced in paragraphs 4.2 to 4.6.

In areas where an explosive gas presents a hazard, the motor protection is denoted by a sequence of letters detailing the type of protection. When the motor meets the appropriate harmonised standard/s in terms of electrical, mechanical and thermal requirements this sequence commences EEx. This designation will appear on the motor name/rating plate.

In a dust hazard environment, motors are referred to as “DIP” types, but this designation may not appear on the name/rating plate. EN 50281-3:2002 (or EN 61241-10:2004) describes the classification of areas where combustible dusts are or may be present, and EN 50281-1-2:1998 gives details of the selection, installation and maintenance of equipment for use in a potential dust hazard.

4.2 EEx nA - non sparking (EN 50021:1999/EN 60079-15:2003)

- Category 3 equipment may be installed in a Zone 2 area.
- Normally offered for temperature classification T1, T2 and T3.
- No sparks capable of causing ignition during rated operation.
- No dangerously hot surfaces internally or externally during rated operation.

4.3 EEx e - Increased safety (EN 50019:2000/EN 60079-7:2003)

- Category 2 equipment may be installed in Zone 1 or Zone 2 areas.

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[4] Motors using the multiple protection concepts of EN 50284 are allowed in Zone 0, although this is a very rare occurrence

[5] These EN 50*** series of Ex standards are gradually being replaced by the EN 600** series, following the IEC number series.

- Normally offered for temperature classification T1, T2, T3 and T4.
- No sparks capable of causing ignition at rated operation nor during start or fault conditions.
- No dangerously hot surfaces internally nor externally in rated operation, during start, or in fault conditions.

4.4 EEx p - Pressurised (EN 50016:2002/EN 60079-2:2004)

- Category 2 equipment may be installed in Zone 1 or Zone 2 areas; Category 3 equipment may be installed in Zone 2 areas.
- Normally offered for temperature classification T3, T4, T5 and T6 [6].
- Enclosure purged and pressurised by a protective gas, when motor starts and during running.
- Surface temperatures limited on the outside of the enclosure.

4.5 EEx d - Flame proof (EN 50018:2000/EN 60079-1:2004)

- Category 2 equipment may be installed in Zone 1 or Zone 2 areas.
- Normally offered for temperature classification T3, T4 and T5 [6].
- Flameproof enclosure.

  NOTE: EEx d motors may be offered with alternative termination box(es), especially with EEx e boxes, which allow more termination space. In this case the motor becomes EEx de, where the motor complies with the appropriate EEx d standards, and the termination box(es) with the appropriate EEx e standard. EEx de is commonly used; other combinations are more or less theoretical ones.
- Surface temperatures limited on the outside of the enclosure.

4.6 DIP - Dust Ignition Protection (EN 50281-1-1:1998)

Dust is categorised by the likelihood of its presence, and whether it is electrically conductive (e.g. carbon, light metal, etc.).

- Category 1 for Zone 20 Normally no power engineering equipment
- Category 2 for Zone 21 (Dust tight) Equipment, IP 6X
- Category 2 for Zone 22 Conductive dust (Dust tight) Equipment, IP 6X
- Category 3 for Zone 22 Non conductive dust (Dust protected) Equipment, IP 5X

  Note: In areas classified as Zone 22 with conductive dust IP6X dust tight equipment may be used according to the forthcoming Standard EN 61241-14 clause 6.4.1.
- Temperature classification.
- Surface temperature limited on the outside of the enclosure.

4.7 Marking of motors

Motors complying with ATEX 95 (officially known as 94/9/EC) must be marked in accordance with the provisions of the directive.

The motor manufacturer should consult the directive, the Commission Guidelines, and the relevant EN Standards for details of the actual markings that will be required. Figures 5 and 6 show two examples of the types of marking that may be applied to a motor.

[6] Rarely used

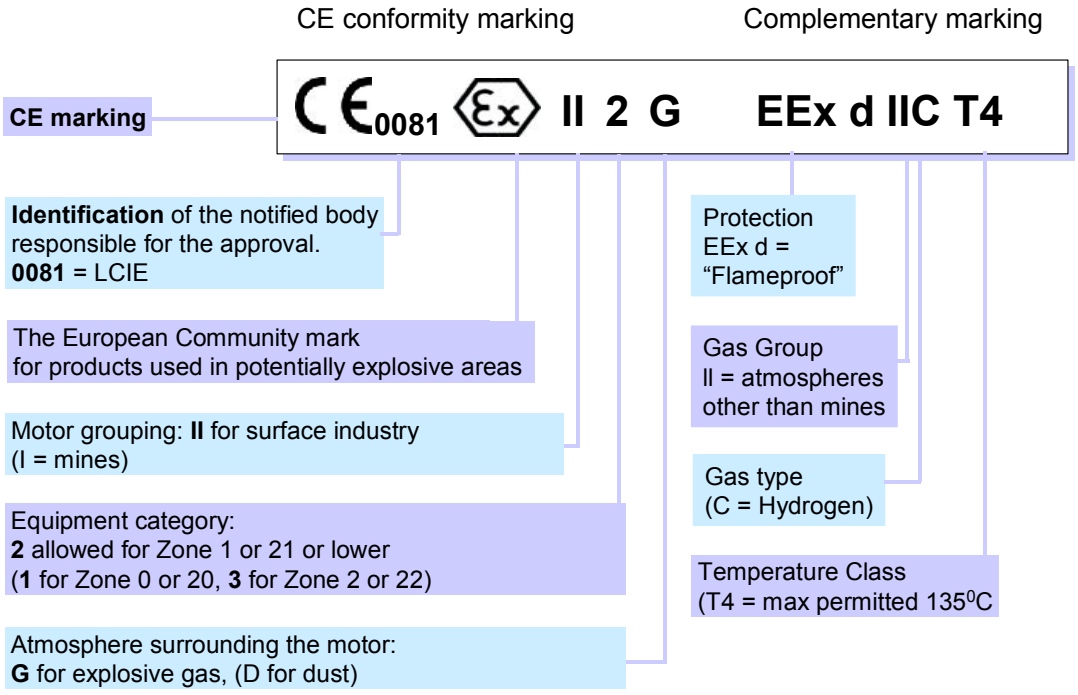


Figure 5 – Example of ATEX Labelling (Gas Hazard)

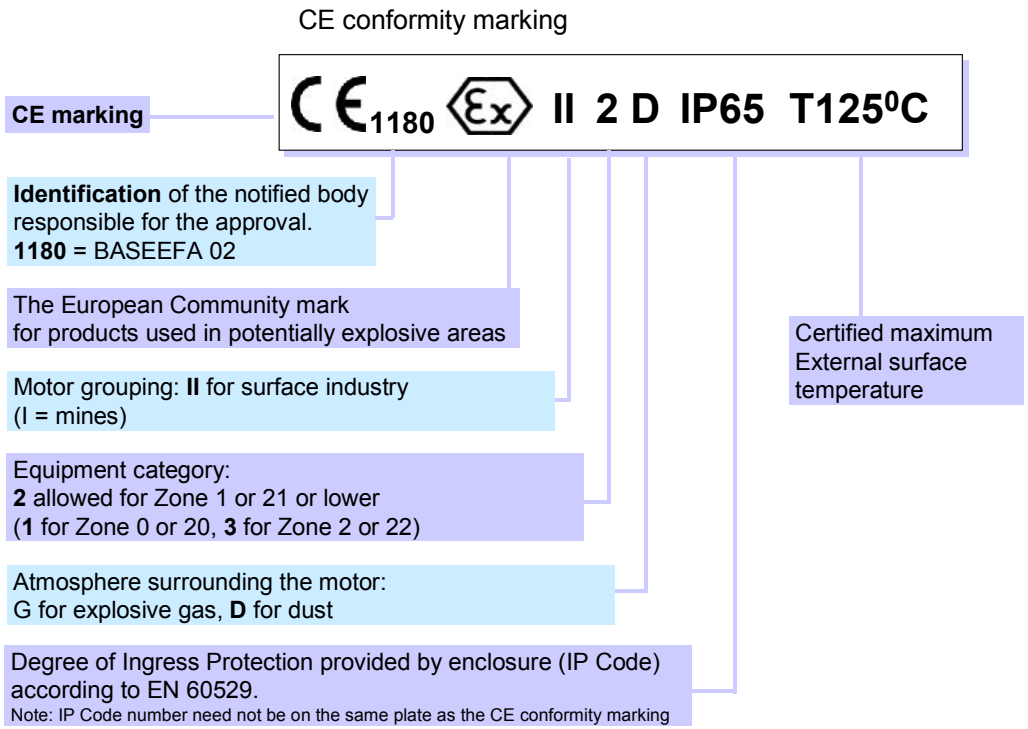


Figure 6 – Example of ATEX Labelling (Dust Hazard)

5 Power Drive System (PDS) used in potentially explosive atmospheres

5.1 Operating conditions of the PDS

Usually only the motor and driven load will be installed in the potentially explosive atmosphere, with the CDM in a safe area. In this case the motor will carry a nameplate similar to those shown in Figure 5 and Figure 6.

If the CDM is designed for installation in the potentially explosive atmosphere, it will also carry a nameplate similar to those shown in Figure 5 and Figure 6.

Compared to a motor connected directly to a mains supply, the motor manufacturer must take account of a converter supply (BDM/CDM) changing the operating conditions mostly due to:

- reduced cooling for self ventilated motors at reduced speed, due to reduced air flow;
- increased losses due to non-sinusoidal supply at the motor terminals leading to increased temperature rise, compared to sinusoidal supply;
- specific additional heat generation, particularly in the rotor cage and supporting structure as a result of harmonic currents;
- induced voltages in the rotor, which can lead to currents through the bearings (due to PWM technology and high switching frequency);
- dielectric heating due to high frequency/voltages.

For these reasons the application of the new Directives calls for extra attention to be paid when an Ex-motor is used with a frequency converter (CDM), and may require them to be tested together for certification.

Note also that equipment not installed in the potentially explosive atmosphere, but having an effect on equipment within it may also be subject to the Low Voltage Directive.

5.2 Selection of Ex-motor and BDM/CDM for PDS applications

5.2.1 General

The safety aspects include ensuring that:

- no additional risk exists of sparks due to premature insulation failure or to shaft voltages/bearing currents;
- no additional risk exists of exceeding the temperature class due to extra losses and possibly lower cooling.

These aspects are considered in further detail in the following clauses.

5.2.1.1 Risk management of sparks

The motor and converter manufacturers will ensure that bearing currents are limited and sparks are prevented using techniques including:

- suitable stator insulation materials and techniques;
- reduction of voltage transients;
  - o electrical filters.
- prevention of excessive bearing currents;
  - o insulated bearings or bearing housings, usually at the Non Drive-end;

- o reduced or optimised switching frequency;
- o electrical filters.

Typical measures that may be recommended by the motor manufacturer include those shown in IEC 60034-17:2002 and IEC 60034-25:2004

5.2.1.2 Risk management of excess temperature

5.2.1.2.1 General

The temperature class of the motor shall be checked by calculation or by testing as required by the appropriate standard.

There are two main methods for diminishing the risks of excess surface temperature:

a) to have a physical feedback signal from the motor (thermal sensing element) and use this signal to initiate shut down in the case of excess temperature;

b) to control and limit the heat ($\Rightarrow$ temperature) which can be generated by the motor.

5.2.1.2.2 Temperature sensing

This technique uses thermostats, thermistors or RTD devices embedded in the stator windings, with the appropriate controls to ensure that the temperatures are within the permitted limits.

This does not always control any additional temperature rise within the rotating element, and for high power motors the manufacturer/Notified Body may stipulate the use of additional thermal detectors at the bearings.

It is also mandatory that the protection used in conjunction with the temperature detectors is suitable for the purpose (including any intrinsic safety barriers where appropriate). As the correct functioning of the protection is critical to the safety of the overall system, the functional safety of the protection should be assessed and approved in accordance with the appropriate standards.

This method is applicable to all motor types.

When considered specifically for an EEx d design equipped with suitable integral thermal protection, type testing can demonstrate that for a sample electrical input and motor load, the protection will trip the motor before any surface temperature reaches the limit. This must also include a period after de-energization. In this case a “blanket certificate” may be issued detailing only the input and load parameters.

5.2.1.2.3 Control of heat generation

Control of heating is achieved by limiting the current passing through the motor at a specific frequency. As the torque generated is directly related to current, a **loadability curve** may be established, which gives the maximum continuously available torque at a particular speed or frequency, when the motor is fed at the correct voltage and frequency. The curve is dependent on the motor design, and can be advised by the manufacturer. The loadability curves must take into account the CDM technology**,** the surface temperature class of the motor, and the type of Ex protection.

In many cases a manufacturer will publish the loadability curves for his products to allow users to check that the load characteristics fall within the PDS capability. Figure 7 shows an example of a loadability curve for a cage induction motor, fed by an inverter. This shows the reduction in torque capability at low speeds due mainly to the

reduction in ventilation, a reduction in torque at base speed to allow a sufficient margin for safety, and a reduction above base speed due to the application of a constant voltage (field weakening).

The manufacturer's confirmation should always be obtained before running a motor above its base speed.

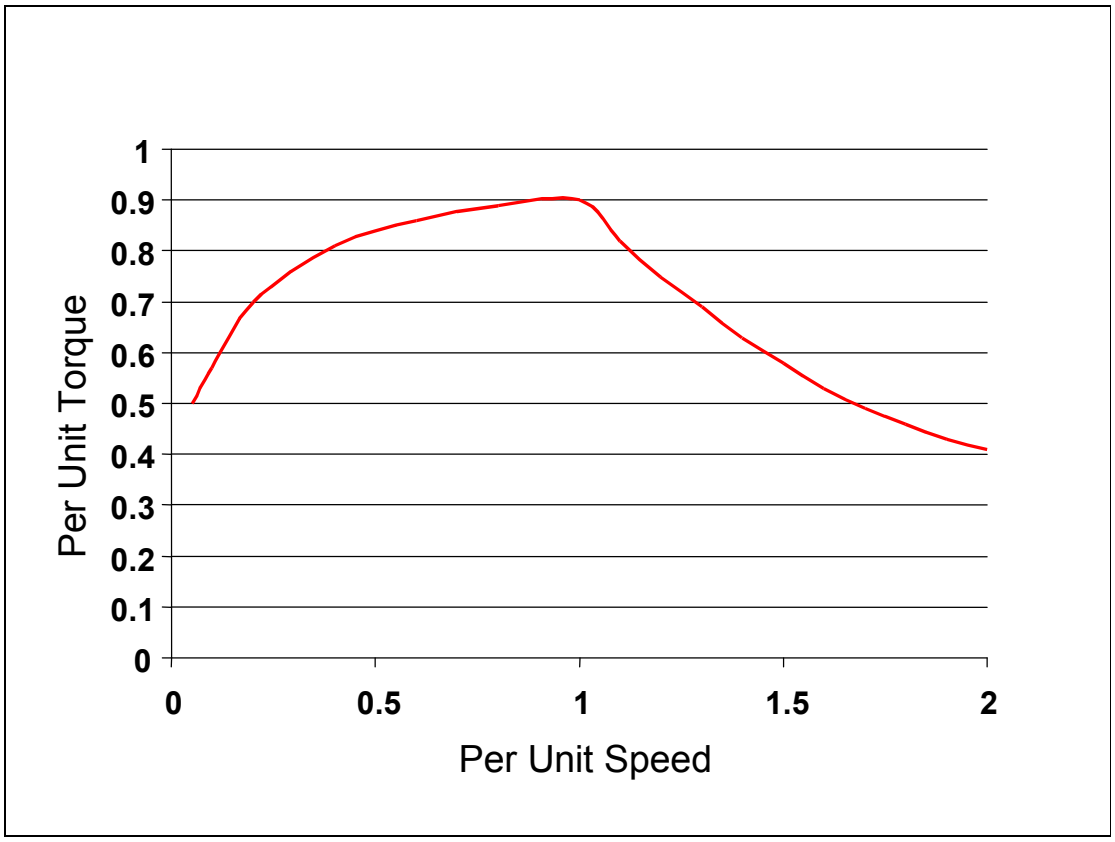


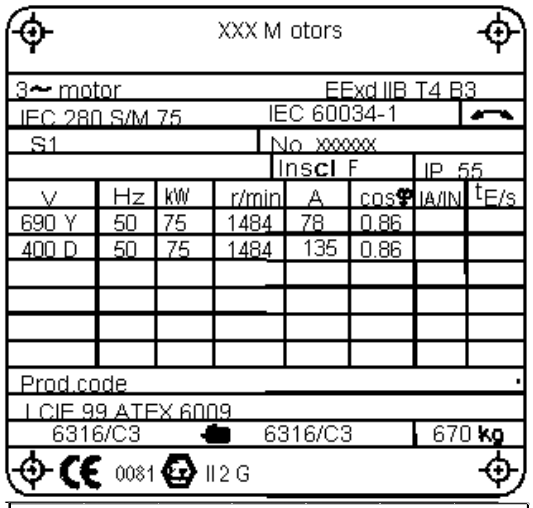
Figure 7 - Example of loadability curve established by test for induction motor of for PDS use

5.2.2 Additional marking

The details of rated power output and other relevant CDM information should be delivered with the motor. This may be done using **additional marking** or in the **operating instructions**, which gives the user the conditions for use of the PDS.

The additional marking includes:

- relevant electrical characteristics of the converter;
  - these may include inverter type (typically PWM, CSI), switching frequency, d.c. bus voltage and peak rate of voltage change.
- maximum load torque corresponding to the speed range allowed according to the application;
  - in a centrifugal fan or pump application; only the torque at maximum speed has normally to be considered;
  - for a constant torque application; the exact value of the torque has to be considered at the minimum and maximum speed corresponding to the application;
  - for intermittent duty applications the duty cycle must be detailed.



Complementary marking
Frame size and basic standard data

Sinusoidal supply data
(If appropriate)

CE Conformity marking

XXX Motors						
3~Motor	E280SMA4 EExd IIB T4					
No						
	CONVERTER SUPPLY					
Converter Type:	VOLTAGE-SOURCE/PWM					
Switching frequency:	> 1kHz					
Field Weakening Point	400 VD 50 Hz					
V	**Hz**	**kW**	**r/min**	**A**	**cos φ**	**DUTY**
400	5	6	133	124		S9
400	50	60	1488	110		S9
400	65	60	1934	105		S9
CONSTANT TORQUE 386 Nm 5 - 50 HZ CONSTANT POWER 60 kW 50 – 65 Hz						

Converter limitations

Converter supply data
(Shows a constant torque load from 133 r/min to 1488 r/min, with constant power from 1488 r/min to 1934 r/min)

Figure 8 - Typical Variable Speed Motor Marking

In many cases motors for variable speed applications are considered to be definite purpose and as such they are specifically designed for a given application. The marking will be in accordance with the specific manufacturer's standard practice.

Documentary evidence of the specific conditions of use should be obtained from the motor manufacturer, and retained.

5.3 Additional requirements for the PDS

5.3.1 Specific requirements

For specific requirements, refer to the relevant standards on electrical apparatus for potentially explosive atmospheres and for use in the presence of combustible dust.

5.3.2 Installation rules

- For Gases EN 60079-14:2003 is applied ⇒ ATEX 137.
- TN supply: TN-S only permitted in the potentially explosive atmosphere.
- TT supply: A residual current device shall be used in Zone 1 (Category 2) area.

  NOTE: the compatibility of this device with any EMC conducted emissions filter will require assessment.
- IT supply: An insulation-monitoring device shall be provided to indicate the first earth fault.

- Protection devices: Short-circuit and earth-fault protection devices shall prevent automatic reclosing of protection device (e.g. no automatic restart) under fault conditions.
- Isolation: To allow work to be carried out safely, isolation (for example isolators, fuses and links) shall be provided. Means must also be provided of cutting of electricity supplies to the potentially explosive area in an emergency.
- The radiated emissions levels of the generic EMC standards are implemented.
- Protective devices for variable speed motors shall be evaluated in accordance with the standards for the specific type of explosion protection.
- Dust area requirements are specified in EN 50281-1-2:1998 / (EN 61241-14:2004 and EN 61241-17:2005) ⇒ ATEX 137.

5.3.3 Inspection and Maintenance Rules

- For gases EN 60079-17:2003 is applied ⇒ ATEX 137.
- For dust EN 50281-1-2:1998 / (EN 61241-14:2004 and EN 61241-17:2005) is applied⇒ ATEX 137.
- An initial inspection.
- During operation either:
  a) regular periodic inspections; (the interval depends on risk assessment and is three years as maximum) or;
  b) continuous supervision by skilled personnel.
- A history of maintenance activities.
- Isolation of all incoming connections. (Isolation means withdrawal of fuses and links or the locking off of an isolator or switch).

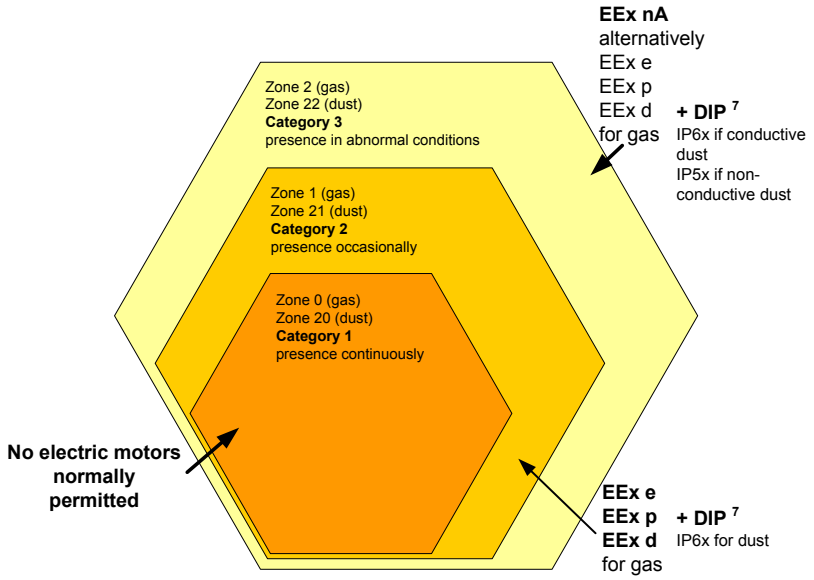


Figure 9 - Permitted equipment categories [7]

[7] DIP Info not linked to EEx

Table 2 Permitted equipment categories

Category	Zone	Hazard	Protection
1	0	Gas	No electric motors permitted, except in special circumstance [8].
	20	Dust	
2	1	Gas	EEx d, EEx de, EEx e, EEx p or combined protection type, like EEx pe as an example.
	21	Dust	DIP 2D IP6X
	21	Gas and Dust	Same protection as for gas as well as DIP 2D IP6X, provided that the explosion characteristics of the mixture (e.g. ignition temperature) are within the same limits as those of the components of the mixture.
3	2	Gas	EEx nA *alternatively any equipment suitable for Zone 1.*
	22	Conductive Dust	DIP 2D IP6X [9]
	22	Non conductive dust	DIP 3D IP5X
	22	Gas and dust	EEx nA as well as an appropriate DIP, provided that the explosion characteristics of the mixture (e.g. ignition temperature) are within the same limits as those of the components of the mixture. *alternatively any equipment suitable for Zone 1.*

5.3.4 EEx nA - non-sparking

5.3.4.1 Equipment (ATEX 95)

- Motor:
  - can be installed in zone 2 area, only;
  - no sparks or dangerously hot surfaces capable of causing ignition during rated operation, when related to duty type S1 or S2 in accordance with EN 60034-1. For duty types S3 to S10, starting and load conditions shall be taken into account;

[8] Motors using the multiple protection concepts of EN 50284 are allowed in Zone 0, although this is a very rare occurrence

[9] In areas classified as Zone 22 with conductive dust IP6X dust tight equipment may be used according to the forthcoming Standard EN 61241-14 clause 6.4.1.

  - maximum surface temperatures will be inside the motor enclosure.
- PDS according to EN 50021:1999/EN 60079-15:2003:
  - if no “blanket certificate” exists, the combination shall be tested together or if this is not practical safety shall be shown by calculations;
  - otherwise the inverter shall be designed to limit certain parameters, in which case it may be used with any motor suitable for the application of appropriate voltage and output rating; U_n<1000 V: dU/dt < 500 V/μs and Upeak < 1 kV to earth;
  - With form-wound winding and U_n>1000 V: dU/dt < 500 V/μs, Upeak < 2 x line voltage to earth.

5.3.4.2 Installation (ATEX 137)

- PDS according to EN 60079-14:2003:
  - prevent any over voltage spikes and higher temperatures in the motor or its terminal box;
  - safety devices prescribed by the manufacturer or the Ex NB e.g. thermal feedback sensors must be connected in a suitable manner.

5.3.4.3 Inspection and Maintenance (ATEX 137)

- PDS according to EN 60079-17:2003:
  - No requirements.

5.3.5 EEx e - Increased safety

5.3.5.1 Equipment (ATEX 95)

- Motor:
  - can be installed in both zone 1 or 2 areas;
  - no sparks capable of causing ignition during rated operation or during start up and fault conditions;
  - no dangerously hot surfaces capable of causing ignition during operation including during start and fault conditions;
  - maximum surface temperatures will be inside the motor enclosure.
  - PDS according to EN 50019:2000/EN 60079-7:2003:
  - shall be designed and type-tested by Ex NB as a unit (each combination must be tested). The test shall be performed with the protective devices provided.

5.3.5.2 Installation (ATEX 137)

- PDS according to EN 60079-14:2003:
  - shall be type tested for this duty as a unit with the protective devices provided;
  - safety devices prescribed by the Ex NB e.g. thermal feedback sensors must be connected in a suitable manner.

5.3.5.3 Inspection and Maintenance (ATEX 137)

- PDS according to EN 60079-17:2003:
  - the correct selection of the tripping time characteristics of protective devices shall be checked.

5.3.6 EEx p – Pressurised

5.3.6.1 Equipment (ATEX 95)

- Motor:

- o can be installed in either zone 1 or 2 areas;
- o enclosure purged and pressurised by a protective gas, prior to starting and when the motor operates;
- o maximum surface temperatures limited on the outside of the enclosure.

- PDS according to EN 50016:2002/EN 60079-2:2004:
  - o the safety of the combination shall be shown by calculations or other measures. Be aware of the operational speed range to determine the position and pressurisation of the minimum pressure point within the enclosure.

5.3.6.2 Installation (ATEX 137)

- PDS according to EN 60079-14:2003:
  - o No requirements. However, safety devices prescribed by the Ex NB, including pressurisation monitoring and thermal feedback sensors, must be connected in a suitable manner.

5.3.6.3 Inspection and Maintenance (ATEX 137)

- PDS according to EN 60079-17:2003:
  - o No requirements.

5.3.7 EEx d – Flameproof

5.3.7.1 Equipment (ATEX 95)

- Motor:
  - o can be installed in either zone 1 or 2 areas;
  - o flameproof enclosure;
  - o maximum surface temperatures limited on the outside of the enclosure.
- PDS according to EN 50018:2000/EN 60079-1:2004:
  - o temperature rise shall be measured;
  - o motors selected using manufacturers proven loadability curves for variable speed duty (see Figure 7), and incorporating a suitable protection device should not require combined tests. In the absence of such curves or evidence of test, the selected motor and CDM shall be tested together as a unit to ensure the motor meets the requirements of a given external temperature classification;
  - o either a direct temperature control by embedded temperature sensors or other effective measures shall be provided. The action of the protective device shall be to cause the motor to be disconnected. The motor and converter (BDM/CDM) combination does not need to be tested together or;
  - o the motor shall have been type-tested by Ex NB for this duty as a unit in association with the converter (BDM/CDM) and with the protective device specified.

5.3.7.2 Installation (ATEX 137)

- PDS according to EN 60079-14:2003:
  - o The motor shall be installed with the protective device specified.

5.3.7.3 Inspection and Maintenance (ATEX 137)

- PDS according to EN 60079-17:2003:
  - o No requirements.

5.3.8 DIP - Dust Ignition Protected

5.3.8.1 Equipment (ATEX 95)

- Motor according to EN 50281-1-1:1998:
  - may be installed in dust hazard area, or area with both gas and dust hazard;
  - for dust hazard can be installed in either Zone 1 or 2 areas, but must also comply with requirements for appropriate gas hazard. Hybrid mixtures must be considered additionally;
  - category 2D, (Conductive dust) Ingress protection IP65 minimum;
  - category 3D, (Non conductive dust) Ingress protection IP55 minimum;
  - surface temperatures limited on the outside of the enclosure.
- PDS according to EN 50281-1-1:1998:
  - safety devices prescribed by the manufacturer or the Ex NB e.g. thermal feedback sensors must be connected in a suitable manner;
  - motors selected using manufacturers proven de-rating curves for variable speed duty, and incorporating a suitable protection device should not require combined tests. In the absence of such curves or evidence of test, the selected motor and BDM shall be tested together as a unit to ensure the motor meets the requirements of external temperature with appropriate certification (see figure 10).

5.3.8.2 Installation (ATEX 137)

- PDS according to EN 50281-1-2:1998/(EN 61241-14:2004 and EN 61241-17:2005):
  - The motor shall be installed with the protective device specified.

5.3.8.3 Inspection and Maintenance (ATEX 137)

- PDS according to EN 50281-1-2:1998/(EN 61241-14:2004 and EN 61241-17:2005).

5.4 Notified Bodies and Certification

The Ex NB provides approval that both the motor manufacturer and product fulfil various requirements of ATEX 95 and provides the following two certificates:

- a Quality Assurance Notification;
- an EC type examination certificate.

The Quality Assurance Notification, provided by the Ex NB to the manufacturer, states that the manufacturing process meets the requirements of ATEX Product Directive.

The "EC Type examination certificate" confirms that a specimen of a product is in conformity with the ATEX Directive. EC Type Examination Certificates delivered by the Ex NB are mandatory for any electrical equipment marked as category 1 or category 2, and are necessary before a manufacturer can raise an EC Declaration of Conformity. For category 3 equipment ATEX 95 allows the product manufacturer to raise an EC Declaration of Conformity without an EC Type Examination Certificate from an Ex NB. Ex NB assessment of the manufacturing process is not required for Category 3 equipment either.

In accordance with ATEX 95 the system supplier or ATEX component manufacturer will provide the following markings and documentation:

- the manufacturer shall stamp the motor with the CE marking and other related information;

- the manufacturer must establish an “EC Declaration of Conformity” according to Annex X of Directive ATEX 95. This document is supplied to the customer with the motor;
- instructions for safe installation, use and maintenance must be supplied with the equipment as stated in Annex II of Directive ATEX 95;
- where appropriate a copy of the EC Type Examination Certificate may be supplied.

In the case of a PDS, the motor is normally the only equipment installed in the potentially explosive atmosphere, and the BDM/CDM will be installed in a safe area. The BDM/CDM as a unit does not need Ex NB certification, but safety features related to Ex-motor protection need certification. To ensure safe operation of the PDS, the motor manufacturer must specify the restrictive conditions for use of the motor.

Ex equipment must not be put into service without an EC Declaration of Conformity.

6 Responsibilities

6.1 ATEX 95 Directive

6.1.1 New installations

The procedure for ATEX 95 compliant PDS is presented in Figure 10. Three approaches for responsibilities can be identified.

1. PDS supplier, who manufactures both CDM and EEx-motor, takes responsibility.
   - o A PDS manufacturer is responsible for selection, compliance procedure and delivery of a suitable CDM/EEx-motor combination.
   - o A PDS manufacturer will provide all markings and documentation detailed in 5.4.
2. EEx-motor manufacturer takes responsibility.
   - o As presented in Figure 10, EEx-motor needs to be approved for PDS use. Thus, the EEx-motor manufacturer may take responsibility for the whole procedure even though some co-operation with the CDM manufacturer is desired.
   - o The EEx-motor manufacturer is responsible for dimensioning and equipment selection of a PDS according to instructions from the CDM-manufacturer.
   - o The EEx-motor manufacturer is responsible for the compliance procedure and delivery of an appropriate CDM/EEx-motor combination.
   - o The EEx-motor manufacturer will provide all markings and documentation detailed in 5.4.
   - o The user needs to make sure that he is purchasing the right CDM/EEx-motor combination allowed by EEx-motor manufacturer.
3. System integrator or user takes responsibility.
   - o When a system integrator or user assembles a system from parts of different manufacture, he will become the manufacture of the PDS, and then it is his responsibility to:
     - perform correct dimensioning and equipment selection of a PDS according to instruction of CDM- and EEx-motor manufacturers;
     - ensure ATEX compatibility and the validity of CE marking by performing the compliance procedure presented in Figure 10;
     - ensure the purchase of the appropriate CDM/EEx-motor combination.

- In addition, compliance shall be described in explosion protection document (EPD).

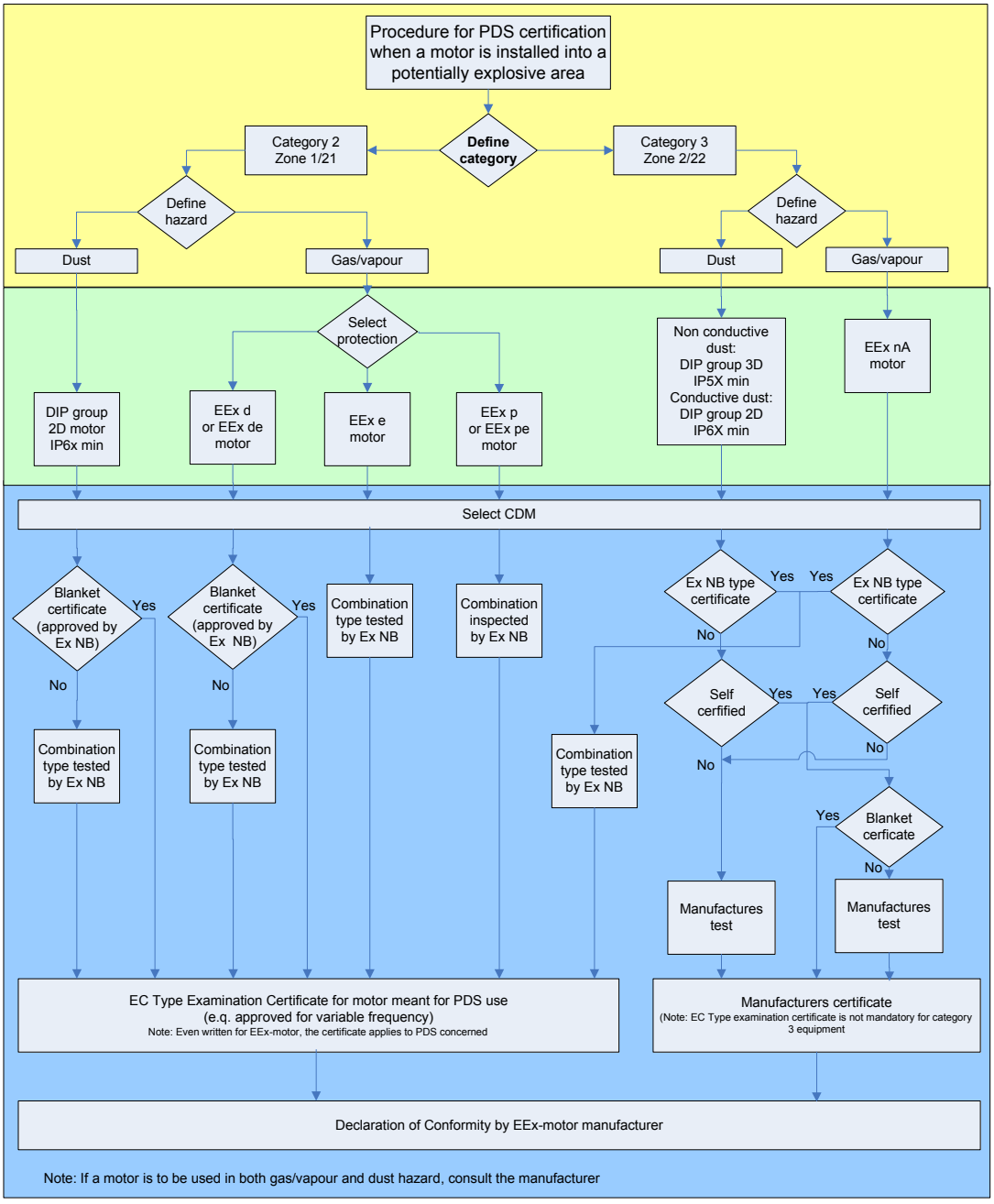


Figure 10 - Flowchart showing selection of equipment to meet ATEX 95 [10]

[10] In areas classified as Zone 22 with conductive dust IP6X dust tight equipment may be used according to the forthcoming Standard EN 61241-14 clause 6.4.1.

6.1.2 Modifications to existing installations

In the event of modifications to an existing installation great care must be exercised.

In the event of the replacement of the BDM/CDM as a spare part where the performance is not affected, the existing motor certification should be examined to determine its validity. However, if an existing motor is to be replaced, only motors with current applicable certification may be fitted.

Where the performance of the drive system is to be changed, the procedure for a new installation must be followed, and current standards applied.

The responsibility for ensuring the safe operation of any modified installation lies with the end user.

6.1.3 Spare parts

A spare part is any item intended to replace a defective or worn out part of a product previously placed and put into service on the EU market. The manufacturer of the spare part is not required to comply with ATEX 95 unless the spare part represents an equipment or component as defined by the directive. Proprietary goods such as terminal boards/studs etc. must comply with the directive since they are classed as equipment in their own right.

If the manufacturer of the original spare part offers a new, different one in its place (due to technical progress, discontinued production of the old part, etc.), and it is used for the repair, the repaired product (as long as no substantial modification of the repaired product takes place) does not need to be brought into conformity at this time with ATEX 95 as the repaired product is not then placed on the market and put into service.

It is the user's responsibility to ensure that only appropriate spare parts are fitted.

6.2 ATEX 137 Directive

ATEX 137 sets certain responsibilities for end user, as detailed in 2.4. The most important PDS related responsibilities are:

- explosion protection measures shall be taken and an Explosion Protection Document (EPD) shall be established;
- use of competent repair shop and, where spare parts are used, to ensure they comply with the legislation where relevant;
- the employer shall implement following equipment selection principles;
  - zone 0 or zone 20 requires category 1 equipment;
  - zone 1 or zone 21 requires category 1 or category 2 equipment;
  - zone 2 or zone 22 requires category 1 or category 2 or category 3 equipment.

ATEX 137 allows user to deviate the equipment selection principles or other requirement given by Chapter 6.1, but the justification shall be documented and issued in "Explosion Protection Document" (EPD). By using same approach, user may take responsibilities of equipment manufacturers, but the justification shall be documented in EPD respectively.

6.3 Summary

Compliance with the ATEX Directives provides improved safety aspects by:

- simplicity - there are only two fields of responsibility. Third parties are responsible either to the manufacturers or by default to the end users, and the duties of each party are clearly defined in the relevant standards (Figure 11);
- safer equipment - certified to ATEX 95 with new design, more demanding testing procedures, and specific quality assurance measures for the design and manufacturing processes;
- strict risk analysis and comprehensive “minimum requirements” of the ATEX 137 (Worker Directive) - this requires employers to protect both staff and the local community through training programs, explosion protection measures, extensive written instructions and a competent safety manager. In some cases, the introduction of ATEX 137 will require existing equipment to be replaced, if it does not meet the minimum requirements described in the Annex II part A of Directive.

On the one hand manufacturers shall provide all documentation and instructions of ATEX 95 certified equipment (see Figure 10) to the end users, and on the other hand end users shall record this data in their “Explosion Protection Document” (EPD) and use it each time it is needed, including occasions when third parties may be involved [11].

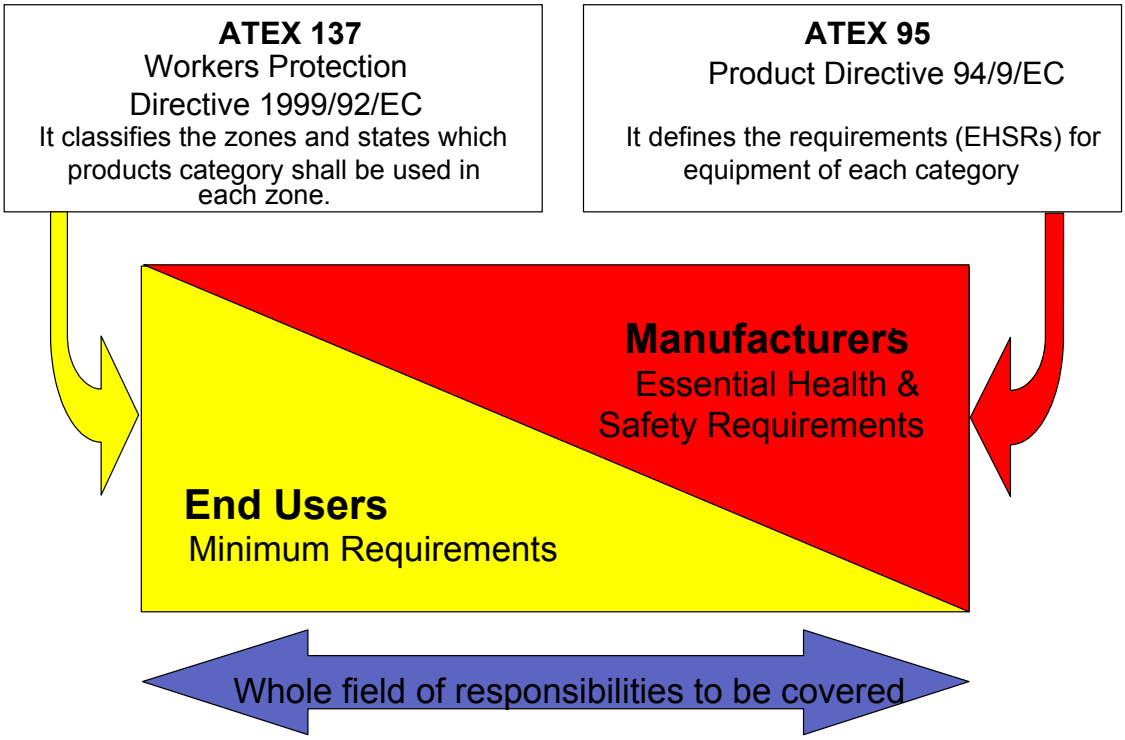


Figure 11 - Responsibilities

[11] EPD is required by ATEX 137 and will be inspected prior taking a plant/device into operation

Glossary of abbreviations

Term or abbreviation	Description
a.c.	Alternating current
ATEX	“Atmosphères Explosibles” – European Directives using French acronym, covering the essential health and safety requirements for products used in potentially explosive atmospheres
Base Speed	Speed at which nominal voltage is applied to a motor
BDM	Basic Drive Module
CDM	Complete Drive Module
CE Marking	Indication of compliance with all appropriate EU Directives
CEMEP	European Committee of Manufacturers of Electrical Machines and Power Electronics
CEN	European Committee for Standardisation, responsible for the preparation of non electro-technical harmonised (EN) standards
CENELEC	European Committee for the Electrotechnical Standardisation – responsible for the preparation of electro-technical harmonised (EN) standards
CSI	Current Source Inverter
d.c.	Direct Current
DIP	Dust Ignition Protection
d*U*/dt	Rate of change of voltage
EC	European Community
EEA	European Economic Area
EEC	European Economic Community
EHSR	Essential Health and Safety Requirement
EN	EuroNorm – Standard issued by CEN/CENELEC
EPD	Explosion Protection Document
EU	European Union
Ex NB	Ex Notified Body.
IEC	International Electrotechnical Commission – International Standardisation Body.

IP	Ingress protection (see appropriate standards)
IT	Ungrounded power supply network
PDS	Power Drive System
PWM	Pulse Width Modulated
RTD	Resistance temperature detector
TN	Power supply network having neutral grounded at more than one point. 3 types of TN system are recognised
TN-C	TN system with common neutral and protective earth conductor throughout the system
TN-S	TN system with separate neutral and protective earth conductors throughout the system
TN-C-S	TN system where neutral and protective functions are combined in a single conductor in part of the system.
TT	Power supply network with neutral grounded at a single point, with separate protective earth
U	Voltage (Generally used with suffixes)

Comparison of Standards

Various standards in the EN 50000 series are being replaced by EN 60000 series (corresponding to the equivalent IEC standard numbering), this table is provided as a comparison. Only current EN standards, which have been notified in the Official Journal of the EU can confer a presumption of conformity with the essential requirements of ATEX 95 [12].

Concerning	EN 50000 series standard	IEC/EN 60000 series standard	Date of cessation of presumption of conformity of the superseded standard
General requirements	EN 50014:1997/ A1+A2:1999	EN 60079-0:2004	2007-03-01 (dow)
Protection ‘p’	EN 50016:2002	EN 60079-2:2004	2007-06-01 (dow)
Protection ‘d’	EN 50018:2000/ A1:2002	EN 60079-1:2004	2007-03-01 (dow)
Protection ‘e’	EN 50019:2000	EN 60079-7:2003	2006-07-01
Protection ‘n’	EN 50021:1999	EN 60079-15:2003	2006-07-01
		EN 60079-15:2005	2008-06-01 (dow)
Protection ‘DIP’	EN 50281-1-2:1998 /A1:2002	EN 61241-14:2004	2007-09-01 (dow)
		EN 61241-17:2005	2008-04-01 (dow)
Classification of areas for Protection ‘DIP’	EN 50281-3:2002	EN 61241-10:2004	2007-07-01 (dow)

Note: Generally the date of cessation of presumption of conformity will be the date of withdrawal (‘dow’), set by the European Standardization Organisation, but attention of users of these standards is drawn to the fact that in certain exceptional cases this can be otherwise.

Where “(dow)” is shown in the above list, the edition of the standard shown had not yet been listed in the Official Journal at the time of writing of this application guide.

12 The Official Journal is available on the EU website www.europa.eu.int under EUR-LEX. The current list referring to 94/9/EC is available by reference to the EU ATEX website http://europa.eu.int/comm/enterprise/newapproach/atex/index.htm