USER GUIDE No.4 FIRST EDITION

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

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ROTATING ELECTRICAL MACHINES ASSOCIATION

Developed by the joint GAMBICA/REMA Working Group

Foreword

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 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 has been developed by the GAMBICA/REMA joint working group, and is based on material presented to the CEMEP Technical Board. It represents the views of the group on the requirements for variable speed power drive systems. However, this guide has no legal force, and readers are advised to consult the text of the EU and national enabling legislation, together with the EU Guideline documents.

This guide does not apply to electrical equipment intended for use underground in mines, although the ATEX Directives also apply to this industry. Certain other applications may be covered by product specific standards, or regulations, which must be observed.

Contents

1 Introduction and Terminology

1.1 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 below.

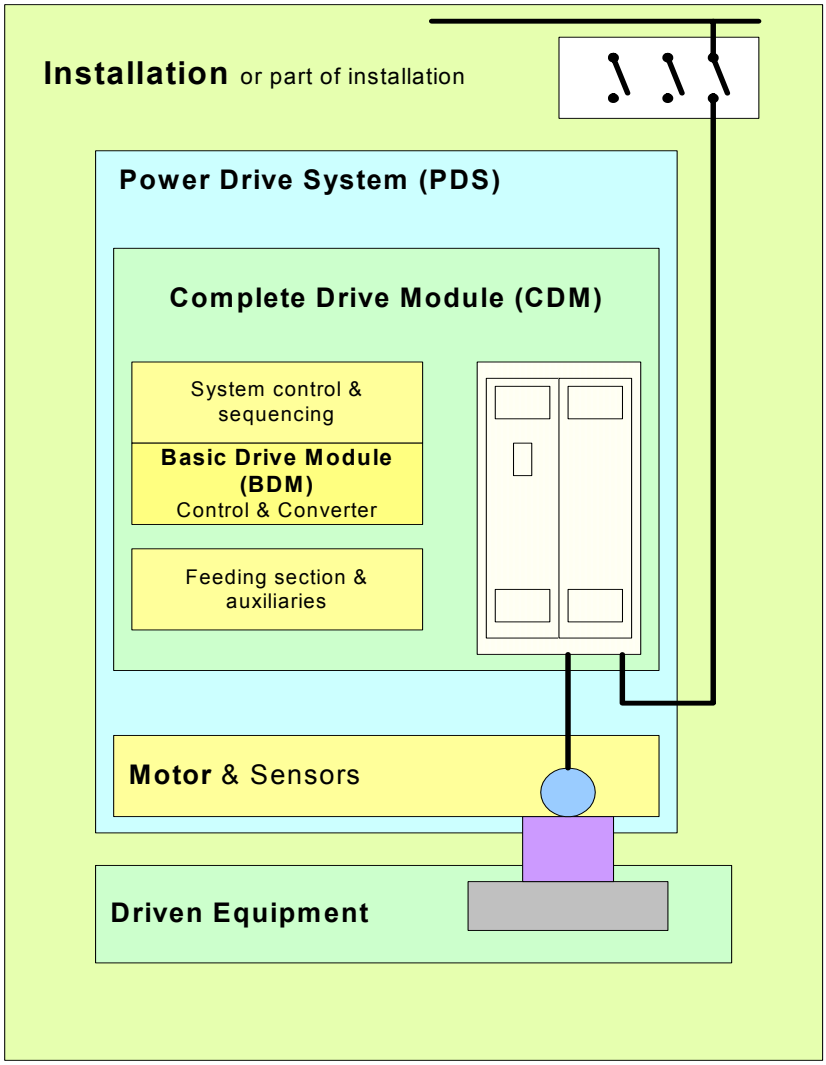

Figure 1 - The Power Drive System

- 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.

An electric motor (and any other part of a PDS) together with the driven equipment, when installed in a potentially explosive atmosphere, may be capable of causing an

explosion. This document is intended to provide guidance for the application of motors in potentially explosive atmospheres.

1.2 ATEX

ATEX is the French acronym for "**At**mosphères **Ex**plosibles" which translates to Explosive Atmospheres in English.

1.3 Terms used in this guide relating to potentially explosive atmosphere equipment [1]

Term	Definition
Blanket certificate	a document confirming that a generic combination of equipments meets the requirements of a specific standard or standards
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 (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

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

Term	Definition
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
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
Ex Notified Body	an independent body which has been notified by national authorities to the European Commission based on criteria stated in ATEX Directive 94/9/EC
Explosive dust atmosphere	a mixture with air, under atmospheric conditions, of a dust layer or cloud which may ignite in certain circumstances
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

Term	Definition
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 which could become explosive (the danger is a potential one)
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 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 94/9/EC (sometimes known as the ATEX 95[3] (or ATEX 100a[3]) Directive) concentrates on the ***responsibilities of the equipment manufacturer***
  - It defines the Essential Health and Safety Requirements (EHSRs) of equipment
- The Explosive Atmospheres Directive 1999/92/EC (sometimes known as the ATEX 137[3] (or ATEX 118[3]) Directive). 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

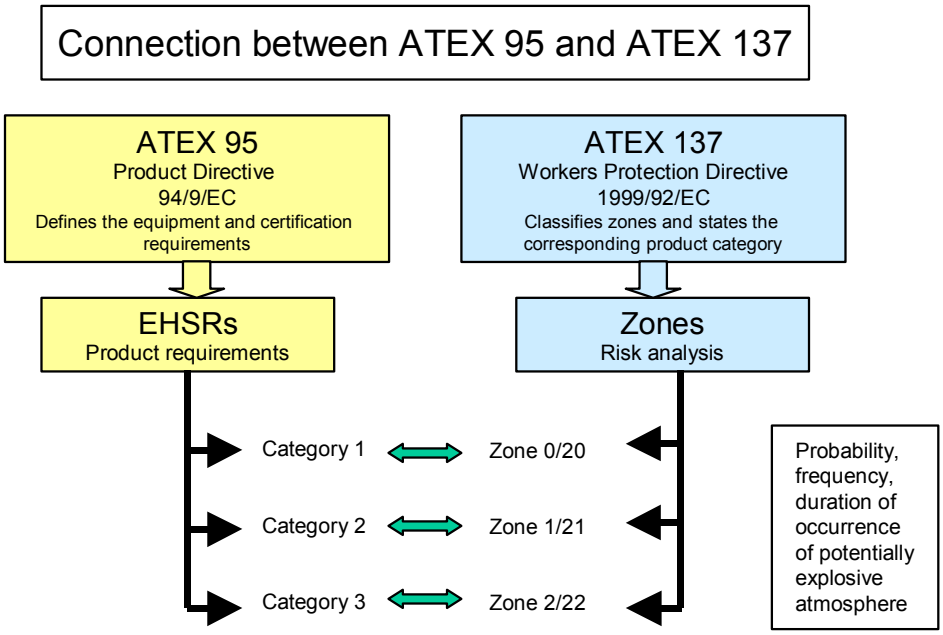

Figure 2 - Application Fields

2.2 The Product Directive (ATEX 94/9/EC)

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: ***ATEX Directive 94/9/EC***.

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[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.

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 94/9/EC 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 paragraph 5.4) chosen by the manufacturer.

2.3 The Worker Protection Directive (ATEX 1999/92/EC)

The European Parliament and the Council of 16th December 1999 adopted *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.

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.

- 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

2.4 National legislation [4]

As with all European Directives, ATEX is implemented in the member countries by national legislation. For example within England and Wales ATEX 95 – the Product Directive - is implemented by the "Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996" (amended 2001).

ATEX 137 – the Worker Protection Directive - and the Chemical Agents Directive (98/24/EC) are both implemented by the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002.

Details of the DSEAR can be found on the UK government website www.hse.gov.uk/spd/dsear.htm.

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

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

- Where appropriate, audit of the manufacturing factory which delivers the Ex-equipment, conducted by an expert on Ex-system quality
- 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:

- Design guidelines
  - Design and maintenance practice
  - Installation and selection concept for the equipment
- Manufacturing
  - Sustaining required quality levels
- Maintenance
  - Assurance of safety over the life cycle
  - Maintenance practice and schedule

4 Text of the UK legislation is available on http://www.hmso.gov.uk/

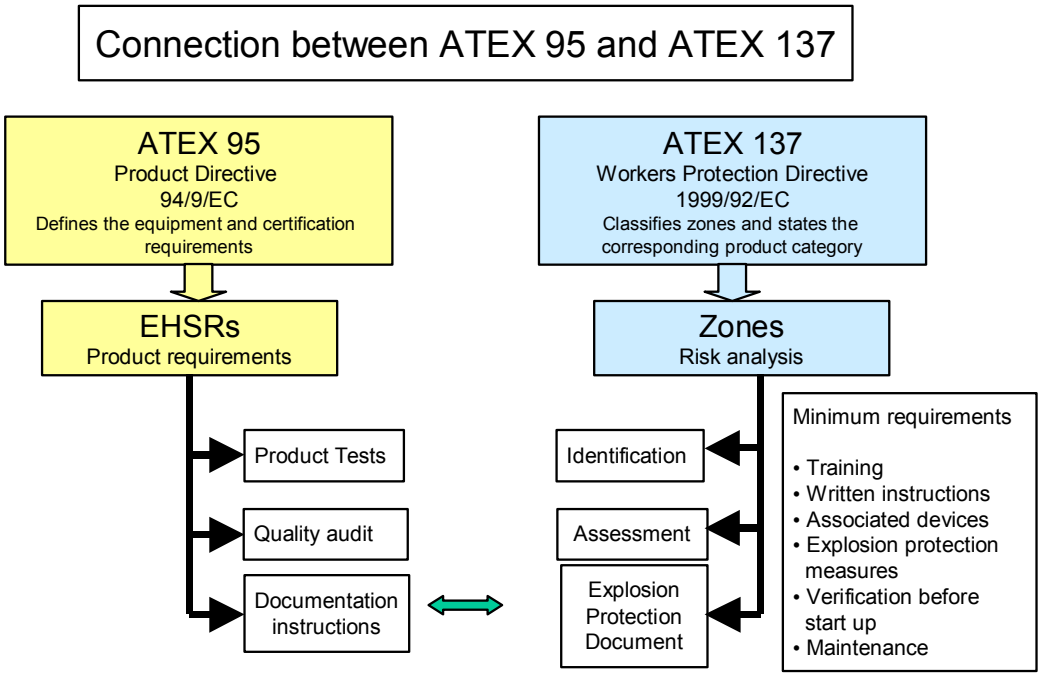

Figure 3 - Comparison of responsibilities under ATEX

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

Table 1 - Categorisation of Zones

Atmosphere	Zone	Definition	Presence of explosive atmosphere per year
Gas	0	Explosive atmosphere is present continuously, for long periods or frequently due to malfunctions	> 1000 h
Dust	20		
Gas	1	Explosive atmosphere is likely to occur due to expected malfunctions	10 ... 1000 h
Dust	21		
Gas	2	Explosive atmosphere is unlikely to occur or, if occurring, is likely to only be of short duration and not in normal duty	< 10 h
Dust	22		

Because of the addition of dust, the new regulations will include a large number of industrial sites, which were not regulated under the previous explosive atmosphere directives. These sectors include power plants using coal or organic material, timber industries, the food industry, etc.

The following standard defines the grouping and categorisation of electrical equipment

- EN 50014:1997 as amended, Electrical apparatus for potentially explosive atmospheres – General requirements
- EN 60079-10:2003 Classification of hazardous areas
- EN 60079-14:2003 Electrical installations in hazardous areas

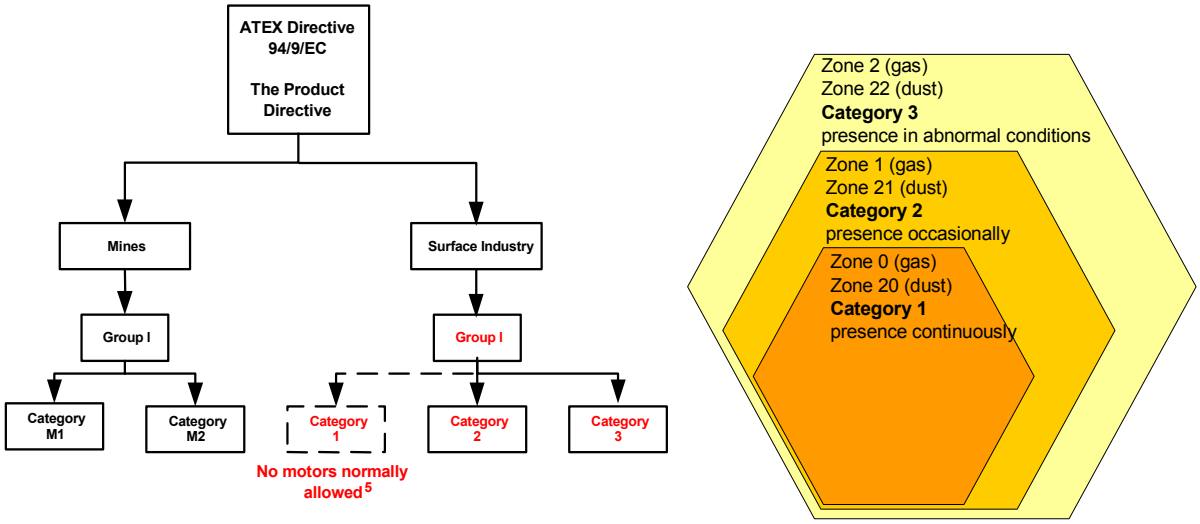

Figure 4 - Categories of Equipment

5 Motors using the multiple protection concepts of EN 50284 are allowed in Zone 0, particularly for dust hazards, although this is a very rare occurrence

4 Electric motors in potentially explosive atmospheres

4.1 Generic requirements

EN 50014:1997 (6) details generic 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 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
- Normally offered for temperature classification T1, T2 and T3
- 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)

- 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 (7)
- Enclosure purged and pressurised by a protective gas, when motor starts and during running
- Surface temperatures limited on the outside of the enclosure

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6 These EN 50*** series of Ex standards are gradually being replaced by the EN 600** series, following the IEC number series. See Page 28

7 Rarely used

4.5 EEx d - Flame proof (EN 50018:2000)

- Category 2 equipment may be installed in Zone 1 or Zone 2 areas
- Normally offered for temperature classification T3, T4 and T5 (7)
- Explosion proof enclosure
- Surface temperatures limited on the outside of the 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.

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 electrical 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
- Temperature classification (Typically 125 ^{o}C)
- Surface temperature limited on the outside of the enclosure

To be sure that the motor is ATEX certified and may be used in a potentially explosive atmosphere, the following marking must appear on the nameplate of the motor.

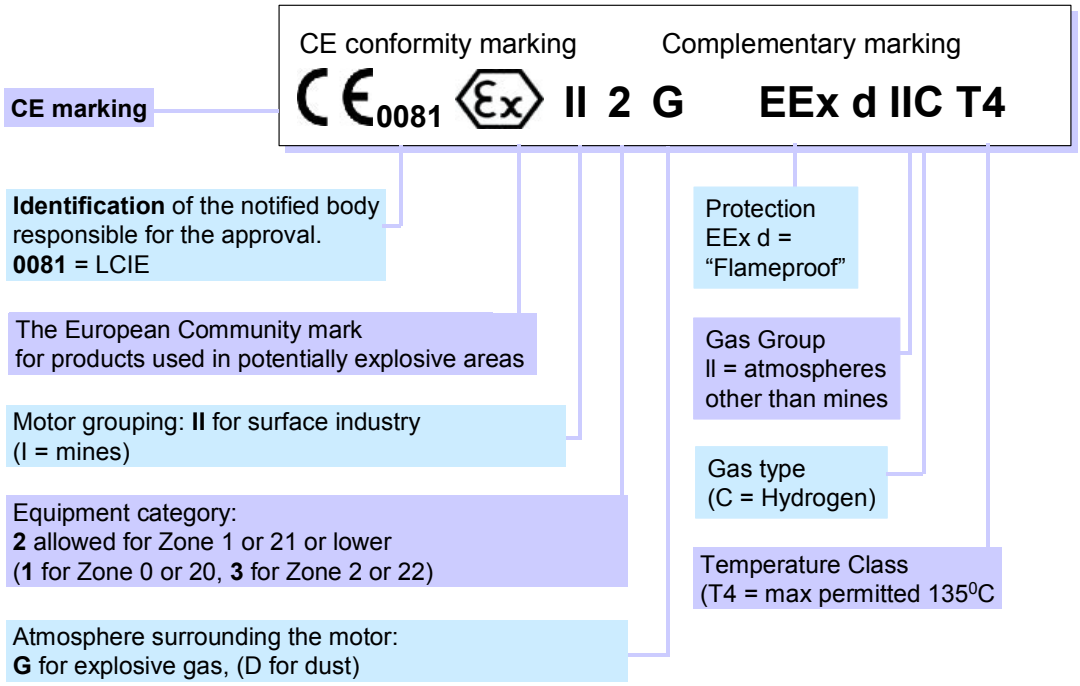


Figure 5 – Example of ATEX Labelling (Gas Hazard)

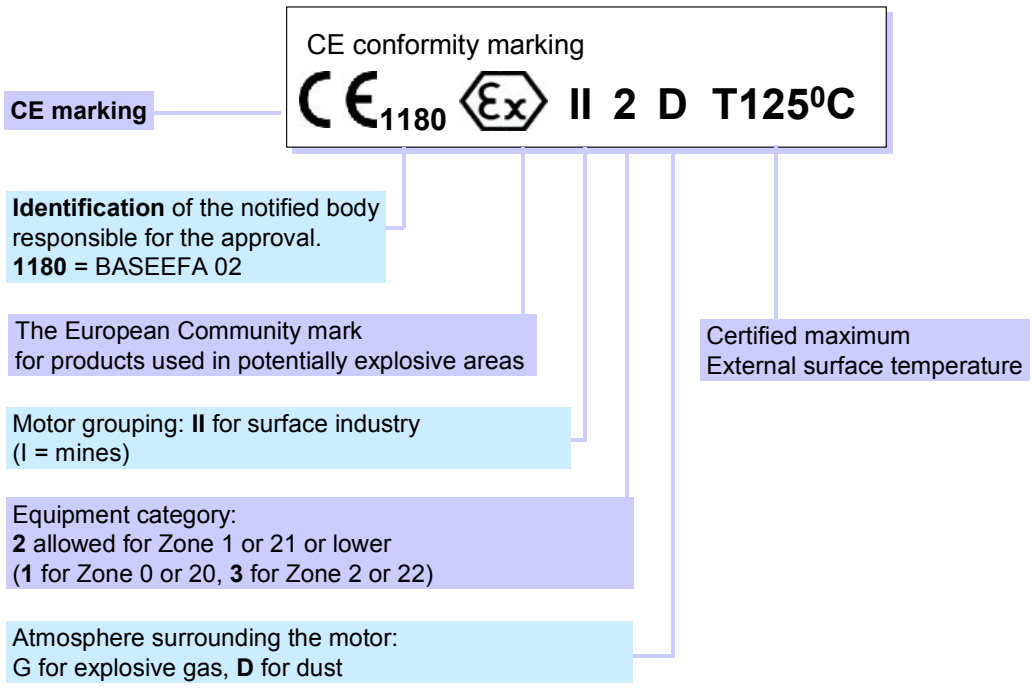


Figure 6 – Example of ATEX Labelling (Dust Hazard)

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.

If the CDM is designed for installation in the potentially explosive atmosphere, it will 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 paragraphs

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 (8)
- Reduction of voltage transients
  - Electrical filters
- Prevention of excessive bearing currents (9)
  - Insulated bearings or bearing housings, usually at the Non Drive-end
  - Reduced or optimised switching frequency
  - Electrical filters

Typical measures that may be recommended by the motor manufacturer include those shown in IEC 60034-17:2002, GAMBICA/REMA Guides No 1 and 2 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 transferred to the motor

8 For further information see GAMBICA/REMA Technical Report No 1 Motor insulation voltage stresses under PWM inverter operation.

9 For further information see GAMBICA/REMA Technical Report No 2 Motor shaft voltages and bearing currents under PWM inverter operation

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 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-energisation. 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.

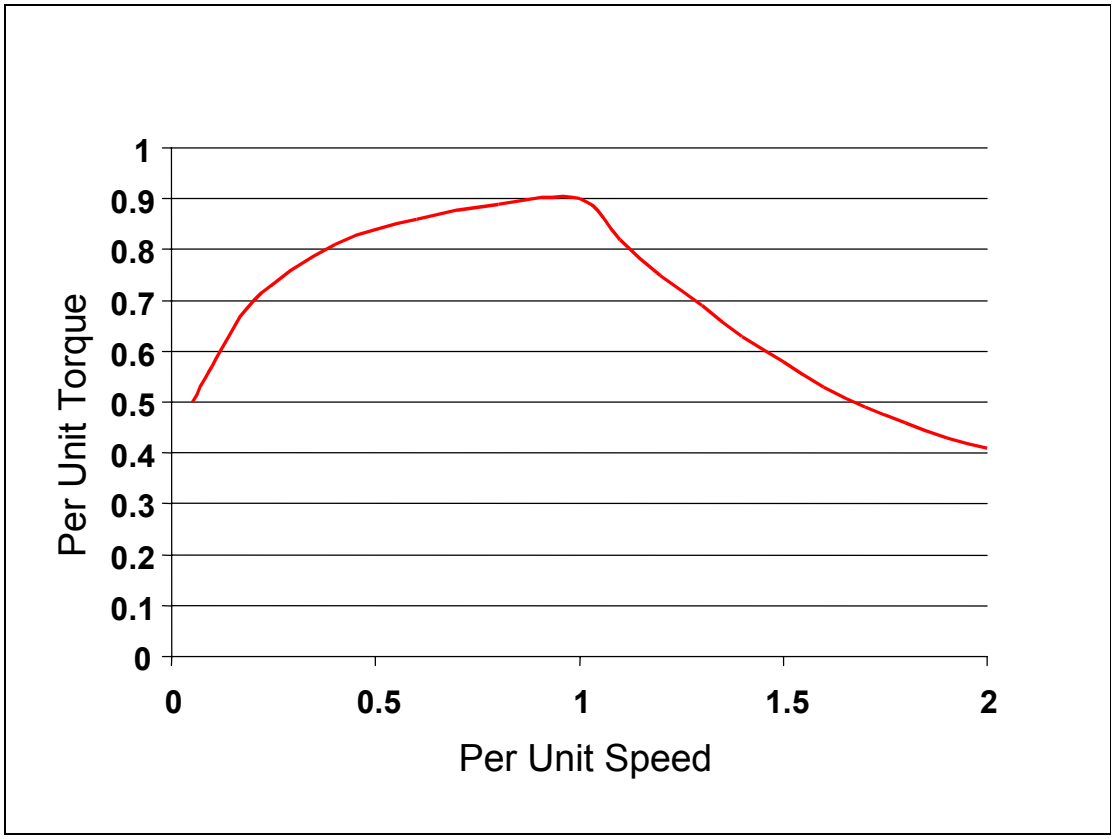


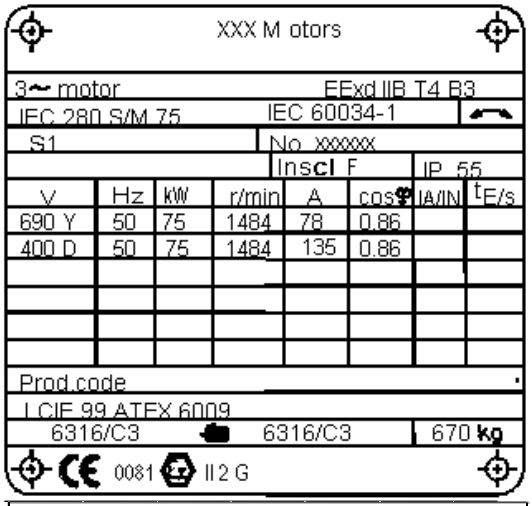
Figure 7 - Example of loadability curve established by test for an inverter fed induction motor

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**, 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 1999/92/EC
- 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 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 EN 50019/EN 60079-7
- Dust area requirements are specified in EN 50281-1-2:1998 ⇒ ATEX 1999/92/EC

5.3.3 Inspection and Maintenance Rules

- For gases EN 60079-17:2003 is applied ⇒ ATEX 1999/92/EC
- For dust EN 50281-1-2:1998 is applied⇒ ATEX 1999/92/EC
- An initial inspection.
- During operation either
  a) regular periodic inspections (maximum interval of three years), 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)

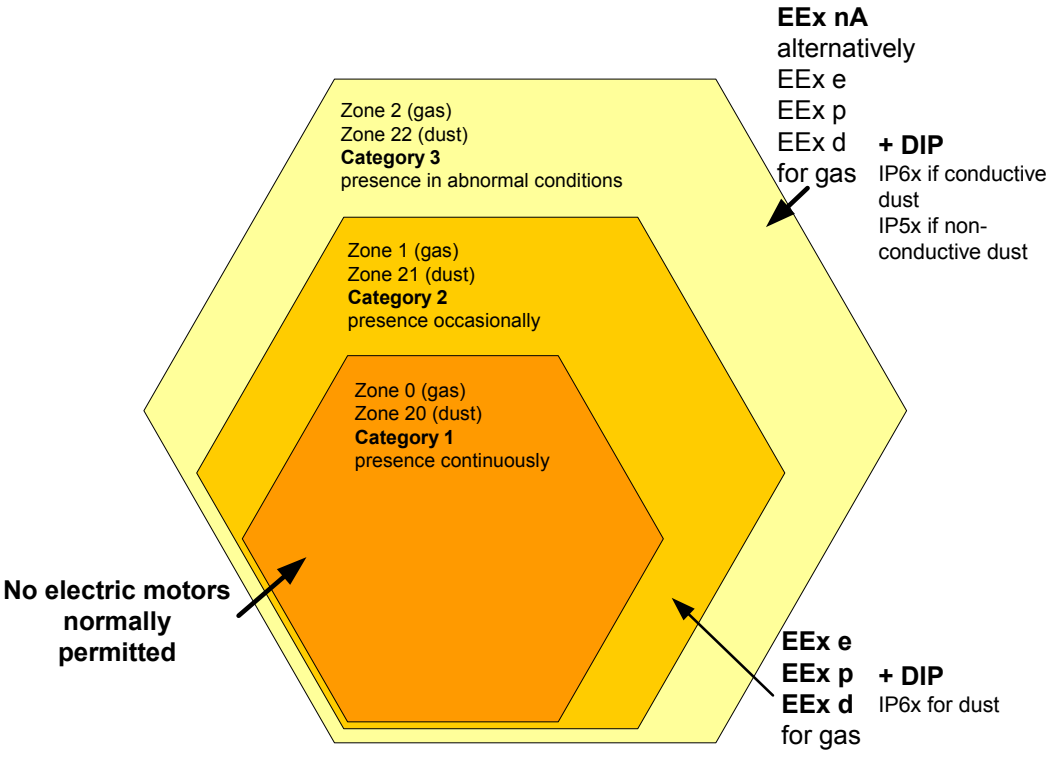


Figure 9 - Permitted equipment categories

Table 2 Permitted equipment categories

Category	Zone	Hazard	Protection
1	0	Gas	No electric motors permitted, except in special circumstance[10]
	20	Dust	
2	1	Gas	EEx d, EEx de, EEx e, EEx p or EExpe
	21	Dust	DIP 2D IP6x
	21	Gas and Dust	As gas plus DIP 2D IP6x
3	2	Gas	EEx nA *alternatively any equipment suitable for Zone 1*
	22	Conductive Dust	DIP 2D IP6x
	22	Non conductive dust	DIP 3D IP5x
	22	Gas and dust	EEx nA, plus appropriate DIP *alternatively any equipment suitable for Zone 1*

5.3.4 EEx nA - non-sparking

5.3.4.1 Equipment (ATEX 94/9/EC)

- 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
  - 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: d*u*/d*t* < 500 V/μs and U_{peak} < 1 kV to earth
    - With form-wound winding and U_n>1000 V: d*u*/d*t* < 500 V/μs, U_{peak} < 2 x line voltage to earth

5.3.4.2 Installation (ATEX 1999/92/EC):

- PDS according to EN 60079-14:2003
  - Prevent any over voltage spikes and higher temperatures in the motor or its terminal box.

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

— 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 1999/92/EC)

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

5.3.5 EEx e - Increased safety

5.3.5.1 Equipment (ATEX 94/9/EC)

- 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 tested as a unit (each combination must be tested). The test shall be performed with the protective devices provided

5.3.5.2 Installation (ATEX 1999/92/EC)

- 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 1999/92/EC)

- PDS according to EN 60079-17:2003
  - — The tripping time characteristics of protective devices shall be checked

5.3.6 EEx p – Pressurised

5.3.6.1 Equipment (ATEX 94/9/EC)

- Motor
  - — Can be installed in either Zone 1 or 2 areas
  - — Enclosure purged and pressurised by a protective gas, prior to starting and when the motor operates
  - — Maximum surface temperatures limited on the outside of the enclosure
- PDS according to EN 50016:2002
  - — 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 1999/92/EC)

- PDS according to EN 60079-14:2003
  - — 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 1999/92/EC)

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

5.3.7 EEx d – Flameproof

5.3.7.1 Equipment (ATEX 94/9/EC)

- Motor
  - Can be installed in either Zone 1 or 2 areas
  - Explosion proof enclosure
  - Maximum surface temperatures limited on the outside of the enclosure
- PDS according to EN 50018:2000
  - Temperature rise shall be measured
  - 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 BDM shall be tested together as a unit to ensure the motor meets the requirements of a given external temperature classification
  - Either a direct temperature control by embedded temperature sensors or other effective measures. 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
  - The motor shall have been type-tested 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 1999/92/EC)

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

5.3.7.3 Inspection and Maintenance (ATEX 1999/92/EC)

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

5.3.8 DIP - Dust Ignition Protected

5.3.8.1 Equipment (ATEX 94/9/EC)

- Motor according to EN 50281-1-1:1998
  - May be installed in dust hazard area, or area with both gas and dust hazard
  - For gas hazard can be installed in either Zone 1 or 2 areas, but must also comply with requirements for appropriate gas hazard.
  - 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.

5.3.8.2 Installation (ATEX 1999/92/EC)

- PDS according to EN 50281-1-2:1998

  — The motor shall be installed with the protective device specified.

5.3.8.3 Inspection and Maintenance (ATEX 1999/92/EC)

- PDS according to EN 50281-1-2:1998

5.4 Notified Bodies and Certification

The Ex Notified Body (Ex NB) provides approval that the both the motor manufacturer and product fulfil various requirements of ATEX Directive 94/9/EC 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 Directive 94/9/EC allows the product manufacturer to raise an EC Declaration of Conformity without an EC Type Examination Certificate from an Ex NB.

In accordance with ATEX 94/9/EC 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 94/9/EC. 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 94/9/EC.
- 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. To ensure safe operation of the PDS, the motor manufacturer must specify the restrictive conditions for use.

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

6 Responsibilities

6.1 ATEX Directive 94/9/EC

6.1.1 New installations

In accordance with ATEX 94/9/EC the system supplier or component manufacturer will provide markings and documentation as detailed in 5.4. Where a system integrator, or user assembles a system from parts of different manufacture, it is his responsibility to ensure compatibility, and the validity of the CE marking.

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

The supply of Non-ATEX certified components as spares for equipment certified pre-ATEX is permitted under the following conditions. Proprietary goods such as terminal boards/studs etc. must comply with the directive since they are classed as equipment in their own right.

The UK Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 act, Part II, Clauses 4 and 5, states that: -

> '--- components supplied as spares, for equipment placed on the market in the Community on or before 30th June 2003 which complies with any health and safety provisions with which it would have been required to comply for it to be lawfully placed on the market in Great Britain on 23rd March 1994, are excluded.'

The above is strictly on the understanding that the components are being supplied for the express purpose of fitment to the intended goods, without alteration and in accordance with the original certification and conditions of use and that there is no autonomous use for that component.

It is the users responsibility to ensure that only appropriate spare parts are fitted.

6.2 ATEX Directive 1999/92/EC

ATEX 1999/92/EC sets certain responsibilities for end user, as detailed in 2.3.

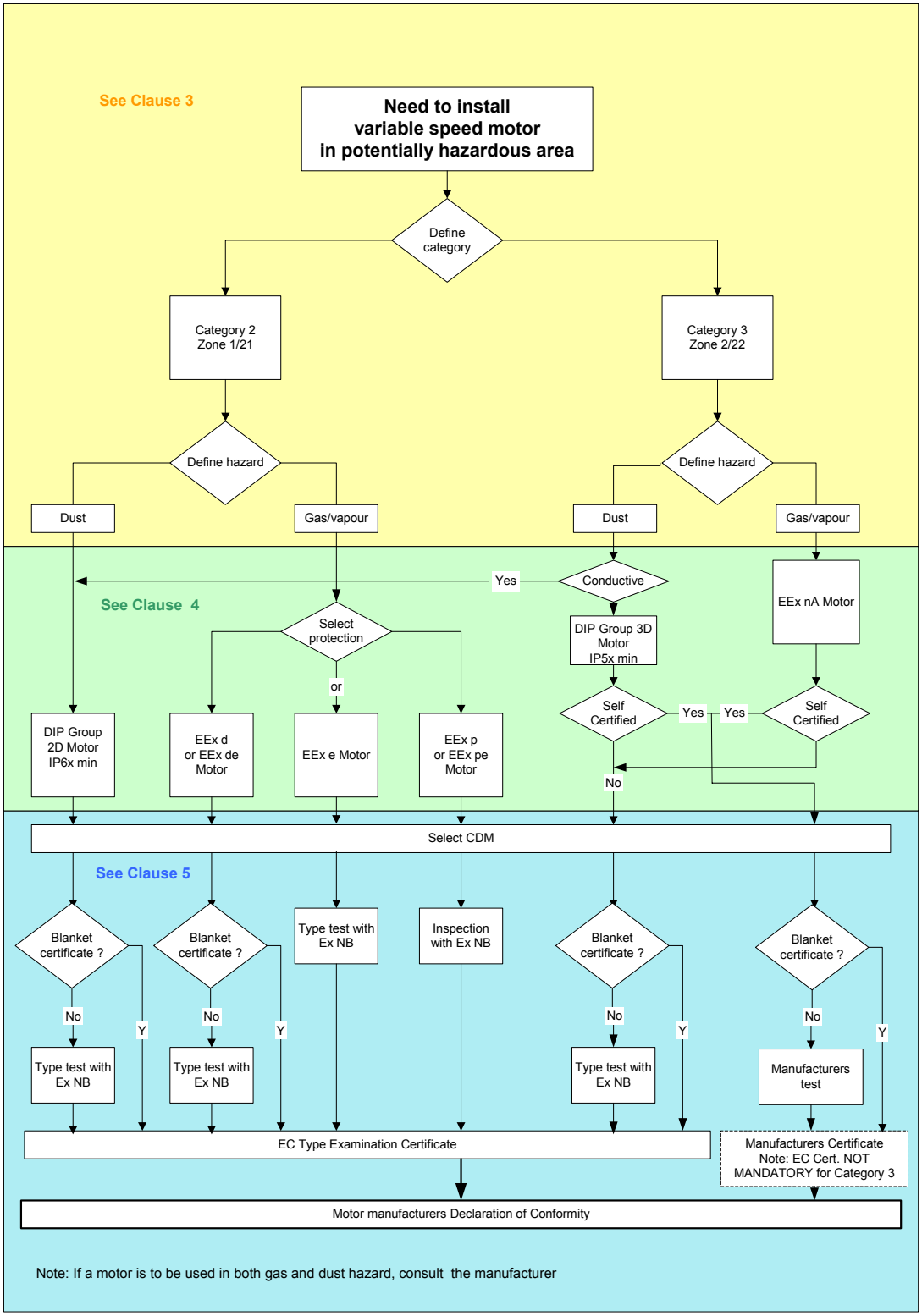


Figure 10 - Flowchart showing selection of equipment to meet ATEX Product Directive

Glossary of terms

Term or abbreviation	Description	Section
a.c.	Alternating current	General
ATEX	“Atmosphères Explosibles” – European Directives using French acronym, covering the essential health and safety requirements for products used in potentially explosive atmospheres	1.2, etc.
Base Speed	Speed at which nominal voltage is applied to a motor	
BDM	Basic Drive Module	1.1, etc.
BSI	British Standards Institution – responsible for the preparation of UK National Standards, prefixed BS *** and publication of harmonised standards in the UK, prefixed BS EN ***	General
CDM	Complete Drive Module	1.1, etc.
CE Marking	Indication of compliance with all appropriate EU Directives	General
CEMEP	European Committee of Manufacturers of Electrical Machines and Power Electronics	Foreword
CEN	European Committee for Standardisation, responsible for the preparation of non electro-technical harmonised (EN) standards	General
CENELEC	European Committee for the Electrotechnical Standardisation – responsible for the preparation of electro-technical harmonised (EN) standards	General
CSI	Current Source Inverter	5.2.1.2
d.c.	Direct Current	General
DIP	Dust Ignition Protection	4.6
du/dt	Rate of change of voltage	5.3.4
EC	European Community	General
EEA	European Economic Area	General
EEC	European Economic Community	General
EHSR	Essential Health and Safety Requirement	2.2
EN	EuroNorm – Standard issued by CEN/CENELEC, normally prefixed by the national issuing body e.g. BS EN	General

Term or abbreviation	Description	Section
EPD	Explosion Protection Document	2.3
EU	European Union	General
Ex NB	Ex Notified Body.	5.4
IEC	International Electrotechnical Commission – International Standardisation Body. Also the prefix for standards prepared by this organisation	General
IP	Ingress protection (see appropriate standards)	5.3.8
IT	Ungrounded power supply network	5.3
PDS	Power Drive System	1.1, etc.
PWM	Pulse Width Modulated	General
RTD	Resistance temperature detector	5.2.1.2
TN	Power supply network having neutral grounded at more than one point. 3 types of TN system are recognised	5.3
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	5.3
U	Voltage (generally used with suffixes)	General

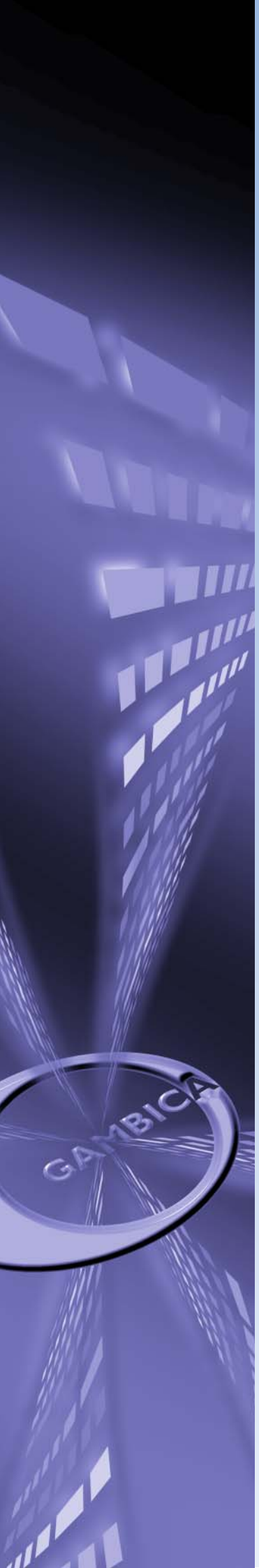
Comparison of Standards

Various standards in the EN 50000 series are being replaced by EN 60000 series (corresponding to the equivalent IEC standard numbering). The following table is provided as a comparison. Only current EN standards, which have been notified in the Official Journal of the EU have validity in the implementation of a new approach Directive.[11]

Concerning	EN 50000 series standard	IEC/EN 60000 series standard
Protection 'p'	EN 50016	pr EN 60079-2
Protection 'd'	EN 50018	pr EN 60079-1
Protection 'e'	EN 50019	EN 60079-7
Protection 'n'	EN 50021	EN 60079-15
DIP	EN 50281	pr EN 61241

[11] 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



This guide has been prepared by GAMBICA's Variable Speed Drives Group and REMA.

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GAMBICA is the Association for Instrumentation, Control, Automation & Laboratory Technology and has a group specifically for suppliers of Variable Speed Drives.

REMA is the Rotating Electrical Machines Association representing manufacturers of rotating electrical machines, other than turbine machines, traction motors or machines for the use in aircraft.

The greatest care has been taken to ensure the accuracy of the information contained in this guide, but no liability can be accepted by GAMBICA, REMA or their members, for errors of any kind.

Always refer to your Drive and Motor Suppliers if in doubt about correct matching.

04/04